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Bell Labs News

JANUARY 22, 1991

Armed with several enhancements, the Conversant Voice Information System has truly become

A Machine That Listens

BY AL CHU

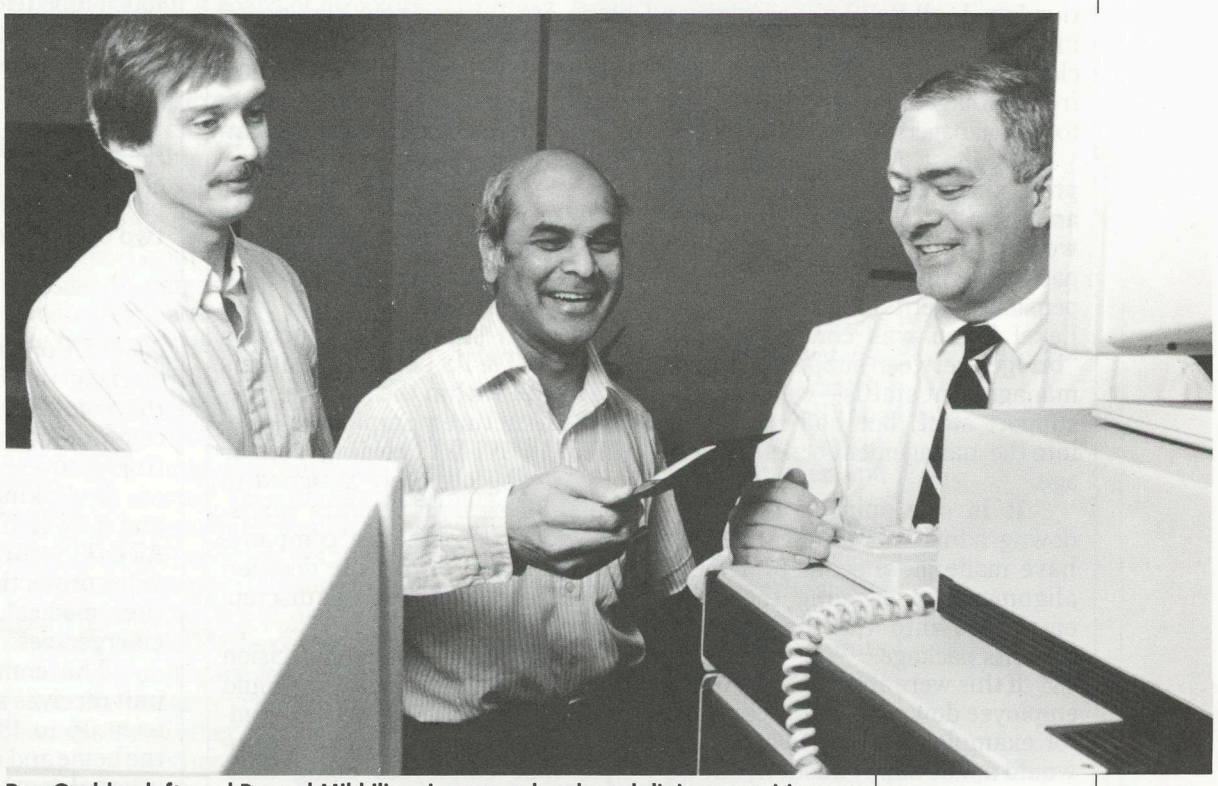
In an effort to stay on the leading edge of the voice-response-system market, AT&T Business Communications Systems announced on Jan. 14 several significant enhancements to its Conversant® Voice Information System (VIS). The new features allow users of either touch-tone or rotary-dial telephones to conduct various types of transactions by speaking naturally into a telephone.

With the new enhancements, the VIS now has a vocabulary of 13 words (zero through nine, yes, no, and zero pronounced as oh.) But more significantly, the system can recognize naturally-spoken, continuous strings of up to 24 digits, as opposed to individual words separated by pauses, as required with older systems. It is also speaker-independent, unlike some systems that have to be 'trained' for the voice of specific speakers. In addition, a word-spotting feature allows the system to pick out specific words from a sentence that contains other, irrelevant words, while ignoring the background noise. Another enhancement allows callers to interrupt system announcements to speed a transaction.

Using these features in a real-life scenario, shoppers could call up a catalog merchandizing operation and tell the system in a natural voice their account numbers, the catalog numbers and the quantities of the merchandise they want to order. They may even think aloud before deciding on the color or the size of a garment, because the system will ignore the "uhs" and the "ahs" or the baby crying in the background (see story at right).

The Conversant VIS is a programmable package of hardware and software developed by Bell Labs' Voice Transaction System Department in Columbus, in cooperation with the Information Principles Research Laboratory at Murray Hill. It comes as a platform upon which customers can build their own applications as needed. Using a menu-driven software tool called Script-Builder, a customer can build an application for the VIS in a few days. Systems for special applications that require larger and different vocabularies can be custom-built by AT&T.

The Conversant product line is the result of an internal venture enterprise set up by AT&T several years ago, and has since been absorbed into Business Communications Systems. Since it was introduced in 1985, the product line has evolved considerably and gained ground in the marketplace. It was the market-share leader in 1989 with 12 percent of the market.



Roy Grubbe, left, and Prasad Mikkilineni, center, developed digit-recognition algorithms in Bob Perdue's speech-recognition development group.

According to Bob Perdue, supervisor of the Algorithm Development Group in Columbus, the new enhancements aim at making the system easier to use by more telephone callers. "In the past, most voice-response systems could only accept touch-tone input. Since a large percentage of telephone subscribers in this country still have rotary phones, they were excluded from these systems."

But making the system accessible to anyone with a phone is no easy task, as people's tones, pitches, inflections, and accents vary a great deal. "In order to teach the system to recognize the speech of many people, we collected tens of thousands of spoken strings of digits, such as credit card numbers, from around the country. We also teamed up with speech researchers in Murray Hill to work on technical trials with customers. These trials allowed us to verify that our technology could really solve business problems, and to determine what kinds of hardware and software were needed to do the job. With our Murray Hill colleagues involved, we were able to have customers' needs directly reflected in our research."

