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PREMISES TELECOMMUNICATIONS NETWORK TECHNOLOGICAL AND FINANCIAL MODELING

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ABSTRACT

Managing a corporate telecommunications premises network has vastly changed as a result of deregulation of the common carrier services industry and the court-mandated divestiture of AT&T. Users now have greatly increased responsibilities for the selection, care, and operation of facilities and equipment on their own premises, and for the selection of and interconnection with carrier-supplied services. Network management at the corporate level has become a complex exercise in economic decision-making, constrained to minimize overall network costs at given levels of service quality and quantity.

Telecommunications premises networks comprise various components, including stations or terminals, e.g., telephone sets and data terminals; telephone key systems (small-group telephone systems used in small offices or as part of a larger system); private branch exchange (PBX) switching systems; multiplexers; wire, radio, IR, and fiber optic links; and local area networks (LAN). A premises network could consist of entirely owned equipment, or leased equipment, or a combination of the two (e.g., owned telephones and leased local switching services from a telephone company's local central office). This paper describes a model to evaluate costs of alternative premises network configurations, taking into account acquisition and operational costs. An interactive user interface accepts entries of network component, quantity, and cost parameters. The model provides a forecast of events and costs, both capital and expense, for each component in the network and for the network as a whole. Applications to several problems are discussed.

1. INTRODUCTION

Premises telecommunications networks include three types of equipment: (1) terminal components, such as single-line telephones, multi-line telephones, and data terminals; (2) intelligence components such as telephone key system common equipment, premises PBX's, data switches, multiplexers, and telephone company central office facilities; and (3) access components such as wire, cable, plugs, jacks, fiber optics, radio, and satellite systems. Each equipment item has many defining characteristics, some technology-related and some economic. Equipment and facilities must be configured from the end-user terminal workstation to high-level intelligence levels to deliver end-end user service. Some examples of premises network elements are given in Figure 1.

Until recently, network decisions were controlled by an integrated services supply industry, which acted under goals and incentives very different from those of firms within the services user community. The transitional state of telecommunications brought on by deregulation and divestiture, and rising expectations by users for greatly improved services creates many managerial dilemmas for any firm that consumes telecommunications services. The management problem is sharpened by rapidly advancing new technology that can improve service quality and may reduce unit operating costs. How can bold moves in deploying new networks for the firm be achieved under these circumstances?

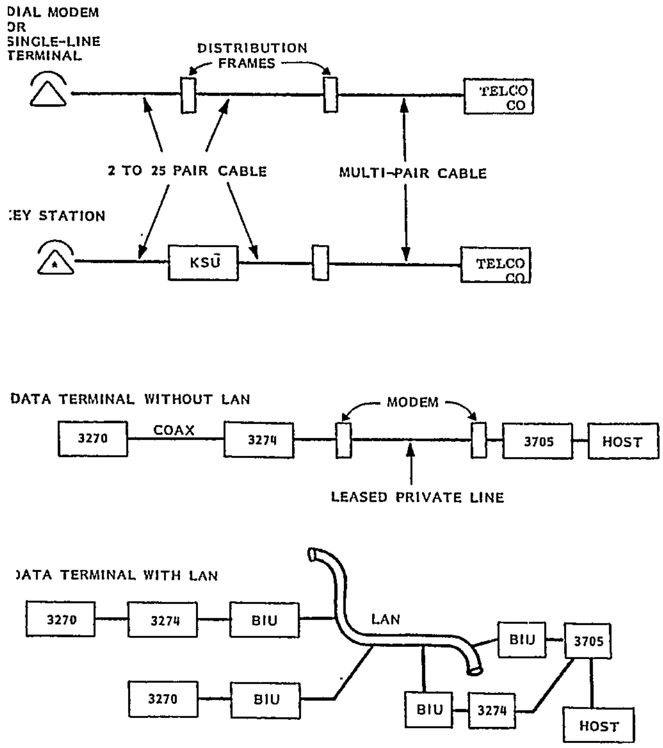

Figure 1: Premises Network Examples

This paper offers two advances in the practice of telecommunications network management and operation for the firm. The first is a network management model that reflects matters within the firm's purview and matches the deployment of network assets. The second is a financial performance simulation that can track and forecast network expenditures at both component level (within the model) and in the aggregate. Immediate benefits are the resolution of financial questions for the network as a whole, and the opportunity to review any proposed change to the network in a common framework. We refer to the union of these two items as "model" in this paper. The model has been applied to several real-world problems, all associated with the evaluation of changing technology and ownership conditions.

