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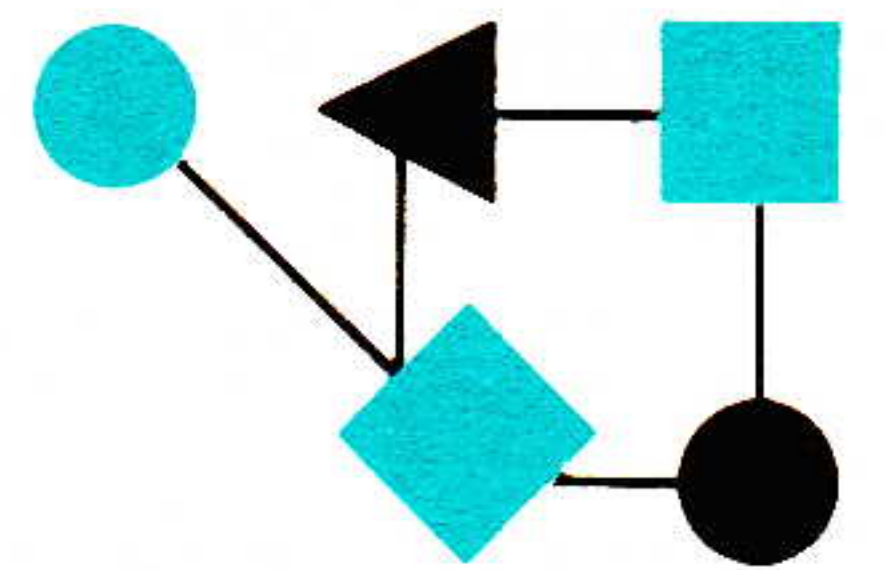
The Interoperability Report

*ConneXions —
The Interoperability Report
tracks current and emerging
standards and technologies
within the computer and
communications industry.*

In this issue:

From the Editor

Reading the popular press it is easy to get the impression that *everyone* is using the Internet. While the exponential growth would certainly tend to support this notion, it is still the case that you need several pieces of equipment in order to "get connected." In other words, the Internet is still mostly for the "computer literate" segment of the population. But what if everyone was provided with an Internet "terminal," much like the way you used to automatically get a telephone set when subscribing to phone service? Well, this is effectively what has happened in France with the *Minitel* system, although Minitel subscribers aren't necessarily Internet users (yet). We asked Jack Kessler to give us an Internet-centric overview of Minitel and discuss some of the lessons learned from this mass-deployment of computer technology to the "general public."

Few parents would dispute the degree to which their children are "computer literate." There seems to exist a natural magnetism between computers and kids, and it is not surprising that so many educational institutions strive to integrate computers into the classroom. And with computers follows networking. A recent informal census estimates the number of teachers and students in the US using the Internet at almost 500,000. Tracy LaQuey Parker gives an overview of various "K–12" networking efforts.

Operators of large networks generally have to develop their own management tools, based on specific requirements. Our third article, by Bill Norton, describes the network management discovery algorithm used to determine the state and topology of the NSFNET.

Every network manager faces the issue of how to deal with existing, proprietary networking technologies that somehow need to be integrated into a whole. In some cases this may mean phasing out a particular technology over time. Craig Finseth discusses the future of DECnet at the University of Minnesota.

The Internet faces one of its biggest challenges to date. Due to the incredible growth of the system in recent years, the 32-bit Internet address space is becoming depleted. Since routing and addressing is performed at the *Internet Protocol* (IP) layer, a new addressing structure means changes to IP itself. Several groups have been working on replacements for the current IP version 4 (IPv4). These efforts are collectively referred to as "IPng" or "IP: The Next Generation." Next month's edition is entirely devoted to IPng. Read all about the selection process, analysis of the problem, and outlines of each of the IPng proposals. Make sure your subscription is current so that you will receive this special issue!

Baby Bell Minitel?

Internet Competition from the French Connection

by Jack Kessler

The Telecom Giants

So the telecom giants are converging on the previously-tidy little world of internetworking. So the Viacoms and QVCs and TCIs and Paramounts and Baby Bells—with their Martin Davises, Sumner Redstones, Barry Dillers, and John Malones (Microsoft and Bill Gates will be in there somewhere)—are descending: upon the careful, comfortable, rigorously-standardized "academic testbed" which until now has brought us "BITNET" and "The Internet" and internetworking generally. This is the old news, now.

But the new, breaking, news is the decision—not yet made, quite—of just what approach to telecommunications is going to be adopted by "the giants," or those which emerge victorious from the current telecom merger bloodbaths. Will they simply plug into the Internet? That seems unlikely: there is much which they appear to want which the Internet does not yet offer, and much which the Internet offers which the mass marketers who run the telcos and cablecos do not much want. The marketers need multimedia and simplicity, for instance, neither of which the Internet does well yet; and they don't need the bland interfaces and arcane command and indexing structures, which so often succeed only in making the current Internet appear to be "information-overloaded."

But is there an alternative? Does the Internet have any competition? The easy marketing answer is: yes—always—there are competitors out there, and there will be more. Monopoly is the dream of every product developer, and it's always an illusion.

The competition: Minitel

Minitel is one Internet competitor. You wouldn't know it, from conversation on "the net." "The net" appears to be synonymous with "The Internet," at least to the 2-PhDs-per-household, 6-figure-income world of current US networking. But the new networking byword, even in the US now, is "general public": this is the market most interesting to the commercial giants which will run US networking in the next century. It is a world also interesting to certain foreign governments which are trying to leapfrog non-ASCII-American-English-speaking populations into the 21st. The Internet does not address this relatively impoverished, uneducated, polyglot world of the "general public," yet.

The French Minitel, though, already is "general public." It has been, since its 1972 introduction. The marketing legend is that the government originally gave terminals away for free, loaded the telephone books online, and then stopped printing the books. (No one admits this now, although they do say that the printed books were hard to come by for awhile back then). Today, 17,000 services are offered, from home shopping to reserving items at the Bibliothèque Nationale to the infamous "sex chat" of "Minitel Rose." All this arrives via 7 million terminals (no longer free, but still cheap), and many millions more free diskettes and commercial "V.23" terminal emulation programs for Macs and PCs.

Users

The total number of Minitel users?: that depends on assumptions about statistics which are as shaky in the French case as they are when applied to the Internet. Minitel knows that nearly 7 million terminals are "out there," with several million more potential terminals in place via Macs and PCs equipped with emulation programs.

Recent estimates of Internet usage rely on a factor of 10: from 2 million known current Internet "servers," they assume 10 human users per server to reach current figures of "20 million Internet users." The same logic, applied to Minitel, might yield 100 million Minitel users! Specious, no doubt—the assumptions cloak all sorts of statistical unknowns, such as the number of unused Internet accounts and Minitel terminals lying around in US academic computer centers and French homes, and the number of uses "typical" of US academic use versus French domestic use. Still, there are a *lot* of Minitel users now. Comparing Internet/Minitel total user figures is networking overkill "bean-counting." The point is that both systems are quite comparably-huge and are growing rapidly. France Télécom claims that usage-time, a figure which they are able to tabulate accurately, now is approaching 10 million hours during some months.

The basic technology is simple, and perhaps even crude by current networking standards. The Minitel is videotex: cute little alpha-numeric graphics screens with rigid indexing and command structures, putting out text and images at intolerably low levels of resolution—25-line pages only 40 characters wide, like those little "information" stands which populated US airports for a while a decade ago—and at insufferably slow rates of speed (1200bps).

Speed

Minitel's current low transmission speed is a major problem. Minitel, New York's able Philippe Belvin explains the problem faced in France itself. There, France Télécom and Alcatel populated the countryside, a decade ago, with smart PADs—*Packet Assembler Dis-assemblers,* known as PAVs—*Points d'Accès Vidéotex*. These were based on the now-outmoded "V.23" norm, which provides for 1200bps maximum input and only 75bps output from a user's modem. The idea at the time, Belvin explains, was to provide for normal typing speeds for output: terminal users typing at more than 9 words per second were not foreseen, but neither was uploading of large datafiles from emulation-package-equipped Macs and PCs. For the latter application—and for fast typists—"V.22bis" (2400/2400bps) and "V.27ter" (4800/4800bps) norms now are being used in the US and elsewhere, and 9600 and 14400 are under development, but at home in France there still is the problem of replacing all those very slow old 1200bps PAVs. (They say this will be done by end-1994; but we'll see, and it will be interesting to see who wins in the current raging debate over exactly what to replace the old standard with.)

