AT&T’s Call Processing Simulator (CAPS)
Operational Design for Inbound Call Centers

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Since 1978, AT&T has been developing the call processing simulator (CAPS) to design and evaluate inbound call centers. The current version of CAPS is a user-friendly PC-based system employing a discrete event simulation model with animation and queuing models of both the telecommunications network and AT&T’s business customer’s call center environment. Using CAPS, AT&T can model a network of call centers utilizing advanced 800 network features before its customers make capital investments to start or change their call centers. In 1992, AT&T completed about 2,000 CAPS studies for its business customers, helping it increase, protect, and regain more than one billion dollars in an eight billion dollar 800-network market. While this is impressive alone, the CAPS tool is also the turnkey for more than $750 million in annual profit for AT&T’s business customers who received CAPS studies.

Over the past 25 years businesses have discovered and embraced the concepts inherent in using the telephone to accomplish a range of business functions from simple to complex. The appeal of universal accessibility, time sensitivity, and cost efficiency in conducting business via the telephone has given rise to the call center industry. Call centers consist of three major elements: telecommunications lines carrying telephone calls that terminate at a specific location, switching ma-
machines at those locations to sort and allocate such calls, and agents who either originate or receive the calls. The primary purpose of the center could be to receive calls for catalog purchases or for airline or hotel reservations, to handle customer service questions and issues, to support field sales efforts, or to manage all sales efforts entirely. Call centers are commonly designated inbound or outbound. Inbound centers are those whose primary function is to receive calls that typically have been placed to an 800 number; conversely, calls are dialed out from outbound centers. The call center concept has evolved into an eight billion dollar 800 service industry intrinsically linking consumers who place calls, businesses whose profitability depends on call centers as their primary customer interface, and AT&T, which provides the telecommunications services.

In 1980, only 1,650 businesses used some type of formal call center; the call center industry employed about half a million people. Today, about 350,000 businesses employ about 6.5 million people in call center environments. Call centers continue to experience double-digit growth as an industry. The cost of the traditional marketing channel continues to escalate while consumer purchases in retail establishments have stagnated. Meanwhile, the cost of communication technology is decreasing and the management techniques used in call centers are improving. In a recent issue of Business Week, traditional retail channels' annual growth was estimated to be one or two percent. Call centers, on the other hand, have enjoyed an estimated 20 percent annual growth in the '90s and are forecasted to continue this double-digit expansion through the year 2000. Several factors have contributed to this trend: less discretionary time for consumer shopping, more single-head-of-household and dual-income families, increased cost of face-to-face selling, and deregulation of the telecommunications industry. JVT Direct Marketing, Inc., of New York, estimated that as much as 50 percent of all retail sales ($500 billion) will be consummated by telephone by the year 2000. The widespread use of call centers has led to the development of more sophisticated technology, market techniques, and management strategies. The $25 billion investment that businesses have made in call centers—in communication technology, long distance services, and computer systems—has resulted in an increasingly competitive marketplace for the communications dollar.

A recent legislative change, called 800 portability, in essence permits the transfer of ownership of the 800 telephone number from the telecommunications provider to the business identified with that 800 number. Originally, telecommunications companies, such as AT&T, assigned business customers an 800 number. Any change in choice of telecommunications provider forced a change in the 800 number. Thus, a company who identified itself in advertising with its 800 number, would be hesitant to change telecommunications vendors. Eight hundred portability allows businesses to either change or split services

Call centers have enjoyed an estimated 20 percent annual growth.

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between telecommunications companies without having to change their 800 telephones. This legislative change has also brought about increased competition for 800 network service revenues among telecommunications companies.

Since 1967, the costs of labor and communications associated with call centers have escalated. As the costs of call center operations increase, businesses attempt to improve call centers’ ability to serve their callers; however, both elements have a significant impact on a business’s competitive position. Businesses establish call centers to talk to their callers; anything that impedes that process undermines the overall success and profitability of the center and erodes callers’ perceptions of the business. Other factors, such as staffing, length of call, number of 800 lines, hours of operation, and busy signals, all affect the outcome of calls. This myriad of complex interacting behaviors has created both opportunities and barriers for AT&T. The opportunities exist because businesses rely on 800 service and callers prefer call centers as the method of doing business. The barriers stem from the problems of managing call centers and the hefty capital investment needed to implement change.

Call center managers are often reluctant to implement change. This is understandable given the tolerance level of callers. In a 1987 study of calls to a catalog company’s 800 number, AT&T found that 52 percent of the callers interviewed would not call back if they were unable to complete their calls on their first attempt. A more recent 1993 call center benchmarking study provides greater insight to caller tolerance. The study focused on calls to an airline’s reservation center:

—Faced with a busy signal, over 30 percent of callers would not call back.
—Faced with a delay of approximately 15 seconds before being connected with an attendant, 44 percent of callers hung up (abandoned the call) and did not call back.
—Faced with a delay of 30 seconds or more before being connected with an attendant, 69 percent of callers abandoned the call and did not call back.

Consumers have less and less time for shopping, and they look elsewhere when they perceive indifference or poor service on the part of call centers. This caller intolerance, coupled with businesses’ dual sensitivity to callers’ needs and to revenue at risk, means that profitable call centers must perfect (or engage in) a tricky balancing act. AT&T recognized this situation and determined to explore possible solutions to such dilemmas.