2. SIMULATION OBJECTIVES

The scope of problems studied lies in accumulating and presenting projected capital and operating costs for telecommunications premises networks of arbitrary size and configuration. The major point in approaching such problems is the large amount of data that must be handled and the effort involved in deriving useful information from these data. For example, a network with many stations, multiple key systems, and various telephone company service arrangements has a population of numerous network components. Their costs must be tracked over time as a matter of competent network management. If the number of terminals grows at some percentage rate annually, a plausible assumption for many firms, the introduction of each new terminal must be tracked for contribution to costs throughout its service life. When various network components are considered, each with unique economic and operating characteristics, an extended cost computation emerges. The model developed uses a definition of network operation and management in terms of life-cycle activities common to electronic systems, and tracks effects of these activities through simulation of operating events and activities at the unit component level.

Two formats are presented as model output. An abbreviated format includes only net present value of all cash flows over the user-requested projected lifetime. When more detailed information is desired, the user may examine month-by-month counts of events (occurrences of any operating activity) and associated costs. These results are discussed in later sections.

3. THE MODEL AND ITS STRUCTURE

Complex electronic systems share certain characteristics that we exploit for this model. We define network operation and management for each network component as four activities: New Installation; Vintage Replacement; Trouble Maintenance; and Move, Change, and Rearrangement. New Installation includes equipment acquisition costs plus costs of placing equipment in service the first time. Vintage Replacement is the replacement of a component that reaches the end of service lifetime. Trouble Maintenance is repair of network components, usually resulting from user complaints of deteriorated service quality or outright failure. Move, Change and Rearrangement is the activity of rearranging the network to comply with the firm's changing telecommunications operational needs. Each activity is triggered by status changes in the firm's consumption patterns, or by some aspect of a component's operating behavior. This further depends on the nature of the firm's consumption modes and ownership preferences. Each activity invokes various costs to the network.

We define a network as the union of its components. The model simulates operating behavior in terms of the four activities for each network component. Any component item that exhibits measurable cost and operating characteristics may be entered in the network under simulation. Costs for each activity are collected at the unit level, i.e., per network item. Thus, a single telephone has a new cost and new installation cost; it is replaced at end of service lifetime with a (possibly inflated) vintage replacement cost; it causes "trouble" periodically, which may be defined stochastically through mean time to failure, for which repair costs are incurred; it will be moved or rearranged according to the firm's business needs, which will incur further costs. Each activity for each network component is defined in terms of rates of occurrence of activity events and costs for each event. These costs, in turn, are adjusted for inflation under assumptions entered to the model. The network structure for our model is shown in Figure 2, which is a simple extension of Figure 1.

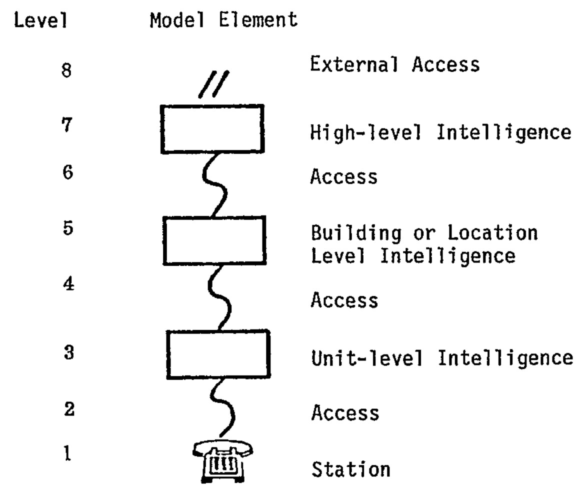

Figure 2: Abstract Network Model

Thus, a network consists of up to eight levels, in order from end-user terminal to access to services beyond the firm's premises. These levels, with examples, are described as follows:

Level	Function	Example
1	User station	Single- or multi-line telephone set, data terminal
2	Access	Station wiring, jack, cabling to common equipment
3	Unit-level intelligence	Telephone key system common equipment items
4	Access	Building wiring items
5	Location-level intelligence	Multiplexers, traffic concentrators, remote modules of a distributed PBX.
6	Access	Telephone company cable to firm's premises for Centrex service
7	High-level intelligence	PBX, telephone company CO for Centrex service
8	Access	Carrier interconnection for long distance service

Additionally, network components and services that interconnect intelligence levels exist and must be modeled. These levels are also accommodated in our model, as follows:

Level	Function
11	Direct access between terminals, without intervening intelligence
13	Direct access between a terminal and unit-level intelligence not associated with this terminal
15	Direct access between a terminal and location-level intelligence not associated with this terminal
17	Direct access between a terminal and high-level intelligence not associated with this terminal
33	Direct access between two unit-level intelligence nodes
35	Direct access between a unit-level and location-level node not associated with this unit level
37	Direct access between a unit-level and high-level node not associated with this unit level
55	Direct access between distinct location-level intelligence nodes
57	Direct access between a location-level and high-level node not associated with this location
77	Direct access between distinct high-level intelligence facilities, other than external access

A point-to-point private line is an example of Level 11; a tie line between two PBX's is an example of Level 77.

