

**DIFFUSION AND ADOPTION OF MULTICASTING: ROLE OF IMPLICIT
VERSUS EXPLICIT COMMUNICATION INITIATION METHODS**

BY

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ABSTRACT

Multicasting is a new Internet-based technology. Its research, development and implementation in networks have strong implications on network-based economies. Functional areas such as marketing, information systems and technology will benefit the most by adopting multicasting. However, in spite of being technologically superior, often a product or a service is not adopted. This may happen for several reasons. We propose to examine some of these reasons as applied to multicasting.

In this study, we aim to determine the ways in which multicasting is diffused in communities and the factors that lead to its adoption. We also hope to obtain some estimates on the process of adoption.

INTRODUCTION

1.0 Innovation on the Internet

The growth and acceptance of Internet technologies is unprecedented in the history of technology. Although the Internet has been in existence since 1969 (Kosiur, 1998), Internet-related technologies and applications have gained popularity after the introduction of the World Wide Web (WWW or Web). Over the years, the basic attributes of the Internet haven't changed much. However, applications such as the Web browser have leveraged the communication power of the Internet in innovative ways. One of the reasons for this exponential growth is the perception that users have of the Web's attributes. Positive perceptions have helped in diffusing Internet access through homes and businesses. Another reason often cited (Mahajan, Muller & Bass, 1990) is that in current technology markets, product life cycles of computers, software, and electronic products have shrunk to the order of a few months. Shorter life cycles force newer products on the shelves before old ones can be phased out. These factors have influenced the adoption behavior of consumers and the diffusion behavior of the markets. Some questions related to this situation are:

- How are consumers influenced about better or innovative products or services?
- What factors influence the decision to ultimately adopt a product or service?
- When consumers adopt new technologies, how quickly (or slowly) do they adopt?

The Internet is an enabler of communication. Enhanced communication leads to better response and turnaround times, which leads to improved productivity in businesses.

Communication is the primary key to the Internet's existence. The Internet was originally

designed for point-to-point communication. However, situations involving mass distribution of data call for transmitting from one point to multiple points. One such technology that enables point-to-multipoint communication is called multicasting. This technology allows for data transfer over the Internet through several channels simultaneously without any noticeable impacts of scalability and quality (Kumar, 1996). Multicasting allows users to send data from one point to multiple points in real-time (synchronously) with minimal consumption of network resources. Multicasting is best suited for point-to-multipoint synchronous communications. As this kind of communication takes place in real-time, the discovery of such media channels becomes critical. The end-user that wishes to access this information makes this discovery via an explicit or an implicit initiation. Each method has its advantages and disadvantages. We propose to study the impacts of such communication initiation methods on the diffusion of multicasting. As in case of the Web, multicasting may bring several advantages to the end-user and may help in the decision of adopting multicasting as a way of distributing information by large users like corporations. We would like to examine the reasons why users may adopt multicasting in future. A better understanding of the reasons why multicasting is accepted over another option can give insights into the consumers' behavior. By doing so, companies and research groups can expect a better return on their investment of information technology resources. Before we go into the details of this proposal, it is important to examine some definitions related to innovation.

1.1 Definitions

Innovation may be defined as a perception that an entity is new (Freeman, 1989). This entity may arise from an existing one, or may be created as a completely different one.

The innovation's movement through a community is called its diffusion (Swanson, 1994). The diffusion of an innovation may be slow or fast, but primarily depends on channels of communication in the community. When individuals (or organizations) in the community make a decision to accept the innovation and use it, it is termed as the adoption of the innovation (Rogers, 1995).

1.2 Rationale for this study

The rationale for the present study is to examine multicasting as an innovation, and to establish the reasons that will help in its potential adoption. This study will attempt to establish the methods by which a community learns about multicasting, and probe into the factors that lead to the ultimate decision to adopt it. If the findings of this study are positive and encouraging, one can expect a better return on investment (ROI) from multicasting for the years to come. This study will combine the approaches of diffusion and adoption to study multicasting as an innovation. The outcome of this combination will help us better comprehend the diffusion and adoption of multicasting technology and services in organizations.

1.3 Research Questions

Some of the questions this study intends to address are:

- What methods of communication enable the diffusion of multicasting?
- How influential is each of these methods in the diffusion of multicasting?
- What are the factors that influence the adoption of multicasting?
- What is the degree of influence of each of these factors on the rate of adoption of multicasting?

1.4 Significance of this Study

Developments in the field of multicasting show promises, similar to those of the Internet. Multicasting has grown out of the inquisitiveness of network researchers in search of a better way to communicate. The applications based on multicasting have gained popularity since its inception in March 1992 (Kumar, 1996). Multicasting applications have recently started appearing on the commercial side as well. IP/TV is an example of one such application developed by Cisco Systems that uses multicasting for corporate video conferencing and delivery of critical information to desktops. Other examples of products that support multicasting are the Real Networks® G2 streaming media player, and the Microsoft Windows® media player.

Similar to the research conducted on adoption of new technologies such as the VCR, fax machines, cellular phones, and Internet, a study on the adoption of multicasting would bring out insights into several aspects of this technology. The cost of hosting scaleable services on the Internet is rising everyday (McKnight & Bailey, 1997). Multicasting provides a solution by allowing high scalability with no noticeable change on the network load. Another concern about the growth of the Internet is that the number of users signing on to the Internet is on the increase. By using multicasting, several groups of users could avoid burdening the Internet with replicated data. Keeping these factors in mind, an examination into the promises of multicasting would be quite worthwhile.

1.5 Organization of this Proposal

The remainder of this proposal is organized as follows:

- ◆ A study of the literature on innovation in general and technological innovation as applied to multicasting.

- ◆ A model to study diffusion and adoption of multicasting and a proposed set of research hypotheses to analyze the rate of adoption of multicasting.
- ◆ A methodology that addresses the issues of data collection and analysis options.
- ◆ A summary.

REVIEW OF RELEVANT LITERATURE

2.0 Introduction

This proposal aims to examine the factors that influence the diffusion and adoption of multicasting as an innovative technology. An innovation is an idea, practice, or object that is new to the adopting unit (Rogers, 1995). Innovation may also be defined as "the first or early use of an idea by one of a set of organizations with similar goals" (Daft, 1978, p197). The process by which innovations spread from one locale to another is called diffusion (Brown, 1981). Diffusion of Innovation (DOI) is the awareness of an innovation, generally spread through different communication channels. Acceptance and regular use of an innovation is called adoption. We propose to use the framework of diffusion and adoption to study the spread and acceptance of multicasting in organizations.

2.1 Types of Innovation

Research in the area of innovation indicates that to better understand the process of innovation, it is important to examine the adoption behavior and identify the underlying constructs (Swanson, 1994). Three modes of distinction are widely accepted: incremental vs. radical, administrative vs. technical, and product vs. process innovations (Damanpour, 1991). The adoption of a particular innovation by an individual or an organization can change the structure of that entity. Radical innovations bring about radical changes in an individual or organization's mode of functioning, while incremental innovations indicate a lesser degree of departure from the existing practices (Dewar & Dutton, 1986).

Multicasting, like many other Internet technologies, rose from existing systems and was

developed to intelligently use the available network resources. Unlike radical innovations, incremental innovations such as multicasting are closely related to their parent technologies. When TCP/IP was introduced as an alternative for developing large networks, the existing network protocols were proprietary. TCP/IP was radically different from the others. Therefore, the costs involved with changing to TCP/IP from an existing network such as Novell® were very high. However, in case of multicasting, the change is incremental as multicasting protocols were developed on top of the existing TCP/IP protocols. This distinction helps in understanding the innovation and reasons for its adoption.

Administrative innovations work towards improving administrative and social constructs of an organization in terms of its structure and its management (Becker, 1967). Technical innovations focus on product and process (Damanpour 1991). Robey (1994) makes a distinction between administrative innovations and technical innovations. He states that the difference between administrative and technical innovations relates to social and technological constructs in an individual or an organization. Administrative innovations tend to lag behind technical innovations. As technology is the enabler of change, technological change is implemented first, and then the users are trained in its administrative implementation. For example, organizations that use local area networks (LAN) have to implement the technology first, and then conduct trial runs before adopting it and training their personnel in working via networks. One of the explanations of this lag is that "...technical innovations are more observable, have higher trialability, and are perceived to be relatively more advantageous than administrative innovations, while administrative innovations are perceived to be more complex than technical

innovations to implement” (Damanpour and Evan 1984, p394). In organizations that use network resources, multicasting will have to be implemented as a technology. Its administrative influences might be secondary. Therefore, we will study the technological factors that influence the diffusion and adoption of multicasting.

Zmud (1982) distinguishes between product innovations and process innovations. Process innovations influence the way in which organizations or individuals conduct their production or operations to provide a service to the consumer (Zmud, 1982). Process innovations often relate to administrative processes such as processing of data, creating reports and other Information System (IS) functions (Fichman & Kemerer, 1993).

Product innovations are the introduction of new products or services that shift or expand an organization's domain (Zmud, 1982). Multicasting is primarily a product innovation as it allows organizations to provide synchronous multipoint services. Factors such as cost, trialability, observability play an important role in determining a product's adoption.

With time the product's adoption influences the process flow of business processes, but these changes happen later. In the primary stages of adoption, the innovation is still being considered as a product. Therefore, we will study multicasting as a product, and not a process innovation.

Traditionally innovation dichotomies have been examined as technology-based vs. organization-based (Sharma, 1996). The prior relates to the changes in technology that are molded on to the organization. A good example is the adoption of groupware software to enable teamwork. In this case, teamwork is the primary organizational goal. Groupware is chosen as an innovation to facilitate and realize the goal. In case of organization-based innovations, the innovation is implemented in the organizational

process to fit the technology. An example of this would be the adoption of telecommuting by an organization. In this case, managerial hierarchy is modified to include more independent remote workers. The organization has to modify its methods of meetings, assignments, deadlines and deliverables. Multicasting is a technology-based innovation that may be implemented to improve organizational goals.

It is important to understand these distinctions because they will play an important role in the adoption of multicasting at various levels. Multicasting is a core technology, which may be implemented in specific products or embedded in the entire organization's network. Once adopted and put to use, it may make an impact on the administrative processes of the organization. For example, live audio/video memos can be sent to people instead of group e-mails. Meetings can be held wherever anyone can participate from his or her desktop. Software configuration and upgrades can be done remotely from a central location. This will solve many problems about maintaining different versions of software on all computers in an organization. Currently, multicasting is being used as a new and upcoming network technology. In spite of a lack of widely accepted standards, some organizations have already implemented multicasting on their Intranets and adopted it as an integral part of their organization's network (Kosiur, 1998). Broadcast.com uses multicasting to support live radio and TV station feeds to computers all over the world. The Box, a popular 24-hour music video channel uses multicasting to update its regional servers with the latest digital videos at regular intervals. Because the process of diffusion and adoption of multicasting can take different routes, it is important to understand the distinctions <what's the importance of distinctions> between various classifications of innovation.