Transmission speed, though, is a universal problem. There is high-speed work under way in France. France Télécom presented—at INTEROP Europe 93 in Paris last fall—T3 applications (actually E3, 34Mbps rather than the US T3's 45Mbps, but same idea and problem) including entertainment and news video, a LAN interconnection service ("bandwidth-on-demand"), and ATM networks. France has super-computing, and one would expect their active participation—as a leading participant, second only to the US—in whatever develops from the current US gigabit testbed developments (now at 1.2Gbps and soon to move to 2.4Gbps).

But French networking practicality—this seems a contradiction in terms, to those who can remember the sad state of French telephony in the 1960s—is more remarkable than their equally-astonishing presence in the forefront of networking research. Imaging applications—including extensive videoconferencing—are being channeled to their already in-place national fiber optics and ISDN infrastructure:

Baby Bell Minitel? *(continued)*

Any French office or home now can have ISDN—two 64Kbps channels and one 16Kbps "signaling" channel—for US$ 60 per month. This may retard the development of higher bandwidth applications temporarily —times are hard financially in France as they are in California—but at least they have the applications off the drawing board and under way.

Both the "Numéris" domestic ISDN infrastructure and the Minitel are demonstrations of the French commitment to this networking practicality. They may be the "low end," but they also are the "mass market," and "mass market" is the key word for networking development for the mid-'90s.

Reasons for success

Minitel has solved, in addition, a number of basic problems which still confront the Internet:

• *Minitel is "fun":* So much of the Internet still appears to normal users in black and white, or via user interfaces which don't take full advantage of modern screen color and graphics capacities. Think of all the Internet "database" services—library catalogs, "information" services—which still appear, albeit through increasingly-elegant commercial telecom software packages, as boring, line-by-line, nongraphic text screens. As one accomplished interface designer has observed to this writer, what Internet interface-development needs is a "Waldo" factor: that innocuous little cartoon-character whom US children will search happily for, for hours, in drawings and cartoons and puzzles filled with similar images—a "fun" factor, something which will make the user *want* to use the graphics. Minitel already has this: all its services are designed to be colorful and graphically appealing.

• *Minitel is useful:* Minitel has a definite commercial orientation: starkly so, by comparison with the Internet's until now equally-definite *anti-*commercial background. Users of the Internet have been its own developers and advocates. But you don't ask the barber whether you need the haircut. Minitel has been customer-driven from its inception, by contrast, and has benefited from a decade of customer complaints and suggestions. The services which it now offers have been user-tested—by real, general public, users, and not just test-developers—over many years. This accumulated customer experience is a priceless marketing investment, which the Internet has yet to acquire.

• *Minitel is easy:* Ease of use is not an Internet hallmark. Its approach in fact has discouraged it: the technology and its applications were developed first, with thought given only after the fact to its ease of use by general users. The term "user-friendliness"—used most often to describe the lack thereof—has passed into the general language from its origins as a complaint against precisely the stubborn computer-type problems which still plague Internet users: delicate and Byzantine syntax, invisible and not entirely logical logic, "intuitive" features which are not intuitive, instruction manuals written in obscurantist American English—the panoply of Internet user interface problems still to be resolved intimidates even sophisticated academic users, and one wonders how it will be made appealing to the less sophisticated and far busier (less time to learn, and less interested) general public.

Minitel, by comparison, is simple and easy to learn, with nearly rigid standardization at most levels, and simple hierarchical structures easy to grasp for users for whom "Boolean" and "hypertext" searching would be merely nightmares: simplistic, by contrast, but Minitel works for the "general public." Minitel even tries to be multilingual—there are multilingual indexes and support services and efforts to accommodate English and other languages online—which put it well in advance of the network nationalism of the ASCII-speaking Internet.

• *Minitel is everywhere:* There is an advantage in being first-to-market. Whether one is the "best" or not, the fact that one got there "first" often gives a firm enough laurels to coast on through years of comparative decline in the quality of its product. This first-to-market advantage has been exploited heavily by computer hardware and software firms, as it has been in other industries. The strategy is to flood the new market with your product, whether the product is "really ready" for the market or not, and then to fine-tune things later: large offices are reluctant to shift to a "better" spreadsheet program, once they have invested the time and money necessary to train staff on an already-acquired one, almost no matter what improvements have been added to the newer program to make it "better."

The Internet's approach has not been marketing-driven, much less concerned with being "first-to-market," and it still isn't. It always has been hard to get Internet accounts, and then it has been hard to get help in using them. The Internet—despite its millions of "users"—still isn't in the American office or home, where the marketers dearly would like to see it. Minitel, on the other hand, already is everywhere, and it particularly is in the French office and home, reaching the French consumer. This was its design from its inception: France Télécom identified its "market" and proceeded to flood that market with its "product," no matter how imperfectly developed Minitel was at the time. Now that Minitel is "there," in France, it is much easier to "improve" it than it is to get over that initial threshold of introducing the Internet, for the first time, to the networking-shy American consumer.

• *Minitel is cheap:* The Internet is agonizing over commercialization this year: the "test" is finished—now things must begin to pay their way. There can be no one at this point who seriously believes that the Internet will be "free" in the future, although there still remain a few disgruntled users who protest their mistaken belief that it was "free" in the past. How much, then, is "cheap"?

Minitel users complain about Minitel prices. But there never has been a consumer who accepted pricing entirely happily: unless it was because the price was comparatively cheaper than some other—and such comparisons will have to wait until the development of network use pricing on the Internet and other Minitel competitors (price-comparing among similar Minitel services already is an active factor in Minitel use). The most interesting aspect of Minitel pricing, however, is that it dramatically demonstrates how hollow are some of the worst fears of the opponents of network commercialization. Minitel's pricing is not like the exorbitant charges of commercial online database vendors—$200–300 per hour, thousands of dollars per month—but more like the charges of telephone companies—pennies and sometimes a few dollars per minute: normal general public French users pay $.07 per minute for many basic services, and between $.17 and $.38 per minute for a vast array of regular commercial offerings.

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These are telephone-call-level charges, as they should be, and are as acceptable to consumers as are telephone rates (some people still feel that telephones should be free, too): they are not the stratospheric commercial database rates which people worried about Internet commercialization usually are thinking of.

So Minitel is 1) fun, 2) useful, 3) easy, 4) everywhere, and 5) cheap, all in stark contrast to at least current perceptions if not realities of the Internet: food for thought for anyone interested in the Internet's growth or marketing, and who doesn't want to hide her head in the sand about the Internet's competition.

Minitel is not taken quite seriously by its French users, and is not taken seriously at all by its non-French observers, as a real contender for the Internet's global market. But it has been improving and growing, steadily and now rapidly and aggressively. It's a mistake in marketing to ignore the competition, and simple arrogance to pretend that there is no competition. Consider, then, Minitel, which is a large and potent and rapidly growing internetworking force, at least overseas and perhaps—courtesy of the Baby Bells and cablecos—in the US in some form one day as well. Consider at least what the Internet might learn from the Minitel, and what the Minitel may rapidly be learning by studying the Internet.

The industry?

The industry which will develop telecommunications in the rest of the decade has gone through some major shifts in emphasis in the recent past, shifts which clearly reflect some of these Internet–Minitel differences.

"... the stories, movies and programs that people want to watch... Without the entertainment and information offerings, all the flashy technology that experts say will soon be heading into homes-from interactive television to the information highway—amounts to little more than hi-tech plumbing." (Steve Lohr, *New York Times,* national edition, 12/23/93, p.C4).

"Little more than hi-tech plumbing"?: the latest interactive television tools and the glorious new information highway!? Well, yes, there was a time when networking hardware, software and systems were central to everyone's thinking. Then there came a time when "applications" became important, hardware, software and systems having receded: having become easy enough, and inexpensive enough, for users and strategists concerned with users to go on to other things. Both these times now are past: ask any firm which got stuck selling just mainframes or even PCs, or programming and custom software. Now it's neither the infrastructure nor the applications: both are firmly established, in industries dominated by cutthroat behemoths and foreign competition—no place any longer for under-funded start-ups.