Figure 3 shows network elements and connecting paths for a more complex case, illustrating the hierarchy and direct access components for a multi-location firm. Such networks are the domain of our model. Figure 3 is the most general case that may be examined. The authors have found this description adequate for our objectives. Analyzing networks then reduces first to translating situations such as given in Figure 1 into appropriate levels for Figure 3 and then to establishing unit cost and operating data.

4. MODEL OPERATION

The model is designed around four concepts: the multi-level network description that accommodates any component encountered or any service provided outside the firm; a catalog of item-by-item network components and service data; a maintenance and operation simulation of ongoing tasks; and the aggregation of capital costs and expenses for the network as a whole.

The model incorporates a component catalog as a permanent reference for cost and technical data. Component data for catalog items may be modified, new catalog items and data entered in the permanent catalog, and items no longer relevant deleted from the catalog. Each level is implemented with hardware and service items, which may be chosen from among alternatives. Each item is identified by an abbreviated name (6 characters) and descriptive title (30 characters) supplied by the user. Following

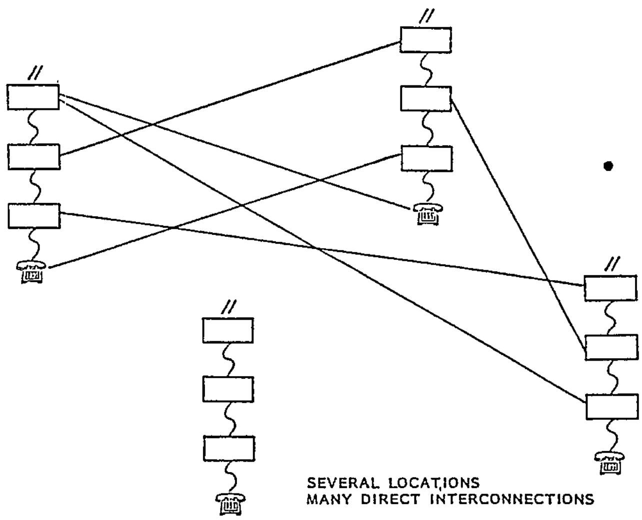

Figure 3: Complex Network Modeling

identification, some 40 data items may be supplied for each item at the unit level. These data fully describe the four activities specified to that item. (As an example, a network component owned by the firm will involve all four activities; one that is leased will ordinarily not be subject directly to Trouble Maintenance and Vintage Replacement costs--these being covered in lease payments.) Figure 4 is a sample of model data for a multi-line telephone station. The Figure also defines all data items that must be entered for each catalog item. These data drive various elements of the simulation in a straightforward fashion: events in each activity are scheduled and executed for every component at every level and costs (both capital and expense) accumulated.

Model operation proceeds by taking user selections for network level components and placing them in the network to be simulated. To review, any item follows a life history defined in terms of the four activities:

New Installation	Original installation of a hardware item or a service unit.
Trouble Maintenance	Repair activities for each item.
Move, Change, Rearrangement	Activities associated with physical moves or service changes.
Vintage Replacement	Removal and replacement of items that have reached the end of useful lifetimes.

Catalog data includes information on costs and frequency of these events, as in Figure 4, which is thoroughly representative.

To run the model, the user may review the permanent catalog and select items, or add new items for evaluation. The model prepares a temporary catalog of items for the current run. The model proceeds through the temporary catalog and adds user-supplied demand and time period information. Options available allow specifying a starting demand and growth (or decline), and the time period within a ten-year calendar during which the item is active for the network. When this data is entered, the model proceeds by invoking an event simulation for all activities at all network levels.

5. OPERATING NOTES

The model evolved from a PC version of the software into a mainframe application for IBM 30XX processors under VM/CMS. The mainframe operation has nearly limitless capacity for a great range of network configurations. Mainframe residence permits access to the model by many users, and allows very large networks with extensive catalogs to be studied.

The model readily facilitates examination of numerous thorny problems for network managers. For example, capital and expense budgeting for the entire network of the firm is aided by defing and simulating operation of the entire network. (The prime task in achieving this goal is the creation of the network catalog initially.) Second, the model allows evaluation of any proposed alternatives for any component class, level, structure, and so on by simulating such alternatives within the entire network, and comparing costs month-by-month. Third, the forecast of activity events can be used to set levels-of-effort for a technician staff, and materially aides maintenance contract negotiations on this topic. Fourth, the whole issue of lease vice buy for the network or any component may be studied in detail. Finally, the timing of any event can be examined for impacts to the network and its costs to the firm.