2.2 Diffusion and Adoption of Innovation

Innovation diffusion and adoption play a major role in the development and implementation of innovative technologies. Various factors influence the profile of adoption and product life cycles. One of the factors, namely diffusion of innovation is the natural starting point in the search for clues about a technology's ultimate disposition (Fichman & Kemerer, 1997). The diffusion process consists of four elements: the innovation itself, communication about the innovation, time taken for diffusion and social system where the diffusion and adoption takes place (Mahajan, Muller & Bass, 1990). As information about the capabilities of an innovation diffuses through communication, the potential adopters become more informed. As time goes by, the diffusion effect cumulatively increases the degree of influence upon an individual to adopt or reject an innovation, resulting from the activation of peer networks of a social system (Rogers 1995). Multicasting as an innovation has been diffusing through peer networks since it was first used in March of 1992 by the Internet Engineering Task Force (IETF) to audiocast its conferences (Kosiur, 1998). As communication increased between the adopters, the rate of adoption of multicasting increased. The first broadcast was to participants at twenty sites on three continents spanning sixteen time zones. This led to the establishment and growth of the Multicast Backbone (MBone) community. Estimates generated in 1997 are that the MBone community consists of over 3400 subnets in more than twenty-five countries (Kosiur, 1998). Many factors have helped in the diffusion of multicasting. As this diffusion, process continues it will reach a point when the end-users will accept multicasting as a viable and reliable service and use it on a regular basis. This

point in the diffusion time-line is the act of adoption. It signifies the fruition of the diffusion process (Swanson, 1994).

2.3 Rate of Adoption

The process of adoption of an innovation is observable in its rate of adoption. The rate of adoption is a strong indicator of the adoption pattern (Rogers, 1995). The rate of adoption is defined as the relative speed with which the members of a social system (Rogers 1995) adopt an innovation. More specifically, the rate of adoption of multicasting is defined as the number of individuals in a community who adopt multicasting in a given period of time such as a year. This number is generally represented as a percentage. The variation (increase or decrease) in the rate of adoption can be described by several factors including the attributes of multicasting, communication between adopting members, its diffusion amongst members (primarily through communication), its value in a community, support from its proponents, and economic factors such as availability and cost. The rate of adoption helps in profiling the product life cycle of an innovation. The introductory phase is characterized by a slower acceptance, a growth phase reflecting the highest rate of consumer acceptance, and a maturity phase when the product acceptance saturates. This profile gives the adoption curve an S shape. For multicasting, we would like to estimate the rate of adoption and place the adoption process somewhere on the life cycle curve. From the standpoint of research, we are interested in the factors that drive the adoption process. We would like to examine the factors that influence the diffusion process and lead to the adoption of multicasting.

2.4 Communication Factors

Communication between the adopters of an innovation plays an important role in diffusing it. Rogers (1995) has indicated that the communication channels in a community adopting the innovation are an influential factor in determining the rate of adoption of an innovation. Rogers (1995) defines the innovation-decision period as the time elapsed from the awareness-knowledge of an innovation to the decision to adopt (or reject). The knowledge stage is when the potential adopter learns about the innovation's existence and gains some understanding. This is the first stage in the innovation-decision process. This stage is dependent on the communication between the potential adopters. The knowledge about an innovation becomes a function of communication. Fichman & Kemerer (1997) state "From a diffusion perspective, the process of diffusion is predominantly a process of its communication through the community." The process of diffusion of information about an innovation often leads to its adoption. Through networks formed with users outside an organization, the user group expands beyond the initial innovator (Fichman & Kemerer, 1997). Newsgroups, e-mail lists and web rings are common methods of establishing such networks. All the evidence stated above reiterates the importance of communication in the diffusion and adoption of an innovation. Let us look further at the mechanisms of communication in a community.

2.4.1 Bass Model of Innovation Diffusion

Long range mathematical forecasts of new product sales have been of considerable interest since the 1960's. Researchers in management and marketing science have contributed to the development of diffusion theory by suggesting analytical models for forecasting the diffusion of an innovation in a social system (Mahajan, Muller & Bass,

1990). The best-known "first-purchase-diffusion-models" of new product acceptance are those of Fourt & Woodlock in 1960, Mansfield in 1961 and Bass in 1969. While Fourt & Woodlock (1960) proposed a diffusion model based on mass media communication, Mansfield (1961) proposed a diffusion model driven by the communication technique of "word-of-mouth". The Fourt & Woodlock model proposes that the influences of mass media on the diffusion process are external to the organization in question. These mass media channels are television, radio, newspapers, magazines, etc. The Mansfield model defines diffusion as being influenced by internal communication, primarily word-of-mouth. In an effort to combine the two models and better define the diffusion process, Bass (1969) proposed a model that emphasized mass media and interpersonal networks. The Bass model considers the influence of these two variables to be independent of each other (Bass, 1969).

Several researchers (Bass, 1969, Mahajan & Muller, 1979, Mahajan, Muller & Bass, 1990, Rogers, 1983, Gurbaxani, 1990, Jain, Mahajan & Muller, 1991, Rogers, 1995, and Morrison, 1996) have conducted studies to examine the influences of mass media and interpersonal communication on innovators and imitators. They conclude that while both innovators and imitators are influenced by mass media, only imitators are influenced by word-of-mouth. An explanation for this observation may lie in the fact that word-of-mouth communications are conducted internally within an organization, and therefore more susceptible to imitation. To study the diffusion of multicasting we will primarily focus on the mass media aspects of communication over the Internet for two reasons:

1. Multicasting is a network technology best suited for one-to-many or many-to-many kinds of communication (Kumar, 1996). Multicasting is not suitable for

one-to-one communication as characterized by interpersonal or word-of-mouth type of communication. In fact, the current default mode of the Internet, namely unicasting is geared toward the one-to-one model of communication. Multicasting is an attempt to overcome the drawbacks of one-to-one communication.

2. Mass media communication applies to both innovators and imitators. By targeting the mass media mode of communication, we will be able to examine both innovators and imitators.

The Bass model has been used for studying a variety of products. Representative companies (Eastman Kodak, RCA, Sears and AT&T) have used the Bass model to validate the market behavior of new technology products (e.g. cameras, fax machines, and consumer electronics) (Bass, 1986). Jain, Mahajan and Muller (1991) have used the Bass model to examine the diffusion of technological products like the facsimile, and office automation products. In line with these studies involving technology, we will examine the diffusion of multicasting using the Bass model, focusing on mass media communication as the driving force.

2.4.2 Communication and Multicasting

In terms of using multicasting for mass communication, we must examine the different ways in which multicast communication takes place. When data are requested over the Internet, a remote server delivers the content to a client. For example, if there are one hundred users requesting the same data *simultaneously*, one hundred data streams are replicated by the *server* to serve one hundred *clients*. This type of a client-server relationship is administered on a one-to-one basis, giving it the name *unicasting*. The

MBone, however, enables multicast of data streams to multiple hosts simultaneously (Figure 1).

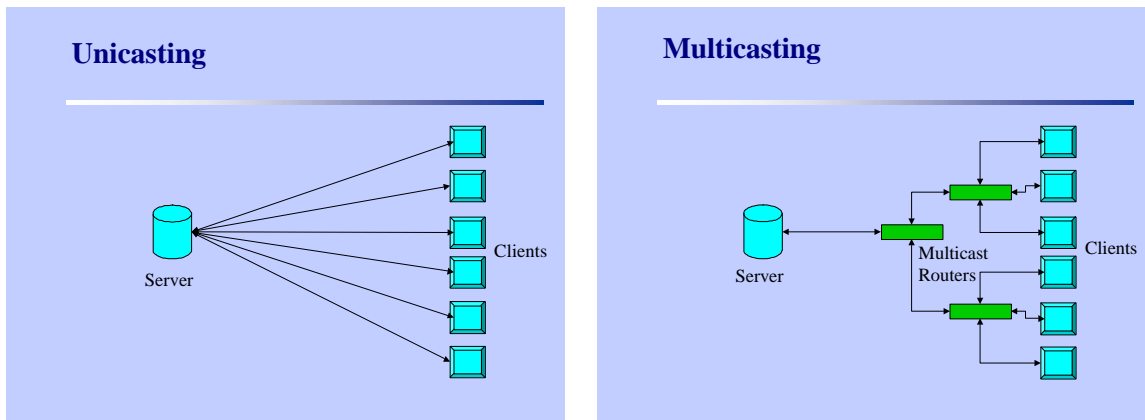


Figure 1: Unicasting vs Multicasting

MBone isn't a broadcast scheme. In broadcast schemes, the server sends the data packets to *all* nodes on the network. Each client then has to either accept or reject the packet.

However, in multicasting, a server makes the data available at a group address, and only those clients *interested* in accessing the data join the group, thus gaining membership to the group. Therefore, the client gains multicast access *on demand*. See Appendix A for details on multicasting.

2.4.3 Multicast Sessions

When multicast data are provided over a multicast network for a given period, it is called a session. However, before accessing multicast-based sessions, a session owner needs to allocate, reserve and advertise the session over the multicast-enabled network (Schooler, 1996). These sessions are provided to users at multicast addresses. Once advertised, each client can tune into and tune out of these sessions. The ways in which information about

sessions (their duration, content quality, and media type) can be provided to users are classified in several ways. Some of these classification schemes (Schooler, 1996) are:

- Point-to-point vs. Multipoint communications
- Synchronous vs. Asynchronous interactions
- Explicit vs. Implicit initiation models

Point-to-point communications are those where two users are involved, such as in a videophone conversation. Multipoint communication is conducted between multiple people such as a video delivered to multiple viewers (e.g., videoconferences). For mass media communication, point-to-multipoint communication is the preferred method.

Interactions between people in real time are called synchronous interactions (face-to-face, telephone, Internet chat, and video conferencing), while those that are time delayed are called asynchronous. E-mail, web pages, and postings in newsgroups are examples of asynchronous interactions. While asynchronous interactions allow users to access information according to their own schedule, synchronous interaction is popular in cases of live transmissions such as corporate broadcasts, meetings, radio and television.

Explicit initiation models are those in which the user specifically initiates the request to participate (e.g. telephone calls, e-mail messages, and web queries). The activity of typing a web address in a browser or clicking on a hyperlink to access a website is an example of explicit initiation. In implicit initiation models, the client simply announces its availability and location. The source of data (i.e. server) then sends the data. This process is transparent to the user. The user does not specifically request for any data. Therefore, the data appears to be *pushed* to the client. Tuning a radio to a particular frequency and receiving radio programs at that frequency automatically is an example of

implicit initiation. Schooler (1996) states " Explicit initiation uses invitations to request user participation. An implicit approach publishes an address where a user can ``tune in" to a session without getting pre-approval to join; thus the invitation is implicit." In particular, implicit initiation models allow users can *tune in* to a session using services such as a rendezvous directory service. Several collaborative web schemes work in this fashion (Kumar, 1996). While the Internet is primarily based on explicit initiation, the events that thrive on real-time data such as stock prices, breaking news, and anti-virus patches work best with implicit initiation models.

Based on the technology and the user requirements, multicasting is best suited for point-to-multipoint, synchronous communications. These communications may be initiated explicitly or implicitly. All combinations of the three types of classifications are listed in Table 1.

