Published Paper:

Werner, Roland. (1972). A model and simulation of the awareness process within innovation diffusion: A summary of the research project. Proceedings: The Fifth Annual Simulation Symposium (pp. 293-321). New York: Gordon & Breach.

A MODEL AND SIMULATION OF THE AWARENESS PROCESS WITHIN INNOVATION DIFFUSION: SUMMARY OF THE RESEARCH PROJECT[1]

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Abstract. This project has three objectives. The first goal is to clearly identify the major processes operating in the technology innovation diffusion phenomenon. The second goal is to construct, based on the wealth of empirical research in Sociology and Geography, a comprehensive micro-level model of one of these processes. And, the third goal is to provide an indication of the applicability of simulation technology to the study of a complex social process.

To fulfill the first goal, a general model of technology innovation diffusion is proposed in which a minimum number of important processes are identified. To fulfill the second goal, the awareness process, the first process identified, is modeled. The state of non-aware individuals precedes the awareness process and the state of aware individuals follows it. To fulfill the third goal, a simulation of the awareness process model is written using the GASP II simulation language. A preliminary description of an early simulation run shows that complex social relationships begin to appear in this information process only after some initial saturation of the community with aware individuals. The early tail of the cumulative awareness curve also seems to indicate a rising trend.

 Portions of this research were supported by an NSF Dissertation Research Grant No. GS-3121. Research facilities were provided by Social Systems Simulation Group, PO Box 6904, San Diego, California 92166-0904. Phone/Fax (619) 216-1601.

INTRODUCTION

The diffusion of a technology innovation can be imagined as a dynamic social process. Many researchers visualized this process as consisting of stages between the time an individual becomes aware of an innovation and the time he adopts the innovation. Although great variation existed in the number of stages postulated, a uniform sequence emerges that is consistent with most of the research.

The sequence begins with an event during which the individual "first hears" of an innovation -- an awareness of an innovation occurs. A period of decision-making follows during which the individual forms either a positive or a negative attitude toward the innovation. The duration of this period of decision-making is highly individualistic, variable, and therefore difficult to define. In past research, the greatest elaboration in the number of stages occurred for this mental process. This mental process is followed by a second event during which the individual "first adopts" the innovation -- the adoption of the innovation occurs. The time between the awareness of an innovation and the adoption is called the adoption process.

An analysis of the empirical diffusion studies in rural sociology (Ryan and Gross, 1943) and in marketing and advertising (Lavidge and Steiner, 1961) which attempted to define a unidimensional, discrete stage diffusion process, and of the studies which attempted to validate this diffusion process (Mason, 1962; 1964), supports the following conclusion (Werner, 1971). The empirical evidence suggests that the individual has least difficulty identifying the time when he <u>first hears</u> about an innovation. This is the event when the individual first receives information from whatever source that makes him aware of an innovation. This is followed by a mental process of variable duration during which the individual makes a decision about the innovation. He forms either a positive or a negative attitude toward the innovation. The time when the individual <u>first adopts</u> the innovation is also easily identified by him. It is at this time that the individual incorporates the innovation to a greater or lesser degree into his own life style and is said to have adopted the innovation.

The technology innovation diffusion model described here incorporates only the empirically most identifiable process in innovation diffusion. The individual is first exposed to information about an innovation -- awareness, and then after a time he may adopt the innovation -- adoption. An assumption that may be made, therefore, is that <u>the model of the diffusion of a technology innovation consists of at least an awareness process and an adoption process.</u>

<u>A TECHNOLOGY INNOVATION DIFFUSION MODEL</u>

Thus far, two distinct processes operating within technology innovation diffusion have been identified, the awareness process and the adoption process. It is suggested that these two processes, alone, do not fully describe innovation diffusion. To do so, two additional processes must be added, the discontinuation process and the readoption process. These processes are only introduced here so that a complete model of technology innovation diffusion may be presented. Such a model is presented in Figure 1.

These processes occur sequentially as the figure indicates. The first process, the <u>awareness process</u>, occurs between the state that includes individuals who are not aware of an innovation and the state containing those who are aware of an innovation. The second process, the <u>adoption process</u>, occurs between the state that includes those individuals who are aware of an innovation and the state containing those who have adopted the innovation. The third process, the <u>discontinuation process</u>, occurs between those individuals who have adopted the innovation and those who have discontinued using it. The fourth process, the <u>readoption process</u>, occurs between

