NEW METHODS FOR ADMINISTRATIVE AREA
AND LOCAL ENTITY USAGE FORECASTING

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ABSTRACT

This paper describes the method presently being used or trialed by the Bell System for projecting load rates expected to be offered to the talking channels of local switching entities. These load rates are forecasted at the administrative level for management control purposes, and the local switching entity for engineering purposes. A variety of methods are used ranging from very naive extrapolations to complex mathematical procedures. Whatever method is applied, judgment based upon an understanding of the service and cost objectives of the business and a thorough consideration of assumptions must be applied before using a model generated forecast for switching equipment provisioning.

1. Introduction

Forecasts of talking channel traffic flow are made in order to help determine the size of the local switching entity network, such as line link frames in No. 5 Crossbar or line link networks in No. 1 ESS. The load-service relationship, the manner in which service quality deteriorates as load increases, of this type traffic is relatively stable. Therefore, talking channel provision may be based solely on consideration of the grade of service rendered under average load conditions. The average used is referred to as Average Busy Season (ABS). The Average Busy Season CCS* per main station (CCS/MS) for an entity consists of the average CCS/MS for the time consistent busy hour of the business days in the busy season. The busy season is defined as the three highest load months of the year, not necessarily consecutive. To derive the anticipated talking channel network load, separate forecasts of main station growth are applied to the CCS/MS forecasts. While the purpose of this paper is not to discuss main station forecasting, it should be pointed out that main stations are also forecasted using both an administrative or "top-down" and a "bottom-up" approach. Forecasting the latter at the local switching level is based more on a study of land use, economics, and demographics, rather than on projections of historical data. Having thus discussed the background of the variable, CCS/MS, dealt with in this paper, let us now turn to the two fundamental approaches used in making its forecast.

2. Administrative Forecasting

Administrative forecasts of CCS/MS are typically made at the Operating Company or Area level within the Bell System. As presently structured, nineteen Operating Companies containing seventy-seven Areas make up the Bell System. While administrative views of CCS/MS are not used directly for engineering purposes, they nonetheless play a very important role. Their purpose is to aid management in "top-down" analysis of the reasonableness of the summations of individual entity forecasts. Since the average Bell System Company has about 500 local switching entities, it would be an overwhelming and self-defeating task for a Company's top management to attempt appraising the reasonableness of their CCS/MS forecasts by analyzing each of the 500 individual entities.

While the techniques in use today for administrative forecasting are quite elementary, this is not because of a lack of interest in more advanced techniques. Company, Area, and Bell System CCS/MS data are derived by taking a main station weighted average of the CCS/MS occurring during the busy season of each entity. The effect of this process is to produce a number for the large geographical area which cannot be associated with a precise point in time. This makes it difficult, if not impossible, to look for exogenous variables that would correlate well over time with the dependent variable. Another factor that must be taken into account is that we have been gathering Company CCS/MS data and summarizing it on a uniform basis at System Headquarters for a relatively short period of time. Only in 1972, was a uniform Bell System plan adopted for gathering and aggregating such data. Data are available prior to this date, but must be used with caution because of the lack of uniform reporting definitions and limitations imposed by data collection devices. Another limitation that must be taken into account is that the technical skills of the switching engineering people making administrative forecasts are generally in areas other than statistics.

The reason for management's interest in the forecast of this variable is directly linked to customer service and capital dollar expenditures. Looking at the capital side, 82 million main stations at 3.2 CCS/MS are currently forecasted for the Bell System in 1981. This amounts to 262 million CCS. A miss of only 3% on the high side in the forecast of CCS/MS would give a forecast of 3.3 CCS/MS or 270 million CCS - an excess of $ 8 million CCS. Estimates of current switching investment per CCS in the Bell System are in the neighborhood of $100. Therefore, even a seemingly small miss of 3% in the aggregate level of Bell System CCS/MS could yield an increase in capital requirements of about $800 million. While these costs are associated with overforecasting, one can argue that underforecasting is equally expensive due to costs associated with advancing equipment jobs, maintenance, overtime, handling customer complaints, etc.

Because of the ever increasing need to manage our capital investment better and still maintain satisfactory service levels, recent efforts have been directed toward providing methods for making administrative forecasts. For the reasons previously discussed, these methods are very elementary.

* One CCS is one hundred call seconds of usage per hour and is equivalent to 1/36 Erlang.

