STRATEGIC PLANNING FOR RURAL SERVICE IMPROVEMENT AT THE MANITOBA TELEPHONE SYSTEM-A SYSTEM MODELLING APPROACH

by

TOM L. SCHAFFNIT

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
MASTER
in
BUSINESS ADMINISTRATION

Winnipeg, Manitoba

ISBN 0-315-63253-4

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ACKNOWLEDGEMENTS

I would like to thank Dr. Roger I. Hall for his guidance and support throughout this project. His personal concern and kindness have made it possible for me to bring this project to fruition.

I would also like to thank Dr. John Mundie and Dr. Robert Kieschnick for agreeing to read the thesis.

In addition, I would like to thank the Manitoba Telephone System for providing details and data to make the simulation as realistic as possible.

ABSTRACT

The rapid changes in the telecommunications industry are driven by the accelerating pace of technological innovation, and the ever more sophisticated communications of the global community. The Manitoba Telephone System is the crown corporation that provides telephone and other telecommunications services within the province of Manitoba. As a crown corporation, the Manitoba Telephone System is subjected to higher levels of political pressure than a 'private sector' company. The present climate in the province has placed rural service improvement quite high on the political priority list. Such rural service improvement programs typically have capital requirements of hundreds of millions of dollars, so program decisions are rather significant to the financial well-being of a telephone company. Of the possible areas for improvements to rural telephone service in Manitoba, customers have indicated that the highest priority is the conversion of multi-party to single-party service. There are a number of possible program options that could be employed to implement the conversion to single-party service. Since planning decisions for such programs are based upon the analysis of complex interrelationships, among a large number of variables, advanced methods of analysis of strategic alternatives are needed. In order to investigate the impact of such policy alternatives upon the network planning of the Manitoba Telephone System, a descriptive model of relevant portions of the telephone system has been assembled using the methodology of Systems Dynamics. This model has been programmed in DYNAMO to allow computer simulation of the alternative policy directives.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The telecommunications industry is in a transition, turmoil, or opportunity stage, depending upon one's perspective. The rapid changes in this industry are driven by the accelerating pace of technological innovation, and the ever more sophisticated communications needs of the global community (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Brock 1981, Beauvais 1984, Communications Canada 1987). It has been said that the telecommunications networks, or 'electronic highways', are as essential to the Information Age as the transportation infrastructure was to the Industrial Age (Forester 1987, Communications Canada 1987). Telephone companies have evolved into telecommunications companies, providing the 'electronic highways' that carry voice and data communications by using the constantly evolving Public Switched Telephone Network (PSTN) that was originally built to provide basic telephone service.

In Manitoba, the Manitoba Telephone System (MTS) is the crown corporation that provides telephone and other telecommunications services within the province. Although telecommunications has historically been a regulated monopoly within

Canada, competition has emerged in a number of areas (for example, terminal equipment and private lines) (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986). Universal service - basically, the provision of telecommunications services to everyone - provides the historic rationale for the existing monopolistic structure within the telecommunications industry (Littlechild 1979, United States General Accounting Office 1986).

As a crown corporation, the Manitoba Telephone System is subjected to higher levels of political pressure than a 'private sector' company. Many of the policy decisions are motivated to a much greater extent by political pressure than by technological or economic influences (Langford 1986). The present climate in the province has placed rural service improvement quite high on the political priority list. Other prairie telephone companies have announced extensive programs to improve telephone service in rural areas, which has increased the pressure on the Manitoba Telephone System to make similar improvements. Such programs typically have capital requirements of hundreds of millions of dollars, so program decisions are rather significant to the financial well-being of a telephone company. Since these decisions are based upon the analysis of complex interrelationships among a large number of variables, advanced methods of analysis of strategic alternatives are needed.

Rural service improvement is a policy area that illustrates many of the fundamental concepts of telecommunications policy. The dilemma associated with rural service improvement is that the cost of providing services in rural areas is substantially higher than in areas of higher population density. These higher costs are mainly the result of two factors: (1) The capital and maintenance costs for the access loop (basically, wires to the customers premises) are higher in rural areas because the average distance to each customer from the telephone exchange office is much greater than in urban areas, and the costs of these access loops are proportional to distance, and (2) the economics of the switching equipment used in telephone exchange offices favour larger offices - thus, the offices in small, rural communities exhibit a higher switching equipment cost per customer. In spite of these increased costs, the revenues that are available from rural service are lower than for service in larger urban areas due to the rating principle of 'value of service' - which specifies a higher basic monthly rate for exchanges that include a larger number of customers. Over the last ten years, for example, the rates charged in Winnipeg have been approximately fifty percent higher than those charged for similar service in local exchange areas with fewer than 500 customers (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Littlechild 1979).