In 1979, AT&T technical support personnel worked with the operations research group to develop a simulation model to study various operating scenarios for a major airline’s reservation center. Because the simulation study had satisfied the customer and promoted AT&T sales, the global network design group (GNDG) decided to evaluate the simulator as a standard sales-support tool. As word spread of the success with the airline, business customers and AT&T business sales teams alike requested similar consultative support. Because of this demand, the GNDG funded the business operations analysis group (BOA) to produce a user-friendly version of the simulation model to be used by the sales force. BOA, in conjunction with GNDG, developed the first
such system to run on a mainframe under the TSO operating system. The front end was written in PL/I and the simulator was coded using GPSS/H. The call processing simulator (CAPS) simulates the interactive behavior of the operational variables in inbound call centers. AT&T uses CAPS to propose optimal staffing, trunking (number of phone lines), network routing, and premises routing. CAPS can demonstrate cost/benefit trade-offs and can show the implications of good versus bad service levels. It can also show the effects of proposed operational changes in an inbound call center, using what-if scenarios, and it is most extensively used in this manner.

Since 1979, CAPS has continued to evolve, and computer and network technology has improved; AT&T account teams can now evaluate costs and benefits of increasingly complex advanced 800 network features for their customers. Today, CAPS is window based with animation capabilities.

**Call Center Overview**

A business can use the power of telecommunications to serve many customers with agents located at a few call centers. A call center consists of incoming access lines (trunks), a switching machine (usually an automatic call distributor [ACD]), and agents waiting at work stations connected to the ACD (Figure 1). An ACD does exactly what its name implies: it automatically distributes calls to available agents. If all agents are busy, the caller receives a recorded message that all agents are busy, and the call is delayed until an agent is available.

As shown in Figure 1, the caller dials the center's phone number (usually an advertised toll free 800 number) and is con-
nected to the center via the phone network. As incoming calls enter the network, lines are seized if available.

Sometimes, a caller will find that the telephone number is busy, that is, no trunks are available. Such a caller may repeat the call later or may try a competitor, resulting in loss of business.

Trunk groups connect callers to a group of agents, called a gate. The agents in a gate provide similar service. Those callers who make a connection with the call center are answered by agents. If all agents are busy, the ACD can delay the call. A queue associated with each gate holds the caller on a first-come-first-serve basis until agents become free. A recorded announcement can be used to notify the caller of the delay; the longer a caller is delayed, however, the greater the likelihood he or she will abandon the call. The caller may repeat the call or may take the business to a competitor. Some callers will abandon immediately, even if an announcement asks them to wait; some may be willing to wait a very long time. The type of service the callers want and the availability of that service elsewhere are factors that determine callers’ tolerance for delay.

The average time an agent spends with a caller depends upon the type of service the caller needs. Once the agent and caller complete their conversation and the caller hangs up, the trunk line is released and becomes available for another incoming call. The agent, due to such post-call work as completing forms or questionnaires, may not necessarily be ready to take another caller even though one may be waiting.

This is a very simplified version of a call center. In reality, the interactive behaviors routine in a call center vary. For example, calls may be transferred or conferenced between agent gates. Also, many call centers have voice response units (VRUs), which prompt each caller for alternative ways of handling their calls. In addition, ACDs can be configured to overflow calls between agent gates if one gate is very busy. The following example shows how Bon Voyage Travel Agency, a hypothetical business, is configured to handle calls.

At Bon Voyage Travel, agents plan and book trips for several types of customers. Most of the travel agency’s orders are placed by phone, so the call center is an important part of the agency’s daily business. To handle three different types of customers and to help with the overflow of calls that often occurs, Bon Voyage has divided the lines into four trunk groups and the agents into four gates (Figure 2).

The personal travel gate handles calls from customers who want help in planning and booking their personal vacations. There are two agents in this gate. Calls for this group come in on two trunk groups: the public trunk group and the special trunk group. The public trunk group consists of two lines (555-3071 and 555-3072), which are advertised in local newspapers, in the Yellow pages, and in national travel magazines. The special trunk group consists of one line, (555-4950), which is reserved for special clients who book several trips with Bon Voyage Travel each year.

The charter travel gate arranges trips for large groups of people, frequently for local and national holiday clubs. There are three agents in this gate. The charter trunk group consists of five numbers: 555-6667,
Figure 2: To handle different types of customers and to help with the overflow of calls that often occurs, Bon Voyage Travel Agency has divided its lines into four trunk groups and the agents into four gates.

555-6668, 555-6735, 555-6770, and 555-6868. Occasionally a person who has previously made travel arrangements through a holiday club calls to make individual travel arrangements. In these cases, an agent in the charter travel gate transfers the call to an available agent in the personal travel gate.

The corporate travel gate handles business trips for large corporations. This gate, which consist of two agents, is the main gate for the corporate trunk group made up of three trunks identified with an 800 number. Sometimes the charter travel gate and the corporate travel gate handle similar group trips, so during peak calling hours, the corporate travel gate serves as a secondary gate (a backup gate) if the charter travel gate has more calls than it can handle.

People working in the support gate are mainly responsible for bookkeeping, advertising, and trip packaging, none of which are directly related to the ACD. The number of people active in this gate varies according to the incoming call traffic. Since they have some experience as travel agents, they are sometimes asked to back up the personal travel gate when call traffic is heavy in the public trunk group. That is, the support gate becomes a secondary gate covering the public trunk.
Such trunk groups and gates are typical for a travel agency; other types of businesses would have different names for their gates. A wholesale distributor might have trunk groups and gates for inside sales and for customer service (credit card and billing inquiries). A brokerage firm might have trunk groups and gates for stock quotes and for customer orders, and so on.