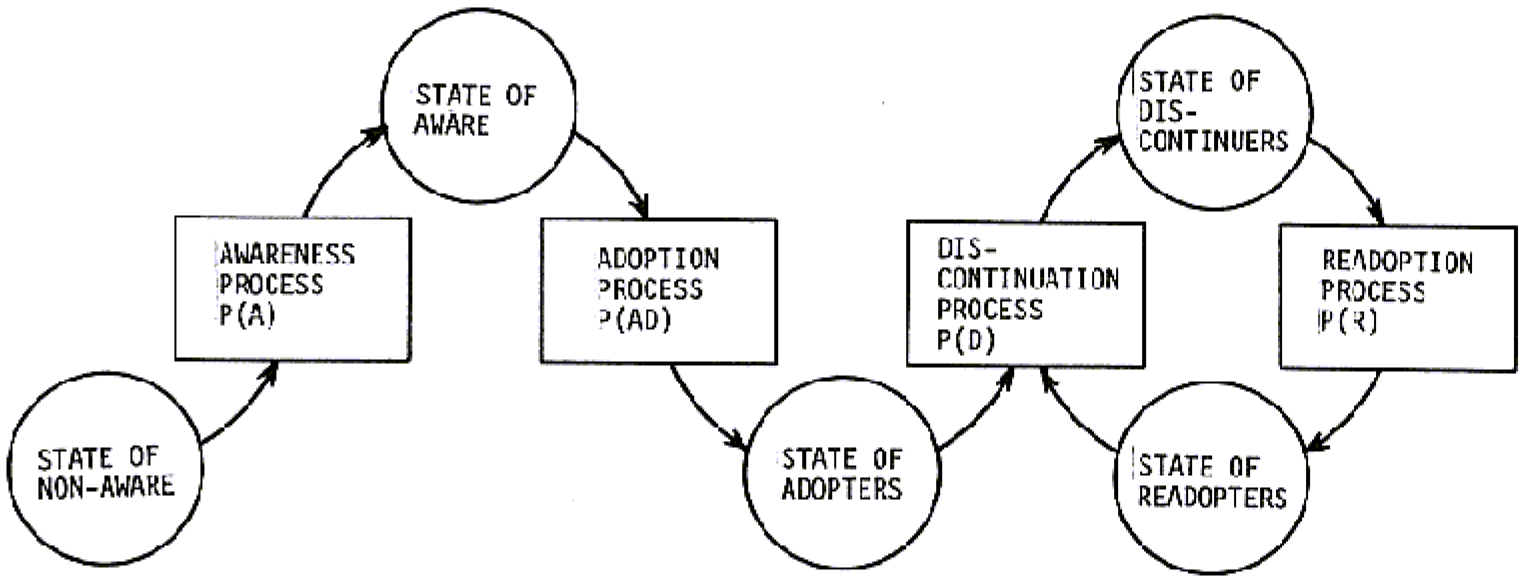

Figure 1. A Technology Innovation Diffusion Model

those individuals who have discontinued using the innovation and those who have readopted its use. The last two processes, the discontinuation process and the readoption process, constitute a cycle that can continue indefinitely. An individual may discontinue using an innovation, then change his mind and readopt, then discontinue, etc. The length of stay in each state -- non-aware,
aware, adopters, discontinuers, readopters -- is variably and depends on the assumptions and parameters used to model each of the intervening processes and their associated probabilities of occurrence. Additionally, an individual may remain for an indefinite time in any state. For example, an adopter may use an innovation, never discontinue its use and never find a substitute. Thus while others are changing states, this individual resides indefinitely in the adopter state.

The focus of this project is on the awareness process only. This includes those individuals who are not aware of an innovation (the state of non-aware), the awareness process by which they may become aware of an innovation, and those individuals who have become aware as a result of this process (the state of aware). The model of the awareness process within technology innovation diffusion is presented in the next section.

THE AWARENESS PROCESS MODEL

The recent contribution by geographers provided a systematic approach to the study of innovation diffusion. Most of the models, though, dealt with predominantly spatial processes. It soon became apparent that the spatial processes alone were not enough to fully describe the diffusion of an innovation through a community. Katz, et al. (1963: 247) suggested that "what is needed is a wedding of studies of the channels of decision-making and the social structural approach to the study of diffusion so that influence and innovation can be traced as to how they make their way into a social structure from 'outside' and as they diffuse through the networks of communication 'inside'." The implication was that social communication processes had to be included in more complex formal models of innovation diffusion.

The model of the awareness process within technology innovation diffusion presented here combines the social processes and the spatial processes into a unified view of the awareness process. Channels of communication of information about an innovation, particularly impersonal sources of information (communications media) and personal proximity sources of information (spatial processes), form the bridge between the community and the outside. Social structural features, opinion leaders differentiated from other members of the community and the structure of the community social network, are instrumental for understanding the awareness process within technology innovation diffusion.

The awareness process exposes formerly non-aware individuals in the population to information about an innovation. Several sources of information are available through which this information about an innovation can be transmitted and to which the non-aware individual may be sensitized. These sources of information are: ephemeral social contacts (called the proximity source), social contacts of greater duration that have been conventionalized (called the social network source), and a wide variety of impersonal, non-social sources (called the impersonal source) (Beal and Rogers, 1960; Simmons, et al. , 1967). The individual may also remain uninformed and therefore non-aware. Figure 2 presents the awareness process flowchart that utilizes these information sources.

The receiver of information about an innovation is either an opinion leader, or he is not (Lazarsfeld, et al. , 1968; Katz and Lazarsfeld, 1955; Lionberger, 1963; Rogers, 1962). An opinion leader mediates between the information source and the rest of the community. His location in the social network is strategic since he filters, interprets, and modifies information that