Now it's the users: the clients, the voters, the customers. Who will they be? What will they want? What will/should the systems be designed to give them? Firms which have the answers to these questions can stake claims in the latest networked information market niche to fall open to new entries. Firms which develop expertise in marketing—in anticipating and answering user demands and needs—will dominate this niche, in this phase in which the general public, at last, is to get access to this technology. The point is that the industry will stay on the point, and that firms which get distracted by other, older, less-central concerns—like hardware and software and even networks—will miss their market.

The concept!

So the customer is king, in this new phase of information networking development. The demands of hardware and software—of the technology—don't dictate the way they used to. This is the long-awaited dream of several of the industry's leading apostles, who have longed for the day when the technology would become "invisible." Things are getting so easy and omnipresent as to be taken for granted by the users, like the telephone or any other now-common tool. We're nearly there, although not everyone in the industry wants to admit it. The question now becomes, "what will the customer want?"

A 1970's expression, coined during a more free-wheeling and acquisitive time than these belt-tightening and penny-pinching 1990s, was, "unclear on the concept." This was said back then of those who didn't properly appreciate the true meaning of the latest giant corporate merger and/or acquisition. Today it might be said of those who still think that the telecom giants—Baby Bells, cable companies, or whomever—who are crashing in quickly on the information networking party are going to be interested in purveying the refined and high-principled academic content currently carried on the Internet. Of course there are lapses, even on the Internet: USENET is rowdy, and heaven—or someone—only knows what goes on in personal e-mail (some Internet service providers, and certain foreign governments, would like very much to find out). But generally the Internet's traffic content is pretty sedate.

Sedate, that is, by comparison to what any reasonable forecast of the intentions of the cable companies, and the global entertainment industry which is behind them, might predict. "Entertainment" is a polite word for what the opening of networking to the general public undoubtedly will involve. An even earlier generation—the 1960s, this time—would have called it, "sex 'n' drugs 'n' rock 'n' roll." There's much reason to fear it, it's nearly impossible to control it, and it's foolish to deny its existence.

And if the majority wants it, the majority probably will get it. There are in addition, though, brave attempts being made to carve out a reserve for minority concerns and interests on the new "nets." Uses like community information networks, educational applications, and libraries, have their advocates. Vice President Gore and Representative Markey—among others in government prodded along relentlessly and effectively by Mitchell Kapor and the Electronic Frontier Foundation—are leading the rising movement to carve a "National Public Network" out of the Information Superhighway's high-speed traffic jams. There will be, in other words, "sex 'n' drugs 'n' rock 'n' roll"; but there also will be community bulletin boards, distance education, online libraries—these latter services perhaps traded for the right to purvey the former, along the lines traditional to the FCC and government regulation generally—whatever the customer wants, and then some.

The emphasis, though, clearly has shifted at last to the networking customer. The purpose now, finally, is to please that customer, and no longer to conform to the restrictions of the technology. Approaches and firms which realize this will win: those which don't will lose. Dave Barry digs at this in *Newsweek* magazine (January 3, 1994), where he "looks back on the 90s" from a vantage point located somewhere in the 21st century, and discovers what the networking customer really wanted all along: "This is not to say that technology was an unadulterated plus in the '90s. The Information Superhighway was pretty much of a dud.

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Baby Bell Minitel? (continued)

Remember that? By the mid-'90s, just about everybody was hooked up to the vast international computer network, exchanging vast quantities of information at high speeds via modems and fiber-optic cable with everybody else. The problem, of course, was that even though the information was coming a lot faster, the vast majority of it, having originated with human beings, was still wrong. Eventually people realized that the Information Superhighway was essentially CB radio, but with more typing. By late in the decade millions of Americans had abandoned their computers and turned to the immensely popular new VirtuLib 2000, a $14,000 device that enables the user to experience, with uncanny realism, the sensation of reading a book."

The answers?

Who will win?: never a nice question in a competitive situation. Better to ask some functional questions, such as, "Who satisfies the customers better?" One recent appraisal of the Internet's user-friendliness—by Peter Lewis in the *New York Times,* Sunday edition, 12/12/93—paints a bleak picture of that player's prospects: "...woe to the individual executive or computer novice who wants to tap directly into the rich depths of the Internet. Despite all the recent hyperbole praising the Internet as the precursor to the national data highway, establishing a direct connection to the Internet is about as easy for a novice as traveling a muddy road on a pogo stick, with traffic signs written in UNIX ... a company might want the text of the recent North American Free Trade Agreement and an analysis of its impact on, say, the automobile industry. Such information exists on the Internet, but one is likely to hear a giant sucking sound as the Internet user is drawn ever deeper into the network in search of it."

But all is not lost. Lewis' disenchantment may apply to networking generally—to Minitel and others as well as to the Internet—and may have more to do with Lewis himself than it does with networking (his children may feel more comfortable with it already than he ever will). But he's right, for now: no networking approach which follows Henry Ford's dictum—"The customer can have any color he wants so long as it's black,"—will succeed when the other competitors are offering bright colors, options, and other varieties and choices.

How good—or at least how flexible—is the competition now? Some generalities about Minitel's current advantages to the user already have been suggested: that it is, 1) fun, 2) useful, 3) easy, 4) everywhere, and 5) cheap. It has developed still other tricks, these aimed at easing use by the service provider:

1) Minitel has solved the billing problem still to be faced by the Internet. Minitel users' charges are tabulated by the government telephone monopoly. They then appear simply as debits to users and credits to providers, on the normal, already accepted and understood, monthly telephone bills. This Minitel "kiosk" billing system eliminates expensive layers of service providers' bookkeeping overhead.

2) Small providers have an established and thriving secondary infrastructure which eases their ability to purvey goods and services over the Minitel. One typical small service provider is Daniel Bouillot, who runs his growing "Lisière" publishing service from his home in the Alps. Both he and his users connect via the normal Minitel. His users pay 1.27 francs per minute—about US 22 cents—of which the telephone company keeps 30%, crediting the rest to an established wholesaler which provides support, pays the taxes, and ultimately credits "Lisière" itself: almost no bookkeeping for Bouillot, to support a readership for his service which can grow almost without limit.

There are many other angles—government policies, business ideas, approaches, tricks—which can be brought to bear on any serious effort to "satisfy the customer" in information networking. The point is that an approach "clear on the concept"—one which realizes that customer-satisfaction has taken priority now in networking, and that the customer increasingly will be a member of the "general public" and not some wealthy, highly-educated, or otherwise-special elite—will succeed where other approaches will fail.

The future!?

There are plenty of crazy predictions for the future of internetworking floating around on the nets. Some cloak themselves with an aura of numerical respectability: one extrapolates current trends and finds there will be more e-mail addresses on the planet than there are people, by some fast-approaching date. My own favorite futurist story is that of the 1875 prognosticator who predicted that at then-"current rates of production" the city of London would be fifteen feet deep in horse manure by the year 1950: I think of his prediction every time I read the latest networking superlatives.

It is interesting, though, to see what Minitel has "just waiting 'round the bend." These are ideas currently in development: pipe-dreams, perhaps, but pipe-dreams which have some hope of being with us within a year, unlike predictions of "paperless libraries" and "fully-informatised societies" which may take longer to accomplish:

• *Electronic billing and payment systems:* Minitel is developing a means by which consumers can pay for merchandise and services both a) by direct debit and b) by remote payment (using the well-known chip-equipped "SmartCard," available in any French "tabac," and card-readers attached to Minitel terminals), all at great savings both to consumers and vendors;

• *Photo-Minitel:* Minitel has introduced the transmission of low-resolution photographs, adequate for many sales and other information applications, on their national network (4800bps and 9600bps—those new "PAVs"—several seconds to transmit, but useful nevertheless);

• *Audiovideotex:* Minitel projects are devoted to mounting video/audio combinations in services on the network, again available immediately to the general public unlike more sophisticated but less accessible projects in the US;

• *Multimedia:* the true dream of networking's coming era—Minitel is equipping its standard terminals with graphics capacities, with moving graphics applications being developed for ISDN transmission, and a hoped-for upgrade of the national PAD/PAV infrastructure to handle ISDN by the end of 1994.

Minitel's role in the Internet's world?

• *Foreign competition:* Many foreign governments don't share the high value placed on "free democratic access to information" so treasured by the Internet. They also have no enthusiasm for the reckless-spending R&D patterns which produced Silicon Valley and US networking. Will Singapore and China and Pakistan be more inclined to adopt the Internet's "free access/profligate R&D spending" approach, or the Minitel's appearance, at least, of offering the opposite?

