THE CN NETWORK MODEL

R.D. Jones, D.C. Lach and J.W. Metsos
Canadian National Railways
Montreal, Quebec, Canada

The Canadian National Railways' desire to develop a network simulation grew in recent years with the availability of large third generation computers, better data bases, and the increasing tendency of key operating people to approach railroad problems from the systems viewpoint.

As the volume of CN's market expands, the mix of traffic alters, resulting in a constantly changing geographical pattern of flow. In addition, the accent on traditional standards of service for such traffic as preference and bulk loads is shifting. The individual customer's requirements for such things as the pick-up time at his siding, the delivery time at the consignee, and consistency of service, are becoming more stringent.

The task of setting up an operating plan to meet these traffic volumes and service requirements is inherently complex. Without a network simulation, it is virtually impossible to predict the operational feasibility and the effects on customer service of proposed simultaneous changes in train schedules, train marshalling, routine procedures in yards, yard or mainline track facilities, and other resources.

The network model is designed to help answer questions such as:

1. At any given mix of traffic, should the railroad run longer trains, shorter trains, or some of each?

2. What is the probable effect of a new yard or main track plant on operations elsewhere?

3. What are the implications of alternative train schedules and marshalling arrangements?

4. Can marginal additions of capital in physical plant improvements keep pace with a gradually increasing level of traffic, or must the railroad face up to major changes in main track and secondary plant?

5. What are the probable effects on other movements of entirely new patterns of service in the fields of passenger, express, container, or unit trains, in which service guarantees may be part of the transportation specifications?

FEATURES OF THE CN SYSTEM

It may be useful to precede further discussion of the model by a general description of some of the major features of the CN system. The top left hand corner of figure 1 shows in fair detail the eastern portion of the railroad. Most stations are only of local importance; they act mainly as origination and termination points for traffic.

Many of these stations feed into large terminals which are the major decision centers of the railway. The track layout in figure 2 illustrates the main areas in a typical large terminal. In the inbound area, trains are inspected, serviced, and broken up into strings of cars for processing through the yard. The classification area is analogous to post office mail boxes where traffic is sorted into tracks each of which is designed to hold cars of specific classes, destined to specific stations. Strings of cars are pushed by a yard engine over a lead track into the classification area where each car is switched into its proper track. In automated "hump" yards, the lead is a physical hump or hill and cars roll into position as directed from a tower overlooking the area. From here, cars are pulled by other yard engines onto outbound trains waiting in the outbound section. Each train carries specific traffic for specific destinations and its size is limited in terms of car lengths, tonnage limits, or motive power availability. Outbound inspection is performed and trains may be delayed awaiting the arrival of connecting traffic, crews, or power.

Connections between trains are very significant since it is usually by way of a series of trains that a car reaches its destination. Missed train connections lengthen the transit time of affected cars and cause chain reactions throughout the network.

There are also groups of resources in a yard which are not only limited but also variable with time. These include inspection crews, servicing crews, and one or two pools of yard engines. Strings of cars compete for these resources based on an often obscure set of dynamic priorities. Figure 3 summarizes the operations in a large terminal.

Trains run from yard to yard over tracks where they experience delays when meeting, being overtaken, or following behind other trains of higher priority. A conflict is resolved by placing the less important train into one of the sidings located every few miles along the line.

THE CN NETWORK MODEL

The simulation program, written in Simscript 1.5, is a further development of the St. Louis-San Francisco Railway's network model which was itself based on William P. Allman's research with the National Bureau of Standards.[1,2]

Cars enter the model on trains originating outside the network being simulated or as individual cars becoming available at their origination nodes. This input may be based on real life data or on traffic projections.

The chosen portion of the railway system must be reduced to an equivalent network of nodes and links by extracting major terminals, combining groups of stations into single nodes, and ignoring minor points, as illustrated in figure 1.

At nodes representing large terminals, yard operation times are approximated by linear functions. Inbound inspection crews and yard engine pools are limited and can be varied with time as in real life. Although at present there are no limitations on the model's track capacities, periodic snapshot reports showing the current contents of nodes can be used to reveal intolerable congestion. The model assumes unlimited motive power availability. However, this limitation can be partially neutralized by studying train performance reports which indicate the power that would have been required for a particular train.

