Public switched telephone networks like many others in telecommunications are undergoing an exciting change in technology, its application, and the new services it engenders. These factors are influencing the design and development of the network and the manner in which it is operated. Historically established teletraffic standards must be reviewed, updated, and enhanced in order for the industry to keep abreast with these changes. Bell Canada together with Bell Northern Research Ltd. has derived an approach to accomplish this essential function. The evolutionary background of traffic standards and the review/updating methods recommended are described in the following.

1.0 INTRODUCTION

In these difficult economic times, business is attainable only if a good product can be provided at reasonable cost. Business practice by a telephone operating company is no exception. The quality of its main product, which is service, is compared to benchmarks collectively known as traffic standards. These standards specify the quality of service the telephone company selects to provide to its customers, and consequently (through the mediation of load-service relationships) the equipment quantities needed to provide this desired level of service.

Extremes are costly. Surpassingly good service will generally require excessive capital outlays for equipment.

Exceptionally poor service will result in somewhat different costs being incurred, namely:

- customer dissatisfaction which engenders complaints and reductions in the use of the service,
- waste of switching system resources (e.g.: Insufficient equipment results in blocked calls and repeated attempts. Each represents an unproductive use of call-processing resources).

Clearly then, it is of fundamental importance to strike a good balance between the objective quality of service as expressed by suitable traffic standards and the costs above.

It is evident therefore that standards are intimately related to:

- customer service expectations, and
- switch/network performance (obtainable through suitable load-service relationships).

The services which are provided by public and private networks as well as the technology which supports these networks are both continually evolving. As a result, an evolutionary pressure is brought to bear on traffic standards. There is continuing need to achieve a service quality vs cost balance that is most advantageous.

Conversely, traffic standards can affect the evolution of technology by conditioning customer service expectations over a period of time. These mutual influences of traffic standards and technology are explored in the following.

In particular the influence of traffic standards, the forces that shape them, their evolution, and traffic standards management systems will be discussed.

2.0 THE INFLUENCE OF TRAFFIC STANDARDS:

Within Bell Canada, traffic standards cover a diverse number of functional concerns, including:

- accessibility, expressed as dial tone delay,
- switchability, expressed as blocking,
- routing principles, and
- numbering plans.

Each traffic standard has two primary applications:

(1) Equipment and/or Systems Design:

Traffic standards influence the development of new telecommunications equipment and systems by specifying design requirements for inclusion in Performance Requirement Documents (PRD's) which are submitted to manufacturers.
and system developers. The service objectives specified in these documents establish the performance levels to which this equipment or system design must conform.

(2) Switch and Network Operational Performance:

Traffic standards are used in the development of capacity tables and related operational practices. These documents are used for the planning, provisioning, and servicing of the network.

Many traffic standards are directly related to the customers' perceptions of service. Thus, faithful administration of these traffic standards will result in customers becoming accustomed to specific service levels through exposure.

Surveys which identify customer expectations can be difficult to interpret. However, better results can be obtained by striving for service consistency. This simply means that we assume customers expect exactly that quality of service to which they have become accustomed.

An example of how this approach in setting traffic standards has been used is outlined in Section 4.2.

3.0 THE FORCES THAT SHAPE TRAFFIC STANDARDS:

3.1 Traffic standard development is influenced by a variety of strong external forces including:

- customer service expectations
- radically new service offerings
- changing traffic characteristics
- rapidly changing technology and its application
- government regulation
- international influences

Some of these forces, for example regulation, can constrain some operating company activities. Others, such as new services or the application of new technology, provide vast opportunities if properly managed.

The rest of this section deals with the impact of customer expectations, regulation, and international involvement on standards evolution. The next section treats new services and the application of new technology.

3.2 The Consistency of Service:

If customers have been exposed to uniform levels of service for prolonged periods, they are likely to be averse to any perceivable degradations in this service.

This approach has been found to be useful for dealing with traffic standards that address existing services. In this case, the quality of service provided to customers can be well estimated or measured. For new services, there are no precedents to draw upon, and other approaches are needed. Section 4 discusses these approaches.