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Hereafter, is a discussion of four methods for making administrative forecasts of CCS/MS.

3. Reasonableness Check (RC)

This procedure was originally developed as a manual procedure, but is now also available on a time-shared computer basis. The brevity of the discussion to follow arises from the fact that this method was discussed in a paper presented by N. D. Blair at ITC/2. While this method has no particular statistical foundation, it nonetheless does have intuitive appeal, and tends to produce projections that are not unreasonable to the eye. Year-to-year percentage increases in CCS/MS are calculated and the average is applied to the most recent actual data point. One year intervals are used to calculate the first year's forecast, two year intervals for the second, etc. Likely ranges for each forecast year are developed by applying maximum and minimum historical percentage changes to the most recent actual data point. This approach is illustrated in Figure 1. The ranges are apt to be quite wide since they are based upon maximum and minimum percentage changes.

**FIGURE 1 - Reasonableness Check (RC)**

4. Average Annual Change (AAC)

This procedure makes use of a time-shared computer program which, among other things, plots the data and produces a matrix of all possible combinations of the average annual numerical change. Again, this method has a limited statistical basis, but will produce projections that a manager can intuitively feel comfortable with. Perhaps the most important aspect of this method is that by placing emphasis on data plots and the matrix of annual changes, it leads the user into the data analysis without the formality that often surrounds the term. The basic steps in the AAC process are as follows:

1. Plot historical data.
2. Using knowledge of the data, identify plausible causal factors for changes in past trends.
3. Based upon the analysis in Step 2, determine if any period of time represents growth that might reasonably be expected in the future.
4. Again, based upon knowledge of the data, decide if the most recent data point warrants adjustment.
5. Print out the Average Annual Change table.
6. Apply the selected AAC value to the point selected in Step 4.
7. Repeat steps 4 through 6 if you wish to try alternate projections.

**Note:** If Step 4 does not reveal a representative growth period, one may be judgmentally selected.

The time-shared aid for using the AAC technique requires very little user input. Figure 2 shows the input requirements for Company X, and the resultant plot of the data. At this point, the user must interact with the mechanized aid and exercise judgment based on familiarity with the data. This will allow the user to accomplish the tasks listed in Steps 2, 3, and 4 above.

**FIGURE 2 - Average Annual Change (AAC) Technique**

Figure 3 gives a pictorial view of the user judgment applied to the data for Company X. The assumptions and knowns introduced by the user were: a new, more uniform CCS/MS reporting plan was introduced in 1972; the data prior to 1972 must be used with caution because of the lack of uniform reporting definitions and data collection device limitations; the 1974-1975 period was influenced by adverse business conditions; a severe winter occurred in 1978 stimulating customer telephone usage. Based on this information, the period from 1972 through 1977 was selected as a representative growth period for the future. The computer generated AAC matrix and the specific annual change figure selected are depicted on the bottom portion of Figure 3.

At this point, a specific judgmental value must be assigned to 1978 and then the selected AAC value must be applied for projection purposes. Figure 4 shows the adjusted value for the most recent data point and the resultant projections. Plots and tables similar to this are produced by the AAC time-shared aid. While not applicable to this particular data, the time-shared aid allows for the testing of alternatives by altering either the annual change, the most recent data point, or both. When additional projections are required, the AAC matrix depicted on Figure 3 provides ready access...
to a variety of annual change values.

Where:

\[ Y_t = \text{ABS CCS/MS at year } t \]

\[ \alpha_t = \text{random error.} \]

The RW forecast is, therefore, simply the last actual data point. This model is based on the premise that year-to-year changes in CCS/MS levels are more or less random and unpredictable, and that any long-term growth pattern is masked by annual fluctuations. No computer program or confidence limits have been developed for this model. If developed, however, the confidence limits would be comparable to the model discussed in the following section. Using the same data, as in the preceding examples, the projections based on the RW model are as follows:

1979 1980 1981

Random Walk 3.01 3.01 3.01

6. First Order Autoregression AR(1)

This model is a special linear regression model using ABS CCS/MS values one period (year) ago as the independent variable and the current CCS/MS value as the dependent variable. In mathematical notation, the model description is

\[ Y_t = \mu + \phi Y_{t-1} + \alpha_t \]

where

\[ Y_t = \text{ABS CCS/MS at year } t \]

\[ \mu = \text{a constant term derived by linear regression} \]

\[ \phi = \text{a coefficient derived by linear regression} \]

\[ \alpha_t = \text{random error} \]