Minitel has made a good start on international connectivity. Easy connections are available from Minitel in France to similar "videotex" services or to distributors in many countries:

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Germany, Spain, Luxembourg, the Netherlands, Switzerland, the UK, the US, Portugal, Gabon, Italy, Madagascar, Korea, Japan, Andorra, Belgium, Denmark, Finland, Ireland, Chad, Chile, Djibouti, Egypt, the Ivory Coast, Lebanon, Niger, Senegal, and Togo. Local Minitel dialup numbers are available all over the US and Europe, and in Hong Kong, Japan, the Philippines, South Africa, and Singapore.

Lest anyone think the expansion trend has slowed, respectable rumors appeared in December that Minitel might purchase the British videotex service, Prestel: a "pig in a poke," perhaps, as Prestel has been doing poorly, but competitors might watch now to see what is done with Prestel, as an indication of Minitel's aggressiveness—and likely failure or success—in other foreign markets. Minitel even can reach the Internet, although the Internet can't reach Minitel: some Minitel services now offer Internet e-mail, and some French Internet nodes have added Minitel "kiosk" access.

• *Competition at home (in the US?!):* The great networking question now looming in the US itself is whether the sophisticated academic Internet will "scale up" to the "general public." When the telcos and cablecos cease their merger bloodletting, and sit down to decide which path to pursue to disseminate their sex 'n' drugs 'n' rock 'n' roll to the US "general public," will *they* turn to the careful, high standard, academic Internet model, or to the simple, colorful, already-sexy—after all, it's French—Minitel?

I won't take sides myself. I am an admirer of what both systems have achieved, and I am an overly-enthusiastic user of both. I personally don't think the telecommunications model for the next century has been developed yet, anyway. The Internet and Minitel both are working on it, certainly, but neither yet is there: the new synthesis will use the best aspects of both—or perhaps the worst, but a bit of both. The least each can do at this point, then, is to take a good firm look at the other: beginning with an admission that the other exists, which is perhaps a hard task in either case. General public networking via the Internet may be more efficient. The same via Minitel might be more fun. The next century might thank us if we give them something in networking which offers a bit of both.

(Free PC/Mac telecom Minitel diskettes are available in North America from (voice) 212-399-0080. Try it and see, enjoy and/or shudder, back to the future!)

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There are a few other good books and periodicals out now, in English and other languages as well as in French, on Minitel and on the development of global Videotex generally: many are referred to in the above magazines.

A typical Minitel terminal. Notice the compact size.

JACK KESSLER has academic degrees in philosophy, law, and library and information studies, and has pursued these and other subjects at Yale, Oxford, and the University of California. He spent fifteen years in the handicraft importing business, until he found the glamor of international travel to be at odds with the joys of married life and of the raising of two small boys. His love affair with books and love/hate relationship with the computer are long-standing. While an importer he fought the automation battles of the 70s and 80s, most often siding with the Luddites against the machines but then reluctantly giving in. He's still suspicious. Currently he works as a networked information consultant, and has just concluded a one-year study in France of the French Minitel and of foreign library applications of the US Internet. He is a member of the American Society for Information Science, the American Library Association, and the California Library Association. His ambition in life still is never to take another airplane trip. His Internet Internet address is: kessler@well.sf.ca.us — also reachable from Internet nodes on Minitel.

The Internet K–12 Connection

How Students and Teachers Are Using The Internet

by Tracy LaQuey Parker, Cisco Systems, Inc.

Introduction

A recent informal census conducted via voluntary reporting over the Internet estimates the number of teachers and students (individual and classroom accounts) in the US using the Internet in some fashion, either directly or indirectly, at almost 500,000. This figure is much larger than anyone had guessed; initial estimates proclaimed 100,000 people.

The number of educational resources, databases, mailing lists, and archives is also growing rapidly—so much so that one educator recently lamented on an education mailing list there was too much available, that the sheer number of distributed services was large enough to overwhelm the novice teacher embarking for the first time on a digital professional development trip. (This problem is being addressed with the appearance of user friendly search and retrieval tools that present a simple, organized face of the Internet, such as *Gopher* and the *WorldWideWeb.*) [1–4]

In this article I'll present a round-up of some of the major groups and activities that are shaping the future of the Internet's role in education. Then we'll take a look at some projects that benefit administrative, instructional, professional development and community outreach projects and applications, and some exciting current initiatives around the U.S.

Internet Society: Spearheading international efforts

Much of the international direction and evangelism for K–12 networking is being headed by the Internet Society's K–12 Committee. The *Internet Society* (ISOC) is a professional organization that is chartered to facilitate and support the technical evolution of the Internet as a research and education infrastructure, and to educate the members on its technology, uses and applications. The ISOC's K–12 committee was formed about a year ago to promote the use of networking in the classroom, discuss issues related to teachers and children accessing the Internet and to propose concrete and useful solutions to barriers facing educators and students.

Among other efforts, this group is currently organizing a workshop to bring together educators from all over the world to this year's Internet Society's annual conference, *INET 94,* held June 13–17, 1994 in Prague, Czech Republic. (For more information about INET 94, contact: INET–JENC Secretariat, c/o RARE Secretariat, Singel 466–468, NL-1017 AW Amsterdam, The Netherlands, Phone: +31 20 639 1131, Fax: +31 20 639 3289, Internet: `inet-jenc-sec@rare.nl`). There, they will work towards solutions and models on such issues as connectivity and curriculum development.

IETF involvement

Among the many projects its members are working on, the *Internet Engineering Task Force* (IETF) is working on school-related efforts. For example, the IETF's *Internet School Networking* (ISN) Working Group recently wrote a document called "FYI on Questions and Answers—Answers to Commonly Asked Primary and Secondary School Internet User Questions," which was published as RFC 1578. The various sections answer questions about obtaining an Internet connection, technical implementation and technical options, security and ethics, educational collaboration, projects and resources.

National efforts

On the national scene, there is the well-known *National Research and Education Network* (NREN) part of the *High Performance Computing and Communications Act* of 1991. The more recent *National Information Infrastructure* (NII) initiative, which is much broader in scale, is intended to benefit K–12 education in terms of ubiquitous connectivity to all schools. Indeed, the Clinton/Gore Administration recently issued an ambitious challenge calling for all schools and libraries to be connected to the NII by the year 2000. Many businesses have responded with pledges to make this a reality. [5]

COSN

The *Consortium for School Networking* (COSN) is a membership organization of institutions, companies and individuals charged with promoting the use of computer network technology in K–12 education within the United States. Services COSN provides to its members include regular newsletters on networking topics of interest, an extensive on-line *Gopher* server of education networks, projects and resources. COSN has also testified to Congress on behalf of K–12 networking interests.

One of the latest efforts from COSN was a project funded by the National Science Foundation and being conducted in cooperation with the *Federation of American Research Networks* (FARNET). [6]

The project, called "Building Consensus and Models" brought together representatives from industry and national, state and local levels. Five groups formed, each charged with laying out the key requirements and proposed models for a certain topic. The topics and models included educational reform and restructuring for a technology-intensive society; connectivity and access; technical and user support; financial; and curriculum and content. (See the COSN *Gopher* for more information.)

State projects

In the U.S., state-level discussion are underway for a mix of connectivity and content solutions. Many states have decided not to re-invent the wheel and are recommending schools and districts connect to existing mid-level and commercial networks, while providing a multi-phase approach to giving teachers and administrators Internet connectivity.

One example of state-based education networking is the Texas Education Network, also known as *TENET*. TENET has received lots of attention because of its success in leveraging an existing network, the *Texas Higher Education Network* (THEnet) as a backbone networking infrastructure. THEnet is a statewide Internet-connected network that provides services to over 100 education and research organizations in Texas. It is operated and maintained by the University of Texas System Office of Telecommunication Services in Austin, Texas. [7]

The requirements for access are minimal; an educator can dial into one of 18 local points of presence (Cisco CommServers and modem pools connected to THEnet member universities) using existing equipment in his home or classroom: a computer (PC or Macintosh), a modem and a phone line. (An 800 number serves those not located in a local calling area.) The costs for access are low; teachers can currently get an account on the TENET computers for $5/year.