	Explicit Initiation		Implicit Initiation	
	Synchronous	Asynchronous	Synchronous	Asynchronous
Point-to-Point	Unicast	Unicast	Unicast	Unicast
Point-to-Multipoint	Best suited for Multicast	Unicast	Best suited for Multicast	Unicast

Table 1: Communication Schemes

2.4.4 Framework for Implicit-Explicit Initiation Systems

To understand the role of initiation in multicasting, let us examine a framework that classifies such systems. Related to implicit and explicit initiation methods is a technology popularly termed as *push technology*. Ordinarily, Internet applications obtain data from the server when the user (the destination of data) requires it. This is achieved by *pulling* the data from the server. As the act of obtaining the data is initiated explicitly by the user, the pull systems are classified as explicit initiation systems (Malhotra, Gosain & Lee,

1997). Many Web browsers function in this mode. Push systems are defined as those where the server (or source of data) sends or “pushes” the data to the client based on some predetermined scheme of preferences. This mode of access is initiated implicitly by the system, and not the user. Malhotra, Gosain and Lee (1997) describe these systems via their framework of push-pull systems. They suggest three dimensions to study the implications of such systems. These are the system’s conformance to user’s needs, the information processing requirements by the user, and the perceived control of the user about the information accessed. Malhotra, Gosain, and Lee (1997) propose that while there are no *pure pull* or *pure push* systems, an ideal system is one that maximizes the conformance to needs and perceived control, while minimizing on the processing requirements. Figure 2 describes these dimensions and the placement of pull and push systems in the enclosed three-dimensional space.

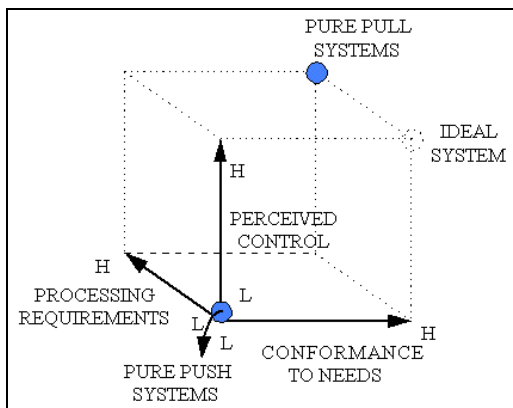


Figure 2: Framework for Push-Pull Systems (from Malhotra, Gosain & Lee, 1997)

They also propose that systems that afford the users the ability to transition from push mode to pull mode as and when required will gain a higher acceptance (Malhotra, Gosain & Lee, 1997).

Let us apply this framework to multicasting. The diffusion of multicasting through a network may be done using a variety of methods including webpages, newsgroups, e-mail, and rendezvous directory services. Of particular interest are the session directory (sdr) services, which fall under the category of rendezvous directory services (Schooler, 1996). These are implicit initiation services (see Appendix B for a detailed description of rendezvous directory services). Information about sessions announced via sdr is displayed to users synchronously using multicasting. Perceived control is high as the user can control the information that comes to his or her computer. The session is accessed *only on demand*.

The session directory displays pointers to current sessions. The pointers give the end user information such as the title of the session, its content type (audio/video/collaboration tools) and the audience it is meant for. The user can then decide to join the data stream based on the information provided in the pointers. Therefore, conformance to needs is high.

Multicasting was designed to avoid processing overload. Therefore, the processing needs for multicasting in general are low. These descriptions place rendezvous directory services close to the ideal system as described by Malhotra, Gosain and Lee (1997).

Therefore, given the importance of implicit initiation, we propose to examine the implications of implicit initiation via rendezvous directory services in diffusing multicasting.

2.5 Perceived Attributes of Innovation

Communication initiates the diffusion process. Once this process has started, other factors come into play that help in establishing and consolidating the influences on the

intention to adopt the innovation (Allen, 1998). One approach to understand this role is to examine the attributes of an innovation, and the value they have for a potential adopter. Rogers (1983) defines the attributes of an innovation as “perceived”. He states, “It is the receiver’s perception of attributes of innovation and not the actual attributes as classified by experts that affect the rate of adoption” (Rogers, 1983, p212). The perceptions toward the attributes induce behavior on the receivers’ part. This behavior then results, positively or negatively, in the adoption. Rogers (1995) defines five perceived attributes of innovations: 1) relative advantage, 2) compatibility, 3) complexity, 4) trialability and 5) observability. These attributes allow researchers to classify innovations instead of studying each innovation as a unique case.

1. *Relative advantage* is the degree to which an innovation is perceived as being better than the idea it supersedes. Multicasting is better than unicasting in situations that require synchronous transmission of data to multiple destinations. Rogers (1995) also generalizes that "...the relative advantage of an innovation, as perceived by a social system, is positively related to its rate of adoption". We would like to study the reasons why multicasting would provide a relative advantage over unicasting.
2. *Compatibility* is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters. Compatibility is also positively related to the rate of adoption. As multicasting was developed from unicasting, it is expected to be adopted well.
3. *Complexity* is the degree to which an innovation is perceived as relatively difficult to use. The degree of complexity has a negative relationship with its rate of adoption. If

multicasting proves to be complex in its implementation and use its chances of adoption will decrease.

4. *Trialability* is the extent to which an innovation can be experimented with on a free-of-charge or no cost basis. Rogers (1995) suggests that trialability is positively related to rate of adoption. Companies and research groups have been very generous with multicasting software and hardware support. Many free and trial versions of software are given out to potential adopters. This should lead to an increase in the adoption rate.
5. *Observability* is the ability to observe the adoption of an innovation into a community. A higher degree of observability has a positive influence on its adoption because as time goes by, the visibility of the innovation increases, thus increasing its awareness. Quality of Service (QoS) in multicasting is directly related to the quality of data received at the user's end. The QoS depends on factors such as reliability of data transmission, data reception, and loss of data streams. These factors are readily observable. Therefore, observability in multicasting becomes closely related to the Quality of Service (QoS). The QoS effort in multicasting and a host of other Internet services is very strong (Schooler, 1996). Observable changes in the service such as better video quality, better sound and lower latency of data will work as proof positive and lead to a higher rate of adoption.

Rogers' model identifies the *members* adopting the innovation as the essential players in the adoption process. The early studies on the attributes of adoption were conducted with farmers for hybrid seeds of corn (Rogers, 1995). The results of these studies indicated that the perceived attributes were able to explain a major share of the variation in the rate

of adoption of the innovation. Later studies conducted in the fields of education and technology indicated similar results (Holloway, 1977).

In his research on education, Holloway (1977) organized a study with one hundred high school principals around the five attributes and found support for the framework of perceived attributes as presented by Rogers (1962). Moore and Benbasat (1990) conducted studies to measure the impact of perceived attributes on adopting an information technology. They developed a Likert scale type instrument with 37 questions, 7 scales and acceptable levels of reliability. These questions covered the five perceived attributes and perceived voluntariness. Their methodology and results have also supported Rogers' framework of rate of adoption. Kearns & Huo (1992) found that based on eight adoption studies about computer innovation, five perceived attributes (as identified by Rogers) played a major role in explaining the variation in rate of adoption. Goldman (1992) conducted a study on the attributes of innovation in the campaign for healthier babies, and reported the five perceived attributes as being significant in the explanation in the rate of adoption of dietary supplements for babies. In another study, Allen (1998) found support for three (relative advantage, compatibility, and trialability) of the five perceived attributes in the explanation of the adoption of personal computer operating systems in corporations. Throughout innovation studies, literature and research widely support the influence and validity of the perceived attributes of innovation, namely 1) relative advantage, 2) compatibility, 3) complexity, 4) trialability and 5) observability.

A sixth variable of importance is perceived voluntariness. Moore (1989) found that perceived voluntariness plays an important role in the explanation of rate of adoption of

information technology by end users. It was later included in an information technology adoption study by Moore and Benbasat (1991). While there are good reasons to include some form of voluntariness in adoption studies, some researchers have not found conclusive results. Allen (1998) did not find support for perceived voluntariness in the context of adoption of the Windows 95[®] operating system. From another perspective, it is important to note that if a user adopts an innovation due to pressure from a higher authority, its adoption may have different implications from voluntary adoption (Rogers, 1995). Due to conflicting results and the major role that voluntariness plays in adoption, we would like to examine it further.

2.6 Innovation Adoption Model

The users who accept an innovation are categorized based on the degree of their involvement with the innovation and its adoption. As our study focuses on the adoption of a technological innovation, the innovation adoption theory provides an ideal basis for research. According to the *Rogers Adoption of Innovation* model (Rogers, 1995), the patterns of innovation include innovators, early adopters, early majority, late majority, laggards and rejecters.

Innovators are enthusiastic, energetic, thrive on change and are almost obsessed with adventure (Rogers 1995). Early adopters are well-integrated individuals, sought out by their peers for their technical information and advice (Rogers 1995). Early majority adopt new ideas shortly before the average person and their value system centers on deliberateness (Rogers 1995). Late majority are recognized as followers who are skeptical of innovations; adoption is both an economic necessity and a response to social pressure (Rogers 1995). Laggards, the last to adopt any innovation, possess almost no

opinion leadership. They are often described as "near isolates and dedicated to tradition" (Rogers 1995). Rejectors openly oppose any innovation and openly encourage others to do likewise (Rogers 1995).

Rogers (1995) has established that the adoption process approximates a normal distribution. The innovators constitute 2.5% of the total organization. Early adopters, the next 13.5% provide a path for others to follow. The overall adoption curve includes points representing awareness, interest, evaluation, trial, and adoption (Herbig & Kramer, 1993). Multicasting is currently available in the market as an innovative technology. Research groups and network engineers are studying it currently. Multicasting is still not considered a mainstream technology as:

- The current IP (IPv4) doesn't support multicasting natively (Kosiur, 1998).
- An estimated 3400 of the total subnets support multicast on the Internet (Kosiur, 1998). The Internet has approximately 70,000 nets (Semeria, 1996).
- Limited numbers of companies use it for applications of public access.

This leads us to believe that multicasting is well past its early innovation stages and is currently being tested and observed by early adopters. Therefore, we will be able to test the influence of factors related to communication, and perception of multicasting among innovators and early adopters.

2.7 Summary of Multicasting as an Innovation

Multicasting is being used on an experimental basis for transmissions ranging from live videoconferences, and music concerts to live NASA shuttle launches. Experimental systems are being developed to deliver video-on-demand to households using multicasting (Almeroth & Ammar 1997). Corporations are already using worldwide

distribution of software and upgrades through multicasting (Kosiur, 1998). The concept of advertising and delivery is changing. Multicasting of product information using directory services such as Cisco Systems' IP/TV (Cisco Systems, 1999) or FVC.com's ICast (FVC.com, 1999) can translate into a more informed and more current audience. It also supports the vision of a common platform (the Internet) for all services to the home and office. Multicasting by design is a mass media service. We propose to examine the diffusion effects of communications by using the initiation methods as the differentiating factor.

Units of innovation in various studies range from hybrid corn in agriculture, to fax machines in technology (Rogers, 1995). From the literature, it is evident that perceived attributes of various units of innovation played an important role in supporting the adoption process. We propose to study the influence perceived attributes of innovation on the adoption of multicasting. These impacts and influences will have significant implications on research in marketing, decision making and information systems.

Finally, the onset of multicasting has information technology consequences in relation to the design, development and implementation of hardware and software. An examination of the impacts of the complexity of technology, compatibility in terms of platforms and upgrades, and trialability of limited-use services on the adoption of multicasting would prove worthwhile.