This states that the next value, \( Y_t \), of the process is given by \( \phi \) times the previous value added to a constant term plus a random or unpredictable quantity. The basic reason that this model yields reasonable results when applied to entity aggregations of CCS/MS is that these series tend to be stationary, i.e., remain essentially in equilibrium about a constant mean level. The properties of AR(1) models are such that the absolute value of the coefficient, \( |\phi| \), is less than one when the series is stationary. The estimate of the dependent variable in the distant (i.e., \( N \) very large) future can be expressed as

\[ Y_{t+N} = \frac{\mu}{1-\phi} \]

5. Random Walk (RW)

The Random Walk model is the most naive projection technique and in other disciplines is sometimes referred to as a "persistence forecast." This model is a very special case of an autoregressive type model where predicted values are based upon statistical relationships to past values. In mathematical notation, the model is

\[ Y_t = Y_{t-1} + \alpha_t \]
This says that as long as the CCS/MS series is stationary, the AR(1) projections of this series will tend toward some long-term average value expressed by the above equation. Forecast confidence limits may also be placed about these projections. With the same data, the results for the AR(1) model are shown on Figure 5.

7. Tracking and Aggregating System

Because there are 10,000 local switching entities, 19 Operating Companies, and 77 Areas in the Bell System, we make use of mechanized procedures to monitor talking channel usage both at the administrative and local switching entity level. Once each year we enter into a data base the actual ABS CCS/MS for each entity and forecasts of CCS/MS and main stations for the next five years. With such a system, as each year passes, we can compare the actual usage for each entity with forecasts made one, two, three, four, or five years ago. This same system also allows us to aggregate CCS/MS data from different type switching points, and produce a number which reflects changes in customer usage characteristics rather than changes due solely to switching equipment conversions. For this type consistency, we convert all usage to time-consistent originating plus terminating (O+T) CCS/MS. An example of this would be aggregating CCS/MS data from a SXS office engineered on an originating (O) CCS/MS basis with a No. 5 Crossbar Office engineered using the traditional O+T CCS/MS. When aggregating, the data base recognizes the SXS and converts its CCS/MS to O+T. Because of the large number of planned equipment replacements engineered on other than O+T CCS/MS, additional conversion algorithms will be needed. Without the ability to aggregate dissimilar measures of talking channel usage, forecasting and tracking at the administrative level would be impractical.

As mentioned earlier, the mechanized usage tracking system has been available since 1972. It is currently being enhanced so that it will provide in addition to the traditional accuracy measurement reports: additional algorithms for aggregating dissimilar CCS/MS data, analysis capabilities via user data base queries, and storage for data that will be available to new forecasting aids under development.

8. Comparison of Results

One way to test the administrative forecasting methods discussed previously is to do an ex post forecast test. This was done for the four models in question by looking at one and two year ahead forecasts starting in 1975 and ending with the latest actual, 1978. For example, data from 1967 through 1974 was used to make a one year ahead forecast for 1975 and a two year ahead forecast for 1976. The model forecasts were then compared to the actuals. The actual data interval was then lengthened in one year increments until finally 1967 through 1977 was used to predict 1978. This procedure was used on data for both the Bell System and each of its nineteen Operating Companies. Because of the existence of the mechanized reporting system discussed previously, both System and Company forecasts based on aggregations of entity forecasts were available for comparison. For purposes of distinction, these latter forecasts will be referred to as Company Views. Figure 6 summarizes the results in terms of average absolute percent miss.

Another way to analyze these same results is to look at the distribution of the forecast misses. For the four methods or models, there were a total of 560 separate forecasts made (140 per model) and compared to actuals. There were a total of 140 Company View forecasts. The distribution of misses separated between Model and Company Views is shown below.

9. Reconciling Differences

Each year, Bell System Companies are asked to make administrative views of CCS/MS five years into the future using the methods previously described in this paper coupled with sound management judgment. They are then requested to test the reasonableness of their entity summation or micro-view against both the administrative or macro-view and any ranges produced by the models. After this process is completed, a company should either feel comfortable with their micro-view, adjust their macro-view based on additional knowledge, or adjust specific entity forecasts.