The success of this project is obvious: after a little over 2 years of operation, 30,000 educators are using TENET. The Internet and TENET have been demonstrated enthusiastically in every school district and the benefits and uses are now obvious to many people.

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The Internet K–12 Connection *(continued)*

As a result, many school districts are planning for direct connections to the Texas Higher Education Network. Additionally, all 20 Texas Education Service Centers have recently connected to THEnet.

Other states have had similar successes to TENET's. *Virginia's Public Education Network* (VAPEN) and *Florida's Information Resource Network* (FIRN) are also dial-up networks servicing thousands and thousands of teachers. The state of California offers dial-up Internet access to teachers through the California State University network; this K–12 network is called *California On-line Resources for Education* (CORE) and is operated collaboratively by the California State University system and the California Department of Education. Oregon announced in September 1993 their ambitious OPEN initiative (*Oregon Public Education Network*) to connect all school districts, giving Internet access to 500,000 educators and students. And other states have announced or are working on statewide initiatives.

Benefits of using the Internet in education

In order for the Internet to successfully be integrated into schools, benefits must be shown for all aspects of education: instructional, administrative, professional development and community involvement. The Internet is already proving itself in these areas as evidenced by some major initiatives. Some of these projects are described here.

Administrative uses

There is quite a big business in US education for administrative applications, systems that provide everything from student record creation and maintenance, class scheduling, to food services and accounting. For the most part, these systems are accessible to local district or regions only and are not networked into larger systems.

This is unfortunate as there is much need for the ability to transfer administrative information between schools and districts. The US student population is very mobile. According to "A Study of the Feasibility of Implementing a Statewide Process for Electronically Sharing Student Information" (a collaborative effort by the California Department of Education, Far West Laboratory for Educational Research and Development and the California Educational Data Processing Association, published October 1992), it is estimated in California alone that as many as 20% of the student population change schools annually.

Furthermore, according to the study, the current method for exchanging student records and reporting to state and federal agencies costs California a staggering $50 million each year. It's not only expensive, it's time consuming; the average time spent transferring a record using the current system is 24 days.

Clearly what is needed are standards for the exchange of this information across a common network, such as the Internet. Using *Electronic Document Interchange* (EDI), student records could be transferred across the Internet to other schools, as well as universities and community colleges. The time could be cut from weeks to seconds and the cost savings estimated are considerable; according to the above California study, the cost drops from the current average $15 per transferred record to $4. (And some people think that $4 is too high, that the cost could be mere pennies per record.) Indeed, with savings like these, a business case can certainly be made for installing a network infrastructure and a link to the Internet.

A project called SPEEDE/ExPRESS, the *Standardization of Post-secondary Education Electronic Data Exchange/Exchange of Permanent Records Electronically for Students and Schools,* is taking the lead in defining standard record formats, and is also working with schools, universities and states to implement pilot projects.

It will take some time before standards exist for a ubiquitous networked student record transfer system. But the Internet is serving in other administrative capacities. The Texas Education Agency (TEA) currently makes many documents available on-line on TENET, including calendars, legislative summaries, directories, forms and spreadsheets. The hard copy versions are also mailed to schools, but an increasing number of people are realizing they can receive the information much faster by downloading it from the network. TEA could save millions of dollars in duplication and postage by making these documents solely available via the network. Indeed, the State of Texas has estimated annual savings of $1.4 million based solely on access to TENET.

Professional development

Many teachers are using the Internet for professional development. Consider the plight of specialized instructors, such as journalism or physics teachers. Many schools or school districts only employ one such teacher. As a result, the librarian or woodworking instructor often feels isolated and must become very self-sufficient in areas such as curriculum and professional development. With a network such as the Internet, these teachers now have support groups; "places" a teacher can go to share ideas with and ask questions of others in their discipline, as well as download resources for use in the classroom.

For example, Pat Gathright, the journalism teacher at MacArthur High School in San Antonio, Texas, is a true believer in the benefits of networking and using the Internet. Ms. Gathright has a TENET account and uses it to collaborate with other Internet-connected journalism teachers across Texas and the US.

"I have the sole responsibility on my campus for the yearbook, newspaper, Journalism I, and Photojournalism," she says. "Few of my fellow teachers can come close to understanding what my job is like or help me with some of the problems I face each day. But I know that I can log onto the Internet and share with my journalism friends across the state a desktop publishing trick that I learned at a workshop, a place to find information on a story my students are working on, or just news about my day."

In addition to collaborating with colleagues, teachers can also engage in dialogues with field experts. Using the Internet, teachers can connect to NASA's *Spacelink* (operated by the Marshall Space Flight Center in Huntsville Alabama) and send questions to space experts, including space shuttle astronauts.

Another project provided by the *Educational Resources Information Center* (ERIC), a US national information system, provides an Internet-based question-answering service for teachers, library media specialists, and administrators who have questions about K–12 education, learning, teaching, information technology and educational administration. Anyone involved with K–12 education can send an e-mail message to "AskERIC" and receive an answer within 48 working hours.

The Internet K–12 Connection *(continued)*

Teachers can also download useful information, guides and images for use in the classroom. Many are taking advantage of on-line United Press International (UPI) newsfeeds, the daily CNN (Cable News Network) Newsroom curriculum guide, NASA space images, and regularly updated weather reports; all of these are easily accessible and available on the Internet.

What K–12 students are doing

One of the best publicized uses of the Internet is for instructional purposes. Children love computers and computer networks and there are lots of distance learning projects being conducted, ranging from electronic pen pals to collaborative/comparison studies.

One such project involved students from different countries comparing prices, packaging and contents of various products, integrating math, social studies, language and geography. (Most of the students were not even aware they were learning!) Other readily available information services are providing students with the latest in current events. Some of these include US White House press releases and briefings; Radio Free Europe reports; and United Nations News.

Perhaps one of the most interesting uses of the Internet recently for education is the *Global Schoolhouse Project*. This project is one example of how the Internet can be used to transmit video for educational uses. Sponsored by the US National Science Foundation, the Global Schoolhouse was demonstrated during the US National Science and Technology Week in April 1993.

The participants in this "school without walls" were children ages 10 through 13 from four geographically distant schools: Jefferson Junior High School in Oceanside, California; Cedar Bluff Middle School in Knoxville, Tennessee; Longbranch Elementary School in Arlington, Virginia; and Oldfield House School in Hampton, United Kingdom.

As part of their studies, the students spent six weeks prior to the event studying watershed pollution in their local areas. The curriculum was created by the FrEdMail Foundation (*FrEdMail* stands for Free Educational Mail Network), a non-profit organization devoted to creating and fostering meaningful distance-based projects using computer networks.

The students had an ambitious goal; to read *Earth in the Balance* by US Vice President Al Gore and then conduct ground-water pollution studies in their communities. Beginning three weeks before the demonstration, the students met in two weekly videoconference rehearsals over the Internet to give progress reports and show video clips of their research.

During the videoconferences, each group of students could see, in real time, all of the other groups and themselves on a quartered computer screen. For the demonstration event in April, US government officials in Washington, DC joined in the discussion, listening to the students' reports and asking questions. The students continued to meet in weekly videoconferences after the demonstration until the end of the school year; more meetings have been planned for the future.

During the Global Schoolhouse videoconference, a Sun Microsystems SPARCstation acted as a reflector, taking the video data from one site and reflecting it to the other three sites. A second reflector, located at Cornell University in Ithaca, New York, sent copies of the video data to a viewing site in Vienna, Virginia, where guests could monitor the videoconference.

The second reflector also sent the video data out over the Multicast Backbone (MBONE), a collection of sites around the world that co-operate in global video and audio conferencing for various events.

During the videoconference, each desktop computer had a video camera and a projector connected to the monitor. The video camera fed the live action to the computer. Audio was provided by a traditional audio conference bridge. Cisco routers provided the main gateway between the LANs and the Internet and T1 or Switched Multimegabit Data Service (SMDS) lines provided access to the WAN.

The videoconferencing software, *CU-SeeMe,* is freely available on the Internet and is still currently being developed by Cornell University's Information Technology Organization (CIT). It allows one-to-one, one-to-many, or many-to-many connections. A user can be either a receiver, or a sender and receiver. To receive, one only needs an Internet-connected Macintosh capable of displaying 16 grays. Sending requires the same plus a SuperMac VideoSpigot board, a camera, QuickTime™ and Spigot VDIG extensions added to the System Folder. (For more information, see the resources section at the end of this article.)