Over-the-road delays between trains are approximated on each link and are added to a train's running time as the simulation progresses. Passenger trains run on schedule and exist in the model only to delay freight trains.

Each train is described by defining certain characteristics for each node and link on its path. A train's take list at a node specifies in priority sequence, the classification tracks from which it is to take cars, where these will be set off, and how they will be handled at those nodes. A train's capacity at each node is also specified.

Connections between trains for traffic, power or crews can also be defined and limits may be set on the length of time a train will wait for a late connection.

Output reports not only exhibit the operating performance of selected trains, yards, and links but also provide service-oriented information indicating the quality of service provided by the proposed system.

The paper will describe in more detail the data storage structure and the logic of some of the major portions of the model.

<u>References</u>

1. Allman, William P., "A network model of freight system operations", Simulation of Railroad Operations, published by the Railway Systems and Management Association, pp. 129-140, October 19, 1966.

2. Bellman, J.A., "Railroad network model", a paper given at the Second International Symposium on the Use of Cybernetics on the Railways, October 1 to 6, 1967.

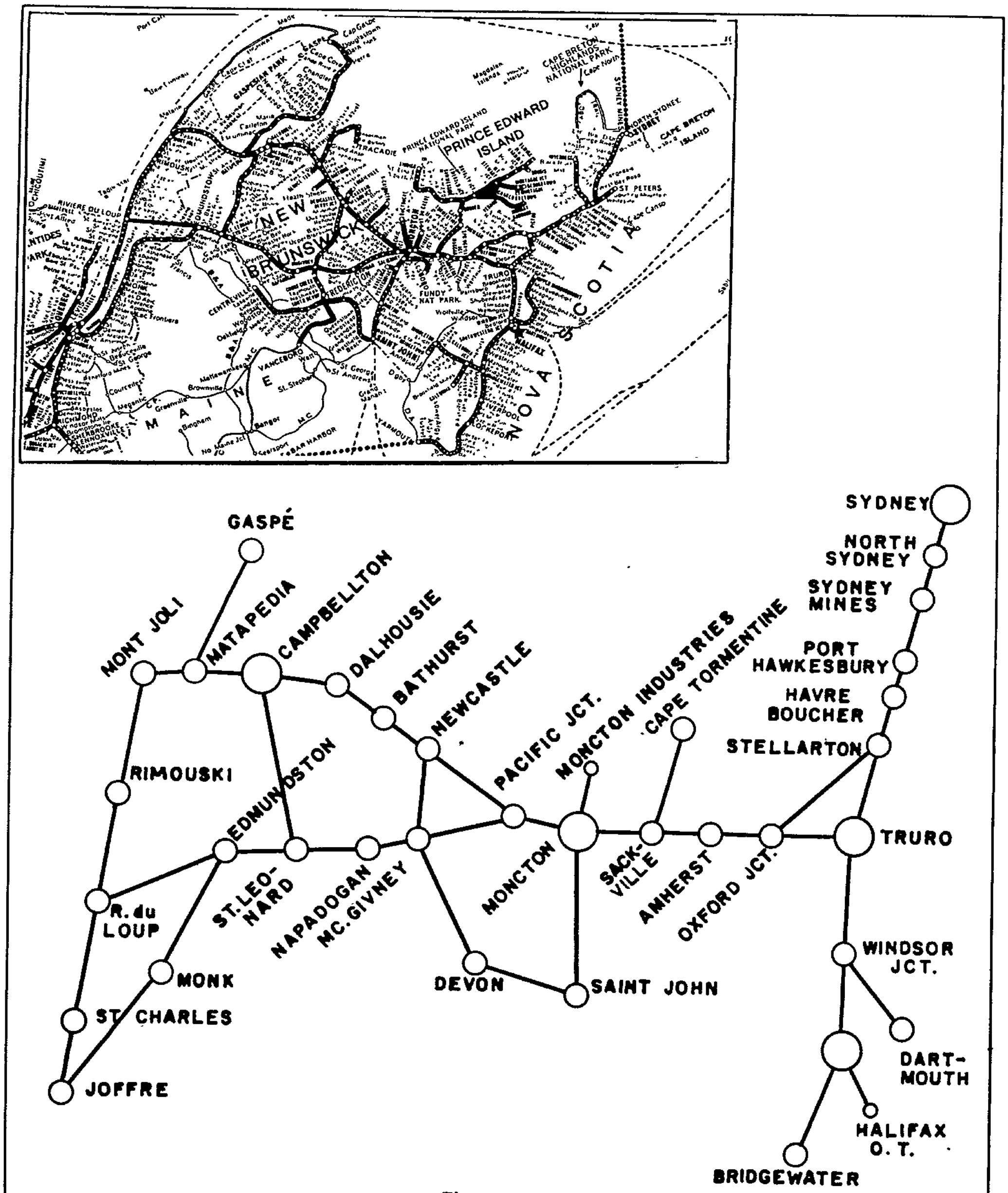

Figure 1

A Network Representation of the Atlantic Region Mainland.

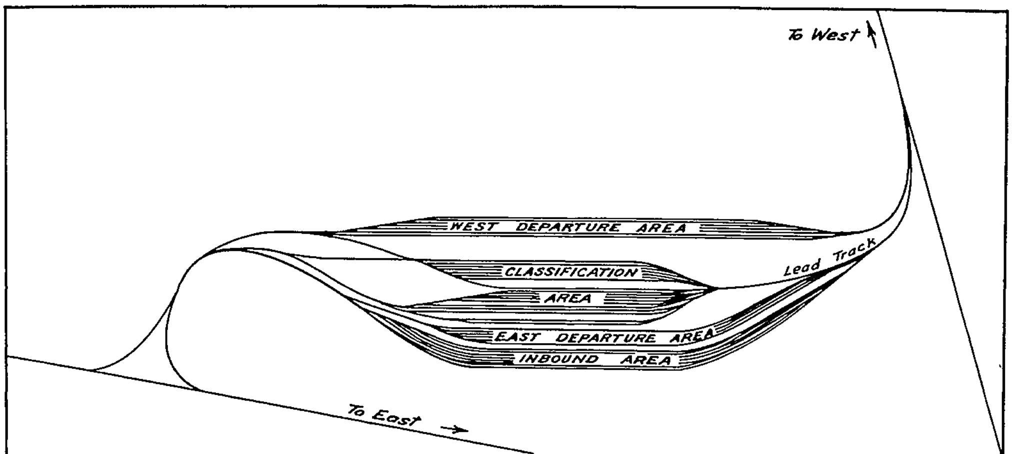

Figure 2
Schematic track layout of a large terminal

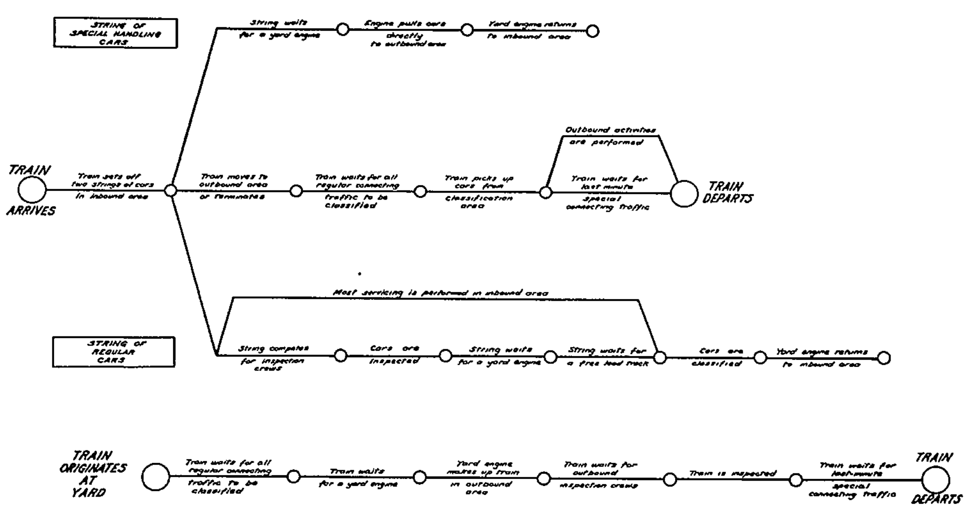

Figure 3 — SUMMARY OF OPERATIONS IN A LARGE TERMINAL