MODEL

3.0 Introduction

Based on the literature discussed in the previous chapter, we propose to explain the rate of adoption of multicasting by all the variables that influence it. To achieve this, we propose to collectively use all the important factors that help in the diffusion of multicasting and in its adoption.

3.1 Theoretical Model

The theoretical model for this study draws its strengths from two primary research streams. These are the areas related to the diffusion by communication and the perceived attributes of innovation. While these fields have very different origins, their contribution to the field of innovation is immense. Communication plays a central role in Internet related technologies. Researchers have found communication very helpful in the explanation of variation in diffusion (Bass, 1969, Mahajan, Muller & Bass, 1990, Cooper, 1990, Fuller & Swanson, 1992). Many other studies on innovation have established that the explanation of the variation in the adoption patterns can be accomplished primarily by the perceived attributes of innovation. Perceived attributes are also important in network technologies. In such networks, communication channels can be activated almost instantaneously. For example, e-mail messages can travel across continents in the order of a few milliseconds. The response rates for feedback are relatively high (Berger, 1994). This induces a perception of a high degree of observability. Another interesting observation as stated earlier is that while the Internet has existed for a long time, public popularity of this medium has grown only recently. Many researchers attribute this to the

development of Web (Kosiur, 1998). The Web has created a very easy to use interface with low underlying complexities as compared to operating systems such as UNIX. The new interfaces and webpages have increased the advantages the Internet can offer to the typical user (Berners-Lee, 1992). Several other factors such as free trial software, the Open Source Initiative (for Linux operating system), declining PC prices, faster modems, and flat-fee based Internet access have encouraged the growth of membership on this worldwide network. Similar factors may help in the adoption of multicasting.

We propose to use the research of diffusion through communication to establish the role of communication in the initial stages of diffusion. We also propose to use the research of perceived attributes of innovation to establish the role of support factors in the adoption process. As the study relates to multicasting, the factors will relate to various aspects of multicasting technology and services.

3.1.1 Communication Initiation Models

In the previous chapter, we established the importance of communication in the diffusion process. We also examined the various ways in which mass-media communication takes place in networked systems. We have found evidence that points to the choice of initiation methods and their role in the communication process. However, we have not found any evidence in this regard that relates to multicasting. As multicasting is an efficient alternative for mass-media communication, we propose to examine the impact of initiation methods on mass-media communication, which in turn affects diffusion of multicasting, leading to the adoption of multicasting.

3.1.2 Perceived Attributes of Innovation

We also looked at the various factors that lead to the adoption of an innovation once the initial knowledge about the innovation has diffused. Since many researchers have found support for the perceived attributes of innovation as defined by Rogers (1995), we propose to choose the following variables:

- Relative advantage: The relative advantage that multicasting provides to the consumer compared to unicasting.
- Compatibility: The degree to which multicasting protocols and services are compatible with existing protocols and services.
- Complexity: The degree of complexity involved in obtaining multicasting at the consumer's end.
- Trialability: The degree to which multicasting can be obtained on a trial basis.
- Observability: The degree to which consumers can observe implementation of multicasting through a change in quality of service (QoS).

3.1.3 Voluntariness

What degree of control do the consumers have in implementing multicasting at their end? The influence of control will be represented by perceived voluntariness. This variable has been included in research by Moore and Benbasat (1991). A similar variable description has also been used by Rogers (1995) to describe the degree of control over the decision-making process. It is described as individual, collective or authority based. Malhotra, Gosain and Lee (1997) also consider perceived control to be an influential factor in the acceptance of push-pull systems. Therefore, we will include it as an independent factor.

In our study, perceived voluntariness will be defined as the perception of the degree of control the end-user has in adopting multicasting.

3.1.4 Rate of Adoption

The dependent variable in this study is the rate of adoption of multicasting. In measuring the rate of adoption, we will define it as the percentage of users of Internet-based products and services who use multicast capable products and services at any given point in time. While this number is continuously changing, we hope to collect information cross-sectionally and correlate the factors influencing adoption of multicasting.

3.2 Model Representation

We would like to propose an initial model with all the variables described in the previous section. The conceptual model is presented in Figure 3.

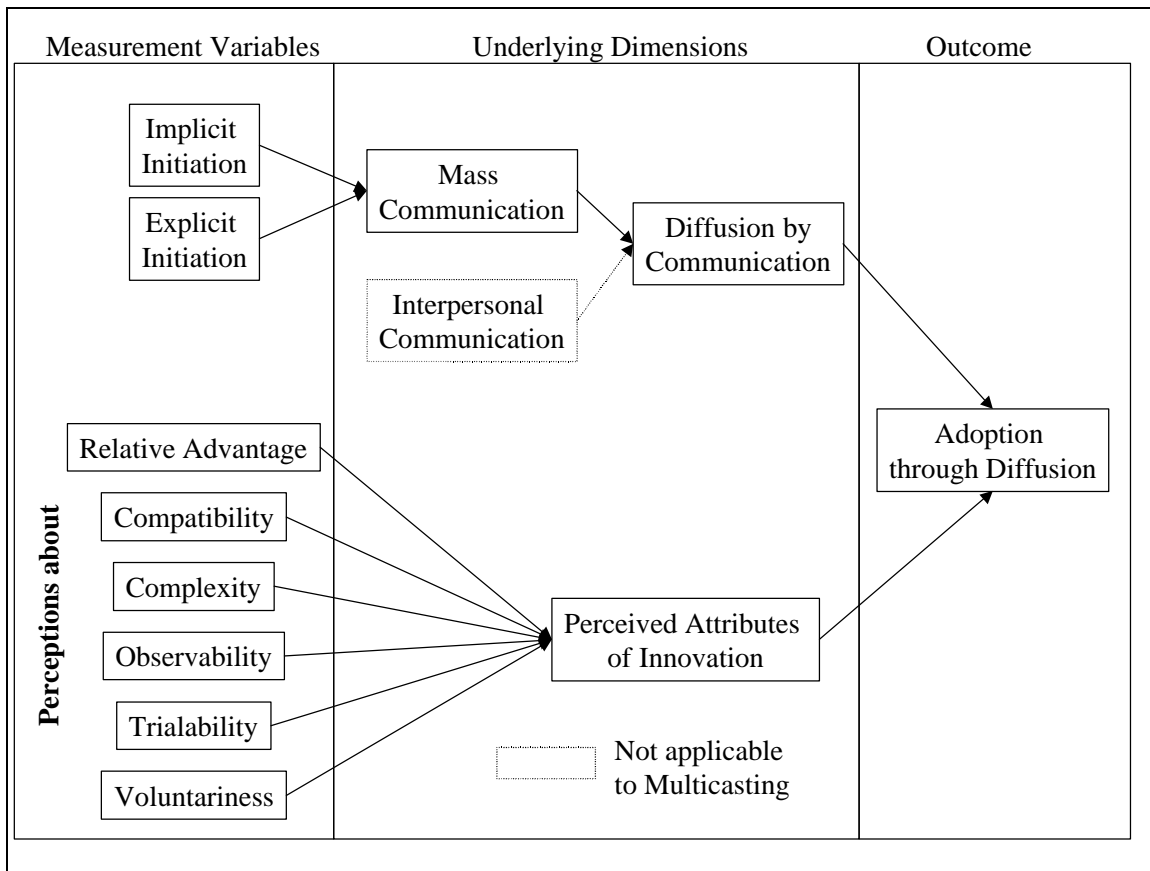


Figure 3: Model Representation

The outcome variable is the rate of adoption. This variation is determined as a function of the underlying dimensions of diffusion by communication and the perceived attributes of the innovation. Diffusion by communication is a factor of the different modes of communication. As multicasting is a mass media service, we will not include the influence of interpersonal communication on the diffusion of multicasting. The mass media communication dimension is affected by two variables, namely implicit initiation and explicit initiation.

Following the line of influence of the perceived attributes of multicasting, we will represent it as a function of how the end user perceives the various attributes. These attributes are, relative advantages of multicasting, compatibility of multicasting with

existing systems and processes, the complexity experienced in using multicasting, the trialability afforded by various multicasting software and hardware, the observability of the Quality of Service (QoS) of multicasting and the voluntariness involved in choosing to use multicasting. Therefore, the overall rate of adoption of multicasting becomes a combined function of initiation models, and the user's perceptions about relative advantages, compatibility, complexity, trialability, observability, and voluntariness.

3.3 Research Hypotheses

The variables identified in the previous section are part of the model used to represent the role of various influences on the rate of adoption of multicasting. Next, we have to analyze the degree to which each one of these variables contributes to the measured variation in the rate of adoption. Certain influences may be strong enough to be noticeable while others may be so weak that their presence simply cause statistical aberrations in the analyses. By generating hypotheses about each variable, and identifying its expected behavior, we can set the stage for collecting the required data and testing the influence of these variables.

3.3.1 Research Question 1: Role of Communication Initiation Methods

Based on the communication literature discussed earlier and the arguments made in favor of implicit initiation methods, we would like to prove that due to the real-time nature of multicasting, implicit initiation methods work better than explicit initiation methods. Our argument is that implicit initiation methods diffuse more relevant information about multicasting than explicit initiation methods. On the other hand, webpages, which provide information explicitly, have to be searched and indexed by search engines or

listed in Web directories. A user can learn about their existence only through searches or through announcements in newsgroups or at meetings or conferences (Press, 1997). The discovery and relevance of the sources are left to the user. Another reason to support implicit initiation methods over explicit initiation methods is the classification of multicasting on the framework developed by Malhotra, Gosain & Lee (1997). Multicast systems using implicit initiation methods are classified as ideal systems for information acquisition and have a higher chance at being accepted. Therefore, putting these reasons together, we propose the following research hypothesis:

H1: Multicasting will diffuse more rapidly through implicit initiation methods rather than through explicit initiation methods.

We hope to test this hypothesis statistically and prove that there is no evidence that implicit initiation methods are inferior to explicit initiation methods in diffusing information about multicasting. If proved, this would lead us to accept that implicit initiation methods are equal to, if not better than, explicit initiation methods at diffusing information about multicasting.

The implications of this outcome would mean that vendors of multicasting would do better in the market if they use rendezvous directory service interfaces instead of webpages. The Internet Engineering Task Force (IETF) has several proposals defining and refining the methods in which such services work. For example, the Multicast Source Discovery Protocol (MSDP) is one such standard (Kosiur, 1998). If proven successful, the multicast industry will support such protocols in their products and leverage the implicit initiation process as demonstrated in the sdr. If however, we do not find any

significant evidence to support implicit initiation methods, then the method of choice would continue to be explicit initiation via webpages.

3.3.2 Research Question 2: Relative advantages

A relative advantage of one product or service over the other is one of the most important contributors of change. Prior to the decision to adopt, the user has to evaluate the effectiveness of the innovation, its value to the existing system, the degree of efficiency it brings to the workplace and its overall impact on productivity (Lind & Zmud, 1991).

When unicasting was adopted over existing proprietary network technologies at the time, unicasting presented several advantages over proprietary technologies. Currently, multicasting can provide several relative advantages over unicasting, but the technology is applicable only in point-to-multipoint cases. For example, multicasting can provide several benefits for live broadcast systems used by radio and television stations.