**Causes of Lost Calls**

Lost calls are lost business opportunities for the call center. Since most lost calls are related to the call center, managing a call center efficiently entails knowing the reasons for lost calls. Those reasons can include improper personnel scheduling, insufficient personnel to answer calls, insufficient network service lines or trunks, improper or insufficient arrangement of center terminal equipment (gate arrangements), operational problems such as poor training, poor handling of various types of calls and slow data system retrieval time, limitations in space or equipment, and lack of motivation on the part of the business to handle all calls.

Caller’s willingness to retry and eventually to complete the call depends on the center’s function and the degree to which the customer is captive, that is, has no other source for the product or the service or for information. In general, however, lost calls usually represent lost business, and even for captive callers, poor service may have a long-term effect on their decisions regarding future business.

**Advanced 800 Network Services**

AT&T often used the CAPS model to demonstrate the effects its advanced 800 network services will have at a given call center. These services include (1) basic routing features, (2) announcement features, (3) call redirection features, and (4) routing-on-demand features. When used in combinations or individually with a call center’s ACD, each of these advanced features helps customers who have multi-location call centers to route calls to the appropriate centers. These features are outlined below:

The basic routing features are geographic routing, which allows calls to be routed based on their point of origin; point-in-time routing, which allows calls to be routed based on time of day or day of the week; and distribution routing, which includes call allocation. Call allocation permits AT&T’s business customers to allocate calls to different call centers or to designate different call-routing arrangements on a percentage basis. The customers specify what percentage of their traffic goes to each center or arrangement and is especially useful for distributing calls to centers of different sizes or capacities.

Announcement features include call prompter, which uses a recorded announcement (generic or customized) to prompt callers to enter one or more digits to determine their call’s routing.

Call redirection features include alternate termination sequences/network queuing (ATS/NQ). ATS permits a customer to specify a sequence of terminations (centers) to which traffic may be routed if the preferred termination is unavailable. A different alternate routing sequence may be specified for each termination in the network, and each routing sequence may contain up to 100 terminations. If the customer purchases the net-
work queuing option, the final handling may be to route the call to a network queue, where it is held until a termination serviced by the queue becomes available or the caller abandons.

All of the routing-on-demand features offer customers the capability to request and make quick changes to their call-routing paths by calling AT&T’s advanced features transaction center.

**Automatic Call Distribution Systems**

ACDs are essential for the efficient operation of a call center; these systems equitably distribute calls to available agents. Present ACDs are computers and can be programmed. Calls can be programmed for distribution to the work force in order of arrival or in order of a priority that promotes the most efficient use of the agents. Historically, ACDs have been the sole device that call center managers could use to balance call traffic among multiple locations. However, the process of taking calls into one center, queuing those calls through the ACD, and then rerouting the calls to a different center is costly, inefficient, and dependent on constant monitoring and re-engineering to assure that call-handling capabilities between locations are adequate. ACDs, in consort with advanced network services, can optimize a call center’s capabilities.

**The CAPS System**

Analysis of a call center is complicated by the interactions of many known and unknown behaviors. Some are easier to measure than others; average agent talk time and the number of calls offered to the center ACD are known from data produced in ACD management reports. Other types of behavior, such as the rate and nature of abandonment and retrial can only be inferred from special studies of management reports, intuition, or queuing theory.

Analytical models of queuing systems produce precise results from measured and summarized data. These results have no variability from run to run but represent expected, average performance. Such models must also assume generalized, theoretical behavior (for calls and servers) or they will be impossible to solve. Simulation, on the other hand, provides a method for explicit, nontheoretical call behavior. The modeler can incorporate into the model the complicated concepts of call abandonment and retrial and use distributions based upon empirical data.

Even when the simulation model cannot perfectly represent all aspects of the system, it is still the best tool for comparing interactions of call behavior, call management, and facility planning. After it is fine-tuned, the simulation model can be used to study the call center in different modes of operation. Analysts can perform what-if analyses by assuming different agent management techniques, new facility levels, and changes in caller behavior. They can do all these studies without affecting the current operation of the call center.

We selected simulation as our primary modeling tool for two reasons. First, we could use it to develop expeditiously a model of a complete system. Second, simulation, with its graphic capability, is easier to understand than an analytic queuing approach. This makes customers feel more comfortable with the solutions recommended.

Today, the AT&T sales force uses CAPS
to facilitate our customers' strategic decisions (for example, to perform cost/benefit analyses of new network or ACD features)

Lost calls usually represent lost business.

and operational decisions (for example, to decide on staffing levels and trunking levels for special promotional campaigns). The windows-based interface provides the user with a standard environment for decision-critical input and output. The user can display center configuration reports, performance reports, and business cases graphically or in text format. The system also has animation capabilities for visually illustrating the complexities of a call center.

The system core is composed of four modules: the simulator (see the appendix), queuing models, the forecaster, and the scheduler. The simulator is the main engine of CAPS and is written using discrete-event SLAM II. The queuing module provides initial solutions to the simulator and solves simple noncongested call-center systems. The forecasting module can be manipulated to determine future call demand using a variety of techniques, including applying growth factors to call demand, applying double exponential smoothing methods to the data, and using analytical hierarchy methods to predict the call demand that will result from special promotional campaigns. The requirements the simulator or the queuing models generate for agents for different times of day may not be practical from the standpoint of managing a work force. Work schedules for the requirements generated may result in a surplus or a shortage in coverage over the day. To overcome this difficulty and to make simulated results realistic, AT&T uses a scheduler (based on a network flow approach) to automatically (and iteratively) adjust simulated requirements to determine optimal staffing levels.