If the latter path is chosen, enhancements being made to the present mechanized tracking system will assist the Companies in narrowing down the universe of entities. By using rather simple English type ad hoc commands, a user will be able to do such things as list entities having poor forecasting performance, or list those entities over a certain size exceeding a certain forecasted growth rate.

While it has been considered, no specific allowable deviation between the Company micro- and macro-views has as yet been established. Among other factors, a key problem in setting such a range is that it would probably not be reasonable to establish one single value that would be reasonable for all Companies. For the time being, it is felt that the decision as to the need for reconciliation should rest with the Switching Engineering personnel in the Operating Companies since they bear the ultimate responsibility for balancing service and cost. Figure 7 compares the most recent summation of all the Company administrative views with the micro-view and the aggregation of all Bell System entities. The closeness of these two views illustrates that

FIGURE 6 - Forecasting Comparisons

One Year Ahead Two Years Ahead

<table>
<thead>
<tr>
<th>% Miss</th>
<th>% Miss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Views</th>
<th>Company Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overforecast</td>
<td>197 35 103 74</td>
</tr>
<tr>
<td>Underforecast</td>
<td>322 58 34 24</td>
</tr>
<tr>
<td>Zero Miss</td>
<td>41 7 3 2</td>
</tr>
<tr>
<td>Total</td>
<td>560 100 140 100</td>
</tr>
</tbody>
</table>

These results reveal that the models produce, on the average, forecasts that are closer to the actuals and more evenhanded than the Company Views.
the individual Companies are not allowing an excessive spread to exist between their micro- and macro-views.

FIGURE 7 - Busy Season CCS/MS Administrative Forecasts

10. Local Switching Entity Forecast Results

As discussed previously, a uniform mechanized forecast tracking and measurement system was adopted in 1972. To date, usage forecasting results at the switching entity level have shown marked improvement due in large part to the existence of this system. From a managerial point of view, it has allowed us to focus attention on entity forecasting performance and aggregations of their projected future loads. This latter task has been accomplished by making use of administrative techniques such as those discussed in this paper. Entity forecast performance is summarized at the Area, Company, and System level by viewing forecast accuracy in various categories. Two significant indicators are percent of the entity forecasts falling within ± 2% of the actual, and the distribution of the forecasts missing the ± 2% target. The second category is usually referred to as Forecast Balance and can be expressed in terms of one number using the expression

\[
\text{Forecast Balance} = \frac{\text{No. Forecasts Missed High} - \text{No. Forecasts Missed Low}}{\text{Total No. Forecasts Missed}}
\]

The closer this number is to zero, the more balanced the CCS/MS forecasting job. Figure 8, based on all Bell System switching entities, shows the marked improvement made in both categories during recent years.

Since the measurement plan has now been in existence for seven years and there has been a high level of management interest in CCS/MS forecasting for some time, it is not reasonable to expect continued forecast improvement without some additional stimulus. It is hoped that recent work aimed at improved entity usage forecasting will become the catalyst for further improvement.

11. Improved Entity Forecasting Data

In the same time period discussed above, there has been a substantial shift toward mechanized collection and processing of traffic data which has probably had a significant effect on improved forecasts. The responsibility for data accuracy has been assigned in the Bell System to the Network Administrator who uses the Total Network Data System, TNDS (3), as a tool in collecting and validating data. The near real-time validation of data in TNDS is relatively unsophisticated, consisting of removing numbers which are clearly impossible (such as circuit occupancies

FIGURE 8 - Entity Forecasting Results Improving

higher than 1.0) or which are known to have been collected during a period of central office or data collection system malfunction. The initially validated data are then processed by the Central Office Equipment Report, COER, a subsystem of TNDS, in which further validation checks are made. COER then presents data to the forecaster in summarized form for use and interpretation.

With manual entity forecasting, CCS/MS values are predicted which will be expected on the average business day in the time consistent busy hour of the three highest months of the year. Working with this single number per year has been all that the traffic forecaster has used in the past because, lacking data processing aids, there has been no evidence that any further detail would improve the estimates. Certainly the errors which are unavoidable in a manual data collection environment appear to be sufficient to mask the value of the sophisticated forecasting algorithms.