However, multicasting is of no relative benefit for point-to-point communications.

An innovation may be very fancy or technologically advanced, but if the relative advantages it brings to the user are few, the charm of the innovation withers away quickly. Multicasting will be advantageous only to companies that use point-to-multipoint communications. As stated by Rogers (1995), greater relative advantages will lead the user to a faster adoption. Keeping these facts in mind, we propose the following research hypothesis:

H2: Rate of adoption of multicasting is expected to be high because of its relative advantages over unicasting.

We will test this hypothesis statistically. If successful, we will conclude that the relative advantages provided by multicasting are greater than, if not equal to the relative

advantages provided by unicasting. If the relative advantages provided by multicasting are not significantly greater than those of unicasting, then the investment in this innovation will be risky and expensive. However, if the evidence is positive, then companies and research groups can invest more into the development of multicasting and make it a mainstream technology.

3.3.3 Research Question 3: Compatibility

Compatibility of an innovation can be studied at several different levels. Compatibility can be technical, social or political (Rogers, 1995). We would like to examine the technical compatibility of multicasting with the existing IP-based networks, software, hardware, operating systems, and user interfaces such as browsers and directory services. Higher compatibility with existing systems and architecture allow users to use new technology alongside the older ones. This leads to better comfort levels for the user for the following reasons:

1. The investment of time and resources in adopting a new system is minimal if the new system is compatible with the old one.
2. The existing system is still available to fall back upon if the new system fails.
3. The users can transition from older systems and move on to the new ones slowly over a longer period.

Better comfort levels lead to lesser anxiety and improve the chances of adoption (Allen, 1998). Another reason why compatibility is an important issue is that when IP-based unicasting was initially implemented, it was a part of the original design of Internet-based networks. This was a radical change from existing networks provided by Novell® or Microsoft®. It took a major effort for companies to transition to IP-based networks.

Multicasting however, is an incremental innovation on the unicasting concept. Therefore, compatibility of multicasting with unicasting is high. All these arguments are in favor of a higher degree of compatibility of multicasting with unicasting. Therefore, we propose the following research hypothesis:

R3: Rate of adoption of multicasting is expected to be high because of its high compatibility with unicasting.

If the hypothesis proves to be right, we can conclude that multicasting is as compatible, if not more with unicasting compared to the compatibility of IP-based unicast systems with their predecessors. Early on, when multicasting was experimental, the software and hardware were only compatible with high-end systems. Currently, multicast capability is available natively in most popular operating systems and software such as the Windows[®] Media Player. Therefore, if the network is multicast-capable, most users can access multicast content in a single mouse-click, without any extra installations or configurations.

3.3.4 Research Question 4: Complexity

Complexity is the inverse of ease-of-use; a variable often discussed in the adoption of innovative information technology (Davis 1989, Moore 1989, Karhanna & Straub 1999). One of the reasons that is cited for the relatively slow adoption of the Linux operating system is the lack of ease-of-use in installing it. The complexity of an innovation implies more work in implementing it. Similarly, while initial adopters may be willing to put in the extra amount of work to implement multicasting, the slow adopters and laggards would find the complexity to be a valid excuse to stay away from it. In all, the return on

investment on the user's part is little if complexity is high. These aspects lead us to propose the following hypothesis:

R4: Rate of adoption of multicasting is expected to be high because it is less complex to use.

Easy to use systems are always more acceptable than complex systems. This is one of the reasons why services such as America On Line (AOL) are so successful. For the same reasons, multicasting will be adopted faster if the degree of complexity is reduced in terms of its installation, configuration and use.

3.3.5 Research Question 5: Trialability

Longer trial periods increase familiarity of the user with the innovation. Shareware and freeware modes often allow users to try out an innovation before they are completely convinced of its value and use in their work. This trial offer can be compared to playfulness, which has been studied by Allen (1998). In his study, Allen (1998) examined the effects of playfulness on the level of anxiety of a particular technology. He found that lower level of anxiety with a technology leads to higher adoption rates. Initially, when the Internet-based services first came out the National Science Foundation (NSF) had restricted the use of the Internet to education and research purposes only. However, generosity on part of the vendors is more noticeable now. Due to trends set by Microsoft™, Netscape™ and communities that support Linux™, more companies are offering their products for extended trial periods or even at no charge at all. Another reason why trialability plays an important role in the adoption of multicasting is that currently, there are several proprietary standards and the IETF regularly updates the protocol definitions for multicasting. Trialability allows users to test various flavors of

the same technology and decide which ones are right for them. Therefore, we would like to study the influence trialability has on the adoption of multicasting. We will use unicasting as a benchmark to compare the influence of trialability of multicasting. We propose the following research hypothesis:

R5: Rate of adoption of multicasting is expected to be high because of its high availability and trialability.

We hope to test this hypothesis statistically and if successful, we can conclude that the degree of trial provided to users gives them a fair chance to evaluate the use of multicasting against unicasting, without undergoing pressures of adoption.

3.3.6 Research Question 6: Observability

Observation is an important part of feedback. Greater opportunity to observe leads to the reinforcement of initial perceptions about an innovation's attributes. This observability is a direct reflection of the quality of service (QoS) received by the user. In the case of multicasting, these changes could be observed in the audio and video quality, frame rate of video feeds, and latency levels of the information (in applications such as ticker tape applets). An observable change in the QoS is important. For example, if an organization were to change the web services from Microsoft to Apache, the end users who see web pages would not know the difference unless they observe a change in the QoS such as faster responses to queries. The observable change then encourages the user to adopt or reject the service. This leads us to formulate the following hypothesis:

R6: Rate of adoption of multicasting is expected to be high because of its high observability in the Quality of Service.

We would like to conclude that multicasting possibly offers an observable change from the existing unicasting technology. The observable changes are perhaps the most easily

understood of all attributes of an adopting. Therefore, by enhancing the QoS of multicasting, the vendors can encourage faster adoption.

3.3.7 Research Question 7: Perceived Voluntariness

Perceived voluntariness plays an important role in the adoption of multicasting. In the case of multicasting, the network service provider must provide the user with access to a multicast-enabled network. The user then opts to use multicast software instead of unicast software to get data streams. Voluntariness is perceived by the user as the degree of control over his or her decisions or choice. This control works towards decreasing pressure to adopt which decreases the anxiety about the technology. As stated earlier, Allen (1998) found that lower anxiety levels lead to higher rates of adoption. Therefore we hope that higher perceived voluntariness will lead to higher adoption rates.

R7: Rate of adoption of multicasting is expected to be high because of a high degree of voluntariness on part of the users.

The outcome of perceived voluntariness and its influence on rate of adoption has interesting implications. Individuals adopting this technology may relate it to the idea of playfulness and pursuit of the innovation as a hobby or personal interest.

3.4 Summary

The theories and their applications that are explained in this section will be the foundation of this study. We have consolidated most major reasons that would lead to the adoption of multicasting. Some of these are a function of communication that exists between potential adopters. Others relate to the perception that the users have about the technology itself. As both kinds of variables relate to the end-user, the outcome of this research will provide insights into the ways in which people will adopt multicasting.

Based on the hypotheses stated here, we will investigate further into the methods to measure the variables and test these hypotheses. The details of the methodology are explained in the next section.

METHODOLOGY

4.0 Introduction

As this study is based on the perceptions of end-users and the communication between them, we have to examine appropriate methods by which we can quantify their opinions. We will then be able to statistically analyze their input and interpret results meaningfully. Furthermore, we have to ensure that the results are valid and applicable to a variety of end users. To ensure the quality of research and the validity of its results, it is important to describe and understand the research methodology. This methodology includes the research design, population identification, sample description, measurement instrument and the methods for collection of data. We will examine these in this chapter.

4.1 Research Design

Some studies in this field have captured data over time, based on server and network performance statistics. In other instances, while the studies called for an ideal approach, due to resource constraints an alternative method was chosen. Some of the alternative strategies available to us are case study, field study, lab experiment, and field experiment (Cook & Campbell 1979). Given the behavioral nature of this study, we would like to analyze the opinions of end users. Therefore, to examine the diffusion and adoption of multicasting, we propose to conduct a field study using questionnaires to capture the responses of end-users. We propose to use the field study setting as the value of this study depends on the external validity of the results. Using real world corporate end-users will ensure a higher degree of applicability of the results to real world users. By using corporate users for the survey, we can also capture the responses of users who work with

private multicast-enabled networks not visible on the MBone. The increased external applicability will allow us to extend the results to other similar organizational groups.

4.2 Validity Issues

The sample base will be drawn from a working population that is familiar with the area of multicasting in one way or another. We hope to capture their perceptions and attitudes through a series of questions. The sample description being very similar to the population identification, the external validity of this study is expected to be high.

Moore and Benbasat (1991) originally developed the instrument we propose to use in our study. This instrument is a result of several factor analyses in the original study and many other studies by independent researchers (Allen, 1998). Due to these reasons, we hope that the instrument will lend high construct validity to the study by measuring the appropriate constructs.

Internal validity allows a researcher to claim that it is, in fact, the treatment or program that caused a change in the group that was treated (Cook & Campbell, 1979). In order for a researcher to make a causal claim about a treatment or program, he or she must be able to show that:

1. There is a relationship between the treatment and the effect.
2. The observed effect occurred after the treatment was implemented.
3. There are no plausible alternative hypotheses.

Criterion 3 is usually the most difficult for a researcher to meet. Especially in social research, where it is often impossible to insulate groups from exposure to their social environment or regulate their reaction to the experience of being evaluated, events, conditions and responses unrelated to the treatment or program under study can have an

impact on the group. As this study is social in some ways and is being conducted in the field, the internal validity is not expected to be high. However, we will attempt to control it by avoiding the biases and influences from extraneous sources. Some of these biases and sources are discussed later in this chapter.

4.3 Population Identification

Computer mediated environments such as the Web are not very well understood and possess unique characteristics distinguishing them in significant ways from traditional, physical targets (Hoffman, 1996). Multicasting as a computer-mediated technology is in its initial stages of development and deployment. It is currently available for experimental use in universities or corporations within their intranet services. One of the essential components of multicasting is the network itself. The network must be multicast-enabled to provide any multicast support. In this study, we would like to target individuals working in organizations where such capabilities exist. Even if the capabilities exist, the individuals may or may not choose to use it. This choice depends on many factors including awareness, need and requirements of the organization. As multicasting is an Internet-based technology, we would like to describe the end-user population based on the outcome of some demographic profiles of users of the Internet. This approach will reduce the biases between the population and the sampling frame. Following are some interesting statistics:

- Most surveys place the users at 16 years and above (Hoffman, 1996), but the significant population exists between 21 years and 50 years of age (GVU, 1998).

Most of these are university and corporate users.