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What Makes it Tick?

BY BOB FREED

The Conversant® Voice Information System (VIS), AT&T's innovative new speech-processing product (see story above), is based on two important breakthroughs: a statistical approach to speech-pattern matching, and the ability to pick out key words from a string of speech.

Most present-day speech-recognition systems work by extracting spectral features over time from incoming speech and comparing them with stored patterns, or models.

"The most popular and successful matching method being used now is based on Hidden Markov Models (HMM)," according to David Roe, a supervisor in the Speech Research Department in Murray Hill. The Conversant VIS uses this technique.

In HMM, features like the frequency spectrum, distribution of acoustic energy, and duration of different sounds in a word spoken by many people are measured. Using the mathematical mean and variance of each of these features, a statistical model is made and compared with the unknown word. The result is a much more reliable match than is possible with other forms of pattern matching.

The HMM and high-speed digital signal processors, such as the WE® DSP-32C and DSP-16, underlie the Conversant VIS and several experimental systems.

Just as you may jot down only

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In This Issue:

LETTERS TO THE EDITOR

We, the undersigned Level 7 personnel at Bell Laboratories in Indian Hill, would like to voice our opinions on the unfair downgrading of our health, savings and pension benefits.

The only notice we received was an after-the-fact letter last August notifying us that we were not being treated consistently with employees performing jobs similar to ours in other AT&T entities with regard to management/non-management benefit assignment. In order to align benefits plans equitably throughout AT&T, effective Jan. 1, all Bell Labs employees in Level 7 support staff occupational classifications are being transferred from management benefit coverage to non-management benefit coverage.

As most AT&T people earn promotions, their salaries increase and their benefits expand. We have worked up to this compensation package (which includes health and pension benefits). Traditionally, a Level 7 job was considered the "bridge" between support staff and management status—we were still support staff, but had moved up into the management benefits package.

It is our opinion that this downgrading was unfair. It would have made more sense to achieve alignment by bringing the other employees into the management benefits package.

If this were an across-the-board employee downgrading because of, for example, decreased profits, we would not be happy about it, but we would have understood. But to single out the Level 7 support staff positions seems to be very discriminatory.

(signed by 48 Indian Hill employees)

Judy Foster, Manager, Benefits Administration and Delivery, responds:

The Level 7 support staff position at Bell Labs has always been a non-management position. To understand why Level 7s were included in some management benefits plans, one must look at history. The savings plan, for example, began in 1969 as a plan for *salaried* employees (not necessarily management employees). As salaried employees, Level 7s were included in this plan. It wasn't until 1989 that the eligibility criteria for participation in the savings plans became based on management status. Similarly, prior to 1980, there was a single pension plan for all AT&T employees. When the non-management pension plan was established, Level 7s remained in the management pension plan, consistent with their participation in the Savings Plan for Salaried Employees.

However, AT&T's benefits plans are increasingly structured along management/non-management lines. For example, three distinct health plans were recently established for management, non-management and retired employees.

The letter above suggests that the other employees doing similar work could have been brought into the management plan, rather than the Level 7s removed. When compared with similar job functions within AT&T, Level 7 positions clearly fall within the non-management structure. Employees elsewhere in AT&T holding similar jobs are appropriately assigned to non-management benefits plans. Last year, as part of a company-wide benefits review, the decision was made to finally end this discrepancy.

While I understand this decision is not the one most Level 7s would have preferred, I support the company's decision to uphold the principle that employees doing comparable work receive comparable pay and benefits.

Bell Labs News *welcomes letters to the editor on issues relevant to Bell Labs employees. All letters must be signed, and will be treated as if submitted for publication unless otherwise specified. We reserve the right to edit for length and clarity, and can not guarantee that all submitted letters will be published.*

Send letters to:
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Editor
HL 1A-422

NEWSLINE

If you feel like you're not getting important information fast enough, call AT&T NEWSLINE for late-breaking news about what's going on in the company, the industry and the world.

908-221-NEWS

BULLETIN BOARD

1991 AT&T Design For "X" (DFX) Conference, June 12-13, Columbus, Ohio.

AT&T employees are invited to submit abstracts for the annual conference on DFX: design for manufacturability, testability, installability, reliability, maintainability, safety, serviceability, electromagnetic compatibility, and other downstream considerations. This year's themes are cross-functional teamwork, design/DFX trade-offs, and payoffs from implementing product/process DFX. DFX will be discussed for AT&T products from component through system level.

The deadline for abstracts is Feb. 14. For instructions on submitting electronic abstracts, send e-mail to Helen Corboy, *pruxn!hac.* To discuss topics and content of abstracts, contact Dave Gatenby at (609) 639-3162, *pruxg!dag.*

PRODUCT NEWS

Cordless Answering Machine

AT&T's Cordless Answering System 5600, which provides a new way for people to get messages from their answering machine—through the system's cordless handset—was introduced earlier this month.

A combination cordless telephone and answering machine, the System 5600 allows users to retrieve messages in any one of three ways: via the cordless handset, from the base unit, or by calling in from any rotary or touch-tone telephone.

The cordless phone delivers sound quality equal to that of a regular telephone. Its handset can be used for up to seven days without recharging. The full-featured answering machine tells users the time of day of each message and stores two different outgoing messages.

AT&T also recently introduced the Call Display Telephone 764, which works with caller identification services to show the phone number of incoming calls. It stores the phone numbers and times of the last 64 calls, whether they were answered or not. Four dedicated keys also provide other advanced services, such as call trace, which alerts the phone company to trace and store the last telephone call the user received.

Other consumer products recently announced include an answering machine with a speakerphone, and a low-priced cordless phone that allows users to change cordless channels if they hear interference.

The new products are available at AT&T Phone Centers and retail stores nationwide.

Security System

AT&T Consumer Products is now offering the first security system that combines home protection with communication and power-line control features in one product.

By linking telephone, intercom and power-line capabilities, the AT&T Security System 8300 provides protection against intrusion, fire, medical, and environmental emergencies.

The communication control unit receives and interprets signals from up to 48 protection points in the home and responds by sounding internal or external alarms, turning on lights or calling a monitoring service for assistance.