Let us look at a typical COER report for an example of the kinds of things that can be deduced from additional data. Figure 9 is a COER load report for a typical No. 1 ESS office. For the CCS/MS forecaster today, the most significant numbers are the monthly average CCS/MS shown here circled by a solid line. One is also well advised to look at the 15 "high day" values, encircled here by a dashed line, to help him evaluate the variations of the data*. One might also look at a report for a different hour (not shown here), say in the evening, to see if the character of the office is changing. At least three peculiarities in the particular data shown should be recognized:

1. Only 13 days of data are reported for January. (See column B/M). This can

*This last exercise of judgment could be very much improved if extreme value engineering were used. The TNDS Engineering Report would then, of course, contain extreme value instead of time consistent busy hour data.
er's memory and ability to judge the effect on

At present we have no coordinated way of storing

which is known a priori to have affected data.

Examples are shifts of lines and trunks, local
tariff changes and extreme weather conditions.

ary set of data is a record of network activity

of forecasting models, we look for a 5 year re­

cord of data.

monthly busy hour averages as a compromise

between daily data (which are too voluminous and

The use of the average busy season busy hour as

stability in the data history. We have picked

that forecasters should keep in mind. There may

forecasters are not inclined to spend much effort

if all the days for two weeks are missing.

result not only in sampling error but

A sizable addition of lines (and trunks) was

made during the summer, from about

38,000 lines to 50,000 lines. (See col­

umn NUMBER of MS). This increase by al­

most a third may have changed the charac­
ter of the traffic; all future uses of the
data should recognize it.

3. September unexpectedly appeared as one of the

three busiest months, including a

good many of the high days of the year.

(In fact the dial administrator changed
the timing of the reports for the next
year to start in September.)

We have seen by this single example three things

that forecasters should keep in mind. There may be,
of course many more and for this reason
forecasters are not inclined to spend much effort
on refining the data. We feel this loss can be
repaired by mechanized aid which helps by calling
their attention to data with questionable valid­
ity on a statistical basis, by analyzing the data
for discontinuities, and by constructing and
working a sophisticated forecasting model.

12. Data Needs

The use of the average busy season busy hour as
an averaging mechanism for forecasting and engi­
neering was discussed earlier for administrative
forecasts. The same mechanism is used for entity
forecasting, but the much higher variability of
entity data brings out a need for additional
stability in the data history. We have picked
monthly busy hour averages as a compromise
between daily data (which are too voluminous and
difficult to evaluate) and busy season averages
(which leave out nine months of the year). For
further stability, and to utilize fully the power of
forecasting models, we look for a 5 year re­
cord of data.

A less well defined but an important complemen­
tyary set of data is a record of network activity
which is known a priori to have affected data.
Examples are shifts of lines and trunks, local
tariff changes and extreme weather conditions.

At present we have no coordinated way of storing
such data and we rely heavily on the forecast­
er's memory and ability to judge the effect on

usage; a challenge for the future is to provide
better support tools here.

13. An Experimental Program

The previous paragraph covered the steps that have
been taken to improve basic data. The next step
has been to explore how the CCS/MS forecaster can
use computer power to improve his forecasts.
To gain experience in how this interaction can be
utilized, an experimental interactive computer
program was written. Because forecasters may not
be as well versed in the finer points of forecasting
theory, the program has been designed to lead the
user through a planned sequence of multiple choice
actions leaving freedom to change inputs and
intermediate results. Particular attention was paid to keeping the interface simple so that
extensive training would not be necessary.

Five basic actions were originally provided:
1. Enter data
2. Plot data
3. Screen for jumps
4. Adjust for jumps and correct outliers
5. Project future loads

Much of the data handling and processing required to
provide these functions was achieved through
use of statistical routines which were available
in the Bell System STATLIB (5) with some enhance­ments to meet the particular needs of CCS/MS
forecasting.

14. Building Blocks

Given that a data base is available and readily
accessible to the users, it is important that the
contents be up to date. Thus an opportunity for
entering or modifying small amounts of data has
been listed as the first stage of the forecasting
process. The second stage, namely plotting the
data (and looking at it!), is potentially the
most important. The human eye can easily identify
patterns corresponding to shifts in seasonality,
bad data entry, trend, etc., with very little
training. These same patterns may be difficult
or impossible to detect in displays such as Fig.
9. As a result of examining a plot of the data,
the analyst may return to stage one and modify
the data, or determine which options to use in
later stages.

