Figure 11.8b. COSTS OF POOR QUALITY AND PRODUCTIVITY: Service Industries

EM9005a: New York Times, January 16, 1990, pages A1, A24 and A25

Computer Failure Disrupts A.T.&T. Long Distance

A new worry: is the phone system vulnerable to rogue programs?

By CALVIN SIMS

Millions of people were unable to make long-distance calls yesterday after the American Telephone and Telegraph Company suffered a major failure in the computer program that operates its new long-distance switching equipment.

A.T.&T. said about half the long-distance, international and toll-free 800 calls dialed on its network were not completed. Callers who tried got a busy signal or a recorded message that the call could not be completed because all circuits were busy.

Shortly after midnight the company announced that the computer problem appeared to have been solved and that the switching system had been working normally since 11:30 P.M. A spokesman, Walter Murphy, said the company expected the network to operate normally today, when it will face a heavy volume of workday calls.

"We have put in place some software fixes that stabilized the network and contained the problem," he said. "The root cause of the problem is still to be investigated and determined, but the network should process calls normally today."

Yesterday's telephone problems were spread across the country. Businesses needing instant access to places thousands of miles away had trouble getting through. Rental car companies and hotels reported fewer reservations than normal.

Officials noted that the breakdown caused fewer problems than it might have, because banks, government offices and many businesses were closed for the holiday honoring the Rev. Dr. Martin Luther King Jr.

The company said it noticed the problem shortly after 2:30 P.M. Eastern time. At its network operations center in Bedminster, N.J., a technician who spoke on the condition of anonymity described the scene as "chaotic and almost out of control" as engineers scrambled to identify the problem.

By late afternoon they found it: a failure in the new computer softerware that expedites the switching of calls from one part of the network to another. The new system finds the most efficient path for long-distance calls to travel over the network by allowing the switches to communicate with each other before they process the calls.

Engineers from Bell Laboratories, the telephone company's research arm, then began work on software that would override the problem.

A.T.&T.'s major rivals, the MCI Communications Corporation and the US Sprint Communications Company, also use the new switching technology, but they reported no problems with their long-distance networks yesterday.

MCI and US Sprint did say they received a flood of calls from customers who normally use A.T.&T., which controls about 70 percent of the long-distance market. A.T.&T. operators refused, even when asked, to tell subscribers that they could place their calls with other long-distance carriers by dialing access codes. The operators said they did not know the access numbers, and that it was against company policy to provide information on a competitor.

The failure of the system, which is considered the most sophisticated telephone network in the world, raises questions about the vulnerability of the nation's telephone system to malfunctions in computer software and rogue computer programs like viruses and worms. But Daisy Ottmann, an A.T.&T. spokeswoman, said the failure was "not a virus or worm or anything insidious like that."

"We know what the problem is, and our engineers are in the process of fixing it," she said.

Because of the King holiday, the effects of the breakdown were not as severe as they might have been. But there was no shortage of problems. "I cannot call out," said Art Morriston, regional duty officer for the Federal Aviation Administration in Los Angeles, which covers air traffic in California, Arizona, Nevada and Hawaii. "I've been trying to call a lot of people." But he added that air traffic and safety were not affected because those communications are by microwave transmission.

Other businesses fared better. Sharon Gamsin, a spokeswoman for the New York Stock Exchange, said the financial market was not hurt by the network problems even though it uses A.T.&T., and Roy Berces, communications manager for the Pacific Stock Exchange, said: "Basically, there was minimal interruption. The network trading system has been designed to take this into consideration and switch to an alternative carrier." In Japan, the telephone company KDD reported problems with connections to the United States in the morning but said they eased as the day went on.

'All Circuits Are Busy'

Oriette Mani, manager of the Azer Travel Agency in Los Angeles, said her office had been having trouble making hotel and air reservations for clients. "I've been experiencing problems with 800 numbers," she said. "They say all the circuits are busy."

Kendra Silverman, a spokeswomen for the Hilton Hotels Corporation, said the corporate offices in Los Angeles were having trouble placing calls but added: "It's not disrupting business to any serious degree. I'm able to get through if I'm persistent enough. It may take 10 calls."