Users can determine the desired level of protection, program temporary guest codes and bypass any protection point for easy movement throughout the home. Special emergency buttons act as a manual signal to the monitoring service to call a pre-designated number, such as police, ambulance or doctor.

Additional keypads can be used to arm and disarm the system at convenient locations around the home. With a built-in speaker and microphone, each keypad can be used as a hands-free telephone or as an intercom to send a voice message throughout the system and receive replies from any other keypad.

A hardwired system, the 8300 is compatible with AT&T's wireless security devices, which include smoke detectors, motion sensors and universal transmitters.

Security System 8300 is being sold by a nationwide network of AT&T authorized distributors and dealers. Consumers can call (800) 523-0055, ext. 130, for information about AT&T's security system products and the name of an authorized distributor.

Distinguished Technical Staff Appointments

Distinguished Member of Technical Staff appointments for the fourth quarter of 1990 have been announced. Non-supervisory members of technical staff are appointed to DMTS based on their records of sustained significant individual contributions to AT&T's research and development work.

Each DMTS will receive a one-time honorarium, a permanent private office and services equal to those provided for supervisors, a metal sculpture and a framed letter of congratulations.

The newly appointed DMTS, their locations and departments are:

Area 11

Luryi, Serge ..... MH 11158

Area 45

Albano, Robert E. ..... MH 45431
Artaki, Iris ..... PR 45411
Chung, B. C. ..... PR 45415
Guth, Leslie A. ..... PR 45411
Ling, Hung C. ..... PR 45413
LoVasco, Frank ..... WH 45425
Tulloss, Rodham E. ..... PR 45414

Area 52

Agazzi, Oscar ..... MH 52846
Argade, Pramod V. ..... ALC 52854
Bays, Laurence E. ..... AL 52845
Brown, Michael A. ..... ALC 52853
Chirovsky, Leo M. F. ..... MH 52327
Crouthamel, David L. ..... AL 52822
Darwish, Mohamed N. ... RD 52714
Fazal, Faiq A. ..... MH 52862
Fischer, Frederick ..... ALC 52824
French, Harry T. ..... MH 52843
Juang, Shauh-Teh ..... AL 52821
Kalliat, Mohanan P. ..... RG 52611
Klicker, Kenneth A. ..... AL 52613
Lin, Cheng-yih ..... WH 52611
Marsh, Andrew J. ..... DJ 52461
McLaughlin, Scott S. ..... ALC 52855
Nagaraj, Krishnaswamy ..... MH 52846
Nassif, Sani R. ..... ALC 52864
Petrizzi, Joseph B. ..... AL 52832
Schweizer, Rudolph C. .. STC-52326
Searfoss, Elaine C. AL-52813
Tzeng, Liang D. STC-52351
Wu, Yu-Chun ALC-52866

Area 54

Bochner, Elias ..... HO 54372
Cohen, Kenneth J. ..... WH 54424
Duff, Donald G. ..... HO 54731
Etzel, Mark H. ..... AN 54301
Gemelos, Michael S. .... HO 54329
Kiker, J. Morgan ..... AN 54742
Kremer, Wilhelm ..... AN 54708

Area 59

Wang, Chi-Ming ..... HR 59641

Area 61

Commons, George .. IW XT921B300
Fleming, Philip J. .... IW XT921C000
Hilbert, Ross J. ..... SF XT9253400
Hill, Reginald J. ..... IW XT921B100
Krol, William S. ..... IHC XT921A100
Light, Jeffrey R. ..... IHC XT921A100
Pendergrast, John Stephen ..... SF XT9251600
Piepho, Richard S. .. IW XT921C000
Slaight, Thomas M. .. MT XT921A500
Tekchandani, Suresh ..... LZ XT9155100
Whitten, Douglas E. ..... IW XT9256200
Wismer, Christine A. .. LZ XT9251400

Ever wonder how the Bell Labs budget is determined?

The Birth of a Budget

BY RICHARD Q. HOFACKER JR.

At AT&T Bell Laboratories, the annual budget process takes about as long as a pregnancy. The 1991 budget, for example, began stirring in March 1990, and was delivered as a multibillion-dollar baby last month.

How many billions? During the past few years, the overall Bell Labs R&D budget ranged from $2.1 billion (1986) to $2.9 billion (1990 and 1991). Although the budget appears to be relatively stable, inflation erodes its real value.

Separate budgets are prepared by the business units for the R&D labs in Computer Systems, Business Communications Systems, Consumer Products, General Business Systems, and AT&T Paradyne.

Salary and benefit costs make up a large portion of the expenses included in the budget. Other elements are depreciation, external purchases (such as equipment and contract employees), and internal services (such as rents, telecommunications, etc.). Administrative costs amount to about 20 percent of an organization's budget.

Two budgets are actually prepared for Bell Labs: The *capital* budget, for such items as depreciable equipment purchases or construction, and the *cost-of-work* budget that covers such things as operations and salaries. The cost-of-work budget is what makes up the numbers quoted in this article.

Work programs at Bell Labs are driven by project priorities set by the business units. Product or service managers from the business units work with R&D organizations to adjust the project priorities to fit the business directions and funding levels set by the business-unit sponsors.

Among the factors that influence Bell Labs funding are:

- The actual sales, projected revenues and business strategies of each business unit;
- AT&T's overall cost structure and cash flow constraints; and
- AT&T's corporate financial outlook.

Each business unit starts the budget process by telling Bell Labs how much money is being tentatively committed for R&D funding for the next year's development projects, including forward-looking work, systems engineering, project development, manufacturing support, and quality assurance. These projects were established by the business units as part of their business planning processes.

An industry-wide "benchmark" is referred to by most business units for R&D investment in their particular line of products or services. But if a business unit's revenues are not high enough to cover all the operating, manufacturing, and marketing costs and still leave an acceptable profit level for AT&T, it may not be able to afford the benchmark R&D spending. "Affordability" is a key word in negotiations with the business units.

The strategic direction and content of the development activities for the next year will then be set by the business-unit heads (president level) and Bell Labs executives, who usually are also members of the business unit's board of directors.