3.3 Regulation:

Bell Canada is a regulated utility. As such, many of its internal traffic indicators are monitored by the Canadian Radio Television and Telecommunications Commission (CRTC) to ensure that the service objectives established by Bell Canada are being equitably distributed to the public.

Despite these requirements, fluidity and flexibility of traffic standards administration still exist, as:

- many traffic service indicators are not reported (e.g.: matching loss), and
- changing technology can diminish the significance of formerly reported traffic indicators. (e.g.: Section 4.2 describes how local digital switching technology has replaced the significance of the Dial Tone Delay criteria with those of Terminating Matching Loss (TML) as the dominant standard.)

3.4 International Involvement:

International traffic standards which are used for planning, provisioning and ongoing operations of international networks and circuits are established by the International Telegraph and Telephone Consultative Committee (CCITT) and are documented in CCITT lettered and numbered Recommendations. Bell Canada (as a representative of the TransCanada Telephone System (TCTS) together with Bell Northern Research Ltd. participate actively in the ongoing study work related to these recommendations. The traffic standards work on the investigation and development of traffic engineering principles, numbering and routing plans, and traffic management is of specific interest.

Decisions taken in the international forum by any of the various Study Groups dealing in traffic related matters will directly affect the development of traffic standards for national networks. Therefore, international traffic standards development is closely monitored at the national level to assess the service/economic impacts on the Canadian network.

4.0 THE EVOLUTION OF STANDARDS

4.1 The Past

For over 30 years, the traffic performance of the North American telephone network has been expressed primarily in terms of various forms delay and blocking. Both of these types of measurements were developed during the transition from manual to automatic call processing techniques. Telephone Operating Companies adopted
a collection of traffic standards which were heavily influenced by the prevailing operating and technological conditions of those times, namely:

- limited capability to measure traffic performance
- manual operational data collection and processing arrangements
- the costs and engineering constraints of panel and step-by-step switching technologies
- customer dialing behavior developed from empirical studies

Manual data management and other administrative restrictions were instrumental in the emergence of Time Consistent, Average Busy Season Busy Hour engineering principles for traffic forecasting and provisioning. This methodology, based on the processing of operational data for a single hour of each business day for each switching component of concern, was selected on the basis of a short, comprehensive study which identified the hour during which the traffic load was consistently the heaviest.

Data collected for the Busy Hour was averaged monthly. The period of 3 months of the year with the highest average Busy Hour loads was called the Busy Season. These loads were finally averaged to produce the Average Busy Season Busy Hour (ABSBH) load.

In this way, the quantity of data to be processed was reduced to manageable proportions and the resulting ABSBH load was considered sufficiently accurate for teletraffic engineering. Studies of customers' dialing behavior, and the economics of the dominant technologies of the day, led to the following North American service objective for dial tone delay (DTD):

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Measurement Interval</th>
<th>ABSBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTD</td>
<td>3 sec</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

In other words, over the course of the busy season, at most 1.5% of all calls should be subjected to a Dial-Tone-Delay (DTD) exceeding 3 seconds.

The advent of No.5 crossbar introduced the use of common control switching principles and provided the telephone company with greater flexibility to collect operational measurements. The architecture of the crossbar switch introduced new cross-office congestion measurements, such as:

OML: Outgoing Matching Loss

IML: Incoming Matching Loss

These new performance indicators were measured on an ABSBH basis and were defined in corresponding standards as 2% in both cases.

Crossbar common control components had holding times that were much shorter than the average conversation time of a call. As a result, these components were more sensitive to traffic variations which prompted Time Consistent Engineering methods to be extended to include the highest busy hour (HDBH) and the average of the ten highest busy hour (THDBH) loads of the busy season.

