The Starving, Deprived, Poor Man's Very Own

High-tech, Computerized Phone Network

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Every once in a while, low-cost technology comes along and fills a void in our existence, making our lives easier and less expensive. For several years, my family has been dealing with an enormous problem which has caused great distress and has sucked the life out of each and all of us--answering the telephone. You may laugh and say that it's not a problem, but in my family and many other families throughout the nation, answering the phone is the utmost annoyance--especially if it's not for you or if it's not from someone you want to talk to. We're one of those families that you see on tv or in movies such as The Accidental Tourist in which the family members sit for hours on a couch in front of a tv set totally oblivious to the ringing phones around them. But we didn't used to be that way. In fact, we used to be quite normal.

Our condition began when my brother became popular and moved into a newly built room out in the garage. Most phonecalls would utter the all too familiar phrase, "Is there?" and then the answerer would have to leave his phone off the hook, mount a full scale search throughout the house, and him being home our not, the answerer would then have to remember to hang up the phone or the whole phone system would remain off the hook. And this process would repeat itself at least once an hour, rising to 2 or 3 times an hour on Friday evenings. You see, we had several telephones, but only one phone line, and the addition of an extra line would alleviate some of these problems, but the cost of one was too darn high. So I decided to install an answering machine, phone with hold button, and two-station intercom to compromise. That way, when the phone rang I could choose not to answer it until one of my friends spoke on the answering machine, and then I could quickly pick up the phone before they hung up, or if I decided to pick up the phone myself, and it was for my brother, I could put the phone on hold, page my brother's room on the intercom, and if he picked up his phone, the hold circuitry would automatically disconnect, eliminating the need for me to hang up the phone. Obviously, this system is an improvement over the previous search-and-find-and-hangup method, but the addition of the answering machine actually makes us pick up the phones less often, and we don't even check the messages, since most are for my brother, so we can't tell if any are for the rest of us without listening through the whole tape. Also, if a call comes in on a third phone in a room not located near an intercom, a several-yard hike is required.

So I designed a simple, cheap device to solve these problems, and this device is so amazing that I will a couple of pages to its design. But first, look at what it can do:

The phone rings. The answering machine picks it up on the first ring, but this time it has a different message than the typical "leave your name and number" message. It says in my own pleasant voice, "Welcome to a computerized telephone network. If you have a touch-tone phone, press 1 to talk to Lee, press 2 to talk to , press 3 to talk to ..." and so on. "If you do not have a touch-tone phone, please wait..."

The anonymous caller presses 1 on his touch-tone phone.

"Paging Lee..." replies a synthesized computer voice to the anonymous caller, "If you have an identification code, please enter it now, if not please wait."

Before the computer has time to finish speaking, the anonymous caller enters the number 15 on his keypad.

From speakers mounted in various rooms in our house, the computer announces, "Lee, you have a phone call from ."

I answer the nearest phone, but the computer remains active, silently keeping track of which phone is off the hook and for how long.

says, "Hi Lee, can I borrow your Nirvana cd?"

I say, "I don't know, it's my brother's. Hold on and I'll find out." I enter the keys # and 5 on the keypad.

suddenly hears music, as our computerized phone system completely disconnects from the phone line and becomes a self-powered home intercom system. Over a speaker in my brother's room, the computer says, " , you have a page from Lee. Over my earpiece, the computer says, "Paging ." After several seconds, the computer replies over my earpiece, " did not answer page."

I input the symbol # into the keypad. The computer reconnects me to . "He's sleeping, ," I reply, and she hangs up disappointed.

Suddenly, over speakers throughout the house, the computer announces, "Someone is at the front door." It is my friend , and we decide to go to his house.

Thirty minutes later, and I lock the keys in my car, and I call home to tell my mom to drive up with another set of keys. However, the phone is busy, since I forgot to hang it up when I left.

But I do not worry, since another thirty minutes later, the computer says over all speakers in my house, "Lee's phone is off the hook. Shutdown in 1 minute if there is no response." Exactly one minute later, my phone is disconnected, placing the phone system back on the hook and enabling me to call home, which I do. And my mom comes to the rescue.

These are just a fraction of the things this device can do. These are pretty amazing feats for a single-line household to tackle, but these systems are not new and have been around for many years under the name PBX (Private Branch eXchange) machines. These machine have been used extensively in hotels, banks, and insurance companies. However, only through modern, low-cost technology is such a device feasible for the average home. But for the below average, or poor man's home, the only feasible system is one he can build himself.