The evolution of CAPS (1979–1993) was driven by three key elements: changes in the system’s platform, improvements in telephone network capabilities, and advancements in automatic call distribution (ACD) hardware for the call centers.

**Platform**

The system platform had three components: hardware, software, and presentation. When AT&T first developed CAPS in 1979, the developers wrote it in PL/I on an Amdahl computer running TSO. The simulator was written in GPSS/H. The system was a single center simulation, and results were presented in a business report format. One year later, the developers ported CAPS to VM/CMS, a less expensive operating system.

The next significant change occurred in 1986 as personal computers became widely available. The CAPS users in AT&T, predominantly network designers, all had PCs powerful enough to use for running simulations. Since GPSS/H was not available on the PC, the developers rewrote the system in SLAM and used Clipper (a dBase-like package) for the user interface and a package called Flipper to provide business graphics (bar charts and so forth).

In 1992, they added animation to the simulation using Proof Animation Software from Wolverine. This allowed CAPS users to put solutions into a visual context.
that call-center managers could relate to the operations of their facilities. With the release of Microsoft Windows version 3.1, the developers ported the system into a windows environment where links to spreadsheets and word-processing packages further enhanced the report-generating capabilities of the CAPS system.

The platform evolution was driven by two factors: (1) reducing operating costs while increasing operating speed and (2) improving portability for the end user. Since AT&T uses CAPS to support its sales force by evaluating alternative solutions for AT&T's business customers, it is paramount that it presents these solutions, especially the animations, to the customers at their own facilities and that it develops alternative solutions when needed.

Network
Initially, CAPS simulated a single center. In 1983, AT&T introduced multi-center simulation. As it made new features available on the network, the developers modeled them in the system. These features include call allocation, alternate termination sequences (ATS), and network queuing. AT&T's introduction of automatic number identification (the ability to capture the telephone number of the caller) has improved the quality of the retrieval-and-abandonment information that it can capture.

ACD Hardware
AT&T has introduced advances in ACD capabilities in the CAPS model since its inception. Examples include
(1) Intra-ACD flow, or flow between gates on a single ACD, when a gate's volume exceeds its capacity;
(2) Inter-ACD flow, or flow between ACD's that are linked, either at a single site or in multiple sites;
(3) Priority queuing for different call types;
(4) Call vectoring, which allows the manager of the center to program call flow;
(5) Transfer and conference calls; and
(6) Voice response units.

Customer requirements and advances in network and ACD features have driven the evolution of the model. AT&T has implemented changes using a team approach that involves AT&T's business operations analysis group, its global network design center group, and its customers. As members of the team develop new features or new requirements, they first model them, then validate and verify, and finally implement them. To do this on a timely basis, the entire team must cooperate, especially the CAPS trainers who develop training programs and run them. In addition to explaining how to use the current version of the CAPS system, they emphasize how and why the system works so that users can perform rough-cut validations and can incorporate common sense into proposed solutions.

The CAPS system has evolved in response to economics (How can the customer reduce costs?), technologic advances in the platform, network, and ACD, and customer requirements (What features does the customer want?).

The CAPS Process
The CAPS process is essentially three steps: data collection and analysis, data case simulation (validity), and alternative scenario simulation. The chronology of the process underscores the viability of CAPS as a marketing tool.

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A CAPS study typically begins when an AT&T account executive (AE) becomes aware that a business customer is experiencing difficulties with blocked or otherwise unserved calls, usually because of call volumes. That AE can contact specialists within AT&T who have extensive experience with call centers and who work as consultants with the AE and the business customer to resolve problems. AEs may also initiate CAPS studies when they need to demonstrate the capability of some advanced 800 network features.

During the first step of the CAPS process, the consultant has several meetings with the customer to determine the customer's requirements and to collect information. The consultant collects call traffic characteristics, such as call demand by time of day and the retrial profile, from historical data or from special studies. He or she also produces forecasts of call demand and formulates alternative scenarios (for example, a call center with and without voice response units). Additional inputs include trunk group size, agent group size, configuration of trunk groups and gates, inflow and outflow threshold parameters.

To gain credibility, the simulator must accurately replicate the present configuration of the center(s). A validation process that consists of comparing simulation results with prior data to determine the accuracy is a critical step before recommending system changes. Once the simulation replicates the existing center(s), the consultant can use it to study scenarios of interest to the customer. He or she may formulate additional scenarios or modify factors in the current scenarios. After running any alternate scenarios, the consultant presents results to the customer, making an on-site report of the CAPS findings in the form of a written report, a simulation demonstration, and graphs and charts. The output includes, for example, reports on trunk blockage and occupancy, call abandonment, and average speed and utilization of agents. While AT&T performs frequent CAPS studies for its upper revenue customers as requested by the customers' dedicated AEs, it will perform a study for any commercial customer that qualifies for a study on the basis of apparent need.

To date, more than 200 AT&T network designers (call center consultants) and technical support specialists have been trained to use the CAPS model. During 1992, AT&T performed about 2,000 CAPS studies. All CAPS users receive frequent information updates and attend retraining sessions, since the dialogue between the marketing groups in AT&T (who identify their business customers' problems) and the business operations analysis groups (who formulate the tool to solve those problems) results in frequent refinements in the CAPS model. As demand for CAPS studies increases, AT&T is training additional personnel to identify potential CAPS applications.