The area of rural service improvement includes all aspects of improving telephone service to rural customers. Potential improvements include: (1) provision of more trunk lines between switching offices, so that calls between offices are less likely to be blocked during busy calling periods, (2) replacement of older, analogue switching equipment with modern, digital equipment - which provides quicker, quieter switching, and allows new services (such as call waiting and call forwarding) to be offered, (3) extension of extended area service - allowing toll-free calling between switching offices over wider geographic areas, and (4) conversion of multi-party service to single-party service. Multi-party service refers to party lines - where two, or more customers share the same telephone line. Single-party service refers to the use of a single, private telephone line for each customer. Of the possible areas for improvements to rural telephone service in Manitoba, customers have indicated that their highest priority is the conversion of multi-party to single-party service. This priority is the result of customers' concerns for access to the telephone line when they need to make a call, and the lack of privacy on multi-party lines (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Criterion 1987).

1.2 PURPOSE OF THIS PAPER

The purpose of this paper is to evaluate alternative policies that may be employed by the Manitoba Telephone System to implement a program for the conversion of multi-party to single-party service. Limiting the study to the provision of single-party service to multi-party customers establishes manageable dimensions to the area of study, and addresses the main priority area for rural service improvement. The priority for this type of program stems from the aforementioned activities of other prairie telephone companies, the campaign issues of recent provincial elections in Manitoba, and market research studies of the needs of rural telephone subscribers (Criterion 1987).

There are a number of possible program options that could be employed to implement the conversion to single-party service. The two major categories of programs are: Premium Service and Universal. In a Premium Service program, the individual customer pays all, or a portion of the capital cost associated with converting his service to single-party. The primary policy decisions relating to this type of program are the level of cost charged to the individual customer. In a Universal program, all multi-party lines would be converted to single-party service on an area-by-area basis, and the cost would be borne by the rates that are charged to all customers. The policy decisions relating to this type of program centre on the timing of the program - how soon can the program start, and how long will it take to convert all multi-party customers to single-party service. Program options within Premium Service and Universal program frameworks comprise the alternatives evaluated in this study.

In order to investigate the impact of such policy decisions upon the network planning of the Manitoba Telephone System, a process model of relevant portions of the telephone system has been assembled using the methodology of System Dynamics. This model has been programmed in DYNAMO to allow computer simulation of the alternative policy directives. A description of the model and experiments conducted with it to probe its behaviour under different policy directives follows.

CHAPTER 2

SYSTEM OVERVIEW

2.1 METHODOLOGY

The methodology adopted in this study is known as System Dynamics. For a description of the System Dynamics method see Coyle (1977) and Roberts et al (1983). The rationale for using such a simulation process to model complex systems has been described by Forrester (1982, pp. 3-10) as:

> Most dynamic behavior in social systems can only be represented by models that are nonlinear and so complex that analytical mathematical solutions are impossible. For such systems, only the simulation process using step-by-step numerical solution is available.

This modeling technique offers a tool that has been successfully applied in other policy situations where complex interrelationships of variables obscure the expected results of policy decisions (Hall 1976, Hall and Menzies 1983). This tool is not intended as an exact econometric model, but instead offers an aggregate level working model of the system under study with the capability of evaluating the long-term dynamic effects of various strategic alternatives.

Complex interrelationships are modeled in System Dynamics by constructing a system flow diagram to represent the operation of the system. The system flow diagram is constructed from the 'cognitive maps' that decision makers have developed to explain their particular understanding of the operation of their part of the system, and their views of the 'causal links' that relate their part of the system to other parts. The system flow diagram is constructed, bit by bit, from the 'causal link' interconnections of various 'cognitive maps', based upon discussions with the decision makers (Axelrod 1976).