Community outreach

In addition to the administrative and educational benefits achieved by access to the Internet, there are advantages to providing community access to school resources. Some schools and network projects are encouraging parents to become involved and have offered access via dialup accounts to school systems. Homework assignment archives, schedules, calendars, lunch menus, etc. are just some of the things that can be made publicly available. Additionally, teachers are more accessible via electronic mail for parent/teacher conferences. While community access is not as well defined or publicized yet, it is a crucial part of the educational and community building use of the Internet.

Barriers

There's no question that the Internet is augmenting traditional classes with live data from distant lands and cultural exchange between children. Unfortunately, there are quite a few barriers preventing teachers and schools from making the connection. For one, there is a lack of internetworking technical expertise and vision.

Frankly, it's hard enough for anyone these days to make heads or tails of the bewildering number of choices, and so it's understandable that schools are having problems figuring out which way to go. It's going to take awhile for us to fully understand how the convergence of the broadcast, telephone and computer industries is going to play out and who the players will be. There's concern that committing to one distance learning solution will prohibit upgrading to future technologies.

There are many open system solutions, many standards and many vendors promising the "only" solutions. One organization called the *National Center for Technology Planning* (NCTP) is trying to help. Located at Mississippi State University, NCTP is providing network planning and direction to many schools and archiving technology plans on the Internet.

Perhaps the confusing technology and large number of choices is directly responsible for the next barrier: the lack of existing network infrastructure. A significant percentage of schools don't have local area networks in the computer labs. Therefore access to the Internet for the time being is limited to stand-alone machines with modems.

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The Internet K–12 Connection (continued)

Unfortunately, because of the current practice of most states permitting phone companies to charge business rates for telephones in schools, there are very few phone lines in the classrooms. It is necessary to educate the state *Public Utilities Commissions* (PUCs) about the benefits of access to the Internet via a phone in the classroom; indeed, there have already been several success stories in some states where regulation was introduced to lower costs for phone lines in schools.

Another barrier is one of the oldest problems schools have faced; that is, *funding* for just about anything that is needed. This will continue to cause a problem until schools and districts establish visions and plans. Business cases can and are being made for administrative uses. Savings on educational tools such as textbooks will be realized as more and more on-line books are distributed electronically. Once differences are resolved and standards made for the transfer of such useful information, such as student records and books, it will be easier to allocate funds for network connectivity and access.

In addition to the bewildering amount of information and resources available on the Internet, there's also the perceived notion that the Internet is deliberately user hostile. The Internet is growing up somewhat in this area with the wider availability of information discovery and retrieval applications, such as *Archie, Gopher, Wide Area Information Servers* (WAIS) and the *WorldWideWeb* (WWW). [1–4] Most Internet-connected education networks offer at least a simple menu interface to the Internet. A graphical program called "The Guide" is currently under development by the California Technology Project and early reviews of it are confirming its promise to be one of the easiest to use graphical interfaces to the Internet yet.

And finally, another barrier to using the Internet in the classroom is motivating teachers to throw away the out-dated, incorrect textbooks and instead engage students interactively, exploring the *Web* for current events, real examples and the latest data.

True, the Internet has a little way to go before it can reliably serve as the sole digital lab or classroom, but there are plenty of useful projects going on right now where students are encouraged to use their creativity and common sense. The problem is that teachers need help in learning how to use this technology and how to apply it to teaching.

What is needed are more Internet evangelists, people that can simplify the technology and demonstrate the benefits. And just as school technology coordinators and directors plan for networks and scalability, so must teachers plan for the use of technology in their classrooms. Too many advanced instructional learning systems are sitting gathering dust because of lack of planning in this area. More emphasis must be made by all network planners (administrative and technical) involved on training and motivation.

Conclusion: Education networking is good for business

Despite these barriers, the K–12 community is moving ahead. The Internet promises more equitable access to resources for teachers and students, as well as saving time and money for administrative applications. We will continue to see growth and use of educational resources, increased coordination at all levels, and more user-friendly applications being developed.

The K–12 community is one of the fastest growing groups involved in the Internet. This market is treading on the edges of technology and telecommunications; some schools have adopted technology for the classroom and distance learning projects with open arms, while others are just now starting to think about long range technology visions and plans.

Resources for more information

Consortium for School Networking (COSN):
  1112 Sixteenth Street, NW Suite 600
  Washington, DC 20036
  Phone: +1 202 872-4200   Fax: +1 202-872-4318
  E-mail: `cosn@bitnic.bitnet`

Internet Society (ISOC):
  1985 Preston White Drive Suite 100
  Reston, VA 22091
  Phone: +1-703 648-9888   Fax: +1-703 620-0913
  E-Mail: `isoc@cnri.reston.va.us`

CU-SeeMe:
Available via anonymous FTP on `gated.cornell.edu`, directory `pub/video`

AskERIC:
  ERIC Clearinghouse on Information Resources
  030 Huntington Hall
  Syracuse University
  Syracuse, New York 13244-2340
  Phone: +1 315 443-9114   Fax: +1 315 443-5448
  E-mail: `askeric@ericir.syr.edu`

The Guide: Send e-mail to: `kvogt@eis.calstate.edu`.

The National Center for Technology Planning (NCTP):
  Information available via anonymous FTP on `Ra.MsState.edu`, directory `pub/archives/nctp`.

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[7] LaQuey Parker, T., "Profile: THEnet," *ConneXions*, Volume 5, No. 8, August 1991.

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Network Discovery Algorithms for the NSFNET

by William B. Norton, Merit Network, Inc.

Abstract

Network discovery algorithms are often separated from network state determination algorithms. During the management and operation of the NSFNET, we have found significant benefits from combining network discovery and state determination.

This article describes the network management discovery algorithm used to determine the state and topology of the NSFNET. This algorithm makes the important distinction between nodes and links being up, down, and not reachable. In doing so, it automatically supports the notion of *dependency*. This simple algorithm also deals well with the condition of incomplete network information, which often exists in a busy or congested network.

Initial discovery

Discovery involves collecting network topology information from the network. The basic requirements for discovery to work are network connectivity, a network topology and state store, and the means to interrogate the network. We'll discuss the topology and state store first.

The node and link state store is required to hold the state and topology information. Associated with each node is a state variable, indicating the probable state of the node. There are only three states a node can take:

- *UP:* indicates that the node responded completely to the last poll.

- *NR (Not Reachable):* indicates that the node has not responded to the last poll, and no node has reported adjacency to it during the last poll.

- *BUSY:* indicates that an adjacent node claims the node is responsive, but the node itself has not responded completely to the last poll

In these node state definitions there is no DOWN state. This is because there is no way to determine that a node is, in fact, down. Connectivity may be preventing the node from being responsive. Further, any level of backup connectivity may also fail. While one can make a probabilistic determination that the node is likely to be down, we have found this not to be useful.