**Case Studies**

The efficacy of CAPS is most apparent in some of the case studies of its application. Universally, AT&T business customers have recognized CAPS as a potent design and evaluation tool; many of these customers have requested future CAPS studies. AT&T has used the CAPS capabilities for what-if analysis to preview different human resource deployment and man-
agement techniques, new facility levels, and modifications in call routing and behavior at a business customer's call center—without interrupting its existing business and without its incurring high-risk costs. The following cases exemplify CAPS' impact.

Case Study 1

A major chemical company with call centers at each of its various locations suffered from fragmented communications. It had insufficient control processes in place to handle inbound calls. Consequently, incoming customer calls were needlessly transferred and frequently misdirected among the call centers. AT&T sales and technical support teams offered suggestions to streamline the call centers and to make them more efficient.

Using the CAPS model to graphically illustrate to this client how the proposed solution would work, the AT&T team built a series of models that showed what would happen to call traffic. CAPS allowed the client to see current and future systems and to see observable growth trends. The chemical company attributed to the CAPS studies its decision to revamp the corporate management organization and to centralize all call center management. CAPS was the turnkey and primary factor that sold the chemical company on implementing AT&T's recommendation. In addition, this client recognized AT&T as a unique consultant resource and locked in AT&T as its sole network carrier for all services. AT&T realized new and win-back revenue and successfully protected current revenue. New revenue growth is projected to be eight to 12 percent annually.

Case Study 2

A multifaced corporation considered consolidating two of its hotel entities. Although each of these hotel companies had its own reservation and customer service call centers, the parent corporation envisioned one call center with backup from a separate subsidiary. Before leaping into such a drastic change, the corporation asked its AT&T account team to describe the possible scenarios that might affect its staffing and trunk requirements as well as its inbound customer-call traffic. The AT&T account team partnered with AT&T designers and technical sale support personnel to recommend an overall project for the corporation. The suggestions included AT&T has increased, protected, and regained more than $1 billion.

immediate and long-range strategies that would use AT&T network technology and equipment to optimize a single, highly efficient, expandable call center. The CAPS model allowed the client to envision graphically how the AT&T recommendation would work. As a result of this successful project, this corporation took a new direction in 1992—it asked AT&T to use CAPS to redesign all of the call centers in the parent corporation and in its many subsidiaries. The three inbound call centers, with an existing base of 12 million annual 800 service calls, are now signed solely to AT&T network service, with a projected 1993–1994 base of 15 million calls. This is highly significant in the in-
tensely competitive communications mar-
ket for 800 service. In addition, this corpo-
ration returned all its outbound services to
AT&T as the sole carrier. The parent cor-
poration realized the value of maintaining
a singular partnership with AT&T for its
consultative capabilities, which are facili-
tated by exceptional tools like the CAPS
simulator.

Case Study 3
A well-established corporation derives
its direct market share from five catalogs.
Each catalog had a separate center for mail
orders and its own local telephone number
for customer service. In 1991, the AT&T
account team persuaded the corporation to
do a pilot study to see how a call center,
using AT&T 800 service and feature ser-
dices, could increase the number of orders
placed, streamline administration, increase
the revenue potential per order, and re-
solve customer service calls efficiently.
AT&T used CAPS to design the new call
center and to simulate anticipated call
traffic. For the pilot program, the corpora-
tion mailed one half of the largest of the
five issued catalogs to the existing cus-
tomer base with the new AT&T 800 num-
ber. The other half of the corporation cata-
log client base received catalogs that re-
quired customers to mail in any orders.
The result of this trial program was an im-
mediate 15 percent increase in catalog or-
ders and a reciprocal increase in the dollar
amount per order on those orders placed at
the call center via the 800 number. After
one month of service, the pilot program
showed that more than 75 percent of the
trial program catalog sales were directed to
the 800 number instead of the usual mail
order process. The catalog corporation en-
thusiastically embraced the call center con-
cept and asked the AT&T team to use the
CAPS model to design a fully functioning
order-taking and customer-service call cen-
ter. The AT&T personnel suggested a sin-
gle call center with 100 initial positions
that could be increased to cover peak busy
times. A peak day brought 8,948 calls to
the center. The immediate net to the cata-
log corporation was 26 more orders per
day, averaging $60 per call. The AT&T
team used the CAPS simulator again when
the catalog corporation requested a what-if
analysis of the impact on call routing of an
anticipated second call center. Within 12
months of the inception of the pilot pro-
grams, AT&T realized one million dollars
in new network revenue, with incremental
growth of 10 percent annually. The rela-
tionship between the catalog corporation
and AT&T pivoted on the capabilities of
the AT&T account team to use CAPS to
depict and project the impact of the client's
changing the ways it conducted its busi-
ness without its making capital intensive
investments.

Case Study 4
A major airline's reservation system was
supported by 19 separate call centers lo-
cated near domestic and international air-
ports. In 1992, the airline decided to con-
solidate its reservations centers. The AT&T
AEs contacted an AT&T design specialist
who helped them run a series of CAPS
studies to model efficient, load-balanced
call centers that would accomplish the air-
line's goals. Paramount to the consolida-
tion effort was the focus on reducing the
airline's 10 percent blocked call rate while
increasing facility and human resource effi-
ciency. The result of the CAPS consolida-

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tion and centralized load balancing studies has been a $25 million dollar savings in the airline’s reservations call-center operations costs, a six percent improvement in call completion (reducing the blocked call rate from 10 to four percent), and an increased ability to handle approximately 3,000 more reservation sales calls per day. AT&T, meanwhile, has been strategically positioned as the 800 service communications carrier of choice, while the annual billed network services for the airline have increased five percent on a base of $49 million.