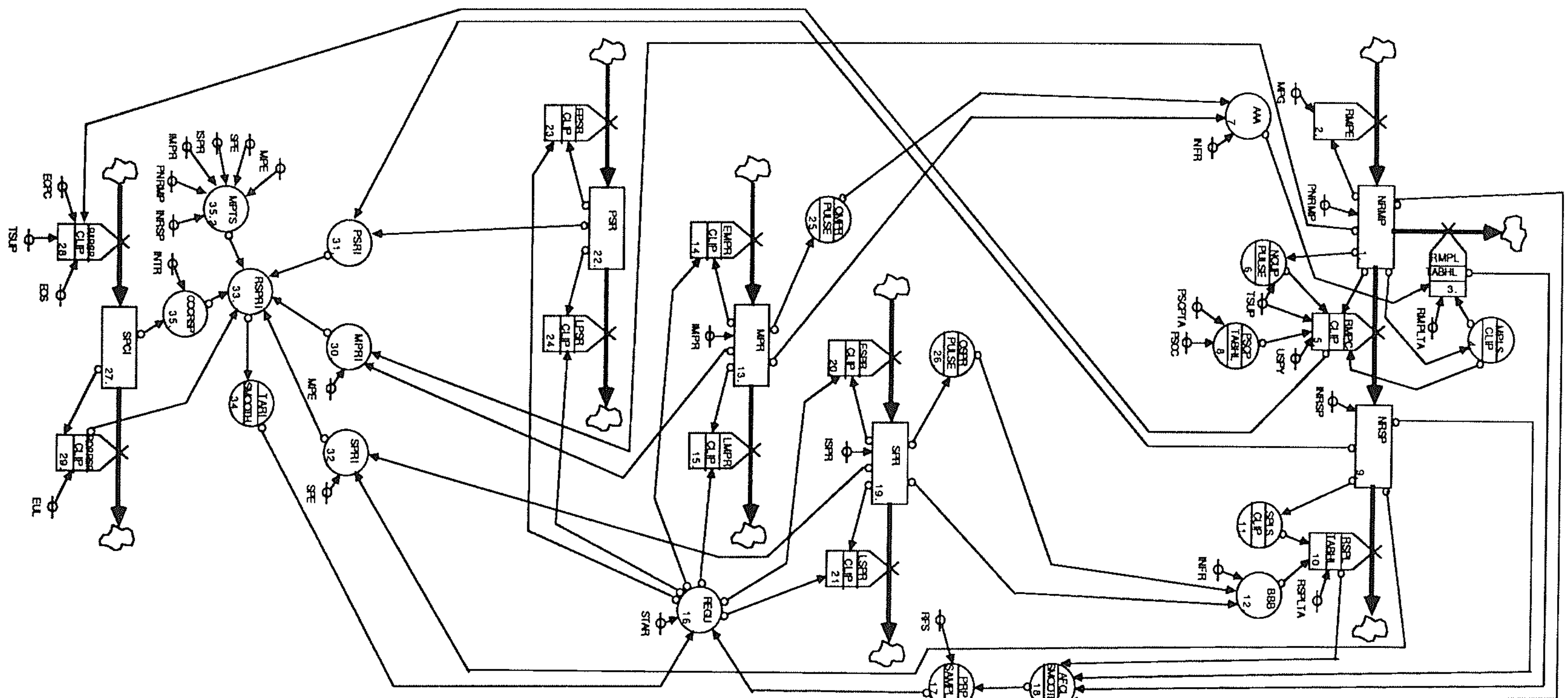
A system flow diagram so constructed represents an excellent medium for communicating the model to the decision makers upon whose 'cognitive maps' the model is based. This communication results in further clarification of the modeling assumptions, as well as a dynamic revision and refinement process for the model.

DYNAMO (Pugh 1983) is the modeling-simulation software package used to aid in building a simulation model of the system under study. This package is used because: (1) the close relationship of the DYNAMO dynamic modeling computer simulation language to the system flow diagram (Dynamo offers a one-to-one correspondence between the required equations and the elements of the system flow diagram), and (2) in the Dynamo language the order of the equations is not important, thus allowing model revisions and refinements to be easily accommodated.