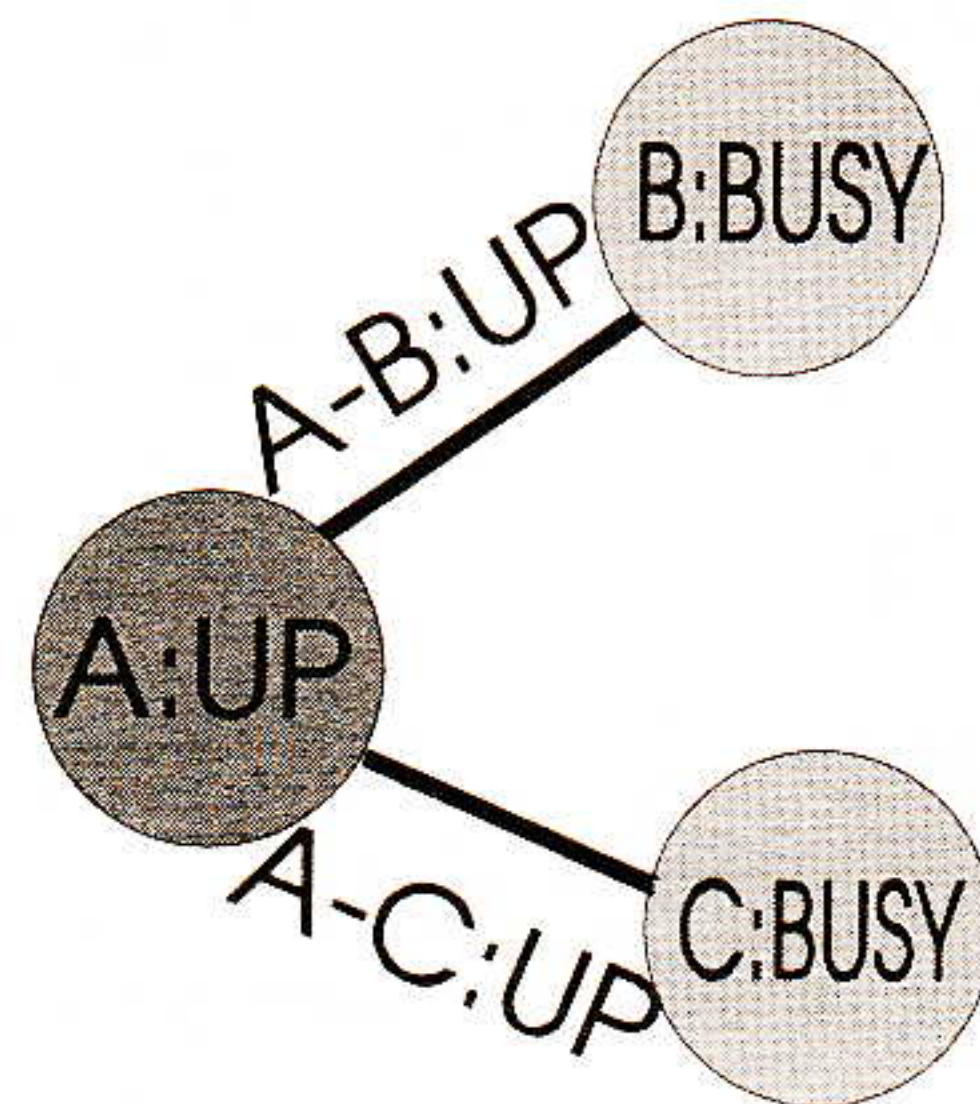Links, unable to respond for themselves, can take on the following states as dictated by their neighbors:

- *UP:* indicates that a node at either end or both ends of the link claimed the link is usable during the last poll.

- *DOWN:* indicates that either end of link claim the link is unusable during the last poll.

- *NR:* indicates that no node reported the existence of this link during the last poll.

A:NR

Node	State	Link	State
A	NR		

Figure 1: Seeding the Discovery Algorithm

The discovery algorithm requires a "seed," that is, at least a single query able node in the store. In this case (see Figure 1), the store consists of a single node A which, since we haven't heard from yet, is assumed to be in the NR (Not Reachable) state. Note that at this time, no links are known, so the link store is empty.
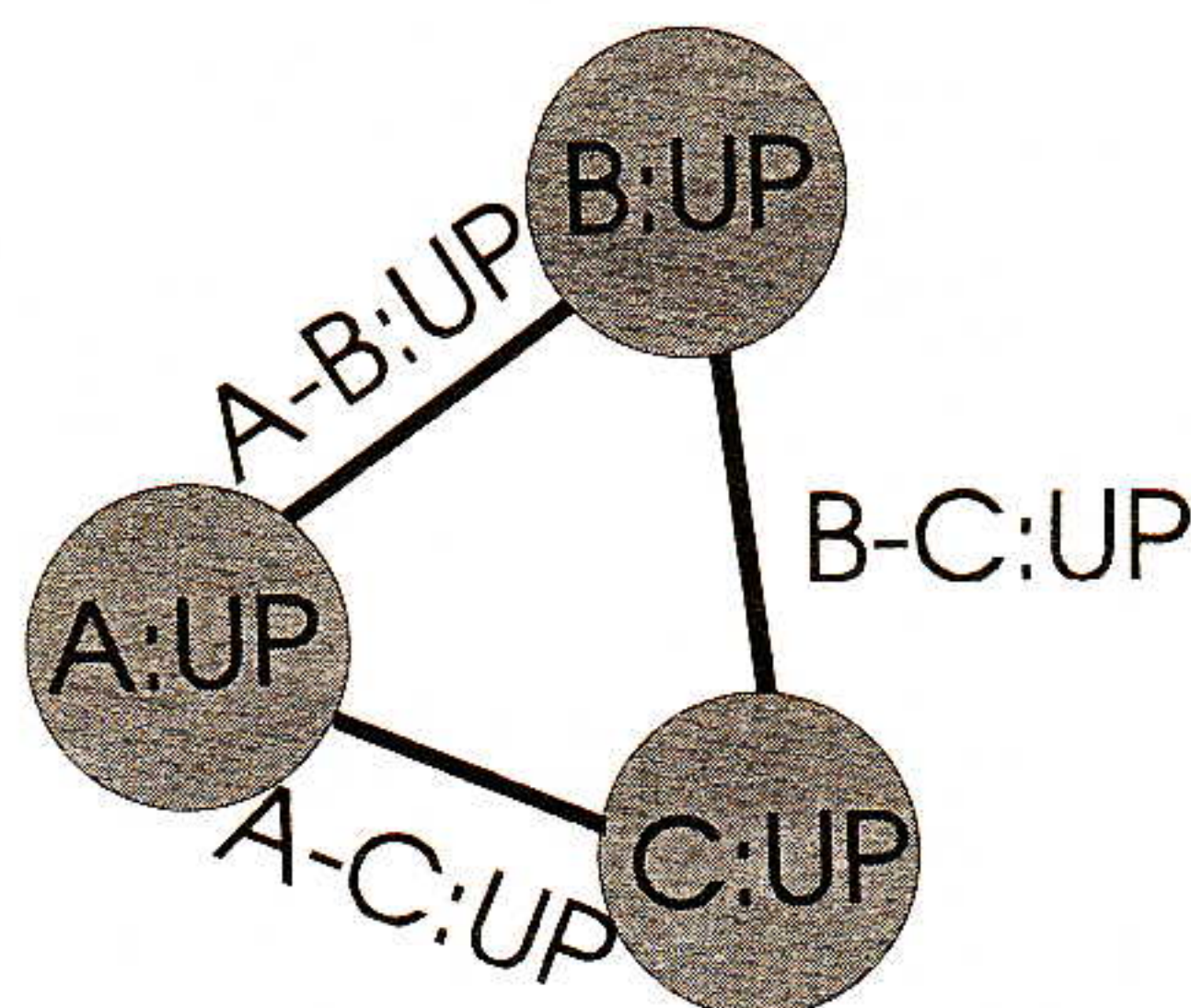

Node	State	Link	State
A	UP	A-B	UP
B	BUSY	A-C	UP
C	BUSY		

Figure 2: Topology after one poll

The first poll consists of adjacency queries of the only node in the store. Node A reports adjacency to node B and C and claims that both links are in the "UP" state (see Figure 2). The fact that A responded is necessary and sufficient to declare that node A is in the "UP" state. Further, A claims that both links "A–B" and "A–C" are "UP" which is necessary and sufficient to declare that links "A–B" and "A–C" are in the "UP" state. This is based on a major assumption described next.

This discovery algorithm expects that each node can tell with some certainty the state of its neighbor. In the NSFNET, the IS–IS link state protocol is used to determine the availability of the links. HELO packets are sent from peer to peer periodically. If a HELO is received, the node declares the link to be UP. One can therefore infer that if a node claims that the link to its neighbor is UP, then the neighbor (peer) must also be UP. Conversely, if a HELO packet is not heard from a neighbor for some period of time, the link is marked as DOWN and is no longer used.

After this first poll, we find that node A knows it has a functional link to nodes B and C so these links are added to the store. Further, since we know these links are functioning, we can infer that B and C are most probably UP, but we haven't heard directly from them. Since this is the definition of the "BUSY" state, both of these nodes are added to the store in the "BUSY" state. Note that in one poll (of only one node) we discovered three nodes and two links.

Node	State	Link	State
A	UP	A-B	UP
B	UP	A-C	UP
C	UP	B-C	UP

Figure 3: Topology after two polls

NSFNET Network Discovery Algorithms (continued)

The algorithm now polls the three nodes A, B, and C for adjacency information, and the store is updated as in Figure 3. Since all three nodes respond in this case, we know all three nodes are up and are marked in the "UP" state. In this scenario, nodes B and C both declared link B–C as being UP, so this link is added to the store.