Case Study 5

A family owned company, headquartered in the Midwest, mines, produces, and supplies various salt products, including table salt and road salts. The company wanted to regionalize and streamline its customer sales and service efforts. Each sales agent had an individual 800 number terminating at his or her desk and had sole responsibility for responding to calls directed to that 800 number, regardless of the nature of the calls (sales or service). The situation was mired with unequal work loads per agent as well as inefficient call traffic management.

The AT&T account team, partnered with an AT&T designer, built two CAPS models for this customer: one model simulated the existing call management system, and the other simulated a centralized, cost-and-

impressed to immediately endorse the AT&T team’s recommended model, even though it meant completely restructuring the marketing and sales division. Less than a year after the new call center was in place, the company owner asked the AT&T account team to run additional CAPS studies to project the impact of the salt company’s new 12 percent annual growth. AT&T was not only able to retain this client, in spite of vigilant communications competitor bids, but also realize a 10 percent increase in its annual billed network revenues from this account.

Case Study 6

One of the AT&T network designers, Frank Domurath, describes a sampling of his own experiences with CAPS:

I guess I’m a charter user of the CAPS. It all began in 1981, when I was assigned to an automobile manufacturer account as [what was called at the time] a power specialist. I had been working with the then vice-president of consumer relations and customer service and his entire staff, on call collect programs for consumers who had a complaint. We also addressed centralization of vertical marketing functions. As soon as I was trained on the mainframe CAPS tool, I was asked by the automobile manufacturer to determine whether each automotive division should have its own technical assistance center or if there should be one corporate center. At the time, the CAPS tool would only provide one simulation per input, so each simulation had to be run several times, and then I had to hand-calculate the average of each scenario. The results were presented to the vice-president and his staff, who determined that, compared with the warranty savings, the automobile manufacturer could suffer the financial penalty of each nameplate having its own center. The application is that if a dealership service technicians can’t repair a problem, they called a centralized group of engineers who walk the technician through the diagnostic process. The automobile manufacturer was able to reduce warranty expense as well as to provide an early warning system of problems occurring with their products in the market.

In 1982, one car division began 800 service
for customers to complain or ask product questions. The center was 50 percent rolled out, and there were inordinate delays (up to 45 minutes) and numerous busy signals. The [AT&T] AE and I discovered a number of problems with how the callers were routed to the center (remote call forwarding with no back-up lines). To make a long story short, CAPS was used to quantify the head count required to handle all the calls when the center was completely rolled out (about double the head count that the customer had allocated).

The CAPS tool helped provide a different car division with information on the financial impact of handling consumer relations in 26 existing locations versus one centralized group. The CAPS tool provided a sensitivity analysis matrix for staffing levels for consumer relations at other car divisions. The tool was also used in the automobile manufacturer’s service parts operation to determine financial impacts of automating a number of calls presented to the center.

I used the [CAPS] tool to size a centralized group to handle another automobile manufacturer’s benefits questions from employees. CAPS was used to resize a center for a third automobile manufacturer’s service contracts center which processes calls from dealerships and customers who have purchased an extended warranty.

Case Summary

Clearly, the CAPS model is the consultative tool of choice for AT&T’s 800 service network design consultants. By deploying CAPS, AT&T has increased, protected, and regained more than $1 billion from a business customer base of about 2,000 accounts per year. Much of its effective market and revenue-share management results from using CAPS to demonstrate advanced 800 network features. CAPS is vital to the marketability of such new and exclusive AT&T 800 network offerings as alternate termination sequences (ATS). CAPS studies frequently demonstrate to business customers a need to upgrade, update, or acquire switching equipment and other telecommunications machinery. Because of the relationship AT&T has forged with business customers during and following CAPS studies, many of them ask AT&T to provide that equipment. Thus, AT&T is able to increase its revenues in “pull through” equipment-sales opportunities initiated by CAPS studies. CAPS enhances AT&T’s consultative profile with its business customers, making AT&T and the client firm partners in a unique marketing relationship.

On its own, AT&T realizes a multiplicity of benefits from the CAPS model. CAPS helps reduce the sales cycle for AT&T, improves the profitability of 800 services, and also helps to reduce access charges. The newest release of CAPS incrementally reduces AT&T’s overhead by taking CAPS from a mainframe to a personal computer environment. This also made the model readily accessible to all AT&T’s 800 service network designers and gave its field sales (account) teams greater exposure to CAPS. The outstanding success of CAPS has given greater credibility and focus to AT&T’s business operations analysis group and heightened awareness within the company of the advantages of teaming with this management sciences organization. The symbiotic relationships among the field sales teams, the 800 network design teams, and the management science teams have led to the development of CAPS and other modeling tools, such as Site Selection (a 1989 Franz Edelman competition finalist [Spencer III et al. 1990]), and NAME510 (a PC-based decision support system for work-force management including forecaster, planner, scheduler, and agent assignment module [Spencer III et al. 1992]).