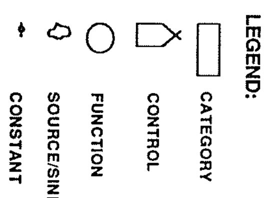
It is important to consider some of the terms that are used in this study to describe common elements of the modelling process. In a Systems Dynamics study, such as this one, the focus is on how many of some specific things (for instance, people or dollars) are in a particular <u>category</u> at each point of time in the model simulation. To illustrate the modelling process, a simple model - containing only one category - is examined. Suppose the single category of interest is the number of people who are taxpayers in Canada. It would be necessary to find out how people moved into, and out of this category. The source of potential taxpayers is outside the system being modelled, and might include people who are too young to work, as well as people who reside outside Canada. What is important to the model is determining how many of these non-taxpayers will become taxpayers at each increment of time. The model uses a control to represent the movement of people from the source to the taxpayer category. Such a control would be analogous to a faucet for controlling water, or a volume adjustment controlling the sound level of a stereo set. Similarly, when existing taxpayers move out of the country, or die, they move out of the category of taxpayers. Another control in the model represents this movement out of the category, and into the sink of former taxpayers (who are outside the model). Thus, this model represents the number of people in the Canadian taxpayer category at a series of points in time. If the initial value for the number of taxpayers is correct, and if the equations for the controls into and out of the taxpayer category accurately reflect real conditions, then this model should be able to indicate the expected number of taxpayers at any particular point in time after the initial time. The terms: category, source, sink and control are used in the same way in the following sections to describe the rural service improvement model used in this study.