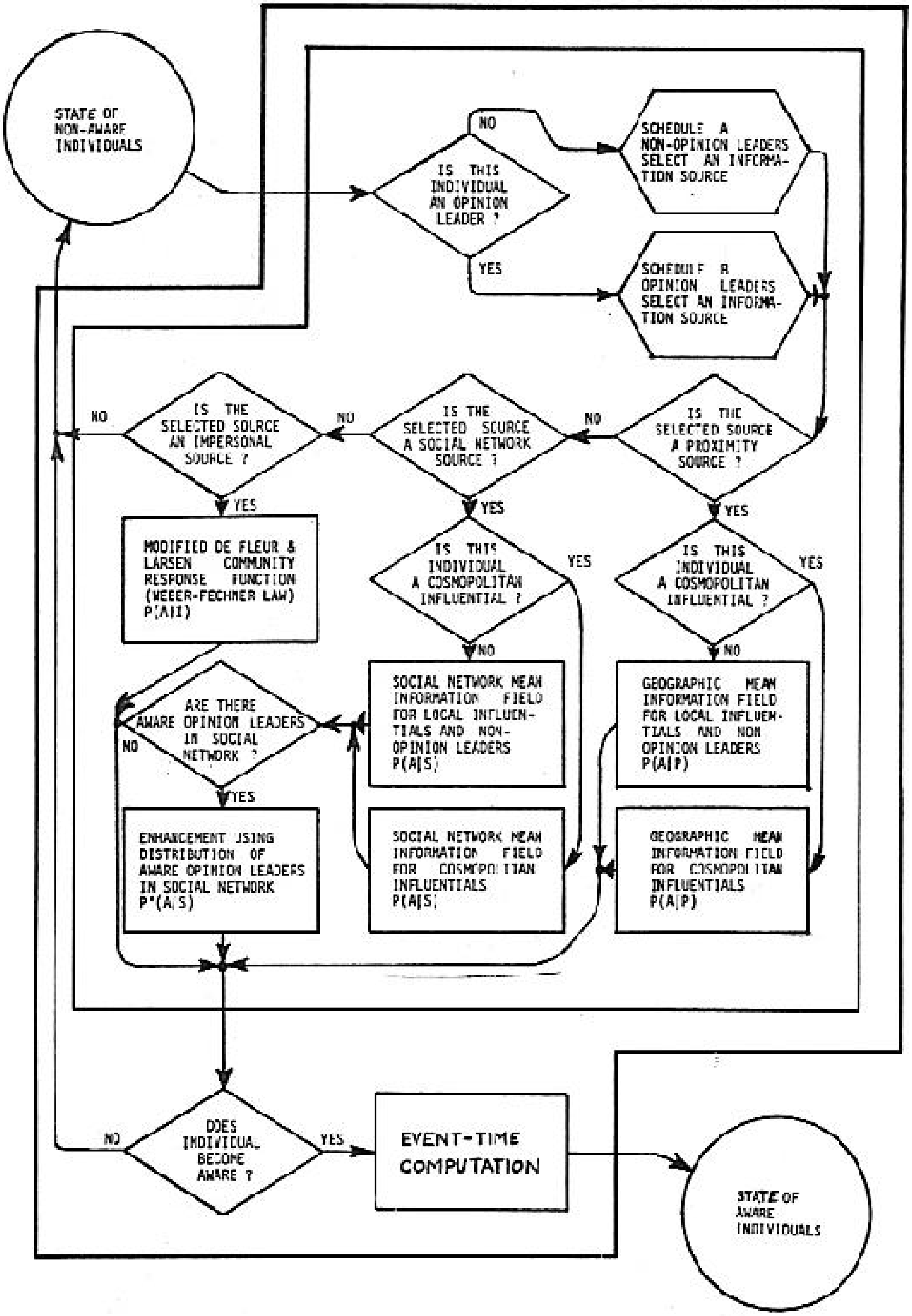

Figure 4. The Awareness Process Flowchart

reaches other parts of the social network. These two groups of individuals, opinion leaders and non-opinion leaders, utilize information sources differently. For example, opinion leaders make more use of all three sources (proximity, social network, and impersonal sources) early in the diffusion process and rely heavily on mass communication, an impersonal source, throughout the process. On the other hand, non-opinion leaders in the community generally make less use of mass communication sources early in the diffusion process than do opinion leaders. But then they make greater use of the social network sources as the diffusion process commences.

Since opinion leaders and non-opinion leaders utilize information sources differently, the probabilities that one of the three sources, proximity, social network, or impersonal sources, will be the one used for first hearing about an innovation differ for these two groups of individuals. Therefore, two empirically derived probability schedules for exposure and utilization of one of these sources of information are introduced (Ryan and Gross, 1943).

The specific probabilities within each of these two schedules, the opinion leaders' schedule and the non-opinion leaders' schedule are: the probability that the individual utilizes proximity sources; the probability that he utilizes social network sources; the probability that he utilizes impersonal sources for first hearing about an innovation; and the probability that he utilizes no source.

Once an individual becomes exposed to an information source, selected with these probabilities, he then has the probability of becoming aware of the innovation given that source, a conditional probability. Since each information source has its own specific distribution of effectiveness, the exposure of nonaware individuals in the population to a specific source differs from source to source.

There are two types of opinion leaders present in a community. These are local influentials and cosmopolitan influentials (Merton, 1957; Carter and Clarks, 1962). Local influentials are mainly concerned with their own immediate physical and social surroundings to the virtual exclusion of broader contacts. Cosmopolitan influentials, on the other hand, tend to be oriented toward a wide circle of social contacts both ephemeral (proximity) and conventional (social network). Both types of social contacts for these influentials are extended through activities such as professional involvement, travel, etc., which widen their horizons. Therefore, cosmopolitan influentials tend to utilize information from sources distributed over larger geographic and social areas than do local influentials. This difference in the way these two types of opinion leaders perceive their physical and social space has a direct bearing on the spatial extent of information sources to which they are exposed.

When, according to one of the two probability schedules, proximity is selected as the information source, the probability of becoming aware of the innovation given proximity sources, P (A|P), is distributed according to the "geographic mean information field" (Hägerstrand, 1967a, 1967b; Morrill and Pitts, 1967). Although there are more people at an increased geographic distance from the individual who know of the innovation, his chance of an ephemeral social contact with one of these more distant individuals decreases markedly with increased geographic distance. This spatial distribution of contact probabilities is extended over a greater geographic distance for cosmopolitan influentials than for local influentials. Therefore, the probability of becoming aware of the innovation given proximity sources of information differs for cosmopolitan influentials and local influentials when applied to similar geographic distances.

In like manner, when the social network is selected as the information source, the probability of becoming aware of the innovation given social network sources, P (A|S), is distributed according to the "social network mean information field" (Werner, 1971). Social network distance is the intimacy with which the individual is socially connected to friends, relatives, colleagues, etc. Here too, the distribution of contact probabilities is extended over a greater social network distance for cosmopolitan influencials than for local influencials. Geographic distances and social network distances are not congruent. The opinion leaders, either local influentials or cosmopolitan influentials, can be social network sources of information for a non-aware individual in the community. If this is the case, then the probability of becoming aware of an innovation given these kinds of social network sources is enhanced for the non-aware individual, P' (A|S). This is due to the strategic position opinion leaders hold in the social network. Opinion leaders are the more active members of the community and actively seek to spread information about an innovation.

When the impersonal source is selected as the information source, the probability of becoming aware of the innovation given mass media sources, P (A|I), is distributed according to a modified Weber-Fechner function (De Fleur and Larsen, 1958: 132). That is, the probability of becoming aware of the innovation given impersonal sources increases at a decreasing rate as exposure to this type of source increases.

An individual may become aware of an innovation with a probability derived from the distribution of information sources (proximity, social network, or impersonal). He also has a probability of remaining nonaware. Included among those who are non-aware are those individuals for whom no information source was selected.

These foregoing probability decisions for becoming aware of an innovation continue throughout the diffusion process. Those who become aware continue to the adoption process. Those who do not become aware may become aware later in the diffusion process. Thus, the awareness process operates on every non-aware member of the community throughout the duration of the technology innovation diffusion process.

SIMULATION OF THE AWARENESS PROCESS MODEL

Recent approaches by geographers to the study of innovation diffusion were more systematic than earlier approaches. Central to this systematic approach was the simulation technique introduced by Hägerstrand in the early 1950's in Sweden (Hägerstrand, 1965, 1967a, 1967b). He used this technique to deal with the spatial complexities of innovation diffusion. This early simulation work was done by hand-simulation and later was adapted to a computer.

One of the first machine simulations dealing solely with message transmission regarding information about an innovation (awareness process) was developed by Deutschman (1962) and introduced personal and impersonal information sources. Later, models of more specific innovation diffusions emerged. Tiedemann and Van Doren (1964) simulated a model of the spatial diffusion of hybrid seed corn in Iowa. Bowden (1965) simulated a spatial model of the decision to irrigate in the high plains of Colorado. And, Wolpert (1966), centering his modeling concepts around the mean information field developed by Hägerstrand, simulated a regional model of information diffusion.