The budget for basic research at Bell Labs is determined by the AT&T group executives, with input from research management at Bell Labs. Funding for research is distributed among the business units.

In the spring, the Bell Labs Budget Group drafts a financial model to determine how much it will cost each technical organization to maintain the same level of effort in the following year (with adjustments for inflation and any extraordinary expenses that were incurred).

The Budget Group gets the process started, then serves as an advisor, or as an intermediary when necessary. It coordinates the information flow and reporting to Corporate Headquarters of decisions between the Bell Labs people and the business-unit management throughout the budget cycle, and provides analyses and other financial advisory support together with other support organizations.

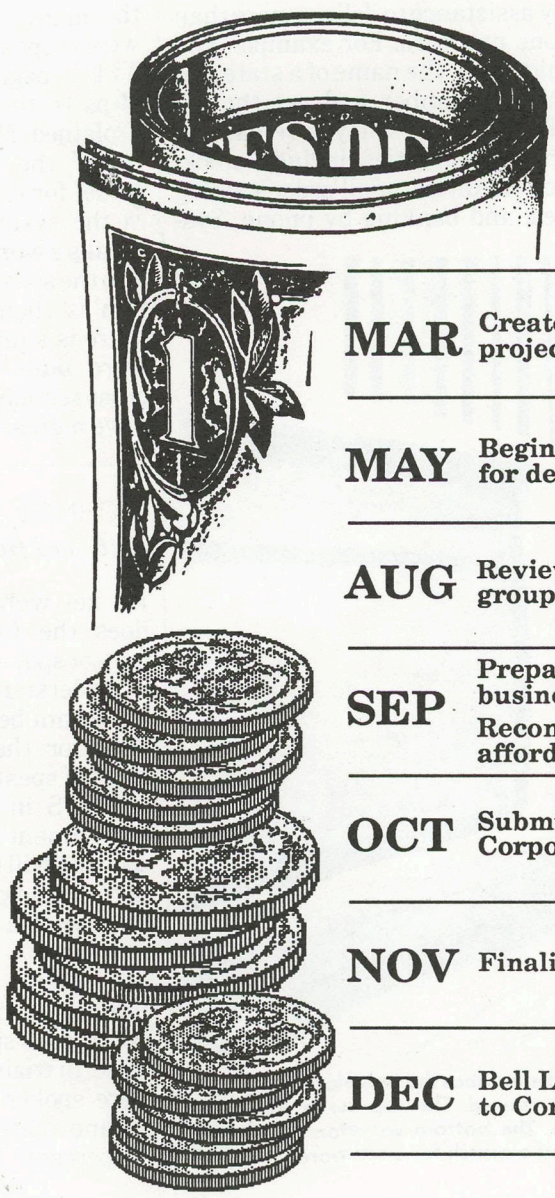
Most of the kinks in the budget negotiations are worked out at the middle-management level: between Bell Labs directors or department heads and the product/service managers from the sponsoring business units. But the business units have the last word.

The project manager and Labs manager determine an appropriate technical head count for each project and the dollars assigned to that project. A delicate balance is needed here to match the limits of the funding to the needs of the project.

By September, a realistic estimate of the next year's R&D costs has been compiled into a "commitment budget," which each business unit submits to AT&T Corporate Headquarters for review. If the Corporate staff finds that the projected profit levels are too low, the proposed R&D funding might be scaled back. In that case, the negotiation process will be reopened. The most concentrated negotiation between Bell Labs and business-unit representatives takes place between October and December.

Throughout the year, more than 40 experts, called Financial Services Specialists (FSS), monitor the status of the current year's actual budget. This activity keeps business units and the various Bell Labs organizations advised on how closely actual expenditures match projected expenditures. This also allows changes to be introduced into the funding, when necessary.

For example, a business unit might want to decrease or increase the funding assigned to a specific project, within its relatively fixed overall R&D budget. ■



Timeline For Developing Next Year's R&D Budget

MAR Create financial model of next year's projected development budget

MAY Begin negotiations with business units for development funding

AUG Review proposed research budget with group executives

SEP Prepare next year's R&D budget for each business unit;
Reconcile funding levels based on affordability

OCT Submit commitment budget to AT&T Corporate Headquarters

NOV Finalize the R&D budget for each program

DEC Bell Labs President presents R&D budget to Corporate Headquarters

What's in the Speech-Research Pipeline?

BY BOB FREED

Now that we have a commercial system that recognizes some spoken words, what's the next step for speech-recognition technology?

"Speech-recognition research is headed in several directions," said Larry Rabiner, director of the Information Principles Research Lab at Murray Hill. "One is large-vocabulary, task-oriented systems, which put no constraints on the speaker's vocabulary or the way he or she speaks. Another direction is the ability to acquire language, both vocabulary and grammar, by listening to a user's speech. A third is language translation, which combines recognition and synthesis in two or more languages.

"The technologies we're focusing on are advanced digital signal processors for high-speed processing; the statistical modeling of speech sounds, syntax and semantics; acoustic-phonetic modeling of speech to create basic phonetic units that are independent of words, vocabulary and tasks; and the possibility of implementing speech algorithms in neural-networks.

Experimental systems now under development at Bell Labs include:

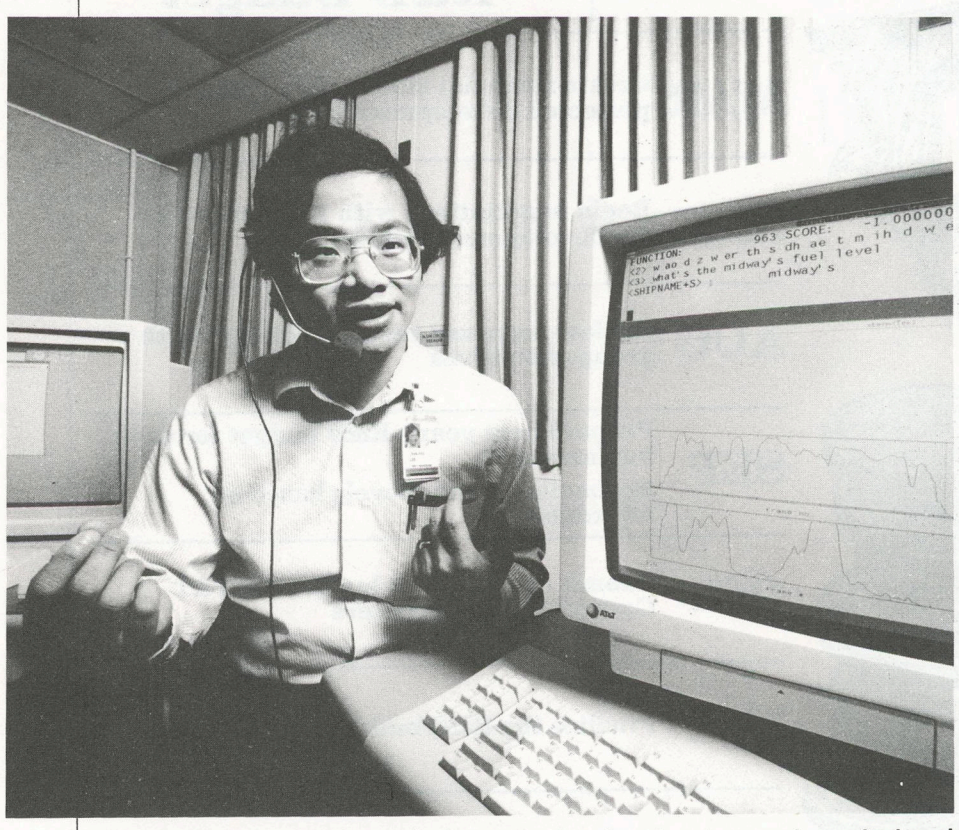
- A large-vocabulary system that recognizes 1,000 words in continuous speech without being trained on an individual speaker. It has already been built in the Information Principles Research Laboratory in Murray Hill. The system uses Hidden Markov Models (see "What Makes it Tick," page 1) to analyze the spectral features of incoming speech, compares them with models of phonemes for a particular application, then uses rules that govern English syntax and semantics to determine the correct words in a sentence. For example, it would select "To be or not to be..." rather than "Two bee or knot too b...." Its word-accuracy rate already exceeds 95 percent.
- Research also is underway on phonetic transcription, which works at the lowest level of continuous speech to convert speech to phonemes and phonemes into text. This method is different from that of the previous system in that it has no direct knowledge of language. Operation is based on acoustic sounds only. After you get a transcription in terms of phonemes, you use your knowledge of English to correct errors and convert the transcription to a meaningful string of words. The advantage of this method is independence not only of the speaker, but of grammar, vocabulary, and syntax as well.
- Another experimental system acquires language automatically—it learns words the way children do, by starting small and simple. This system uses a neural network that processeses information the way the brain does: by learning from example. Each new input expands the model of language that the neural network understands. The model learns new pronunciation, vocabulary, syntax and semantic connections from successive speech inputs.
- In the Digital Architectures Research Department in Murray Hill, a system that reads lips is being studied for speech recognition in noisy places. A solid-state camera focused on the speaker's mouth tracks lip and tongue movements, which are compared with several hundred mouth photos related to speech sounds. Possible applications include aircraft cockpits, space suits, and noisy factories.

What applications might these experimental systems lead to? One speech-recognition system under consideration would expand directory assistance to deliver more than phone numbers. For example, you could speak the name of a state and a phone number and get the zip code of the person you're calling. Other possibilities include stock-price inquiries, mail-order catalog sales, and banking by phone. Systems also could be installed in cars for voice control of accessories.

A data-base management system, whose functions stem from word spotting and understanding word meaning, is under consideration for automated offices. This application could provide a computerized secretary to which you might say, "Please give me the status of the X account," or "Send a copy of last month's inventory sheets to accounting."

Language translation could be valuable to hotels and airlines for their international clientele. Here the challenge is language, not speech. What's needed is a better understanding of the complexity of language and ways of teaching a machine how to acquire it.

"In the meantime," added Rabiner, "speech recognition is becoming more of a reality as we understand how to do it affordably. Increasingly powerful microchips with faster processing rates are steadily expanding system vocabularies. So it's entirely possible that by the year 2000 affordable systems will have vocabularies of some 20,000 words." ■



Chin-Hui Lee, of the Speech Research Department, describes the waveforms displayed by the 1,000-word recognition system he developed. The top curve shows the acoustic-energy contour of a spoken sentence. The bottom waveform shows the number of words the system is evaluating to find a match for each word it 'hears.'

CONVERSANT

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Another significant step in the development process was an intern program, as Perdue explained: "Each year we sent one of our engineers to the research lab in Murray Hill as an intern to learn about the technology that was being developed there. This program, plus all the joint technical trials we have conducted with the researchers, greatly enhanced the technology transfer process from the research lab to the product line."

The technology Perdue refers to covers two fronts: On the software side, it's primarily the development of speech-recognition and related algorithms. On the hardware front, it's the packing of enough computing power into the system to satisfy its huge computation requirements.

According to Prasad Mikkilineni, a DMTS on Perdue's team, the speech-recognition algorithms use the "Hidden Markov Model," a mathematical model that reflects the many different ways that a word is spoken (see "What Makes it Tick," page 1). "There are two steps to the recognition process," explained Mikkilineni. "First, we 'train' the system by building a model for each word and storing it in the system. Then, as someone speaks a word, the system compares it to the stored models. A determination is then made as to whether there is a match. Since the models were built using speech from a cross section of the population, they have a great deal of latitude."

On the hardware side, the VIS platform uses an AT&T 6386 computer running the UNIX* operating system. The speech-recognition hardware consists of a signal-processing board that has a control processor, a number of input/output channels, and two DSP-32C signal-processor chips manufactured by AT&T Microelectronics. The DSP-32C is a 32-bit processor capable of performing 25 million floating-point operations per second (megaflops). The board can run a variety of speech-processing algorithms including speech pattern matching, speech coding, text-to-speech synthesis, and speaker verification.