On a normal business day, the long-distance network handles about 80 million calls. In the first three hours after the problem developed, the company said, well over half the calls dialed were not connected. "In my 20 years I have not seen a situation that affected as many cities as this," Burke Stinson, a company spokesman, told The Associated Press.

A.T.&T. subscribers who find that its service is unavailable can use MCI's network by dialing an access code, 10222, and then 1, the area code and the telephone number. US Sprint's network can be reached by dialing 10333. Users are charged the same rate as the network's regular customers, and are billed through their local telephone companies.

The new switching system, which is the apparent cause of the problem, is designed to process twice as many calls as the previous system, which is now handling most of the calls on the network.

A.T.&T. had a similar disruption in 1988 when a construction crew in New Jersey accidentally severed a fibre optic communications line. The company had to reroute hundreds of thousands of calls from its network operations center in Bedminster, N.J., and there were major delays in service.

(*continued overleaf*)

EM9005b: *Struck Dumb by the Incredible: 1-800-NOTHING*

By JAMES BARRON

In an age of instant communication, when entire encyclopedias of information are transmitted over telephone lines in minutes and businesses count on getting through to far-flung offices in seconds, the loss of telephone service is unthinkable.

Yesterday, America thought about it. For a few hours in midafternoon, millions of people did what they always do – they dialed a 1, an area code and a number. And then, nothing. Or a mysterious busy signal. Or a recording saying, "All circuits are busy."

Suddenly, the heat was off in telphone boiler rooms. Operators were standing by at toll-free 800 numbers. Fast-talking clerks in rental-car reservation centers had no one to quote prices of subcompacts, compacts and full-sized models to. Information-retrieval services had huge pileups of information waiting to be disseminated. Home shoppers who wanted to let their fingers do the walking couldn't. Long-distance romancers were blocked from babbling their sweet nothings, but could scribble them in love letters sealed with a kiss. Telemarketers, who never called a customer they didn't like, could only sit and wait.

Because calling in was a problem, so was checking in. "I can tell you this is the most serious thing I've seen in terms of phone-service problems in the 18 years I've been in the business," said Robert Salmon, an executive of Holiday Inns of Salt Lake City, with 300 operators.

On the theory that roomlessness is worse than phonelessness, Holiday Inns tried to reroute its East Coast calls, which normally go to a reservations center in North Carolina. Some of the calls went to Mr. Salmon's operation, and others to a similar center in Chicago.

Calling out was no easier. Mr. Salmon said he was unable to reach the company's Memphis headquarters.

"Sometimes you get through and sometimes you don't," said Linda Daroci, the chief operator at the Airport Marriott Hotel near Los Angeles International Airport.

Some travel agents complained that they were getting nowhere, even though they dialed airline reservation numbers over and over. The airlines realized something was wrong when the phones stopped ringing. An American Airlines spokeswoman, Mary O'Neill, said the number of calls coming in dropped by two-thirds.

At British Airways, a clerk, Mike Juliano, said things became unusually quiet between 2 and 4 P.M. in the reservations center in Queens. "At a certain point in the afternoon," he said, "we didn't get as many calls as we would have gotten normally."

The sound of no phones' ringing caused some worry about red ink. A branch manager for Dial America Marketing in Omaha, David Haller, told The A.P. that if the phone problem was not repaired quickly, his magazine-subscription company would lose a minimum of $20,000, "and that's conservative."

Entrepreneurs were not the only ones with phone headaches. The only big domestic story on "The CBS Evening News" last night was about how millions of long-distance callers who use the American Telephone and Telegraph Company could not get through. The only problem with covering the big story was the story itself. Producers at the CBS Broadcast Center in Manhattan could not get through to news bureaus. Donna Dees, a CBS News spokeswoman, said the network solved the problem by switching its voice-communication lines to ITT.

Computerized information-retrieval services, which can summon items like 10-year-old newspaper clippings or 10-day-old court decisions, kept on retrieving information. But the Lexis and Nexis services could not send out the material from their headquarters in Dayton, Ohio.

A customer-service representative, Nicky Foster, said 377 printers around the country that were connected to telephone lines were dead for an hour. The delay stretched on for so long that forgetful newspaper reporters trying to retrieve stories they wrote months ago forgot what they were trying to retrieve.