During this same period, a group of geographers at Northwestern University became very active in investigating the innovation diffusion phenomenon (Brown, 1966, 1968; Marble and Bowlby, 1968; Pitts, 1963, 1965, 1967; Yuill, 1964). This group focused on techniques to simulate spatial processes, on barriers hindering the progress of the innovation wave, and further explicated quantitative theories of spatial diffusion.

Recently, a proliferation of simulations of innovation diffusion models has occurred. Alba (1968) contributed a mircro-level model in marketing. Yapa (1969) contributed a spatial macro-level model in geography. And Carroll and Hanneman (1968), Carroll (1969), Hanneman, et al. (1969), Stanfield (1969), and Hanneman and Carroll (1970), collectively contributed to the development of SINDI 1 and

SINDI 2 (Simulations of Innovation Diffusion in a Rural Community of Brazil). These models are part of a continuing study in innovation diffusion by the Department of Communication at Michigan State University.

Many of these researchers pioneered simulation techniques before formal techniques were developed. Only recently have such techniques of general simulation concepts emerged (Gordon, 1969; Naylor, et al., 1966; Martin, 1968; Mize and Cox, 1968). More recently, simulation techniques in specific disciplines have been developed. These special orientations to simulation also provide useful information of more general simulation concepts. These applications have been made for industrial systems (Schmidt and Taylor, 1970) and for economic systems (Naylor, 1969, 1971).

The GASP II simulation language was selected for simulating the model of the awareness process discussed earlier. This simulation language is based on FORTRAN and consists of 24 subroutines that provide the user with many useful housekeeping functions necessary for simulation. The functions that this simulation language provide are 1) an executive subroutine (GASP) that maintains the flow of the simulation process, 2) an initialization subroutine (DATAN) that allows initial simulation conditions to be specified and also reads input data into the program, 3) a group of information storage and retrieval subroutines (SET, FIND, RMOVE, FILEM) that can find a specific observation in ally queue, can remove that observation once found, and return the observation after treatment to any queue, 4) a group of data collection subroutines (TMST, COLCT, HISTO) that can collect time variant and non-time variant information, and also collect information into histograms, 5) two statistics computation subroutines (PRNTQ, SUMRY) that are associated with the above group of information collection subroutines, 6) a monitoring subroutine (MONTR) that can monitor any event or groups of events, 7) an error subroutine (ERROR) that can detect errors in the simulation for debugging purposes,

8) a wide range of random variable generators including a uniformly distributed random variable between zero and one (DRAND), a uniformly distributed random variable between any two real numbers (UNFRM), a normally distributed random variable (RNORM), a log-normally distributed random variable (RLOGN), an Erlang distributed random variable (ERLNG), and a Poisson distributed random variable (NPOSN), and 9) several other supporting subroutines (SUMQ, PRODQ, AMIN, XMAX, AMAX) (Pritsker and Kiviat, 1969: 29). These very useful subroutines constitute the GASP II simulation language.

The relationship of the GASP II simulation language to the subroutines needed to simulate the awareness process described here is shown in Figure 3. A MAIN program is provided to initialize the specific variables of the awareness model that is being simulated and then control is turned over to the GASP subroutine, the simulation flow supervisor. The GASP subroutine in turn calls the event subroutine, EVNTS, every time an event is scheduled to occur. This subroutine in turn selects the event that is scheduled. For the awareness process simulation, these events are 1) a DUMMY event subroutine that initializes the community in which the awareness process operates, 2) the AWARE event subroutine that computes the conditional probability of becoming aware of the innovation and then makes the decision whether an individual becomes aware of the innovation or not. This subroutine utilizes for this probability computation two other subroutines: the PRXMIF subroutine that counts the number of aware individuals in the zones of the proximity mean information probability field and the SOCMIF subroutine that counts the number of aware individuals in the zones of the social network mean information probability field, and 3) the ENDRUN event subroutine that sets the conditions for GASP in order that a final report is printed at the end of the simulation run.