FIGURE 1

SYSTEM FLOW DIAGRAM



CUSTOMER SECTOR **RATES & REGULATION SECTOR** **FINANCIAL SECTOR**



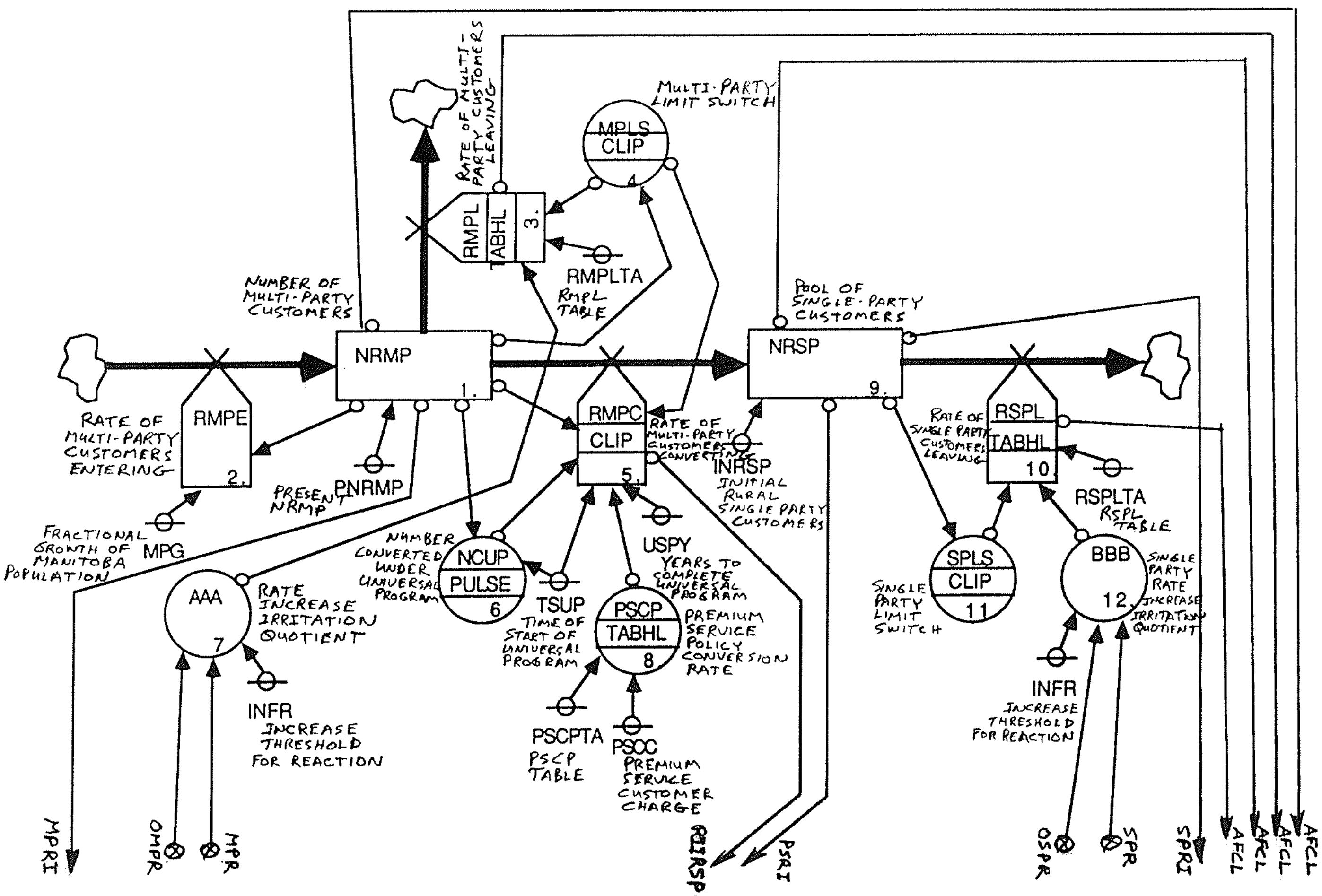
2.2 MODEL OVERVIEW

Figure 1 shows a system flow diagram representing the conglomeration of the various portions of the telephone system that are relevant to the evaluation of the policy alternatives mentioned in the first chapter. Although this total system diagram is complex, it becomes more understandable as the major subsystems are individually examined, and the general meanings of the symbols used in the diagram are described. The total system diagram is divided into three major subsystems: (1) Customer Sector, (2) Rates and Regulation Sector, and (3) Financial Sector. The operation of the total system is best described by discussing each major subsystem individually. Detailed system flow diagrams for each sector are presented in Figures 2-4. An alphabetical list of the definitions of variables used in the model is presented in Table 1 at the end of this chapter.

The Customer Sector (Figure 2) models the number of customers in various categories, and the rates at which customers enter or leave these categories. Referring to Figure 2, the larger arrows represent the movement of customers from the source (representing non-customers) on the left-hand side of the diagram, through the categories for multi-party customers (NRMP) and single-party customers (NRSP). The symbols with crossed lines superimposed on the larger arrows represent the controls for customer movement into or out of these categories. Thus, customers can enter the NRMP category through the control for the rate of multi-party customers entering (RMPE). Similarly, there are two possible paths by which customers can leave the multi-party category: through the