The collection of traffic standards now grew to encompass the following:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Measurement Interval</th>
<th>ABSBH</th>
<th>THDBH</th>
<th>HDBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTD</td>
<td>3 sec</td>
<td>1.5%</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>IML</td>
<td></td>
<td>2%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>OML</td>
<td></td>
<td>2%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

NOTE: N/A = not applicable

These standards were extensively used throughout the 1970's. During this period, Stored Program Control (SPC) analog switches were introduced and dominated new switch installations. In the late 1970's, local digital switching was developed. This triggered a new phase in the evolution of traffic standards.

4.2 The Present:

The introduction of large local digital switches within Bell Canada's network has created further maturation pressure on traffic standards. Typically, such switches have architectures which lead to steep load-service curves and make the switches sensitive to traffic variations and load peaks. Preliminary work conducted by Bell Canada led to the identification of a need for a suitable HDBH Terminating Matching Loss (TML) standard (for our purposes, TML and IML are equivalent and will be used interchangeably).

Work conducted by Bell Northern Research (the R&D arm of Bell Canada) led to the following results:

4.2.1 Service Consistency:

Studies of the matching loss characteristics of pre-digital switching technologies employed by Bell Canada indicated that the high day busy hour TML would be unlikely to exceed 10%. For reasons given earlier, this provided strong support for an objective TML level of not more than 10%.

4.2.2 Machine Performance Characteristics

Often, useful information about practicable service levels may be obtained by considering the behavior of a switch operating at these levels. Figure 1 shows a relationship between offered and carried traffic when originating calls are allowed to wait for switching resources, but terminating calls are blocked. Half the offered traffic is assumed to be originating.
For those digital switches considered, it was found that operation at 10% TML generally maximized the terminating traffic carried. Thus, this level of TML represented a natural boundary for equitable (from a service standpoint) switch operation. Further investigations considered the interface of the call processing capacity, call carrying capacity, and the wasted resources generated by terminating blocked calls. Typical results are shown in Figure 2.

For the largest machine configurations currently feasible, operation in the range of from 4% to 10% TML maximized total system capacity.

4.2.3 Current Standards:
As a result of these considerations, a new Bell Canada Corporate standard is in place today:
As discussed in Section 3.1, evolutionary pressure on traffic standards comes from a variety of sources, including:

- rapidly evolving technology and the methods by which it is administered
- radically new services.

### 4.3.1 New Technology:

The industry trend to utilize high-capacity local digital switches can lead to high-risk situations if deliberate care is not exercised in teletraffic engineering.

The prediction of HDBH loads for such switches becomes very crucial due to their sensitivity to load variations. Time Consistent Engineering does not easily accommodate the monitoring of side-hour peaking or the variability of high day traffic. Never methods, such as Extreme Value Engineering may be better adapted for this purpose.

Furthermore, one of the chief reasons Time Consistent Engineering was originally adopted, (namely, work reduction related to data processing), is no longer valid with the availability of greater automation.

Some of the impact that technological change can have on standards has been discussed in Section 4.2. In addition to the implications of digital switching, other developing trends promise further impetus for standards evolution. Some of these trends are:

- modular engineering,
- satellite connections,
- mobile systems,
- service and network integration

### 4.3.2 New Services:

In the past, only one type of service was available in the telephone network, namely, point to point voice connections. In the near future, however, a large variety of new telecommunications services will emerge. Some important examples of these are:

- electronic messaging for voice, data, and integrated voice/data
- customer initiated conferencing for audio and audio-video
- database access for inquiry and data retrieval
- intelligent networking where people interact with databases through electronic mediation.

To support these new services, the old traffic standards specifying dial tone delay and blocking criteria will still be relevant, but will need:

- enhancements, and
- supplements (new standards)

### 4.3.3 Enhancements

The conventional delay and blocking traffic standards in use today are:

- The average duration of a telephone conversation is 180 seconds.
- The average number of call attempts per circuit per hour is from 15 to 18 (ABSBH).