Case study after case study clearly illus-
rates the positive impact CAPS has on AT&T’s business customers. The customers quickly see a reduction in overhead costs, usually attributable to reduction in labor costs due to effective network and ACD technology. Simultaneously, operating efficiencies jump as call completion increases, queue time decreases, and human resources are optimally deployed. All of these amount to increased revenues for the AT&T business customer who relies on its call center for profitability and affirmation of market share. Businesses that use their call centers for customer service find that the efficiencies designated through CAPS studies result in higher levels of customer satisfaction. The long-term benefits of this are reflected in repeated sales to this base of satisfied customers who identify the business with its call center and perceive that business as efficient and service oriented. As a result of such successes, AT&T business customers have confidence in the simulation studies. They have been willing to change their business operations and risk the lifeline of their businesses on AT&T’s recommendations. The positive outcomes of these scenarios have led business customers to view AT&T as a provider of total solutions.

CAPS has evolved to meet the continuing challenges of a dynamic marketplace. The impressive results attributable to CAPS justify AT&T’s ongoing investment in management science to support its 800 service market initiative.

Acknowledgments
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APPENDIX: The Simulator
The CAPS model simulates call centers using four modules: (1) call generation, (2) network, (3) automatic call distributor (ACD), and (4) call service.

Call Generation Module
Calls are generated by a Poisson process. A call generator is associated with each call type. When the arrival rate is Poisson, the time between call arrivals follows the negative exponential distribution. The average interarrival time varies according to time of day (half hour intervals). In successive half hours, the distribution remains exponential, but the mean is the interarrival time computed from the call load (first offered load) of that half hour. Care must be taken to generate a nonstationary Poisson process in a valid way. We use a general and simple method described in Law and Kelton [1982] known as thinning. In addition to generating a first offered load, this module contains logic for retrial behavior of the calls (Figure 3). Incoming calls either enter the network if there are free trunk groups or are blocked (the caller gets a busy signal). A caller receiving a busy signal may try later or may go elsewhere for services. On the other hand, an entering call will be served if there is a free agent. If no agent is available, the call is in the
queue. Some callers may not be willing to wait until an agent is free and so abandon their calls. Callers who abandon their calls may try later or may go elsewhere for services.

**Network Module**

The network module simulates how an incoming call seizes a trunk group that will connect it into the call center. There may be free trunks, in which case the call goes directly to the ACD module. If the call encounters an all-trunks-busy condition, then the call will either attempt an overflow trunk, if one is specified, or become blocked. If the call is blocked, the caller will retry or terminate. Two optional advanced 800 routing features are call allocator and alternate termination sequences (ATS).

Call allocator allows calls to be routed based on a percentage allocation (Figure 4). Percentages are assignable in a range from zero to 100 percent in increments of one percent. AT&T uses a deterministic approach called "general round robin." It is a static rule with fixed allocations determined by capacity of sites. Let \( p(i) \) be the allocation for site \( i \), such that \( \Sigma p(i) = 1 \). Let \( n(i) \) be the number of calls already sent to site \( i \). The next call will be sent to the first site at which \( n(i)/\Sigma n(i) \leq p(i) \). For the algorithm to be most efficient, the sites should be scanned for the above inequality in nonincreasing order of \( p(i) \) (that is, \( p(1) \geq p(2) \geq \cdots \)).

Alternate termination sequences (ATS) allow the customer to specify a sequence of terminations to which calls can be routed if the primary termination is busy or unable to answer calls (Figure 5). Alternate termination sequences contain from one to 100 alternate terminations. With
ATS, customers specify the maximum calls allowed at each location. This cannot exceed the number of access lines at a location. A termination is considered available if the number of calls in progress (calls that are being served plus calls that wait in queue) at the termination is less than the setting for maximum calls allowed; otherwise, the termination is considered busy. The terminations will be attempted in sequence until an available termination is found or the sequence is exhausted. If no termination is available and the end of a sequence is reached, then a customer-specified final handling treatment will be used (in the current version of CAPS, the call is blocked).

ACD Module

The ACD module simulates the ability of the call center’s ACD to hold calls in first-come-first-serve queues when all agents are busy. Figure 6 depicts an ACD call flow routing scheme called “standard”; Figure 7 depicts a routing scheme called “vectoring.” These figures show that calls can flow between agent gates within a center or between centers based upon the programmed ACD logic. Queue inflow and outflow parameters are used to minimize queue abandonment. The parameters can be set based on the number of callers in the queue or the average time in queue. In-
Figure 5: In network routing using sequential routing, alternate termination sequences (ATS) allow the customer to specify a sequence of trunk terminations. A call is routed in the sequential order of the trunks till it is answered by an available trunk or it is blocked otherwise. A blocked call will either retry or be lost.

Flow thresholds will direct calls to a secondary queue instead of entering the primary queue if the primary queue is congested. Outflow thresholds will send calls to the secondary queue if they have waited too long in the primary queue. These figures show the flow of the ACD module, including the decision making that the calls perform. Calls are continually tested for available agents or abandonment. In essence, the ACD module assigns calls to available agents.

Not all calls that are processed in this module come directly from the network module; some are transfers or conference calls from other gates in the call center. These calls do not abandon in the same manner as calls that begin in the network module. Abandoned calls that arrived from within the network module may retry or terminate.

Call Service Module

The call service module simulates agents serving the calls and agent after-call work. Agents are permitted to transfer calls or conduct conferences with agents at other gates as appropriate. In a conference call, the conferring agent will service the call, and then the caller will return to the initial agent for the remainder of service with...
Figure 6: One option for ACD routing is to use standard call flow. The ACD holds calls in first-come-first-serve queues when all agents are busy. In this option, (1) calls can overflow only from one gate to another in a sequential pattern; (2) if calls meet an outflow threshold and they have nowhere to flow to, they will stay in the original queue; and (3) intermachine trunk (IMT) connects remote call centers.

that agent. In transfers and conferences, the call must enter the queue of the next gate to wait for an agent.