The central computer is the key to the entire system, since it replaces the human component and does all the talking and switching, like an operator. It needs to know what's going on at all times and be given as much control as possible of all things. It must know when a phone rings, how many times, which phones are on or off hook, what time it is and what day, which buttons are pressed on the telephone keypads, and so on. It must be able to switch speaker and phone connections from one person to another, synthesize speech so humans can understand it, and even generate the tones necessary to dial the phone. And then it is up to the software to decide how the computer does it's job. That is the role of the computer--input signals from various sensors, process those signals according to a stored program, and output new signals to control equipment. Those three things can only be done successfully by a computer. So some sort of computer is needed, and I chose the Commodore 64.

A Commodore 64 is an 8-bit, single-board microcomputer which can be purchased used for about $30. It contains 64K RAM and a 6510 microprocessor running at 1Mhz, which may sound puny compared to today's IBM's, but it has far more speed and memory than is necessary for operating a phone network, and buying an IBM would be a waste of money and capabilities. Input and output devices can be attached to the Commodore 64 through a variety of lines in its user port and digital joystick ports. Also, thirty-two additional lines can be added by connecting 2 PIA (Peripheral Interface Adapter) chips to the expansion port, allowing the computer to have over fifty lines which can either input or output signals to various devices.

The input devices, the devices that give the computer information about the status of the phone system are things like ring-detect circuitry, off-hook circuitry, switches, and the most important input device, the DTMF (Dual-Tone Multi-Frequency) decoder chip. Without this $7.00 integrated circuit, this phone network would not be possible, since this paperclip-sized component is the only device that will allow the computer to recognize what buttons are pressed on a

telephone keypad, and that is the only way that automatic call-routing and screening can occur.

"A Touch Tone (dual-tone, multi-frequency, or DTMF) decoder can be a valuable link to a remotely controlled device, such as the phone patch in a repeater. Tone decoders of the past were rather large and unstable because they were constructed from discrete tone comparators such as the NE567. The '567 scheme also required rather expensive capacitors to keep the frequency even remotely accurate over a wide temperature range. Recently, Silicon Systems, Inc. introduced a new line of tone decoder ICs. They are hybrid devices, containing an audio filter, time base, tone decoders and TTL-compatible output drivers all on the same chip. Cost wise, it is less expensive to use the SSI IC as opposed to other methods, and the finished unit is considerable smaller" (1991 ARRL Handbook 34-3).

The Silicon Systems chip cuts down on cost and can connect directly to the phone line and computer, eliminating massive amounts of external circuitry, so that's what this system uses.

The ring detect circuitry is simple and costs around $3.00 to implement, but the off-hook circuitry is a little different. An off-hook detector must be placed in series for each phone on the system, because if someone picks up a phone somewhere in the house and enters a touch-tone code into the keypad, the computer has no idea which phone is sending the code unless some sort of special ID code is entered each time someone wants to access the computer, and the computer needs to know who is sending the code. For instance, if someone picks up a phone and presses the number 7 to call room 7, the computer must know which room is calling room 7 in order to know which intercom speakers to turn on. Putting in all these off hook detectors is not only costly, but phone lines don't always run to a central node but often branch off from a trunk, thus, the entire phone wiring of the house must be changed so that there is a node and it is near the computer. This also consumes extra wiring, but without these sensors, many of the systems features would not be possible--such as the off-hook shutdown in the example when and I locked the keys out of my car.

The output devices are far more numerous. The computer must control a speech synthesizer, do all phone and intercom switching, pick up the phone, dial the phone, blink LEDs, disconnect and reconnect individual phones, switch between the Bell system and the self-powered home system, and even control the answering machine.

"The SPO256 (Speech Processor) is a single N-channel MOS LSI device that is able, using its stored program, to synthesize speech or complex sounds" (Archer Technical Data 1). This is the chip used in the phone network. It has the ability to generate the 59 phonetic sounds needed to produce English speech, but it is no larger than a postage stamp and costs under $12.00.

All the intercom switching is done by transistors and relays. Relays are not solid-state components, but they are cheap to use. The dialing of the phone is done by the sound chip built into the Commodore 64, since it is able to synthesize the correct frequencies for DTMF, or touch-tone, dialing, which is a great benefit since even a stock IBM can't do this without additional hardware.

The computer software is simply a BASIC program running a few machine-language subroutines which can be individually tailored by the programmer to his specific applications. For instance, one could program it to announce all calls on every speaker throughout the house until 11 o'clock at night when the system would then only announce a call to that callers bedroom, so not to disturb anyone else. Or the system can be programmed to simulate call-forwarding. Real-time call-forwarding would require two telephone lines or else a special service with the phone company, but the system could be programmed for shared-time-call-forwarding (my own phrase) which could use the phone line in sort of a time-domain multiplexed way. A caller could call and leave a message on the

answering machine, and as soon as he hung-up, the computerized system would pick up the phone and dial a preset number of his current location and then play the message. This would eliminate the need for him to keep calling his answering machine to check for new messages, a feature many answering machines have. Any feature imaginable could be programmed in, as long as the computer is given the correct information about its environment through sensors, and is given the ability to carry out its programming, through electronic and electro-mechanical devices. Even an alarm system that automatically calls the police could be programmed in, with only the need to add a few sensors on each door or window. So this system is much more versatile than the standard PBX.