- The geographic placement of users is primarily the US. The GVU survey (1998) places number of US users compared to number of European users at a ratio of 10:1. While the GVU survey suffers from self-selection bias, the ratio indicates that the US users are significant majority of the Internet population.
- The recent GVU survey also indicates that as of 1998, the male to female ratio was close to 1:1. This is an interesting trend from earlier surveys, which indicated a majority of males using the Internet.
- Most users are in the process of getting a college degree or have a college degree and are working on a master's degree.
- Technologically speaking, more than 30% of the users have a 56kbps connection.
- Most people are familiar with, and use live chat features, audio, and Java/JavaScript enabled applications. These applications indicate the familiarity of users with interactive technologies.
- Large Internet Service Providers (ISP) mostly provide the services mentioned in the GVU survey. These providers have strong business models and incentives to upgrade their systems to provide multicast services to the customers.
- Most people use computers at work between 21 and 40 hours a week. The familiarity with a computer is high.
- Most users agree that their organization is involved in using the Web for efficient office use. This attitude should encourage the implementation of newer technologies such as multicasting.

The results of these surveys are summarized in the table below.

Population Category	Population Characteristic	Description
Demographic	Age	21 to 45 years
	Gender	Male:female=1:1
	Education	College or Masters
	Location	Primarily US
Technology	Connection	56kbps
	Internet Applications	Chat, Audio, Java, JavaScript
	Online Services	National ISPs
Use	At work	21 to 40 hours
	Organization's involvement	Somewhat agree to strongly agree that involvement is significant

Table 2: Internet Demographics.

We will use this profile as a sampling frame to obtain our sample. As far as possible, we will sample users that fit the above profile. The frame is defined by the typical characteristics of an Internet user. The demographics collected from the sample will help in understanding the biases between the population and the sampling frame.

4.4 Sample Description

We would like to use a random sample of organizational users of technology. These people work in corporations and universities. To obtain such a sample, we would like to approach groups that have such members. This approach will reduce the biases between the sampling frame (Internet users) and the sample. The IP Multicast Initiative (IPMI) is a worldwide, multi-vendor forum accelerating the adoption of IP Multicast (an IETF standard). Through education and marketing, the IPMI is stimulating demand of IP Multicast products and related services. More than fifty companies now participate in this forum. It consists of a large membership of organizations involved with the concept, technology, engineering, implementation and marketing of multicast products and services. The members of IPMI work in a variety of organizations, which include software, hardware, research and development of multicasting and network technology.

We hope to use a random sample derived from mailing lists and memberships maintained by IPMI. The sample description should be very close to the population description as discussed in the previous section. At the time of this writing, we have been successful in opening a dialogue and inducing interest with personnel at IPMI. Their interests in our study are mutual and in-line with their efforts to accelerate the adoption of IP Multicast. Furthermore, IPMI has expressed their pleasure at the fact that this study will be available for general access at public libraries.

A second user group is the MBone group. This is an informal collection of researchers from universities and corporations all over the world that is interested in the research and development of multicasting on the Internet. They operate and communicate via the MBone and several Usenet groups and mailing lists. This group is another prospect for generating a random sample list. Efforts are under way to obtain e-mail lists of users who subscribe to newsgroups used by the MBone members. The approaches are either to obtain e-mail lists from list operators or to use e-mail harvesting programs with permission from the list owners. This e-mail list will help us in generating the random sample. We will then send out e-mail invitations to the randomly selected participants to visit our website and fill out the questionnaire.

4.5 Measurement Instrument

A questionnaire will be used as the measurement instrument for recording the opinions of end-users. As per our model, the outcome is dependent on the underlying constructs. Constructs in turn are described by variables. In our study, we need to measure these variables and quantify them. We will be using a questionnaire to measure the variables. Each variable will be measured using a series of questions. The responses will be

averaged and the average will be used as a representative of the variable in the analysis.

All questions are answered on a scale of 1 to 7 where 1 is the most agreeable and 7 is the most disagreeable.

1	2	3	4	5	6	7
Strongly agree	Agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Disagree	Strongly disagree

Table 3: Likert Scale

Question categories listed below relate to each variable defined in our model. Each question will have an answer selection similar to the one in Table 3.

4.5.1 Initiation Methods

The questions for initiation methods relate to the mode of communication used by the end-users. We will capture this information by asking them questions regarding the different possible modes as mentioned by Schooler (1996). Questions 1, 3, and 7 relate to implicit initiation methods, while questions 2, 4, 5, 6, 8 and 9 relate to explicit initiation methods. We will use the same Likert scale as mentioned earlier.

I get information about multicasting sessions from:

- 1 a session directory such as sdr.
- 2 static web pages.
- 3 web pages that display live sessions information.
- 4 e-mail.
- 5 newsgroups.
- 6 my bookmarks.
- 7 applications that update session information automatically.
- 8 applications where I have to look for session information by clicking on links in a browser.
- 9 personal sources such as phone conversations.

4.5.2 General information

The following questions give us additional information regarding the types of applications that people use for multicasting sessions. The answers to these questions will help us in profiling the users and determine the trends in the future needs of the users.

I use multicasting for accessing

- 1 audio sessions.
- 2 video sessions.
- 3 current text information such as stock quotes.
- 4 white board sessions.
- 5 text chat sessions.
- 6 audio chat sessions.
- 7 videoconferencing sessions.
- 8 live events.
- 9 recorded information.
- 10 software upgrades.
- 11 other uses (please mention other_____).

4.5.3 Relative Advantage

We will use the Moore and Benbasat (1991) study as a basis for our questions. These questions are related to the relative advantages multicasting has to offer over unicasting.

We have modified the statements of the questions to suit the needs of this study. While questions 1,2,3,7,and 8 were originally suggested for a shorter scale (Moore & Benbasat, 1991), we have included them here. These questions will help us in checking the consistency of the answers.

- 1 Using multicasting enables me to accomplish my tasks more quickly.
- 2 Using multicasting improves the quality of work I do.
- 3 Using multicasting makes it easier to do my job.
- 4 Using multicasting improves my job performance.
- 5 Overall, I find multicasting to be advantageous in my job
- 6 Using multicasting enhances my effectiveness on the job.
- 7 Using multicasting gives me greater control on the job.
- 8 Using multicasting increases my productivity.

4.5.4 Compatibility

Compatibility will be measured by asking the following questions. We have included question 3 to capture the compatibility of multicasting with respect to existing software and hardware. While question 2 may cover this aspect, as multicasting is a technical innovation, we will ask this question explicitly as in question 3. Questions 1, 4 and 5 were suggested for a shorter scale, but we will include them for consistency.

- 1 Using multicasting is compatible with all aspects of my work.
- 2 Using multicasting is completely compatible with my current situation.
- 3 Using multicasting is completely compatible with my current computer.
- 4 I think that using multicasting fits well with the way I like to work.
- 5 Using multicasting fits into my work style.

4.5.5 Complexity

Complexity of using multicasting over unicasting will be measured by asking the following questions. Moore and Benbasat (1991) used the ease-of-use variable. We will use the same questions, but call the variable *complexity* keeping in mind that the two are inverses of each other. A higher score on ease-of use would imply a lower score on complexity. We excluded questions that did not get included after factor analyses conducted by Moore and Benbasat (1991).

- 1 I believe that multicasting is cumbersome to use.
- 2 My using multicasting requires a lot of mental effort.
- 3 Using multicasting is often frustrating.
- 4 I believe that it is easy to get multicasting to do what I want it to do.
- 5 Overall, I believe that multicasting is easy to use.
- 6 Learning to operate multicasting is easy for me.

4.5.6 Observability

Observability will be measured by asking the following questions. These questions relate to the Quality of Service as observed by the user using multicasting, and by observing other users using multicasting. We used the questions representing the variable *visibility*

in the Moore and Benbasat study to measure observability. We have excluded the Image category, as multicasting does not seem to have any immediate social implications.

- 1 I would have no difficulty telling others about the results of using multicasting.
- 2 I believe I could communicate to others the consequences of using multicasting.
- 3 The results of using multicasting are apparent to me.
- 4 I would have difficulty explaining why using multicasting may or may not be beneficial.
- 5 I have seen what others do with their multicasting.
- 6 In my organization, one sees multicasting on many computers.
- 7 It is easy for me to observe others using multicasting in my organization.
- 8 I have had plenty of opportunity to see multicasting being used.

4.5.7 Trialability

Trialability has great importance in the areas of technology. Offers vary from limited time trials to free of charge trials for limited use. Multicasting is being developed by universities and research groups. These groups need feedback and comments on their work. The popular way to do this is by giving away free trials for educational use. We will use the following questions to capture the trial experience and its impact on innovators and early adopters.

- 1 I have had a great deal of opportunity to try various multicasting applications.
- 2 I know where I can go to satisfactorily try out various uses of multicasting.
- 3 Multicasting was available to me to adequately test run various applications.
- 4 Before deciding to use any multicasting applications, I was able to properly try them out.
- 5 I am able to experiment with multicasting as necessary.

4.5.8 Voluntariness

The will to choose and decide upon the adoption of a technology plays an important role in the adoption process. We will use the following questions to assess the degree of voluntariness in the adoption process.

- 1 My superiors expect me to use multicasting
- 2 My use of multicasting is voluntary

- 3 My boss does not require me to use multicasting
- 4 Although it might be helpful, using multicasting is certainly not compulsory in my job.

4.5.9 Rate of Adoption

The rate of adoption is the dependent variable in this study. It is difficult to define when an innovation has been adopted. Rogers defines adoption as the acceptance and use of the innovation. We will use the following questions to assess whether the user has adopted or not adopted multicasting yet.

- 1 I know about multicasting but I have never used it.
- 2 I intend to try or use multicasting in the next six months.
- 3 I use multicasting on a trial basis.
- 4 I use multicasting on a regular basis.

Question 1 will identify people who are aware but have never used multicasting.

Question 2 will help in identifying people who have intent to adopt but have not yet begun the process. Question 3 relates to use on a trial basis. This however does not qualify the user as an adopter. Therefore, Question 4 is the only question that will represent adoption.

4.5.10 User Profile

The following questions will help us in ensuring that the users are similar to the ones mentioned in the population description earlier.

1. I work in a
 - a) corporation
 - b) university
 - c) research organization
 - d) other
2. My job title is:

3. I have been using a computer for ____ years.

4. I use network services such as:

- a) e-mail,
- b) web,
- c) newsgroups. (select all that apply)

5. Gender: Male ____ Female ____

6. Age ____

7. Highest Education Level:

- a) High School
- b) College
- c) Master's
- d) Doctoral
- e) Other (please specify _____)

8. I use a ____ to connect to the Internet:

- a) Dedicated LAN or other network
- b) Dialup modem
- c) ISDN
- d) Cable modem
- e) ADSL

The consolidated questionnaire is included as Appendix D

4.6 Population

The target population in this study is the network user who has access to a multicast capable network. As multicasting is a technology with limited applications, we do not expect the population description to cover all Internet users. We would like to target people working in an organization who fit the profile derived from that of an average Internet user. This profile is described to some extent in Table 2.

4.7 Sample

Keeping the population description in mind, we would like to generate a random sample of users from an e-mailing list maintained by IPMI or Mbone newsgroups. An initial e-mail will be sent to the users with identification and tracking mechanisms. This e-mail would invite the people from the sample to visit the website at Broadband Telecommunications Center at Georgia State University. They will be asked to fill out a questionnaire. It is an established fact that a network engineer will know more about multicasting than a manager who uses it to address his regional offices for meetings. This difference could possibly create a difference in the perception levels. We may have to resort to a stratified random sample if we are able to categorize the users based on their job descriptions. A secondary source is the Mbone community, where e-mail addresses will have to be collected from mailing list operators. We can then generate a random sample from these lists.