These standards will have to be critically reviewed. New services will have a variety of different attempt rates and holding times. Investigations of BNR's COCOS (Corporate Communications System) electronic mail system, Bell Canada's teleconferencing service, and other services indicated the following:

<table>
<thead>
<tr>
<th>Service</th>
<th>Session Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text messaging</td>
<td>30 min.</td>
</tr>
<tr>
<td>Voice messaging</td>
<td>90 sec.</td>
</tr>
<tr>
<td>Audio conferencing</td>
<td>30 min.</td>
</tr>
</tbody>
</table>

Analyses of the manner in which office workers communicate and what is known about the likely traffic characteristics of these new services indicate that during the office busy hour, the total communication ccs per user is expected to be an average of 15 CCS. This is three times as much as today's business line usage of 5 ccs per user.

Conversely, some new services have a very short holding time. Often these services will have high attempt rates, as for example:

- personal paging,
- credit card checking, and
- bus schedule information

Many of the new services will be implemented employing distributed processing. Once a customer has obtained access to the network, a specialized Service Module supporting the new service is required. This Service Module may be quite distant from the caller, and will likely be accessed on a delay basis. Effectively, this introduces a complex form of delay where calls queue for resources distributed throughout the network rather than in a single switch.
4.3.4 Supplements

The new services currently envisioned will involve new interactions between the user and the network. In particular, the network will support data processing and storage, and so will need new traffic data measurements and objective standards. Some of the following may be suitable:

- message delivery time
- key stroke response time
- memory integrity
- processing access.

5.0 A METHODOLOGY FOR MANAGING THE EVOLUTION OF STANDARDS:

Traffic standards development or revision requires a carefully planned and managed program of:

- research (data acquisition, modelling, etc.)
- practical validation of research, findings (typically through field trials)
- documentation
- monitoring (for verification and enhancement of the standard)

Bell Canada, in conjunction with its research and development affiliate, the Bell Northern Research Ltd., have devised a methodology to implement such a program. This standards development methodology is designed to capitalize on the individual strengths of the two organizations, and consists of 7 steps:

(1) The identification of the need for a specific standard. This can come from any of the following:

- Operations or Engineering Staff responsible for equipment provisioning or performance analysis,
- Technology Development Staff engaged in assessing the applications of new technology,
- Research and Development Staff who have privileged access to product information and are in a position to predict network traffic implications.

(2) The definition of the need which is comprised of:

- a careful documentation of the problem
- a plan of action specifying objectives and any interim checkpoints (or milestones) together with an identification of the agents responsible for their timely completion.

(3) Research Phase. The research goals are to characterize the traffic in the "new environment" (if applicable) and the impact of the standard on the existing network, its equipment, and customers. Included in this activity are data acquisition and literature search as well as modelling and applicable experimentation.

(4) Optimization of the standard. Here, an analysis of the standard's impact on service and economics is used to formulate final recommendations.

(5) A field or concept trial is used to verify laboratory recommendations and perform any necessary fine-tuning of the standard. In some cases this involves a simple documentation review by experienced operational field personnel. In others, restricted field applications are made through the co-ordinated efforts of interested operations and research staffs.

(6) Implementation. In this stage Bell Canada assumes the responsibility for the final documentation of the standard and its support systems (operational practices, user instruction documentation, etc.)

(7) Ongoing Monitoring. This is done to assess further improvement or modification needs for the standard. The responsibility for this activity is shared as identified in (1) above.

It should be evident that the task of traffic standards development is complex and expensive. Nevertheless, it is a worthwhile activity as it maintains the balance between costs and benefits which permits Bell Canada to remain competitive in the marketplace.

6.0 CONCLUSION

It has been demonstrated that teletraffic standards are subject to a wide variety of pressures. Each has a unique affect on the design and operation of the public switched telephone network. However, there are methods available to develop and/or update traffic standards which will encompass the evolution of technology, its utilization, and the related service opportunities presented. The seven step traffic standards development method now being used by Bell Canada with active assistance from Bell Northern Research takes these pressures into account. The impact on the existing network is assessed in terms of customer service levels and equipment cost impact. The arrangement provides a vehicle for the continued enhancement and ongoing monitoring of traffic standard values. It is an essential part of successfully coping with constant change, which is the life blood of telecommunication. It is an absolute necessity for the continued good health of teletraffic service and the advancement of the industry.