"Unfortunately when it's A.T.&T., we're at their mercy," said Linda Gibbons, Ms. Foster's boss. "Certain things are beyond our control."

1. The main theme of the articles EM9005a and EM9005b reprinted in this Figure 11.8b is how, in our present technological societies, the consequences a mistake in a computer program can adversely affect a large number of people.
   - Identify situations, *other than* the telephone system, where there could be significant adverse effect(s) from computer software failure; in each case, outline the *nature* of the effect(s).
   - Indicate whether you consider that, in general, software failure is of more or of less concern than *hardware* failure; briefly justify your assessment.
     - Compare and contrast the type(s) of precautions that can be taken to guard against the two categories of failure.

2. Outline the steps that you expect A.T.&T. took to check the correct functioning reliability of its switching software *before* it was installed in the 114 switches.
   - Explain briefly whether the failure which is the subject of this Figure 11.8b provides *strong* evidence that these checks were *in*adequate.
   - Compare and contrast the difficulties of ensuring correct functioning of the switching software (*this* Figure 11.8b) and that of artificial heart valves (Figure 11.6a on page 11.29) and of condoms (Figure 11.7b on pages 11.34 and 11.35).

3. In the sixth paragraph of the middle column of the article EM9005b *Struck dumb ....* reprinted above, British Airways clerk Mike Juliano is quoted as having said: *At a certain point in the afternoon, we didn't get as many calls as we would have gotten normally.*
   - Explain briefly how we usually *model* number of in-coming telephone calls; your answer should include a statement of the *assumptions* on which the probability model is based.
   - In light of this *stochastic* modelling, what information would Mr. Juliano need to supply to provide a reasonable justification for his claim of a reduced number of calls in the period under discussion.

(*continued*)

Figure 11.8b. COSTS OF POOR QUALITY AND PRODUCTIVITY: Consumer ..... (continued 1)

EM9006a: New York Times, January 17, 1990, pages A1 and B7

A.T.&T. Pinpoints Cause of Phone Disruption

By CALVIN SIMS

The American Telephone and Telegraph Company said yesterday that it had traced the huge disruption in long-distance service that occurred Monday to a single computer program that malfunctioned and caused a chain reaction in the network.

Company executives said the malfunction occurred in a program at a giant computer switching station in the New York metropolitan area, causing the computer to send out alarm messages to other switching stations.

As a result, many of the 114 switching stations across the A.T.&T. network were essentially frozen, and for much of Monday afternoon and night about half of the national and international long-distance calls were not connected.

By disclosing the problem and saying they had solved it, company officials sought to allay their customer's concerns about the network's reliability. The officials also offered business and residential customers some minimal reimbursment for losses that may have resulted from the service disruption.

Businesses that rely on the telephone to conduct their affairs reported that they lost tens of millions of dollars in missed sales when the switching system failure disrupted most of the long-distance, international and toll-free 800 calls across the country.

For residential customers, the breakdown of the company's network, which is regarded as the most sophisticated telephone system in the world, caused confusion and frustration.

In a meeting with reporters at the company's network operations center in Bedminster, N.J., Robert Allen, A.T.&T.'s chairman, said company engineers worked through the night to resolve the problem and that he doubted that it would occur again.

Mr. Allen said that A.T.&T. had received many complaints about lost revenue from business customers who lease toll-free 800 and outgoing long-distance lines. But he said the company is not liable for business losses that result from service disruptions. He said the company would honor service agreements that require A.T.&T. to pay business customers $20 or $50, depending on the type of toll-free service, for each billed line that was out of service.

'Didn't Live Up to Standards'

To console its residential and business customers who had difficulty completing long-distance calls on Monday, A.T.&T. said that it would seek permission from the Federal Communications Commission to offer customers a day of discount calling, comparable to the price cuts offered on any holiday. Monday was a national holiday commemorating the birth of the Rev. Dr. Martin Luther King Jr.

"Even though it was a one-time hit to the network, it was certainly the most far-reaching service problem we've ever experienced," Mr. Allen said. "We didn't live up to our own standards of quality. We didn't live up to our customers' standards of quality. It's as simple as that. That's not acceptable to us."