To allow many callers to simultaneously use the system's voice-recognition features, plug-in signal-processing companion boards were added to the system. Each board uses multiple DSP-32C chips to provide a 300-megaflops processing capacity. The current VIS has enough companion boards connected to be able to handle 12 simultaneous callers. More companion boards can be added to accept more callers.

"Voice processing is currently a $1 billion market and growing," said Perdue. "It is also a very competitive market. As good as this product is, we can't stand still. We must continue to enhance our system with new features and capabilities that benefit customers, or we will fall behind." He indicated that a number of new features are currently being developed. ■

*UNIX is a registered trademark of UNIX System Laboratories, Inc.

TECHNOLOGY

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the key words in a lecture, so, too, does the Conversant VIS listen for—or spot—key spoken words that it understands. Word spotting is important because it eliminates the need for the user to learn fixed ways of speaking," said Jay Wilpon, an MTS in the Speech Research Department at Murray Hill. "Word spotting will be an important transition technology until we have systems with a full understanding of language."

Special models identify and eliminate from further processing extraneous speech and background noise. In trials where only key words were spoken and there was background noise, word accuracy was 99 percent. When the key words were buried in extraneous speech, accuracy was still 95 percent.

Word spotting will enable Telefonica, Spain's telephone company, to offer toll-free information services for the 1992 summer Olympics in Barcelona. A system developed by the Advanced Services Technology Department at Indian Hill Park was trained on Spanish digits using 8,000 speakers, and provided essentially error-free performance.

Another word-spotting trial set for Spain this year will open the door to command-and-control applications. These command-and-control applications ordinarily require pushing touch-tone buttons to be connected to, say, different services or extensions in a business. But only about two percent of the telephone lines in Spain have touch-tone service. ■

Vive la Différence Synthétique

Syrdal

BY CARL BLESCH

Listen to computer-synthesized speech, and you'll hear a male voice in nearly all cases. That's because it's technologically easier to analyze and recreate the male voice in a computer. But female voices will soon gain a place in the world of synthesized speech as a result of linguistic science and engineering work done at AT&T Bell Laboratories.

"As synthesized speech becomes more commonplace for human-to-computer interactions, customers might sometimes prefer to interact with female voices," said Ann Syrdal, an MTS in the Advanced Services Technology Department in Indian Hill Park.

For example, one current application for computerized speech is a text-to-speech service for speech-impaired people, now under trial in California. Through the service, speech-impaired customers can have their typed text converted directly into speech by a computer, using AT&T text-to-speech synthesis programs.

"In applications like this, female customers may want the computer to represent them in a female voice," said Syrdal.

While there have been 'talking' computer systems that speak in female voices for well over a decade, these systems do not produce synthesized speech. They assemble whole words and phrases that were previously spoken by a person and recorded. Such systems put together a limited combination of messages for specific tasks, such as providing phone numbers in directory assistance systems or prompting people through bank-by-phone transactions. They don't create conversational speech out of long, unpredictable strings of text.

Female speech has a number of characteristics that make it harder to replicate in a computer than male speech, Syrdal said. These include higher pitch and a generally more 'breathy' sound, which is caused by air passing more continuously through the vocal cords. In addition, females have shorter vocal tracts than men, so the resonances they produce are higher in frequency. Because of these higher frequencies, female voices encounter obstacles when carried over telephone lines. Since higher-pitched sounds are filtered out of telephone transmissions, female voices are more susceptible to degradation, leading to lower intelligibility over the telephone.

By understanding these characteristics, Syrdal was able to compensate for them when she created a synthetic female voice for AT&T's text-to-speech system. She created this voice using the same principles that her AT&T colleagues had applied to male synthetic speech: Pairs of sound units, or 'phonemes', are strung together to create speech. With about 1,000 of these pairs, or 'diphones,' any English utterance can be recreated.

To assemble the female diphones, Syrdal recorded a female professional speaker reciting a carefully designed set of sentences. All the needed diphones were represented in this text.

After recording the sentences, Syrdal electronically 'snipped' the diphones from the sentences and loaded them into AT&T's text-to-speech synthesizer. When producing speech from text, the computer picks out the necessary diphones, laces them together, and alters characteristics, such as pitch and duration, to produce more human-like speech.

Syrdal then played her female synthesized voice to listeners and measured errors they made in recognizing sounds. She then either went back to the computer and 're-cut' the diphone to make it more clear, or found a better occurrence of that diphone in the recorded material.

These corrections reduced the total error rate for the synthesized female voice to just 14 percent—compared to the 11 percent error rate for synthesized male voices. Bandpass filters were used to simulate telephone-quality sound. When listeners were similarly tested on human voices actually transmitted over telephone lines, Syrdal noted that they made even more errors recognizing female speech, so the synthesized female voice may actually be clearer than a natural female voice. ■

INDUSTRY WATCH

NCR Takeover Advances

AT&T is attempting to unseat the NCR board through a proxy battle in order to effect its buy-out of the company. AT&T sent letters to NCR shareholders asking them to vote for a special meeting at which AT&T would present a slate of directors to replace a majority of NCR's directors. A 25 percent vote is needed to call such a meeting, and an 80 percent vote is needed to oust the board. As of Jan. 15, AT&T had received tenders for about 70 percent of the outstanding shares of NCR stock. AT&T has also asked the U.S. District Court in Dayton, Ohio, to order NCR's board to remove the company's "poison pill" and other anti-takeover devices. Similarly, a group of NCR shareholders has filed a lawsuit against the computer company in an attempt to clear the way for the takeover. NCR said it spent about $9 million fighting the AT&T offer during the fourth quarter of 1990, during which NCR's income dropped 24 percent. *(various sources)*

Cable Cut Raises Questions

A series of errors led an AT&T employee to cut a vital cable in New Jersey by mistake on Jan. 4, disrupting much of AT&T's long-distance service in the New York metropolitan area. The employee was removing an outdated cable in Newark when he snipped an active cable carrying more than 100,000 circuits into and out of Manhattan. The three New York-area airports lost their long-range radar for 102 minutes, delaying and canceling hundreds of flights and scrambling air traffic control throughout the Northeast. It took more than seven hours to make the repair. The biggest cost to AT&T may turn out to be in damage to its image of providing reliable, high-quality service. The cable break was the third time in a little more than two years that a large part of the AT&T network failed because of a failure in a small piece of the complex system, raising questions about the vulnerability of the nation's phone system. *(various sources)*

Cable Competition?