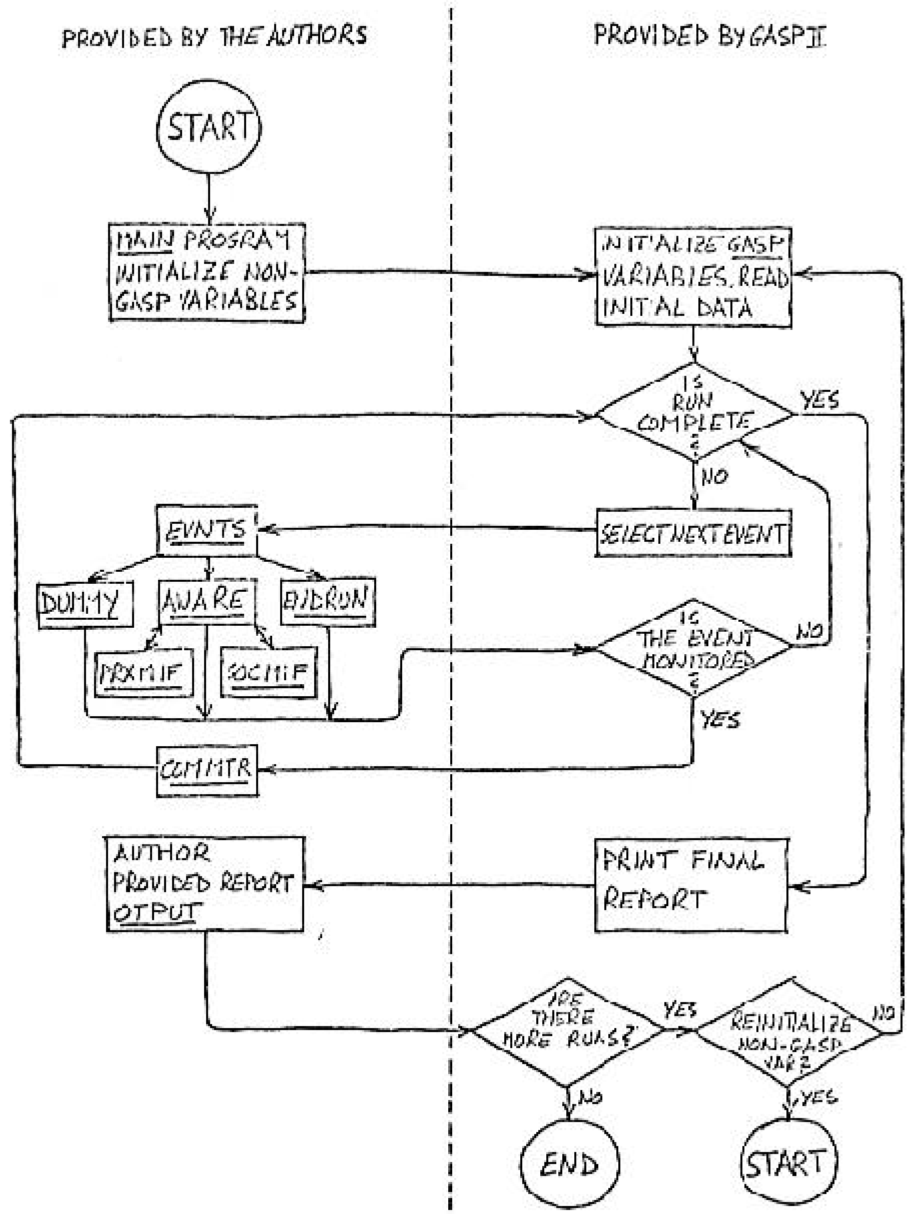

Figure 3. Flow of the System To Simulate the Awareness Process Model (Adapted from Figure 2-5. Pritsker and Kiviat, 1969: 19)

Once an event has been scheduled and selected, the monitor subroutine, COMMTR, can be invoked to monitor that event. This subroutine is programmed to print a map of the whole community with all status changes of individuals in the community since the last time the monitor was invoked. After completion of a simulation run, GASP prints a summary report and calls the OTPUT subroutine. This subroutine prints additional information specific to the model being simulated. The GASP flow supervisor subroutine then either terminates the simulation or reinitializes the program for another simulation run.

SOME PRELIMINARY RESULTS OF THE SIMULATION

The results discussed here are only preliminary. The simulation was debugged and only run long enough for 10 percent of the community members to become aware of an innovation. Two factors led to such a short run. The first was that the debugging of this complex simulation consumed many hours of computer time. The second was that the run, that led to 10 percent of the community becoming aware, alone consumed one and one half hours on an IBM 360/65 computer. The grant that was provided by NSF for the implementation of the model was thus quickly exhausted. It is estimated that a complete run where 99 percent of the community becomes aware of an innovation would require between five and six hours of computer time.

This run was not long enough to generate meaningful histograms or statistics so that this discussion is limited to a description of the activities that occurred during the two and one half cycles of the simulation run. Each cycle was monitored and the resulting community maps are presented in Figure 4 through Figure 6.

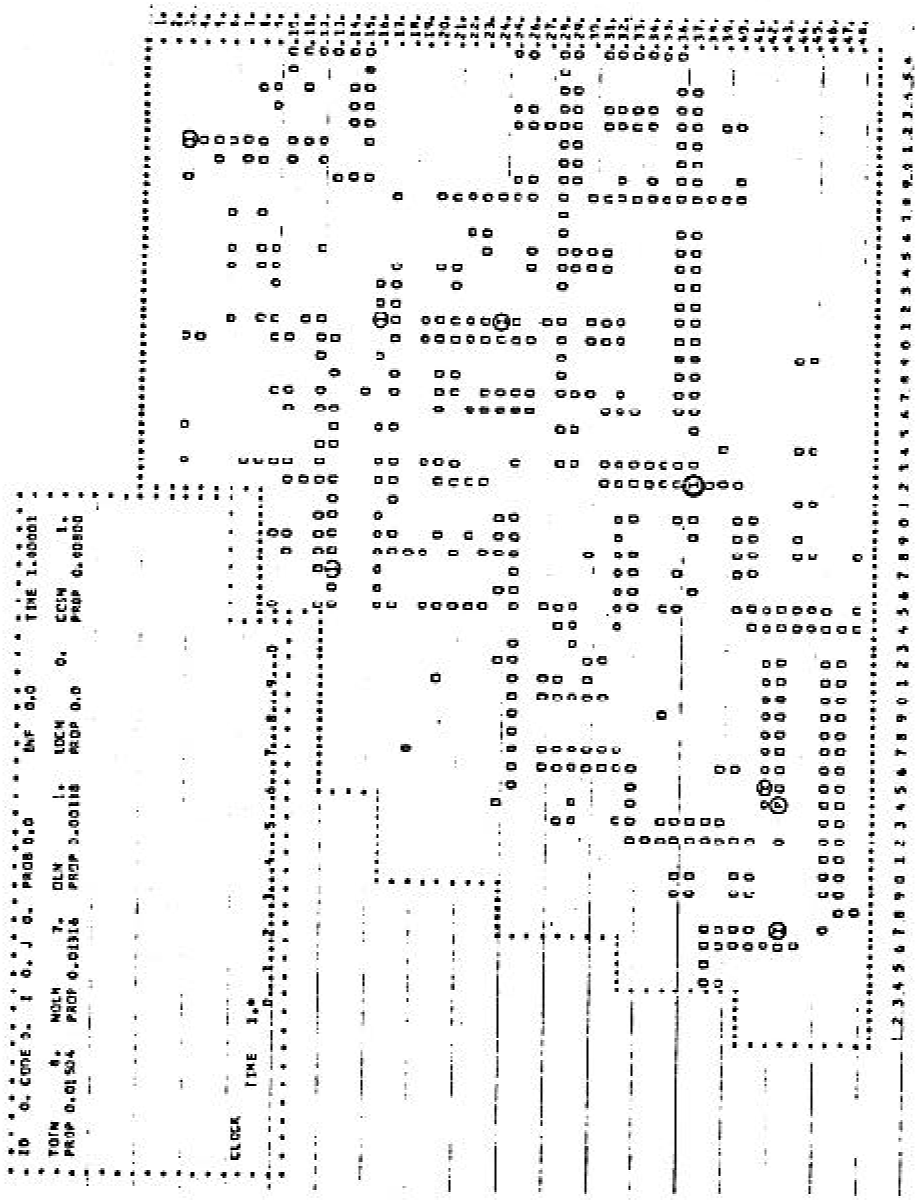

Figure 4. Aware Individuals and Sources of Information Utilized to Become Aware of an Innovation During Cycle 1. (Double circle identifies cosmopolitan influentials; P- proximity sources, I - impersonal sources.)