4.8 Biases

The instrument will be deployed as a web-based HTML form. The data will be captured on a server directly and written to an ODBC database. This method has its advantages and disadvantages. While this method is quick and very cost effective, the measures of reliability and authenticity are areas of concern (see Appendix C for details). To avoid some of the known biases, we propose to create technological and statistical checks. Some of these checks are described below.

Self-Selection: We intend to create the questionnaire so that it is accessible only via a password. This process will eliminate self-selected users largely. The questionnaire page

will be generated on the fly. Therefore, search engines will not index the pages. This will allow us to further avoid self-selection.

Non-response: The user will be identified by a dynamically generated alphanumeric user identification code. This code may be used later to evaluate non-response biases. We can send e-mails to people who did not respond to the survey and find out why they did not respond. Using the e-mail addresses, we may be able to generate contact information and contact them via phone or regular mail.

Duplication and missing values: The questionnaire document will be accessible by any web browser. It will warn users if they submit incomplete questionnaires or exit abruptly. Along with the responses, we also propose to record IP addresses of each visitor's computer. These checks will allow us to check for duplicate submissions and missing values.

Consistency: Finally, we propose to have randomly placed questions that appear similar to questions previously asked. We will use the responses to these questions to check for consistency in answers.

4.9 Data Analysis

Once the data are collected, we will proceed to conduct various analyses. We will begin with the exploratory methods of obtaining the descriptive statistics of the responses. This will help us in determining:

- 1) The central tendencies and spread of the data.
- 2) Outliers or odd cases of responses.
- 3) Normality of the data

If the data are normally distributed and the outliers have either been eliminated or marked for further observation, we will extract a holdout sample and proceed to examine the model based on the remainder of the data. We will perform multiple regression analysis on the data, in an attempt to explain the variation of adoption rate based on the independent variables.

The model is represented as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8$$

Where, β_0 is the intercept, Y is the weight (score of 1 to 7) of the rate of adoption (dependent variable) and the independent variables are represented by the weights (1 to 7) of:

X_1 = implicit initiation
 X_2 = explicit initiation
 X_3 = relative advantages
 X_4 = compatibility
 X_5 = complexity
 X_6 = observability
 X_7 = trialability
 X_8 = voluntariness

We will take the following steps to perform the analysis:

- 1) Perform the F-test by using the Fisher statistic to determine the overall significance of the model.
- 2) Test for multicollinearity, to ensure that the variation explained by each variable is unique.
- 3) Perform the student T-test to determine the individual significance of each variable.

- 4) Determine the final model after going through a cycle of t-tests by using stepwise regression procedures.
- 5) Extract the final model and test its validity with the holdout sample.

Based on the proposed plan of conducting this study, we should be able to answer all the research questions that we asked in the first chapter. Next, we will attempt to summarize all the efforts mentioned in this proposal.

SUMMARY

We hope to answer the questions we posed at the beginning of this proposal. The results of this study will have several implications on research, development, and implementation of multicasting.

Multicasting originated as a concept in the 80's. Even today, work groups at the IETF are working to make this concept more efficient and user friendly. Our study will shed some light on the aspects that make a difference. Access to the hardware, software and networks that support multicasting are freely available to researchers and enthusiasts. As this technology matures, the vendors will rely on established market shares instead of the enthusiasm of innovators and early adopters. Our study will help us in estimating the life cycle patterns of multicasting.

Some vendors have taken the strategic initiative by embedding multicasting in their software. Other companies have multicast-enabled their networks. However, in the end the consumer has to accept multicasting as a way to obtain synchronous data. Our study will help us in evaluating some of the parameters that are instrumental in the adoption of multicasting.

This study is a first of a possible series of studies to examine the diffusion and adoption of Internet based technologies. In this study, we hope to address the diffusion and adoption of multicasting by individuals in organizations. The results of this study will help us in establishing and profiling multicast adoption behavior. It will also pave a path for all future research in the area of innovations in Internet based technologies.

APPENDIX

A) A Primer on Multicasting

Introduction

Experimentation with multicasting technology started on DARPA Research Testbed Network (DARTNET), a small-scale experimental network financed by Defense Advanced Research Projects Agency (DARPA) in the late 1980's. Stephen Deering, one of the primary architects of wide-area multicasting on the Internet, started working on IP multicasting in 1988 and submitted his thesis on wide-area multicasting in 1991. In 1992, the Multicast Backbone or MBone was conceived (Kosiur, 1998). The Multicast Backbone was adopted at the Internet Engineering Task Force (IETF) meeting in March 1992 and acquired the name *MBone* after the July 1992 IETF meeting (Casner & Deering, 1992, Kumar, 1996).

How multicasting works

Internet is defined as a network of interconnected computers that can communicate with each other through a set of protocols called Internet Protocol or, IP (Comer, 1991). The Internet supports several different types of access services including File Transfer (FTP), Telnet, E-mail (SMTP, POP, IMAP), gopher, and the World Wide Web (HTTP). Most access takes place based on unicasting where a traditional multiparty communication between multiple hosts on the Internet involves the following steps:

- Each source packet is replicated into the number of destination hosts.
- One copy is forwarded to each destination host.

- The destinations receive, reassemble and use the packets.

The processes of replicating source information packets and forwarding them to the destination hosts can drain away many resources. These resources dwindle quickly once the number of requests increase. Performance of unicast servers degrades rapidly as the number of concurrent users increases. The multicast scheme however has overcome these limitations, by avoiding the replications at the source server. The information packet is not forwarded to multiple destination hosts, but to one group address or the multicast address.

A multicast address can be distinguished from a unicast address by its numeric composition. Multicast addresses are represented as 224.x.x.x (also known as Class D addresses), while unicast addresses can be anywhere from 0.0.0.0 to 255.255.255.255. Another difference is that multicast addresses are dynamically assigned and shared among all multicast groups. Conceptually, multicast addresses are different from unicast addresses because one multicast address represent several end systems (all users in a group), while each unicast address represents one computer only.

The multicast routers perform the task of replicating and forwarding the information to the interested destinations. This method ensures that the information packet travels as a single source to the point where the multicast capable router can replicate it and forward the copies to the *interested* parties. Only the interested parties join this group and receive the information.

Benefits of Multicasting

In addition to the technical benefits that multicasting can provide to networking, there are several benefits to the community in general. Currently, a few classes of multicast-

enabled applications exist. These target video conferencing, live broadcasts of events such as NASA launches, rock bands or radio stations. Some experimental applications such as office cameras, security monitors, and multicasts of select sporting events exist. However, for services such as IP telephony and Video-on-demand to grow, the multicast-enabled networks will have to support features such as reserving and allocating bandwidth prior to sending movies, providing a better Quality of Service (QoS) and faster schemes of data compression and processing (Schooler, 1997).

B) Implicit Initiation - Synchronous Rendezvous Directory Services

Certain tools that employ rendezvous techniques allow users to get current information live over the multicast enabled network. These tools are more proactive and push the information onto the client machines (Kumar, 1996). One such tool is called the session directory or sdr (Handley, 1998 Jacobson & McCanne, 1998). In many ways, sdr acts like a TV guide for the multicast network. Channel owners can allocate, reserve and advertise using SDr and use the same interface to connect to other sessions. While the act of tuning into the source is user initiated, the information is made available (or pushed) almost as instantly as it is advertised.

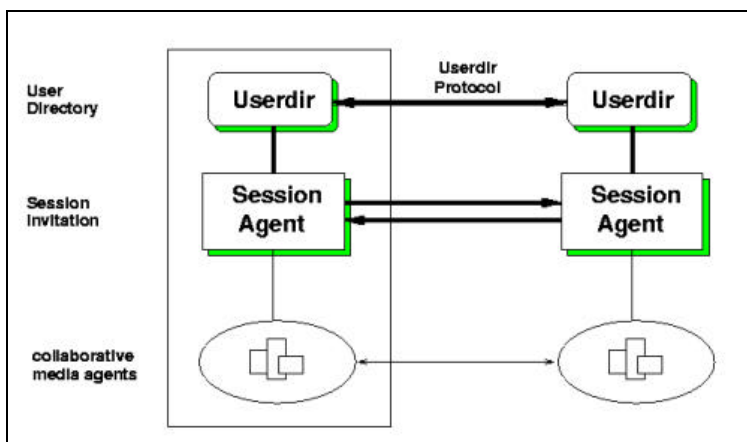


Figure 4: Directory Services

Collaborative media agents such as audio tools, video tools, and whiteboards use session agents to allocate and reserve sessions on the network (Figure 4). The session agent, in conjunction with the user directory then advertises the session and manages the group list that joins or leaves a multicast session. Viewer software such as IP/TV by Cisco Systems (Cisco, 1999) and ICast by FVC.com (FVC.com, 1999) use similar directory structures.

C) Internet Survey Research

Introduction

The Internet is used as a multi-purpose medium for communication and feedback. It has extremely small turnaround time when compared to other means of communication such as surface mail. The Internet also allows a certain level of anonymity. Perhaps the biggest advantage of the Internet as a communication medium is that it is accessible at several locations very easily. These features make the Internet an attractive medium to collect responses from a variety of consumers. The same reasons also pose major threats to the validity of the data and the methods of collection.

Advantages

The Internet provides several advantages. The following are applicable to the use of the Internet as a survey vehicle.

Context: One very important aspect of on-line research is that researchers involved in Internet-based research would be available on-line. These surveys are very well suited for such groups. The population description of such research would involve people with Internet access. Samples taken for such research topics would have reduced sampling frame bias.

Cost Benefits: The cost savings for data collection via the Internet are substantial. Costs estimated by Virtual Architects (<http://www.surveybuilder.com>) are one third of the cost of a mail survey. Comley (1996) estimates the cost at about 15% of mail surveys. Most expense goes in supporting websites, programming, debugging and maintenance. For academic groups, most of these costs are absorbed by the university infrastructure.

Response Rates: One of the potential benefits of an Internet-based survey is the quick rate of response. Mehta and Sivadas (1995) conducted a study, which showed that e-mail generated high response rates, and similar ones to postal surveys. They received about 50% of the surveys within three days compared to three weeks to receive a similar proportion from postal surveys. It is important to note that the e-mail response rates are similar to telephone response rates. However, the combined benefit of quick responses, low cost, easy access, and automated coding of data make the web and e-mail based data collection method a very attractive alternative.

Completion: Bachmann et al, (1996), Mehta and Sivadas (1995) point out that the respondents to e-mail are more likely to fill out open-ended questions than those who receive postal surveys. One of the reasons is the familiarity with typing on a computer vs. writing out responses by hand or using a typewriter. Pitkow and Recker (1994) explain that the reasons for completions are due to software-based checks for completion of responses. Such checks can be implemented easily via client side scripts.

Samples: The nature of the Internet makes web-based surveys reach out to a global audience. This access allows for international data collection (Mehta and Sivadas, 1995). While other methods may come close in terms of global mailing lists, the advantages of quick response coupled with a global reach are unparalleled. Another advantage is that due to lower costs, it is possible to use "oversampling" (Kehoe and Pitkow, 1997) to try to compensate for the under representation of certain demographic groups.