FIGURE 2

CUSTOMER SECTOR

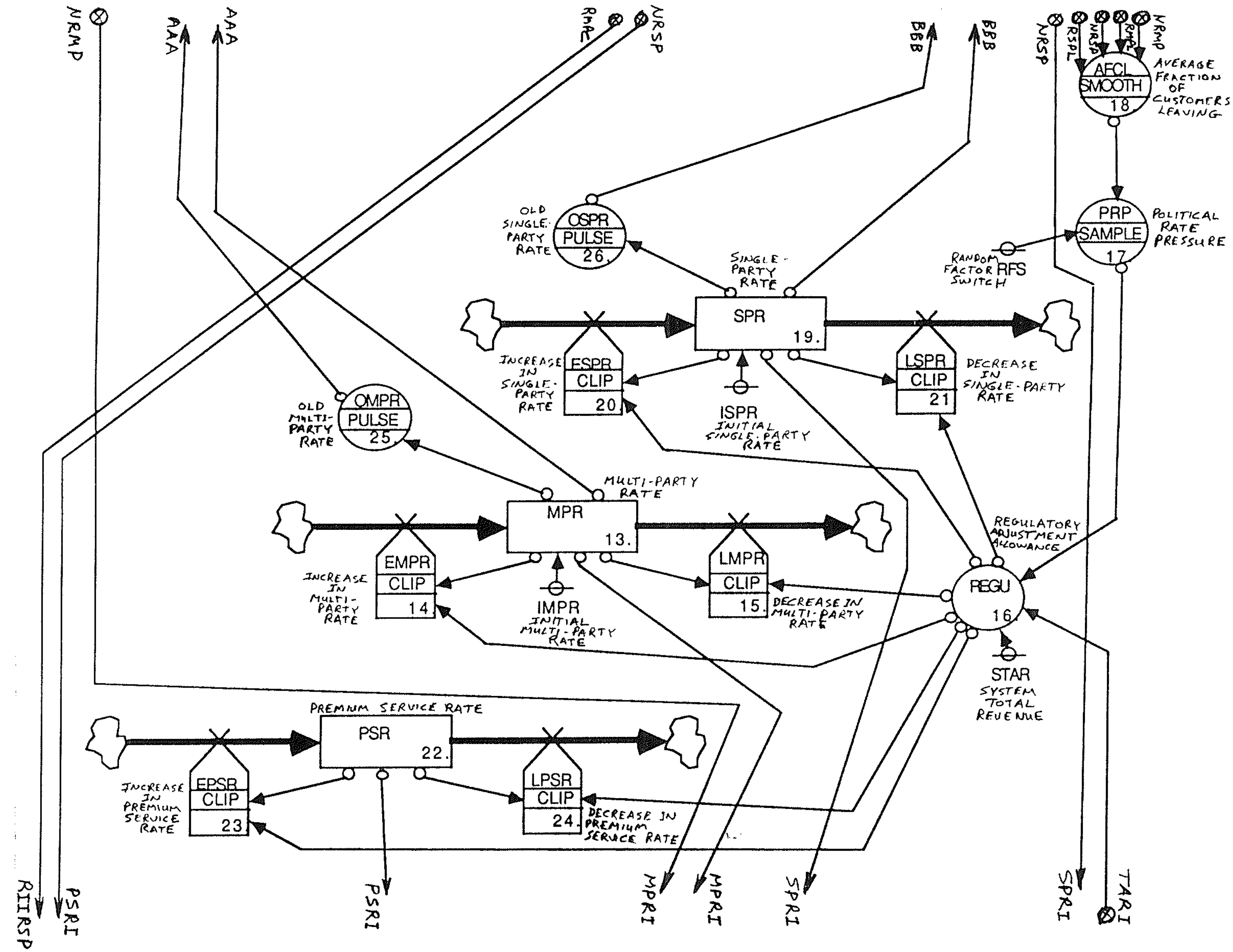


control for the rate of multi-party customers leaving (RMPL) to the sink of former customers, or through the control for rate of multi-party customers converting (RMPC) to become single-party customers in the NRSP category. A closer look at the operation of the RMPC control aids in the further understanding of such movements. RMPC depends on a number of factors; for example, functions (shown in larger circles) for the premium service policy conversion rate (PSCP) and for the number converted under the universal program (NCUP), and constants (shown as smaller, bisected circles) for the time of start of the universal program (TSUP) and for the years to complete the universal program (USPY). Further details concerning the functions and equations which have been used to model such movements for the Customer Sector are contained in Chapter 3. One aspect of the diagram which has not yet been discussed is the smaller arrows. These lines represent information flows; for example, the function for the multi-party limit switch (MPLS) takes information from NRMP concerning how many customers are in this category. If the number drops to zero, MPLS sends information to the controls RMPL and RMPC to stop any additional customer movement out of NRMP (since this category is empty). Small arrows, such as these, extending to the edge of the diagram, indicate interrelationships with other subsystems in the model. Arrowheads, or arrow tails, are shown with a label to indicate which particular function in another subsystem the information flows to, or from, respectively.

The Rates and Regulation Sector (Figure 3) represents: (1) the dollar amounts of the relevant monthly rates that the customers are charged for the various services,