The first cycle is presented in Figure 4. This figure shows that eight of the community members became aware of the innovation. Of these eight, one was a cosmopolitan influential identified by double circles. Seven of the aware individuals became aware utilizing impersonal sources of information and one became aware utilizing proximity sources of information. This latter individual had within his immediate geographic vicinity one individual who was aware of the innovation. This aware individual led to his awareness.

These eight aware individuals represent 1.5 percent of the community. When comparing this 1.5 percent aware in the first cycle of the simulation with the 0.5 percent aware of hybrid seed corn in 1924 (Ryan and Gross, 1943: 17), the awareness process seems to be beginning too rapidly. One may conjecture that this rapid takeoff of the awareness process may be due to an overestimation of the mass media effect. This overestimation of the mass media effect may have occurred in constructing Schedule A and B for information source utilization, i. e. , the proportion contributed by impersonal sources to these schedules may be too large. Since these schedules were obtained from one empirical study (Ryan and Gross, 1943) and little other empirical data of the type needed to construct such schedules is available, the effect of changing parameter values in the schedules would need to wait for the time when experiments could be conducted using this simulation.

The second cycle is presented in Figure 5. This figure shows that during this cycle bringing the total to 34 aware. Of these 26, six were cosmopolitan influentials identified by double circles. Twenty-five of the newly aware individuals became aware utilizing impersonal sources of information an one became aware utilizing proximity sources of information. This latter individual, located at (35, 32), had within his geographic vicinity five other individuals who were aware of the innovation.

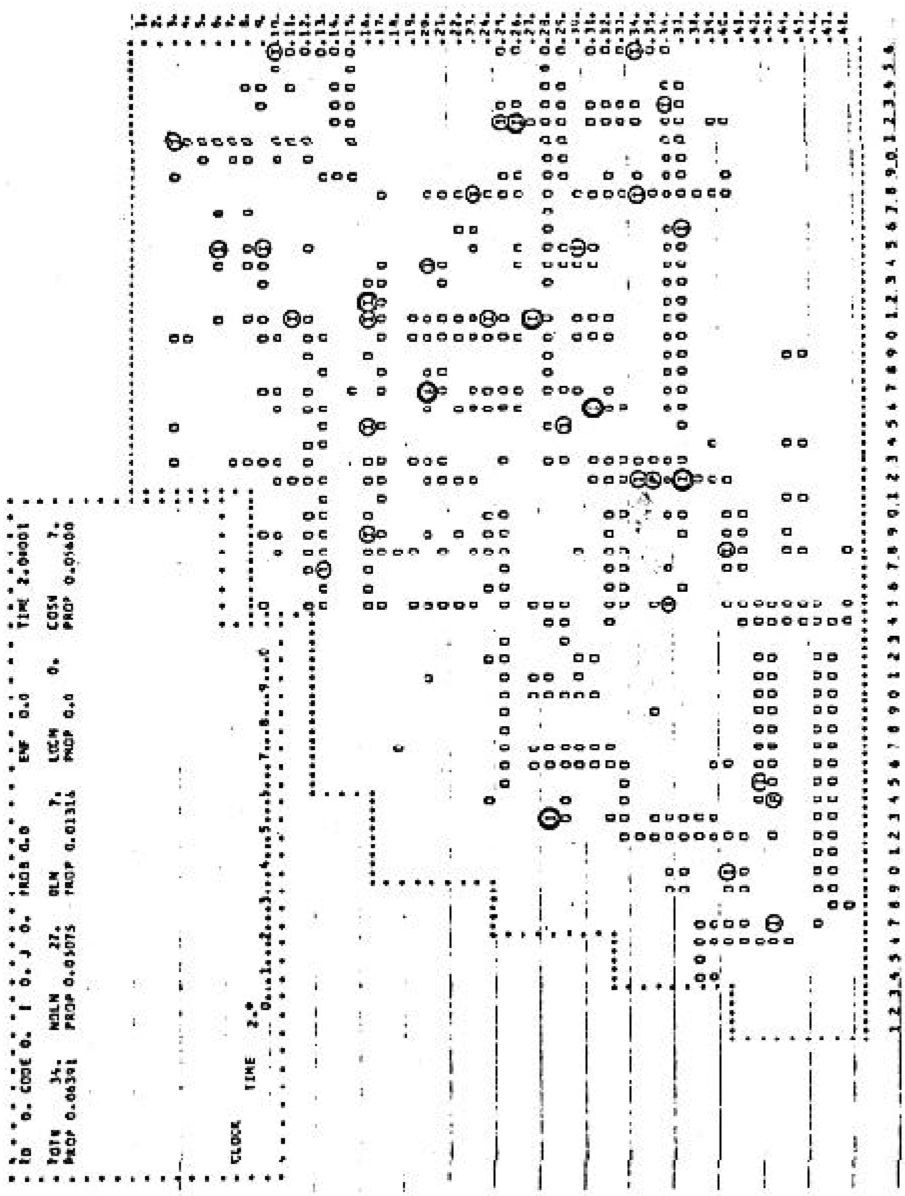

Figure 5. Aware Individuals and Sources of Information Utilized to Become Aware of an Innovation During Cycle 2. (Double circle identifies cosmopolitan influentials; P - proximity sources, I - impersonal sources.)

These aware individuals led to his awareness. However, the cosmopolitan influential located at (31, 36) had not yet become aware and, thus, could not contribute to the probability of becoming aware.

These 34 aware individuals represent 6.4 percent of the community. When comparing this 6.4 percent aware in the second cycle of the simulation with the 2.5 percent cumulative aware of hybrid seed corn in 1925 (Ryan and Gross, 1943: 17), the awareness process seems to be progressing even more rapidly than previously thought. This further points to the too rapid utilization of impersonal sources of information in the simulation. Of the 34 aware individuals at this time, only two have become aware utilizing proximity sources and none have yet utilized social network sources.

The third cycle was only 43.3 percent complete when 10 percent of the community became aware. This is presented in Figure 6. This figure shows that an additional 20 community members became aware of the innovation during this cycle bringing the total to 54 aware. Of these 20, six were cosmopolitan influentials identified by double circles, and three were local influentials identified by heavy circles. Fifteen of the newly aware individuals became aware utilizing impersonal sources of information, two became aware utilizing proximity sources of information, two became aware utilizing proximity sources of information, and three became aware utilizing social network sources of information.