A growing number of cable-TV companies are trying to move into the turf of phone companies. Comcast, a major operator of both cable-TV systems and cellular-phone networks, filed a request with the FCC to conduct a five-city experiment in personal communications networks. The test is intended to determine whether its cable systems can carry telephone calls. *(The Wall Street Journal)*

Long Distance Stocks Down

The stocks of the nation's three main long-distance telephone companies all fell sharply last year after three years of strong gains, and some analysts say they are unlikely to recover soon. Shares in AT&T fell 34 percent last year. MCI fell 55 percent, and United Telecom, the parent of US Sprint, dropped 39 percent. *(The New York Times)*

Laser Sets Record

Scientists at AT&T Bell Laboratories in Murray Hill have built a laser that has broken world records for the speed with which it transmits light pulses. Generating 350 billion pulses per second, the colliding-pulse mode-locked laser is a hundred times faster than state-of-the-art semiconductor lasers used today to drive fiber-optic transmission systems. *(The Newark Star-Ledger)*

U.S. Chip Makers Gain Ground

In 1990, for the first time in more than a decade, American semiconductor companies gained market share at the expense of their Japanese competitors. American companies garnered 37 percent of the worldwide semiconductor market in 1990, up from 35 percent in 1989. The figures suggest that American chip manufacturers might finally have stopped the erosion in their competitiveness. However, experts cautioned that the figures could represent an aberration caused by a decline in prices for memory chips, which are made primarily by the Japanese. *(The New York Times)*

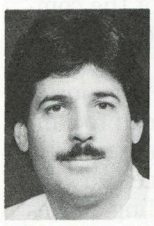
UNIX Unit in Demand

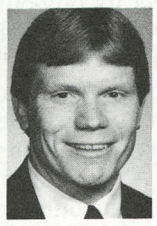
A version of the UNIX* operating system sold by the Santa Cruz Operation, Inc., is fast becoming an industry standard for PCs. Some analysts think the company could rule the UNIX market much as Microsoft dominates the MS-DOS world. Computer companies that re-sell Santa Cruz's operating systems now include Compaq, Digital Equipment, Tandy, Siemens/Nixdorf, Olivetti, Unisys, and Hewlett-Packard. *(The New York Times)*

*UNIX is a registered trademark of UNIX System Laboratories, Inc.

PEOPLE

Promotions


Gerszberg


Harrington


Thomson

Irwin Gerszberg
from MTS (54431) to supervisor, Cellular Technology Applications Group (54417), WH

John Harrington
from supervisor (52856) to head, Custom VLSI Design Department (52856), ALC

David Thomson
from MTS (55432) to supervisor, Speech Processing Group (55432), IHP

Area 11

Johnson, M.G. to MTS I ..... MH 11538

Area 12

Neceda, T. to Assoc. Progr. ..... MH 12381

Area 45

Atwater, S.I. to MTS ..... CB 45354
Ellis, R. to MTS-I ..... PR 45411
Lawrence, M.S. to STA .... PR 45427
L'Esperance, L.D. to MTS-I ..... PR 45431
Palmer, S.R. to MTS ..... HO 45354

Area 51

Casselman, B. to MTS ... HO 51133
Clifford, T.C. to MTS .... INH 51162
Greenman, M. to MTS ... HO 51176
Heinz, K.L. to MTS ..... HO 51133
Hong, E.N.K. to MTS .... HO 51125
Ong, I.S. to MTS-I ..... HO 51136
Saifzadeh, R. to MTS .... HO 51181
Watson, P.L. to MTS ..... HO 51175

Area 52

Bowen, T.J. to Sr. Electron Device Mech. ..... MH 52823
Cise, M. to Sr. Electron Device Mech. ..... MH 52823
Cruzan, P.D. to MTS-I ..... AL 52813
Gabra, K. to Sr. Electron Device Mech. ..... MH 52823
Gould, D. to Electron Device Mech. ..... MH 52823
Jacob, E. to Sr. Electron Device Mech. ..... MH 52821
Jannette, R.J. to STA ..... ALC 52852
Jolly, D. to Electron Device Mech. ..... MH 52823
MacDonald, G. to MTS-I ..... AL 52831
Moccio, S. to Electron Device Mech. ..... MH 52821
Olasupo, K. to MTS ..... AL 52813
Peters, A. to Sr. Electron Device Mech. ..... MH 52821
Pham, H.Q. to MTS ..... AL 52831
Steward, J.P. to STA ..... ALC 52854

Area 54

Lee, H-H. to MTS ..... WH 54584
Patterson, W.W. to MTS ..... HO 54329
Pfahler, J.C. to STA ..... WH 54584
Underwood, B.E. to MTS-I ..... Omaha 54525
Wilson, J.C. to TA ..... HO 54325

Area 59

Singh, K. to MTS ..... HR 59114

Area 61

DeGregorio, F.G. to STA ..... LZ XT9251400
Maziarski, G.F. to MTS ..... MT XT9251500
Monaghan, J.E. to MTS-I ..... IW XT9255100
Smith, B.B. to STA .... MT XT9251500
Viswanathan, D. to MTS-I ..... IW XT9157200
Warren, J. to TA ..... LZ XT9155600

Area 631

Ahmed, M.I. to STA ..... INH 63116
Doty, D.A. to MTS-I ..... INH 63116
Grewe, A.J. to MTS ..... INH 63152
Miller, T.C. to MTS-I ..... INH 63116

Paradyne

Kikolski, H.J. Jr. to MTS-I ..... MT 140310000

Area 7

Foti, B. to Sr. Progr. ..... HL 77456
Gatson, L. to Ser. Clerk ..... HO 77124
Hankinson, M-L. to Sr. Publ. Spec. ..... HO 77163
Hines, N. to Secy. ..... MH 77124
Johnson, T.A. to Personnel Rec. and Reports Admin. ..... IH 7783
Liang, Y.C. to Sr. Ser. Clerk ..... HO 77124
Mazza, T.E. to Secy. ..... MH 77124
McNair, E.M. to Ser. Clerk ..... HO 77124
Session, A. to Assoc. Bus.Oper. Analyst .... HO 77161
Taylor, T.A. to Exec. Secy. ..... WH 77124
Zeltman, C.A. to Ser. Clerk ..... HO 77124

In Memoriam

Philip Boddy,
formerly a head at Whippany, died Dec. 13. He retired in 1990 after 31 years of service and is survived by his wife Margaret.