The call service module uses the following inputs: (1) service characteristics, which include average talk time (ATT) by call type and agent after-call work time (ACW) by call type; and (2) call service patterns, which include conference calls assigned to specific call types and transfer calls assigned to specific call types. The default distributions for service time and after-call work time are both assumed to follow the negative exponential distribution with ATT and ACW given as the respective means. The user may specify a distribution of his or her choice with appropriate parameters.

Validation Overview
The call-center simulator designed jointly by BOA and GNDG has been evaluated to see if it adequately represents an actual call center. We took a three-step approach for validating our model. First, we ran the model with simplifying assumptions (low blocking and abandonment) so we could use analytic formulas to calculate trunk and agent requirements. We used the Erlang-B loss system (M/G/c/c) to calculate trunk requirements and the Erlang-C system (M/M/C/∞) to calculate agent requirements [Gross and Harris 1985]. Simulated results were consistent with analytic results. Next we used animation to verify that the priority-queuing and call-routing logic was modeled correctly. We actually were able to correct some modeling problems that would have been difficult to detect using statistical techniques (we used
animation in 1992 to verify some new features in the simulator.

Probably the most definitive test of the validity of a simulation model is to establish that the model output closely resembles the performance data that would be expected from the actual center. This requires operational performance data from a real ACD. The operational data, such as the number of calls offered, the number of agents, and the average service time, is input to the model. The performance data collected from the ACD, such as calls handled, average speed of answer, and blocked calls, are compared with the corresponding simulated output data. Since both the simulated and actual performance data are from random processes, statistical techniques are used for their comparison.

Since the release of the simulator (October 1980), it has been used to configure many call centers. In most cases, the model results compared favorably with the actual data from the center being modeled. This is additional support for the validity of the model.

We have observed that the model is extremely sensitive to changes in the call abandonment and retrial distributions. Also, abandonment distributions are likely to differ for different industries. BOA has developed a methodology for determining the appropriate abandonment distribution to use in a CAPS model based upon data from the ACD reports.

The CAPS simulation model is a generic
model of a network of call centers. We have made many assumptions in designing this model and its inputs. We recommend that users verify that the model accurately represents the ACD being studied. This can be done by comparing average replicated output data from the simulation model with those from the corresponding real system. If the two sets of output data are similar, the model of the existing system can be modified so that it represents the proposed configuration. If the assumptions in the model of the existing configuration are reasonable in light of the results, then the results of the proposed configuration can be considered valid when using the same assumptions. We can feel confident that the differences in the existing and the proposed configuration model results represent what we will see in reality.

References


In his contest speech, Jeffrey Feldman, Director of Strategic Planning and Market Development for AT&T’s 800 Services, said . . . “In the mid and late 70s, there were some technology changes which made it much easier to use 800 services for marketing purposes. . . . It became the way America shops. That’s the way we like to think about 800 services today; it’s the front door for about 200 billion dollars in sales. That’s an amazing number given that this is an industry that is only 26 years old. . . . My customers understand that using CAPS helps to make sure that every phone call gets through easily and quickly on the first try.

. . . Last year we did about 2,000 CAPS studies. For those customers, the increase in sales, due to about a four percent improvement in productivity, amounted to about one billion dollars in additional revenue. . . . But, customer service is also an important aspect of the call center industry. If you satisfy a customer’s complaint quickly and allow that customer to feel that they had a good experience, 90 percent of those consumers will actually repurchase. So it is extremely important for these folks to be able to get every single phone call through the front door in a very easy fashion. . . . CAPS plays a mighty important role in that environment. . . . CAPS again plays a very important role by illustrating how cost can be reduced. Roughly 70 to 85 percent of the telemarketing center costs are not related to telecommunications, but to agent and operational costs. In the 2,000 studies that we did last year, we reduced those customers’ operating cost by about a half a billion dollars. As a matter of fact one customer told us that we reduced their particular operating cost by about 24 million dollars. . . . Those same customers represent one billion dollars in revenue for AT&T.”
Fay Beauchine, Vice-President of Reservations Sales and Services of Northwest Airlines, said in a video interview...

"AT&T sat down with us in the planning process and talked to our agents, our customers, and us about what our goals were. Then we set about to analyze what we had today and where we were going in the future and to work out the best possible solution to get callers to agents. Particularly in the heavy volume times as well as the normal times. . . . We have seen a great deal of change. Our customers are telling us that they are getting through faster and can hear better. Secondly, our statistics show us that we're answering more calls. In fact, in our latest promotion we answered 20 percent more calls than in a similar promotion previously. We answered it with 20 percent fewer agent hours and 27 percent less overtime and we booked about five percent more revenue. . . . The benefits of this system (CAPS), for not only what it does today, but what it will do in the future, far out weigh any incremental costs that we might have gained. . . . We're seeing the benefits we expected, because our agent utilization is up. We're able to bring that caller to an agent on a more even and consistent basis. That means we're able to book more revenue and not lose that opportunity. We're also able to do that on a reduced cost basis, because we are no longer holding calls in queue that way we used to."

Authors' Note: The major airline referenced in the body of the paper is not Northwest Airlines.