FIGURE 3

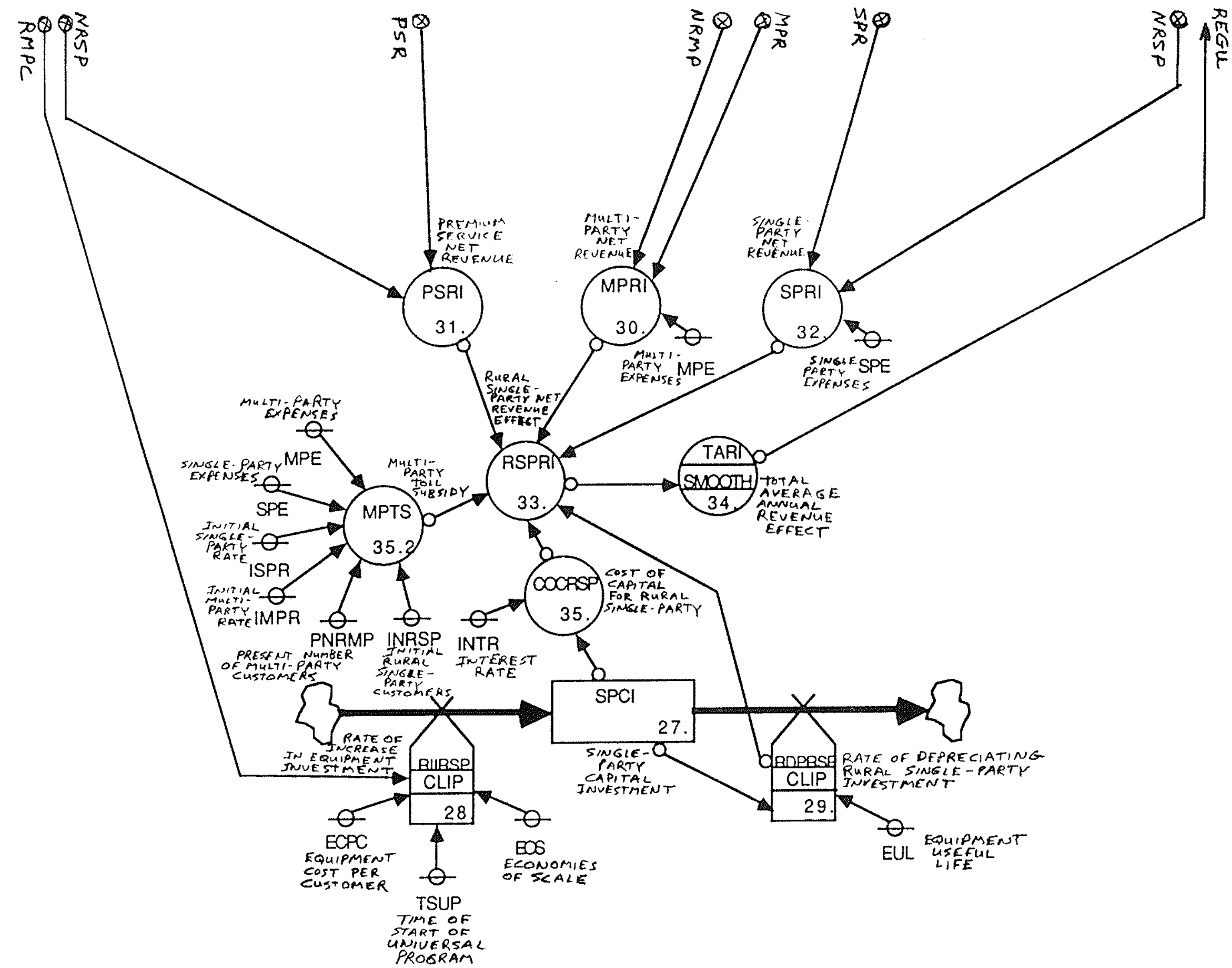
RATES & REGULATION SECTOR



and (2) the process of regulation of these rates by the Manitoba Public Utilities Board. The focus of this sector is on the three categories (shown as rectangles in Figure 3) representing the rates that customers are charged: Single-Party Rates (SPR), Multi-Party Rates (MPR), and Premium Service Rates (PSR). Each of these categories has a similar model structure - a control that regulates the movements into this category (large arrow in), representing rate increases, and a control that regulates the movements out of this category (large arrow out), representing rate decreases. The critical factor regulating these rate controls is the information from the regulatory adjustment allowance (REGU) function (shown as a larger circle). The inputs to this function are provided by the political rate pressure (PRP) function and the total average annual revenue effect (TARI) function in the Financial Sector, as well as the constant representing system total revenue (STAR - shown as a smaller, bisected circle). The PRP function takes an averaged view (average fraction of customers leaving (AFCL) function) of the percentage of customers leaving the network (using information from the Customer Sector), and combines this with a random factor - which represents the changes in political leadership over time. Other functions in this sector provide delayed versions of the rate categories (old single-party rate (OSPR) and old multi-party rate (OMPR)). Information from the current rates and the old rates is used in the Customer Sector to calculate the periodic percentage increase in rates. Details of the functions and equations which have been used to model the Rates and Regulation Sector are contained in Chapter 4.

FIGURE 4

FINANCIAL SECTOR



The Financial Sector (Figure 4) models: (1) the capital investment required for conversion to single-party service, and (2) the total average annual revenue effect of the program on the Manitoba Telephone System. The focus of this sector is the category that represents the accumulated capital investment for the single-party conversion program (SPCI). The control which lets capital dollars be added to SPCI - the rate of increase in equipment investment (RIIRSP), takes information from three constants: equipment cost per customer (ECPC), time of start of universal program (TSUP), and economies of scale (EOS), as well as the number of multi-party customers being converted to single-party service (RMPC) from the Customer Sector. The equations and assumptions used for this control, as well as other functions in the Financial Sector are discussed in detail in Chapter 5. Returning to the SPCI category, the number of dollars in this category is reduced by the depreciation of the equipment - modelled by the control for the rate of depreciating rural single party investment (RDPRSP).