The network failure is a major embarrassment for A.T.&T., the nation's largest long-distance carrier, which has tried to differentiate its service from that of its competitors by advertising the quality and dependability of its network. Telephone industry analysts said the long-distance disruption was a major blow to the company's reputation, and gives the company's rivals, the MCI Communications Corporation and the U S Sprint Communications Company, new firepower in their battle to gain long-distance customers.

"The conventional widsom among telecommunications managers is that you don't get fired for choosing A.T.&T. because it has this aura of invulnerability," said Frank Governali, an analyst with First Boston. "That wisdom changed yesterday. The failure of A.T.&T's network helps give the perception that the other guys can do just as well."

MCI, based in Washington, was quick to take advantage of A.T.&T.'s mishap. "People are starting to review whether they want to have their service with only one carrier," said Kathleen Keegan, an MCI spokeswoman. "We are seeing a slight increase in calls from customers who want to sign up or just ask questions."

Richard Firestone, chief of the common carrier bureau of the Federal Communications Commission, said that the agency had been closely monitoring the situation and was pleased that A.T.&T. had acted quickly to restore service. "The commission has long been encouraging competition in the long-distance industry and one of the rationales is that it provides consumers with alternatives in case there are problems like A.T.&T.'s," Mr. Firestone said. "This situation has served as a learning experience for us all."

A.T.&T. said that although its operators initially refused, even when asked, to tell subscribers that they could place their calls with other long-distance carriers by dialing access codes, the operators were later instructed to give the codes to residential customers who requested them.

The telephone company also said that at the request of a business customer, it attempted on Monday to switch the customer's toll-free 800 service over to a competitor's network but that its engineers were unable to make the connection. A.T.&T. said that it had informed both MCI and U S Sprint of the difficulties it had experienced on its network.

Problem is Pinpointed

The problem turned out to be an error written into the original program that instructs the switching computers where to route the telephone calls. A.T.&T. computer scientists wrote the program, which finds the most efficient path for long-distance calls to travel over the network. The company said that the program had been installed in all of its switching stations and that there had been no major problems with it until Monday.

Company officials said that the malfunction could have occurred at any of the switching stations and that they did not know yet why it occurred in New York. But once it did, it caused all the other programs to start generating the alarm signals.

Once the problem was pinpointed, A.T.&T. officials said, they were able to override the problem program with one that was error-free. They said it would be several days before they would have a permanent solution to the problem.

Asked if the company was certain that the problem was not caused by a rogue computer program like a virus or worm planted by a computer hacker, Walter Murphy, an A.T.&T. spokesman, said, "We can't categorically rule it out but we remain confident that it was not sabotage that caused this disruption."

The switching problem occurred at about 2:25 P.M. on Manday and was resolved at about 11:30 P.M. The giant telephone company said that of the 148 million calls that were dialed on its network Monday, about 56 percent, or 83 million calls were completed.

One company, Idelman Telemarketing Inc., based in Omaha, estimates that it lost $65,000 to $75,000 in service revenue when most of its outgoing long-distance telephone lines crashed, forcing it to send about 800 service representatives home early for the day. Idelman, one of the nation's largest marketers of products by telephone, estimated that its clients lost $100,000 to $200,000 in merchandise sales.

4 In the second paragraph of the middle column of the article EM9006a reprinted above on this page 11.43,, Mr. Allen, A.T.&T.'s chairman, is quoted as having said: *We didn't live up to our own standards of quality. We didn't live up to our customers' standards of quality.*

- What do you infer Mr. Allen means by *quality* in these two statements? Briefly justify your interpretation(s).
- Do Mr. Allen's meaning(s) of quality involve *reduced variation* (*e.g.*, as in Figure 11.3a on pages 11.11 to 11.14)? Explain briefly.

(*continued overleaf*)

EM9006b: **News Analysis**

A Superhuman Collapse – A.T. &T.'s Troubles Show How Computers Defy Understanding Even When They Fail

By JOHN MARKOFF

The failure of American Telephone and Telegraph Company's long-distance switching system on Monday is a warning of the troubling vulnerability of the nation's complex computer networks to unpredictable breakdowns, either accidental or deliberate, computer scientists said yesterday.

The computer systems that increasingly control telephones, bank cash machines, electric power and other routine daily necessities are growing so complex that they defy human understanding, thus making it all but impossible to predict all the ways they might fail.