Of the two individuals who became aware utilizing proximity sources, the one located at (17, 43), was the first individual to become aware in the third cycle. Being a cosmopolitan influential, his proximity mean information field included the area bounded by line 1 through line 33 and column 27 through column 56 in Figure 6. This mean information field included 20 individuals who were aware of the innovation at the time. Of these 20 individuals, two located at (16, 42) and (16, 41) contributed the greatest amount to his probability of becoming aware.

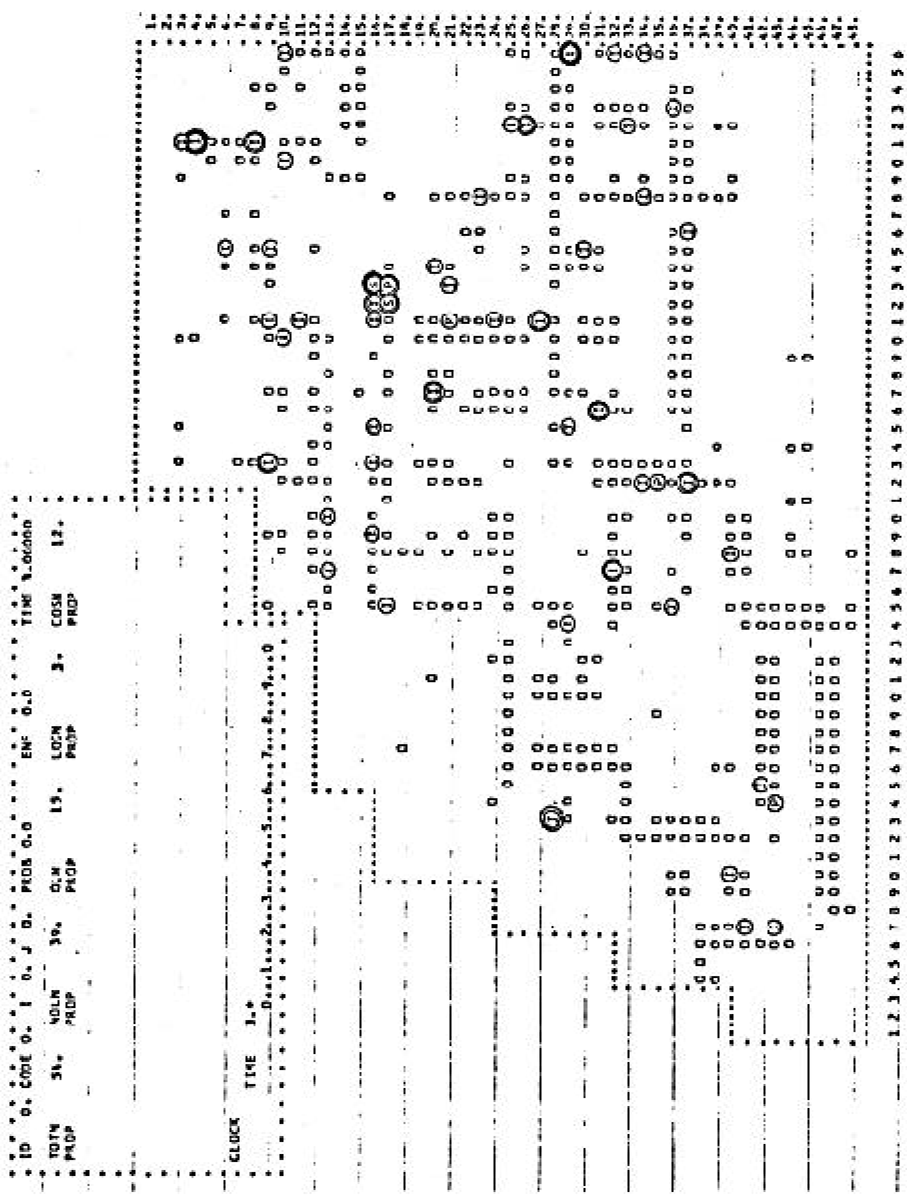

Figure 6. Aware Individuals and Sources of Information Utilized to Become Aware of an Innovation During 43 percent of Cycle 3. (Double circle identifies cosmopolitan influentials, dark circle identifies local influentials; P - proximity sources, S - social network sources, I - impersonal sources.)

All of those individuals utilizing social network sources became aware later in this cycle and did not contribute to the probability at this time. The second individual who became aware utilizing proximity sources of information, located at (21, 41), had at the time of his awareness five individuals within four proximity zones who knew of the innovation. This included the first individual utilizing proximity sources in this cycle. None of the individuals utilizing social network sources had as yet become aware.

The first of the three individuals who became aware utilizing social network sources of information, located at (33, 52), had 11 aware individuals in his social network mean information field at the time. All of these aware individuals were situated beyond the first zone of his social network mean information field, each thus contributing a small amount to his probability of becoming aware. The second individual who became aware utilizing social network sources, located at (17, 42), is a cosmopolitan influential and had 28 aware individuals distributed throughout his social network mean information field. Three of the five individuals in the first two zones were aware of the innovation. These contributed greatly to his probability of becoming aware. The third individual who became aware utilizing social network sources, located at (16, 43), had 16 aware individuals distributed throughout his social network mean information field. Four of five individuals in the first two zones of his field were aware of the innovation. These contributed greatly to his probability of becoming aware.

On closer inspection, aided by Figure 7, it becomes clear that these first individuals becoming aware utilizing social network sources of information are intimately tied together to one another through their social network. All three, ID 458, 105, 163, aware in that order, relied on ID 197, 104, 105, and 195 situated in either the first or second zone of their respective social network mean information fields for awareness of the innovation. This beginning cluster is the first manifestation in this simulation of a complex social process operating in the communication of information about an innovation.