Figure 5 is an example of the difference between leasing station apparatus with maintenance included, and purchasing replacement items and contracting separately for maintenance.

AUTHORS' BIOGRAPHIES

PETER STANEK is an engineer with Lockheed Missiles & Space Company. He has over twenty years' experience in the analysis, design, implementation, and evaluation of telecommunications networks. He has consulted for both private (telephone companies) and public (NTIA, OTA, OTP) sector clients. Peter Stanek studied Mathematics at the University of Chicago where he earned a Ph.D. in 1961.

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CATALOG ITEM : TELEPHONE KEY STATION

BASIC CATALOG INFORMATION...				
NEW UNIT PRICE (AT SCENARIO START)	:	$	93.06	
NEW PRICE INFLATION RATE	:		8.00	%
NEW UNIT WARRANTY PERIOD	:		24	MONTHS
SERVICE LIFETIME FOR NEW UNIT	:		48	MONTHS
EMBEDDED UNIT PRICE (AT START)	:	$	0.00	
INFLATION RATE FOR EMBEDDED PRICE	:		0.00	%
UNIT MONTHLY RENTAL PRICE	:	$	0.00/MO.	
INFLATION RATE FOR RENTAL PRICE	:		0.00	%
NEW INSTALLATION INFORMATION...				
LABOR PER UNIT INSTALLATION	:		0.50	HOURS
LABOR RATE FOR INSTALLATION	:	$	25.00	
MINOR ITEMS PER UNIT INSTALLATION	:	$	0.00	
INFLATION RATE FOR ABOVE	:		3.00	%
FIXED UNIT INSTALLATION PRICE	:	$	0.00	
FIXED INSTALLATION INFLATION	:		0.00	%
VINTAGE REPLACEMENT INFORMATION...				
LABOR PER UNIT REPLACEMENT	:		0.50	HOURS
LABOR RATE FOR REPLACEMENT	:	$	25.00	
MINOR ITEMS PER UNIT REPLACEMENT	:	$	0.00	
INFLATION RATE FOR ABOVE	:		3.00	%
FIXED UNIT REPLACEMENT PRICE	:	$	0.00	
FIXED REPLACEMENT INFLATION	:		0.00	%
TROUBLE MAINTENANCE INFORMATION...				
MEAN TIME BEFORE FAILURE	:		38	MONTHS
LABOR PER UNIT MAINTENANCE	:		1.00	HOURS
LABOR RATE FOR MAINTENANCE	:	$	25.00	
MINOR ITEMS PER UNIT MAINTENANCE	:	$	3.00	
INFLATION RATE FOR ABOVE	:		3.00	%
FIXED UNIT MAINTENANCE PRICE	:	$	0.00	
FIXED MAINTENANCE INFLATION	:		0.00	%
MOVE, CHANGE, AND REARRANGEMENT INFORMATION...				
MEAN LOCATION LIFETIME	:		15	MONTHS
LABOR PER UNIT CHANGE	:		0.50	HOURS
LABOR RATE FOR CHANGE	:	$	25.00	
MINOR ITEMS PER UNIT CHANGE	:	$	0.00	
INFLATION RATE FOR ABOVE	:		3.00	%
FIXED UNIT CHANGE PRICE	:	$	0.00	
FIXED UNIT CHANGE INFLATION	:		0.00	%
NETWORK CONFIGURATION INFORMATION...				
STARTING MONTH FOR THIS ITEM	:		1	
ENDING MONTH FOR THIS ITEM	:		120	
STARTING DEMAND	:		16000	UNITS
ANNUAL GROWTH RATE	:		4.00	%
ITEM IS "NEW" IN STARTING MONTH				
ITEM IS "OWNED"				

Figure 4: Example Catalog Values For Representative Network Component

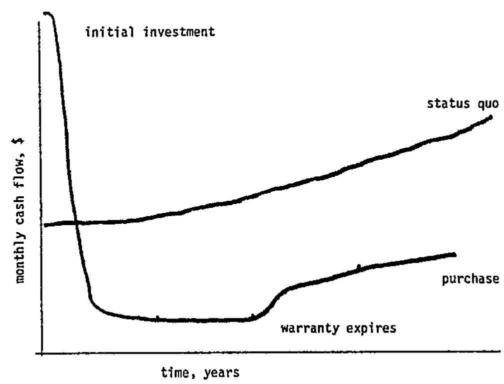

Figure 5: Comparing Status Quo Rental With Purchased Terminal Equipment