"When you have an extremely complex system, there can be very simple hidden failure modes that nobody has any idea about," said Peter Neumann, a computer scientist at SRI International who has studied risks involved in designing complex computer systems.

The innate peril of this computer complexity was highlighted by the A.T. &T. breakdown because the telephone company's switching network was designed with exactly this kind of breakdown in mind. Even though the system was created to prevent any single failure from incapacitating the nation's telephones, that is what happened.

Tracing the Problem

The telephone company's system has been cited as evidence that extremely complex computer systems can be virtually flawless. Indeed, some computer and military experts believe that a space-based anti-missile system composed of thousands of independent sensors and computers could act reliably.

Late yesterday, A.T. &T. officials said they had traced the problem to a faulty program running on a computer that determines which path a long-distance call takes. The faulty program, a new version of the switching software, sent a swarm of overload alarms to other computers in the network, causing widespread congestion.

The computer network should have responded by finding alternative routes for the calls; instead, about half the long-distance calls ended in busy signals or recorded messages for nine hours Monday afternoon and evening.

A.T. &T. has still not explained why the system failed to compensate for the failure of a single component, but the failure is seen as troubling evidence of how vulnerable technology-based systems are to even slight disruptions.

Rogue Program is Recalled

This vulnerability was highlighted in another way in November, 1988, when a lone graduate student disabled a nationwide computer network used by military installations, research centers and universities by inserting a rogue program that copied itself wildly throughout the system.

A.T. &T. said yesterday it does not believe its long-distance network was a victim of sabotage.

In 1980, an experimental computer data network called Arpanet that served as the basis for the network that now controls A.T. &T.'s telephone network failed unexpectedly. Afterwards, its designer determined that a failure of a small electronic circuit in a single computer coupled with a small software design error, propagated instantly through the network, stopping it instantly.

"It may turn out that something similar happened here," said Jonathan Jacky, a University of Washington computer scientist. "Both networks were supposed to have intelligence that precluded a single failure from causing a network crash."

In another example, in 1987, computer designers at TRW Inc., a large government contractor, were surprised to find that a computer network they had strung together in Europe for a United States intelligence agency was exhibiting strange, unpredictable behaviour. On close examination, the engineers discovered nothing wrong with the design of the system, which linked hundreds of computers as part of a military data communications network.

They later said they suspected that they were confronted with the mathematical concept called chaos, a way of describing otherwise unpredictable manmade and natural phenomena like turbulence in rapidly moving water or in the atmosphere.

A.T. &T.'s managers said they first became aware that something was wrong Monday when a giant map of the United States on the wall of the company's network operations center in Bedminster, N.J., began lighting up at 2:25 P.M. The lights were messages from the computers that route long-distance phone calls that they were overloaded. The trouble messages, which are displayed visually on the board, cascaded across the map.

'Just Seemed to Happen'

"It just seemed to happen," 'said William Leach, manager of A.T. &T.'s network operations center. "Poof, there it was."

Also yesterday, network designers at MCI Corporation said that they may have experienced a similar but less significant problem than A.T. &T.'s when lightning struck one of its computerized long-distance switching centers in Ft. Lauderdale, Fla. The strike disabled a network communication switch and jammed five of the company's signal transfer-point computers. But the system was able to handle the outage, successfully routing calls around the troubled areas.

MCI executives said they had installed a version of the same software that caused the A.T. &T. failure, known as Signaling System 7, last April.

5 State the definitions of *independence* as the term is applied in probability theory to *events* and to *random variables.*

- Compare and contrast *these* uses of *independence* with that in the phrase .... *independent sensors* .... near the end of the fifth paragraph of the article EM9006b *Superhuman Collapse* reprinted above.

6 A recurrent theme of the article *Superhuman Collapse* reprinted above is the possibility of malfunction of large computer systems in unforeseen ways as a consequence of their extreme level of complexity. Outline the underlying reason(s) for this phenomenon.

- The capabilities of the human brain appear to mimic some of the characteristics of large computer systems. On the basis of your own experience, indicate briefly how far this analogy is valid with respect to brain malfunction(s) in unexpected ways; make it clear in your answer what aspect(s) of your experience you draw upon.