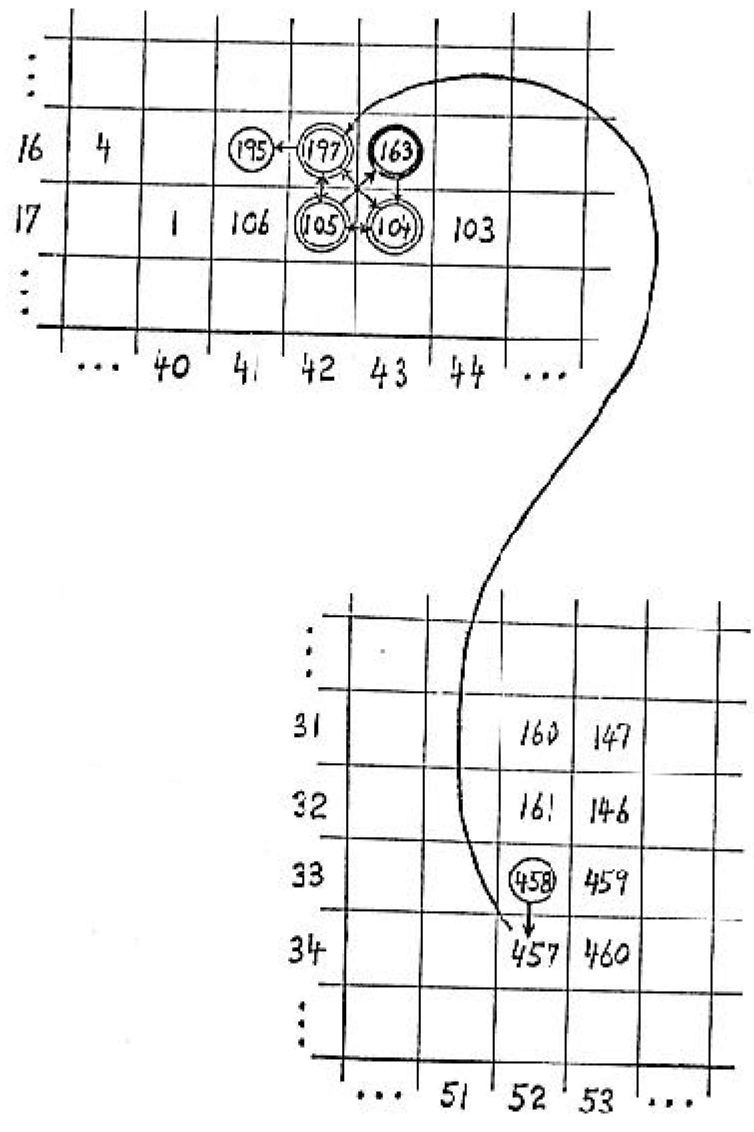

Figure 7. Blowup of a Portion of Figure 6.

Opinion leaders showed an early involvement in the awareness process. Cosmopolitan influentials were first to become aware followed by some local influentials in cycle three. This early involvement of opinion leaders seems to indicate that a certain amount of saturation of information among opinion leaders is necessary for the information to spread via social processes to other portions of the community. This involvement by opinion leaders is expected since they are the more active information seeking and disseminating elements in the community (Rogers, 1962: 232).

If these 54 aware individuals completing 43.3 percent of cycle three are extrapolated at the same rate of generation for the rest of the cycle, then there would be a total of 125 aware individuals at the end of this cycle. This would represent 23.5 percent of the community. Comparing this 23.5 percent aware in the third cycle of the simulation with 3.5 percent aware of hybrid seed corn in 1926 (Ryan and Gross, 1943: 17), the discrepancy in these two cumulative awareness curves is more obvious than previously noted. However, if the first three cycles of the simulation are compared with the years 1927 through 1929, instead of the years 1924 through 1926, the comparison of the cumulative proportions are: cycle one at 1.5 percent to hybrid seed corn at 4.5 percent, cycle two at 6.4 percent to hybrid seed corn at 7.5 percent, and cycle three (estimated) at 23.5 percent to hybrid seed corn at 23.5 percent. The match is markedly improved. The only explanation that presents itself for this match between a later time in the empirical process and the simulation is that, as indicated earlier, the impersonal source utilization progresses too rapidly early in the simulation.

CONCLUSION

This project began with a statement of three objectives. The first goal was to clearly identify the major processes operating in the technology innovation diffusion phenomenon. The second goal was to construct, based on the wealth of empirical research in Sociology and Geography, a comprehensive micro-level model of one of these processes. And, the third goal was to provide an indication of the applicability of simulation technology to the study of a complex social process.

To fulfill the first goal, it was discovered that a general model of technology innovation diffusion could be constructed in which a minimum number of important processes were identified.

To fulfill the second goal, the awareness process, the first process identified to fulfill the first goal, was modeled. To model the awareness process, the state of non-aware individuals prior to this process and the state of aware individuals following this process were included.

To fulfill the third goal, which was to show the feasibility of applying simulation technology to a complex social process, a simulation was written using the GASP II simulation language. A preliminary description of an early simulation run showed that complex social relationships began to appear in this information process only after some initial saturation of the community with aware individuals. The early tail of the cumulative awareness curve also seemed to indicate a rising trend.

These three goals as stated can be compared with a procedure that was suggested by Naylor (1971: 11) for experiments with models of social systems:

> 1. The formulation of the problem. This was done in this project by identifying the major processes of technology innovation diffusion and then explicating one of these processes.
>
> 2. The formulation of a model of a social system. This was done in this project by constructing a model of the awareness process within innovation diffusion by carefully relating all assumptions and parameter estimates that were made to some known empirical fact. This relationship of the assumptions and parameters of the model to known empirical phenomena constituted the first level of validation of the model, empirical validation.

3. The formulation of a computer program of the model. This was done in this project by using the GASP II simulation language. The formulation of the simulation was accomplished with almost no distortion of the original model assumptions.

4. Validation. Some preliminary output of the simulation was described but the run that was made was not nearly complete enough to warrant any discussion about validation. This level of validation would involve comparing the simulation results with historical empirical phenomena in order to determine whether the simulation of the model truly mimicked events that had previously occurred.

5. Experimental design. This would be possible only after it was determined that the simulation truly mimicked empirical events.

6. Data analysis. This would involve the last level of validation in that attempts would be made to forecast future innovation diffusion events.

Occasionally a question arises whether the emphasis of simulation should be on the model of the social process that is simulated or on the computer program written to simulate this model. In the former orientation, the emphasis is on discovering the nature of processes in social systems and as such emphasizes the theoretical considerations of model construction. In the latter orientation, the emphasis is on solving an immediate problem and as such emphasis is on estimating parameter values for expediency. This project focused on the former of these orientations, the construction of a micro-level model of the awareness process within technology innovation diffusion. It is hoped that this model could stand as an initial attempt in constructing a theory of innovation diffusion.

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