Harold Cahill,
formerly an MTS in New York, died Nov. 19. He retired in 1965 after 42 years of service and is survived by two daughters.

David Carter,
a supervisor in the Electronics Technology Planning Center at Murray Hill, died Dec. 5. He began his Bell Labs employment in 1980 and is survived by his wife Karen, a daughter and a son.

Henry de la Hoz,
formerly a receiver—shipper/storekeeper at Indian Hill, died Dec. 18. He retired in 1989 after 18 years of service and is survived by his wife Hortensia and a daughter.

Frederick Faulkner,
formerly a general utility worker at Whippany, died Nov. 30. He retired in 1971 after 15 years of service and is survived by a daughter and a son.

Oscar Kummer,
formerly an MTS at Holmdel, died Dec. 16. He retied in 1977 after 43 years of service and is survived by his wife Ruth.

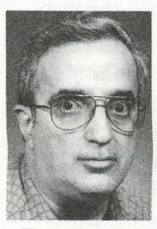
Alan McPherson,
an MTS in the Operations Department at Murray Hill, died Dec. 21. He began his Bell Labs employment in 1963 and is survived by his wife Patricia and three sons.

Clifford Mitchell,
formerly an MTS at Holmdel, died Nov. 28. He retired in 1963 after 43 years of service.

Carlton Schoen,
formerly an MTS at Guilford Center, died Dec. 14. He retired in 1974 after 30 years of service and is survived by his wife Grace.

Charles Scioscia,
formerly a plumber at Whippany, died Dec. 8. He retired in 1979 after 20 years of service and is survived by a daughter.

February Service Anniversaries


Bernardo


Embree


Frey


Lambert


Morrison

Joseph Bernardo Jr.
Murray Hill Facility Operations (77811), MH, Feb. 27, 35 years

Frank Curylo
Cellular Systems Design Department (54413), MO, Feb 2, 35 years

Milton Embree
High Voltage Integrated Circuit Laboratory (52714), RD, 40 years

Henry Frey
Engineering Information Services (77122), HO, Feb. 21, 40 years

Charles Lambert Jr.
Federal Systems DES Department (46225), MO, Feb. 20, 35 years

John Morrison
Mathematics of Networks and Systems Department (11212), MH, Feb. 6, 35 years

30 Years

Leifer, N.A. (14th) 46238
Birecki, Z. (14th) 52391
Crigler, F.W. (6th) 527
Gentry, J.H. Jr. (20th) 54329
MacPherson, W.F. (20th) 55534
Tammaru, T. (8th) XGPN40000
Puryear, R. Jr. (27th) 77881

25 Years

Bjorkholm, J.E. (21st) 11122
Hubbauer, P. (16th) 11518
Estes, G.M. (14th) 45256
Wendland, F.W. (14th) 45262
Vilardi, K.H. (19th) 45265
Isenman, M.E. (14th) 45356
Young, R.C. (21st) 454
Kashuk, P.A. (24th) 51236
Wagner, W.D.P. (14th) 52322
Heirman, L.M. (14th) 54
Tuminaro, R.D. (28th) 54325
Daggett, R.L. (1st) 54374
Daugherty, T.H. (14th) 54588
Noel. R.A. (14th) 54711
Gibbons, J.R. (7th) 55662
Michaels, A.S. (21st) 55686
Brockschmidt, R.W. (3rd) 55813
Khanna, S.P. (7th) 63114
Lebitsch, A. (7th) 63116
Chambers, M. (19th) 77111
Hill, J.E. (14th) 77222
Fresco, S. (7th) 77422
Miller, A.E. (11th) 77811
Fuller, E.G. (23rd) 77881
Johnson, F.T.(1st) 79521

20 Years

Marotta, D.S. (24th) 45266
Bell, B.B. (17th) 45301
Butera, F. (10th) 52391
Siller, C.A., Jr. (10th) 54613
Moffatt, J.P. (3rd) 54744
Strebendt, R. (13th) 55511
Dubina, E.M. (22nd) 55531
Piccininni, V.K. (10th) 55673
White, L.M. (1st) 16AP20000
Sherman, C.J. (1st) XGPA90000
Hardy, R.E. (16th) XGPJ12000
Dunn, A. (22nd) 140340000
Jackson, J.A. (1st) 77221
Blaine, P.C. (16th) 77422
Jablonski, G.C. (22nd) 77442
Rogers, J.L. (23rd) 77811
Young, M.L. (19th) 77811
McKinley, W.G. (22nd) 77881
Mendez, I. (22nd) 77881

15 Years

Bean, J.C. (9th) 11152
Sammon, M.J. (24th) 51165
Dursan, P.T. (10th) 51224
Singer, M.F. (9th) 51235
Jensen, G.M. (9th) 55412
Swinehart, G.E. (4th) 55666
Miller, D.M. (16th) 55675
Ginzer, L.M. (7th) 59534
Madsen, C.M. (3rd) XGPB50000
Seymour, P.L. (24th) XGPC90000
Reynolds, M.J. (6th) XGPJ40000
Melber, J.A. (23rd) XGPP20000
Torok, G.P. (7th) 140310000
Karasiewicz, C.M. (27th) 77122
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Crawley, J.J. (2nd) 79114
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Bailes, L.J. (4th) 79544

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Romanelli, S. (2nd) 16AX40000
Daniel, W.F. (9th) XGPA20000
Wooten, J.L. (8th) XGPC50000
Morris, S.F. (12th) XGPE20000
Bish, S.L. (16th) XGPE40000
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Arfin, J.L. (17th) 79541

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