Many people do not have the time, desire, or knowledge to build their own home telephone network, but money, however, is definitely not a problem. A system like this could be set up for around $100, the price of just an answering machine alone. Just the fact that something like this is possible for such a low cost is an indication of things to come. Microprocessor-controlled answering and voice-mail machines already have many of these features, and it would be fair to assume that in the future, they will incorporate miniature PBX machines inside their tiny plastic cases. But the versatility and ability to customize the home-built machine I have described above will never be matched, simply because of the complexity of the equipment and the knowledge the operator must know in order to use the equipment. However, business systems are a different story.

In the November 26, 1990 issue of Telephony, Adam Rehin wrote in an article called "Calling on CSTAs" that "to accommodate users that want to improve the effectiveness and control of their operations, manufacturers have responded with computer-supported telephony applications (CSTAs) that provide functional integration of computers and telephony.

At the heart of CSTA is a link between a telephone switch--typically a PBX--and a computer that allows commands and status information to be passed between them . . . . The focus to date has been on enhancing computer applications by providing commands for controlling and monitoring telephone calls.

One example is an application that can monitor an extension to determine its status. When the phone rings, the system can answer the call, transfer it to another extension, set up a conference call and finally hang up--all without human intervention . . . . A voice device can do initial caller screening, for example, if the caller has a phone with dual-tone multifrequency (DTMF) that can interact with the device" (26-7).

My poor man's system can do all that.

Geoff Tyler wrote in an article called "PBX-Plus" in the February 1991 issue of Management Services, "Good systems will also give statistics on how well the call handling function is performing with figures and graphs which show the position in real time . . . . Electronic directories for telephone operators are another example of once stand-alone systems coming on board the PBX. Operators now have on-screen name directory and single key-press connection therefrom on even quite modest PBXs" (36).

My poor man's system can do all that, too.

Actual business systems that are in use today have many of the same features in my poor man's system, they are just more expensive. The article "Call Processor Steps Up Claims Handling" from the December 1988 issue of TPT/Networking Management talks about a new Dytel AAX (Automated Attendant eXchange) call processing system and states that "the new system is custom-designed to answer each incoming call to MP&L's [Metropolitan Property & Liability Insurance Co.] claim center, and then prompt callers using Touchtone equipment to enter a '1' or a '2' to indicate a new or existing claim . . . . Callers with existing claims are asked to enter a three-digit code that they are given upon initially making their claim to MP&L. The code automatically identifies their geographic region and connects them to the appropriate claims agent" (50).

Similarly, in "Hybrid Adjunct/Applications Processors: Integrating Voice and Data in Public and Private Networks" by Tom Watson in the June 1991 article from Telecommunications, he writes, "In Europe, a bank in Belgium is employing a large-scale Unisys processor to handle sophisticated tele-banking applications. The bank's system enables customers to not only access information about their accounts, but to actually conduction transactions through touchtone commands to the bank's central mainframe" (22).

And yes, my little Commodore 64 can do the same things as their "large-scale Unisys processor". It's just on a smaller scale.

In the December 1991 issue of Lodging Hospitality, Grace Wagner writes, "Cost-saving and guest-pleasing improvements come in all shapes and sizes. It may be as simple as rethinking some of your operational procedures or updating your PBX with the latest software . . . . Other software options include flexible room/suite designations, allowing multiple rooms and lines to share wakeup calls and voice messaging services; multiple automatic wakeup calls, where each occupant of the same guestroom can receive his/her own wakeup call; and flexible credit limits and restrictions on phone charges, which hotels can establish based on an individual guest's cash deposit or credit card limit" (108).

It's all in the software. That is where the true power of such systems and my poor man's system lie. You give the computer the means, and then it's all up to what you tell it to do.

The economic implications for such devices are good for the businessman since he saves money.

"MP&L's management had worried that customers might have a negative impression of the automated telecom system. The results of a customer survey indicated, however, that there was no dissatisfaction with automated call handling and routing. In fact, comments in response to a survey of over 200 policyholders who used the system in the Cleveland facility indicate that clients appreciate the improved, quickened response" (TPT/Networking Management 51).

The outlook is good for such a system in the business and in the home--there is definitely a need for it. But as for myself, I have never actually built the phone network, just designed one. It's still in the theoretical and prototyping stages and will probably remain that way until I get some more money, for I am a starving, deprived, poor man of my own.

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