The third stage of the forecasting system was de­
signed specifically for data such as CCS/MS,
where gross changes may occur abruptly. Transfers
of large numbers of lines from one entity to another
may produce this effect, for example. The "screen for jumps" algorithm scans the data, looking for such discontinuities.
The method is highly non-linear, relying on "run­
ing medians" to ignore outliers (even blocks of
up to six outliers). The output is another plot of
the data, with potential discontinuities identified.

The fourth stage of the forecasting process makes
use of this information and, optionally, more
supplied by the user. The analyst can direct the
system to allow for trend in the data, specify
dependence on some exogenous variable, and/or to
make corrections for the "extreme value" nature of
the data. This latter correction is sometimes
needed when the data lack a seasonal pattern.

With this information in hand, the system con­
structs a regression model which removes the
effects of jumps, trend, etc., leaving residuals
in a form ready for univariate time series model­
ing at the next stage. The regression model is fit "robustly," detecting and correcting outliers
as they are encountered. Detection is done by
comparing residuals to an appropriately scaled
extreme value distribution. Correction is done by
taking a weighted average of the data and
fitted values, with the weights provided by the
extreme value distribution.

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The projection stage of the forecasting process squeezes what information is to be had from the residuals of the adjustment stage. This is done by constructing a Wiener filter directly from an estimate of the spectrum of the residuals. The Wiener filter algorithm is a non-parametric frequency domain computation which results in a set of time domain coefficients much like the ARMA models of Box and Jenkins. While the Wiener filter produces equivalent forecasts (in terms of mean square error), it is easier to use since the problem of model specification is avoided. This is a necessity if extensive training is to be avoided. The Wiener filter estimation is also done "robustly," detecting and correcting outliers that are "out of pattern".

Finally, forecasts from the Wiener filter and the earlier regression model are combined to yield a forecast of each month's CCS/MS five years into the future. The ABS forecast for each year is then derived from the monthly forecasts.

15. Operating the Experimental Program

In a typical run, the forecaster directs the computer to the data file for the office under study and asks for a plot. See Figure 10. One may ask the program to search statistically for a jump in load level or if it is known from other data that such a jump may have occurred in a particular month, that may be specified. One may ask that outliers be detected and corrected. The results of outlier corrections are shown on Figure 11. A corrected point is indicated by a cross connected to the original value by a line of asterisks. Finally, one can ask for a forecasting run. Figure 12 shows predicted monthly averages with confidence limits. These are included in the graphical output to lend insight into the applicability of the forecasting method. As one would expect, the limits grow as the forecast interval increases.

A single page summary report has recently been added to the system. Details of the modeling process, monthly CCS/MS and yearly ABS forecasts are recorded. In addition, ex post forecasts and the forecasts from the usage tracking system are compared one and two years prior. This comparison, among others, is being used to evaluate the performance of the system.

16. Trial Results

Two Bell System operating companies started in 1978 to use the experimental system and to test its features. The training time for mastering the mechanics of the system was small. On the other hand, the amount of turnover in forecasting personnel has given us problems in determining the long term effects on its users. The recognition of the extent of such turnover is significant in itself and points up a further need for mechanized assistance.

As a result of experience gained in the field, many enhancements and modifications have been made to the program. The summary report mentioned above is the result of an operating company request. Other modifications have affected the statistical algorithms. For example, the system as originally designed modeled trend by allowing the Wiener filter to model the data as being stochastic in both level and slope. It was found that this model was overly sensitive to the trend in the last year's data, so that when trend was present the power of the sophisticated forecasting model was only marginally better than that of simpler models. Recent versions of the system allow the user to enter the starting date for a linear trend, and results are more promising. Further improvement is needed as well in handling known network changes because at the present time, the Bell System is shifting from electromechanical switching offices to electronic ones. These changes may produce large CCS/MS changes at the entity level.

In conclusion, much remains to be done in extending computer power to the CCS/MS forecaster. At the risk of doing some forecasting of our own, we predict that the nature of telephone traffic is entering a period of significant change,
because of new technology, broader access to the network and expanding services. These will challenge our judgment and ingenuity in the future.

Acknowledgements

The experimental usage forecasting system is being developed at Bell Laboratories. The statistical algorithms were designed and implemented by D. B. Preston of Applied Statistics and M. N. Youssef of Teletraffic Theory and Application. The interactive front-end which produces the English dialog with the user was written by D. J. Ellis of Traffic Engineering and Administration. The field testing is being coordinated by J. L. Hunt of AT&T's Network Switching Engineering.

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