Flexibility: The electronic method provides high flexibility for production and modification of questionnaires. These methods also allow for quick production of multiple versions of the surveys with very little additional cost.

Interactivity: For follow ups regarding non-response, survey results and other queries, the on-line method makes it very easy to communicate (Oppermann, 1995). Interactivity also helps in the pre-test phases of questionnaire design and testing.

Disadvantages

The reasons that make the Internet an attractive medium for survey research can also prove to be problematic. Some of the problems that an Internet survey faces are:

Sampling and Representativeness: Sample bias is a pervasive problem in Internet based surveys. Several surveys state that the sample collected via Internet surveys is not representative enough of the cross-section of the population. However, the samples do have some common characteristics. Some of these are that the respondents are computer literate and use the Internet heavily. This is a bias that surfaces the most in Internet surveys. Other biases include that the respondents have higher levels of education and income (Hoffman, 1996). On the whole, Internet use is related to gender, education, income, race, occupation and in some cases, even geographic region (Hoffman, 1996). However, if the target population is familiar with the Internet and comprises of an on-line community, the impacts of such biases are reduced.

E-mail Problems: E-mail addresses collected by automated programs are often inaccurate. People either abandon their e-mail addresses or change their organizations. Oppermann (1995) reported a 25% inaccuracy, while Comley (1996) reported 35% addresses as invalid. Bachmann, Elfrink, and Vazzana (1996) identified 18.3 % of e-mails as undeliverable. With the advent of free e-mail addresses from companies such as Hotmail®, Netscape™ and Yahoo™, it is easier to create multiple e-mail accounts and abandon them later. One of the ways to avoid such inaccuracy problems is to obtain

addresses from reliable databases and companies that collect information via paid subscription services.

Selection Bias: An important feature of a random sample based survey is that the researcher has control over the sample structure and composition. In most Internet surveys, the respondents are self-selected (Bonchek, Hurwitz, and Mallery, 1996). Self-selection bias can be avoided by restraining from advertising the website address or registering it with a search engine. To further protect from random visitors, access to the survey page may be password protected. Self-selection bias gets inflated by repeat submissions and by using multiple computer stations to respond to the questions. These are intentional acts and cannot be avoided. However, by implementing client side scripting techniques to create specialized windows without any navigational or location bars, to check responses before submitting, and to automatically exit the site can prevent such erroneous submissions.

Response Rates: The response rates vary from survey to survey. However, there is a pattern of growing response rates over the years since Internet surveys became popular (Sackmary, 1998). The problem however lies with the identification of the respondents and the follow up to check for non-response bias. Non response may turn out to be due to inaccurate e-mail addresses. However, most modern e-mail services respond back automatically if the e-mail address reached is inaccurate. One may send a "probe" e-mail to check for such inaccuracies before sending any information about the actual surveys.

Data Quality: Due to the quasi-anonymous nature of the Internet, it is not possible to identify who the actual respondent is. However, this problem exists with mail-based questionnaires too. Another problem is the accuracy of the responses. Random responses

may be filtered by exploratory outlier analyses. The sincerity of the respondents also depends on the subject matter.

Privacy Issues: Unsolicited mail is an infamous problem on the Internet. Several people respond back with serious accusations of violation of privacy. It is best to obtain addresses from legal sources and with the permission of all the users. A disclaimer may be added to the outgoing e-mail that the addresses were obtained from a database with permission of the owner of the list.

Software Problems: Older browsers and e-mail clients had several incompatibility problems. However, if the e-mail format is in ASCII text and the web pages follow a common subset of HTML and JavaScript, such problems are minimal. One may pilot test the questionnaires and e-mail against several different browsers and e-mail clients.

Studies cited

Several studies have been conducted since the inception of the Internet. Some of these studies are presented in Table 3.

Table 3: Internet-based survey research (adapted from Sackmary (1998))

Authors (Date)	Methodological objectives	Sample	Distribution Method	Response Rate	Conclusions
Anderson and Gansneder (1995)	Test effectiveness of e-mail surveys	Random sample of active free-net users	e-mail	68%	Online surveys are effective
Bachmann, Elfrink, and Vazzana (1996)	Compare mail and email for data collection	Various membership directories	Email	52.5%	Email can safely substitute mail
			Mail	65.6%	
Bonchek, Hurwitz, and mallery (1996)	Evaluate online document distribution service	18000 current and past subscribers to service	Initial e-mail. Website or e-mail response option.	6%	Low response rate and self selection raise issues of representativeness.
Comley (1996)	Compare mail and email for data collection	Magazine database of email addresses	Email	13.5%	Email surveys are feasible.
			Mail	17%	
Coomber(1997)	Use Internet to survey hard to reach populations on sensitive topics	Posted solicitation on newsgroups with link to website	Website survey	80 self selected responses from 14 countries	Effective but lacked representativeness.
Gordon and De Lima-Turner (1997)	Internet users' attitude towards online advertising	Posted solicitation on newsgroups with link to website	Website survey	30% of the hits on the website completed the survey	Self selection bias and lack of representativeness
Kehoe and Pitkow (1997)	Web user characteristics and attitude	Non random sample through websites and emails	Website survey	55000 respondents to 5 surveys in past 3 years	Methodology relies on oversampling

Kiesler and Sproull (1986)	Compare mail and email for data collection	Randomly assigned sample to mail or e-mail condition	Email	67%	E-mail responses were faster
			Mail	75%	
Kittleson (1995)	Assessment of email as survey tool in public health research	Directory of health professionals	Email	28.1%	e-mail is faster but response rate is not as good
			Mail	76.5%	
Komsky (1991)	Email survey to examine email usage and factors that affect it.	All non-student active users at a university	e-mail sent to user population	41%	Frequent users are more favorable toward the system and tolerant of the system problems
Mehta and Sivadas (1995)	Compare mail and email for data collection	Random sample of names collected from newsgroups	Email (three groups)	40% to 65%	Email can be an effective but limited survey method
			Mail (two groups)	45% and 80%	
Oppermann (1995)	Evaluate email survey method	Directory of members of an association	Email sent to list	48.8%	Email surveys are fast and effective. Main limitation is the number of users
Parker (1992)	Compare mail and email for data collection	Employees at large at a international corporation	Email	68%	e-mail is an effective survey method
			Mail	38%	
Patrick, Black and Whalen (1995)	Characteristics and attitudes of members of a FreeNet system	Survey is made available to all members. Sample is self selected	Either website survey or by email	8.9%	Email is an effective survey method

Schonland and Williams (1996)	Evaluate the Internet as a medium for survey research	Solicited response from self selected members of relevant newsgroups	Website survey	17700 survey responses in 12 months	Website survey format is viable. Concerns about response bias.
Schuldt and Totten (1994)	Compare mail and email for data collection	Sample selected from academic directories	Email	19.3%	Low response rate indicates that researchers must investigate further
			Mail	56.5%	
Smith (1997)	Compare email and website survey methods.	Randomly divided sample taken from directory of web consultants	Email survey (2 groups)	8%, 13.3%	Technical problems and lack of standardization.
			Email solicitation to website survey	2%	
Swoboda, Muhlberger, Weitkunat, and Schneeweis (1997)	Use of newsgroups in email in surveys	Program scanned newsgroups and collected addresses	e-mail survey sent to entire sample	20.8%	Low response rates and selection bias.
Tse, et al. (1995)	Compare mail and email for data collection	Sample selected from phone directory and randomly assigned to mail and email	Email	6%	Mail surveys are more convenient. Email surveys lack anonymity.
			Mail	12%	
White, 1996	Evaluate website survey methodology	Solicited responses through links on the web.	Website Survey	60% of visitors at site completed part of the survey.	Lack of control over sample selection.

D) Consolidated QuestionnairePersonal Data Sheet

1. I work in a
 - a) corporation
 - b) university
 - c) research organization
 - d) other

2. My job title is:

3. I have been using a computer for ____ years.

4. I use network services such as:
 - a) e-mail,
 - b) web,
 - c) newsgroups. (select all that apply)

5. Gender: Male ____ Female ____

6. Age ____

7. Highest Education Level:
 - a) High School
 - b) College
 - c) Master's
 - d) Doctoral
 - e) Other (please specify_____)

8. I use a ____ to connect to the Internet:
 - a) Dedicated LAN or other network
 - b) Dialup modem
 - c) ISDN
 - d) Cable modem
 - e) ADSL

Multicast Access

I use multicasting for accessing

- 1 Audio sessions.
- 2 Video sessions.
- 3 Current text information such as stock quotes.
- 4 White board sessions.
- 5 Text chat sessions.
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- 8 Live events.
- 9 Recorded information.
- 10 Software upgrades.
- 11 Other uses (please mention other_____).

Multicast Source

I get information about multicasting sessions from:

- 1 a session directory such as sdr.
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- 4 e-mail.
- 5 Newsgroups.
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- 7 Applications that update session information automatically.
- 8 Applications where I have to look for session information by clicking on links in a browser.
- 9 personal sources such as phone conversations.

Relative Advantage

- 1 Using multicasting enables me to accomplish my tasks more quickly.
- 2 Using multicasting improves the quality of work I do.
- 3 Using multicasting makes it easier to do my job.
- 4 Using multicasting improves my job performance.
- 5 Overall, I find multicasting to be advantageous in my job
- 6 Using multicasting enhances my effectiveness on the job.
- 7 Using multicasting gives me greater control on the job.
- 8 Using multicasting increases my productivity.

Compatibility

- 1 Using multicasting is compatible with all aspects of my work.
- 2 Using multicasting is completely compatible with my current situation.
- 3 Using multicasting is completely compatible with my current computer.
- 4 I think that using multicasting fits well with the way I like to work.
- 5 Using multicasting fits into my work style.

Complexity

- 1 I believe that multicasting is cumbersome to use.
- 2 My using multicasting requires a lot of mental effort.
- 3 Using multicasting is often frustrating.
- 4 I believe that it is easy to get multicasting to do what I want it to do.
- 5 Overall, I believe that multicasting is easy to use.
- 6 Learning to operate multicasting is easy for me.

Observability

- 1 I would have no difficulty telling others about the results of using multicasting.
- 2 I believe I could communicate to others the consequences of using multicasting.
- 3 The results of using multicasting are apparent to me.
- 4 I would have difficulty explaining why using multicasting may or may not be beneficial.
- 5 I have seen what others do with their multicasting.
- 6 In my organization, one sees multicasting on many computers.
- 7 It is easy for me to observe others using multicasting in my organization.
- 8 I have had plenty of opportunity to see multicasting being used.

Trialability

- 1 I have had a great deal of opportunity to try various multicasting applications.
- 2 I know where I can go to satisfactorily try out various uses of multicasting.
- 3 Multicasting was available to me to adequately test run various applications.
- 4 Before deciding to use any multicasting applications, I was able to properly try them out.
- 5 I am able to experiment with multicasting as necessary.

Voluntariness

- 1 My superiors expect me to use multicasting
- 2 My use of multicasting is voluntary
- 3 My boss does not require me to use multicasting
- 4 Although it might be helpful, using multicasting is certainly not compulsory in my job.

Multicast Use

- 1 I know about multicasting but I have never used it.
- 2 I intend to try or use multicasting in the next six months.
- 3 I use multicasting on a trial basis.
- 4 I use multicasting on a regular basis.

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