Another focal point in this sector is the function for rural single-party net revenue effect (RSPRI), which collects the information concerning the financial impact of the various parts of the model. For example, the function for multi-party net revenue (MPRI) takes information about the number of multi-party customers from the Customer Sector, and information about the amount of multi-party rates from the Rates and Regulation Sector, and combines this information with the constant for multi-party expenses (MPE). The MPRI function then calculates the net revenue effect from all these multi-party factors, and sends the information to RSPRI for summation into the system total. The revenue effects are calculated similarly for the single-party and premium service factors, and forwarded to RSPRI for summation. Another important information input to RSPRI is the cost of the money that has been invested in the single-party conversion program (COCRSP). This function uses the amount of the capital investment (SPCI) and the interest rate (INTR) to calculate the cost of capital. Another input to RSPRI is the multi-party toll subsidy (MPTS). This function takes the initial values of respective rates, expenses and numbers of customers for single- and multi-party, and calculates the amount by which toll revenues subsidize these aspects of rural service. This information is sent to RSPRI for summation. The function for total average annual revenue effect (TARI) produces a delayed version of RSPRI, which is used by the regulatory adjustment allowance (REGU) function in the Rates and Regulation Sector.

The system model that is diagramatically displayed in the system flow diagrams (Figures 1-4) is described in more detail beginning in the next chapter.

TABLE 1

ALPHABETICAL LIST OF DEFINITION OF VARIABLES USED IN THE MODEL

NAME	NO	T	DEFINITION	WHERE USED
AAA	7	A	(1) RATE INCREASE "IRRITATION QUOTIENT"	RMPL,R,3
AFCL	18	A	(1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING	PRP,A,17
BBB	12	A	(1) SINGLE-PARTY RATE INCREASE "IRRITATION QUOTIENT"	RSPL,R,10
COCRSP	35	A	($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY	RSPRI,A,33
DT	36.6	C		NRMP,L,1/NCUP,L,6/NRSP,L,9/MPR,L,13/SPR,L,19/PSR,L,22/OMPR,L,25/OSPR,L,26/SPCI,L,27
ECPC	27.2	C	($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER	SPCI,N,27.1/RIIRSP,R,28
EMPR	14	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE	MPR,L,13
EOS	28.1	C	(1) ECONOMIES OF SCALE	RIIRSP,R,28
EPSR	23	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE	PSR,L,22
ESPR	20	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE	SPR,L,19
EUL	29.1	C	(YEAR) EQUIPMENT USEFUL LIFE	RDPRSP,R,29
IMPR	13.2	C	($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE	MPR,N,13.1/MPTS,N,35.2
INFR	7.1	C	(1) INCREASE THRESHOLD FOR REACTION	AAA,A,7/BBB,A,12
INRSP	9.2	C	(CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS	NRSP,N,9.1/SPCI,N,27.1/MPTS,N,35.2
INTR	35.1	C	(1/YEAR) INTEREST RATE	COCRSP,A,35
ISPR	19.2	C	($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE	SPR,N,19.1/MPTS,N,35.2
LENGTH	36.7	C		
LMPR	15	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE	MPR,L,13
LPSR	24	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE	PSR,L,22
LSPR	21	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE	SPR,L,19
MPE	30.1	C	($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES	MPRI,A,30/MPTS,N,35.2
MPG	2.1	C	(1/YEAR) FRACTION GROWTH OF MANITOBA POPULATION	RMPE,R,2
MPLS	4	A	(1) MULTI-PARTY LIMIT SWITCH	RMPL,R,3/RMPC,R,5
MPR	13 13.1	L N	($/CUSTOMER/YEAR) MULTI-PARTY RATE	AAA,A,7/EMPR,R,14/LMPR,R,15/OMPR,L,25/OMPR,N,25.1/MPRI,A,30
MPRI	30	A	($/YEAR) MULTI-PARTY NET REVENUE	RSPRI,A,33
MPTS	35.2	N	($/YEAR) MULTI-PARTY TOLL SUBSIDY	RSPRI,A,33
NCUP	6 6.1	L N	(CUSTOMER) NUMBER CONVERTED UNDER UNIVERSAL PROGRAM	RMPC,R,5
NRMP	1 1.1	L N	(CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS	RMPE,R,2/RMPL,R,3/MPLS,A,4/NCUP,L,6/AFCL,A,18/MPRI,A,30
NRSP	9 9.1	L N	(CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS	RSPL,R,10/SPLS,A,11/AFCL,A,18/PSRI,A,31/SPRI,A,32
OMPR	25 25.1	L N	($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE	AAA,A,7