Incomplete information

In certain situations, (network instability, node resource starvation, link congestion, etc.), some nodes may be non-responsive. As noted earlier, this algorithm deals with this situation through the BUSY state. As long as either end of the link declares the link to be usable (and neither claim it is unusable), the link remains in the UP state. Thus, the failure of any one node to respond will have minimal impact on the operation of the algorithm.

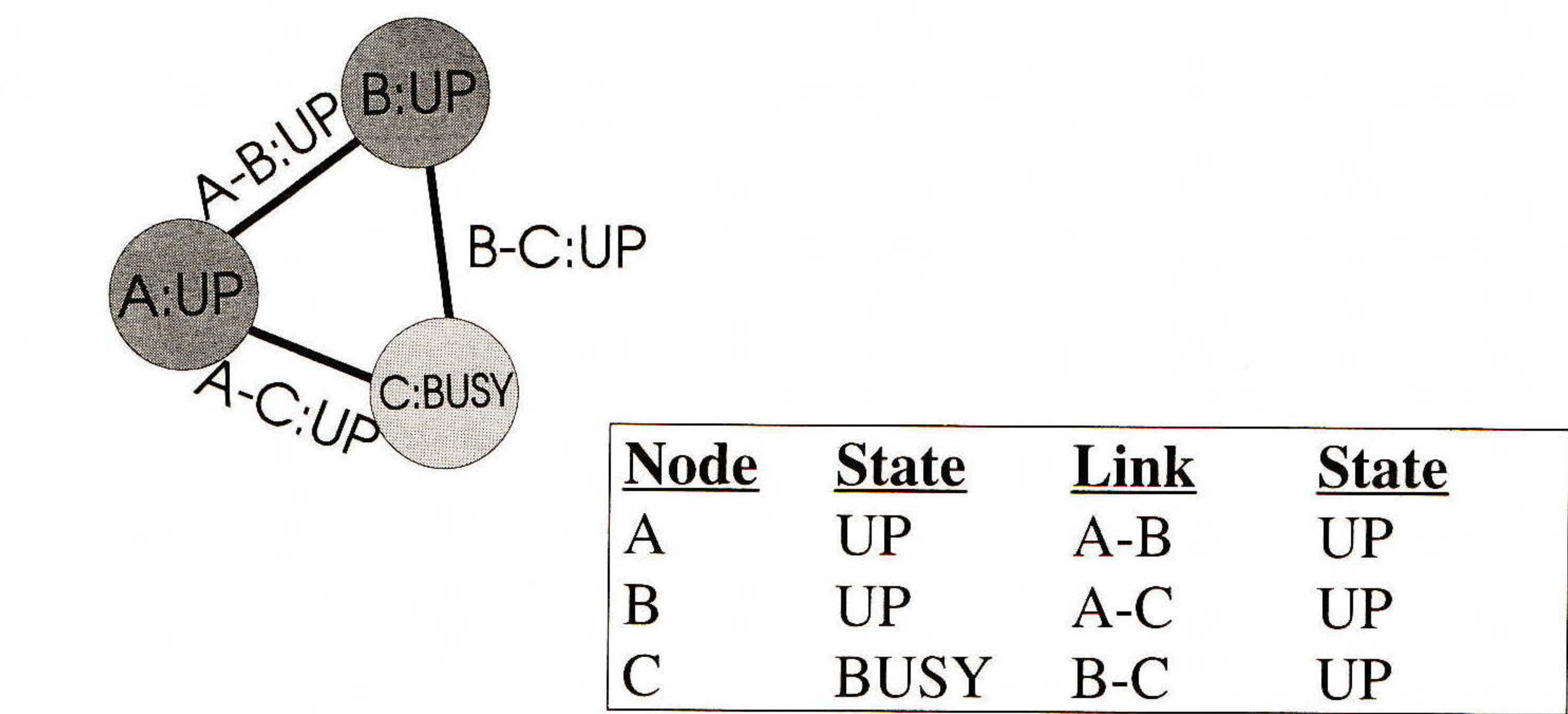| Node	State	Link	State
A	UP	A-B	UP
B	UP	A-C	UP
C	BUSY	B-C	UP

Figure 4: Incomplete information: The BUSY State

In the case above (see Figure 4), an unresponsive node C does not cause any degradation in network state information, because of the ability to infer the neighbors state. To take this one step further, assume that (see Figure 5) both B and C do not respond to a poll. Since A reports functioning links to both B and C, but neither B nor C responded, B and C are both in the BUSY state. Since neither B nor C reported link B–C, this link is determined to be in the NR (not reachable), or "unknown" state. Thus, no false alerts are reported, and the store accurately represents the state of the network.

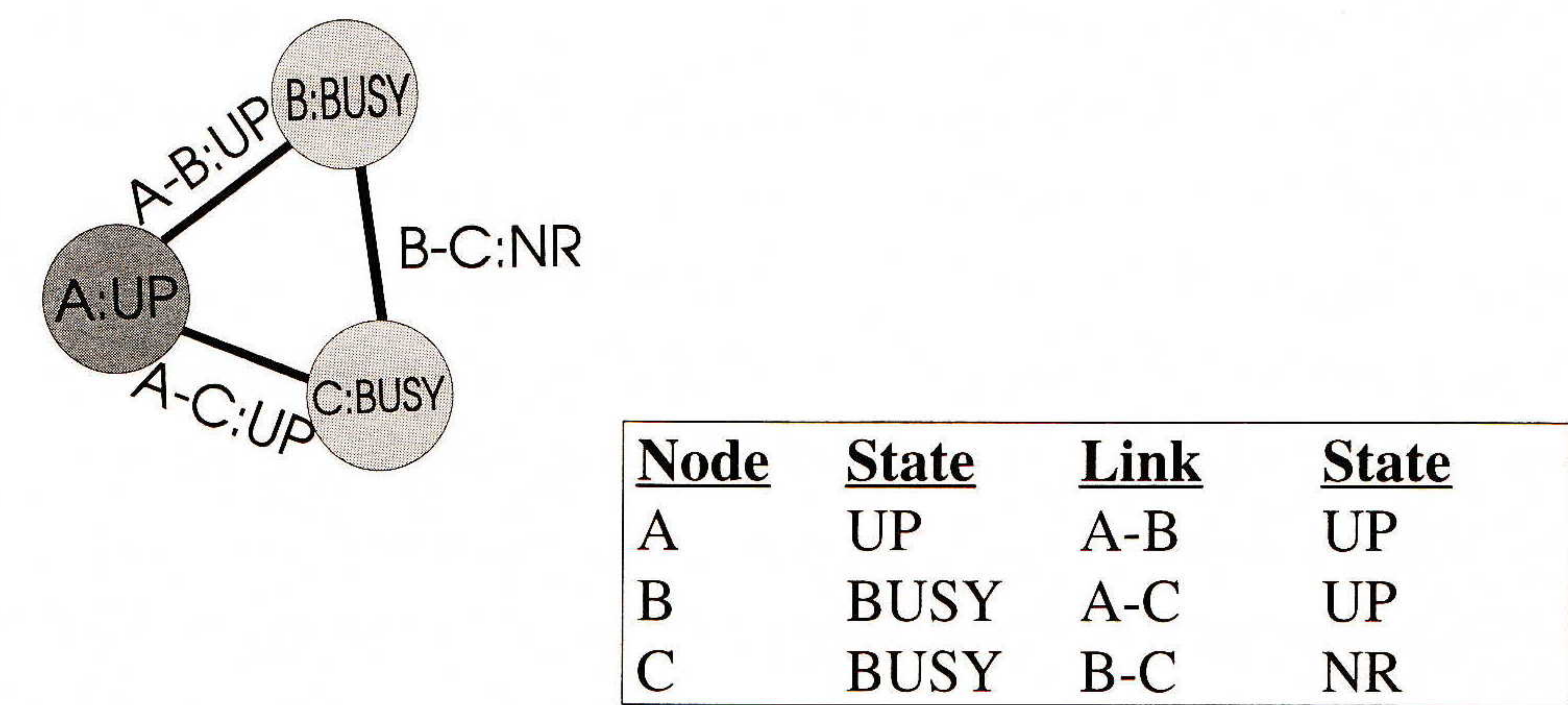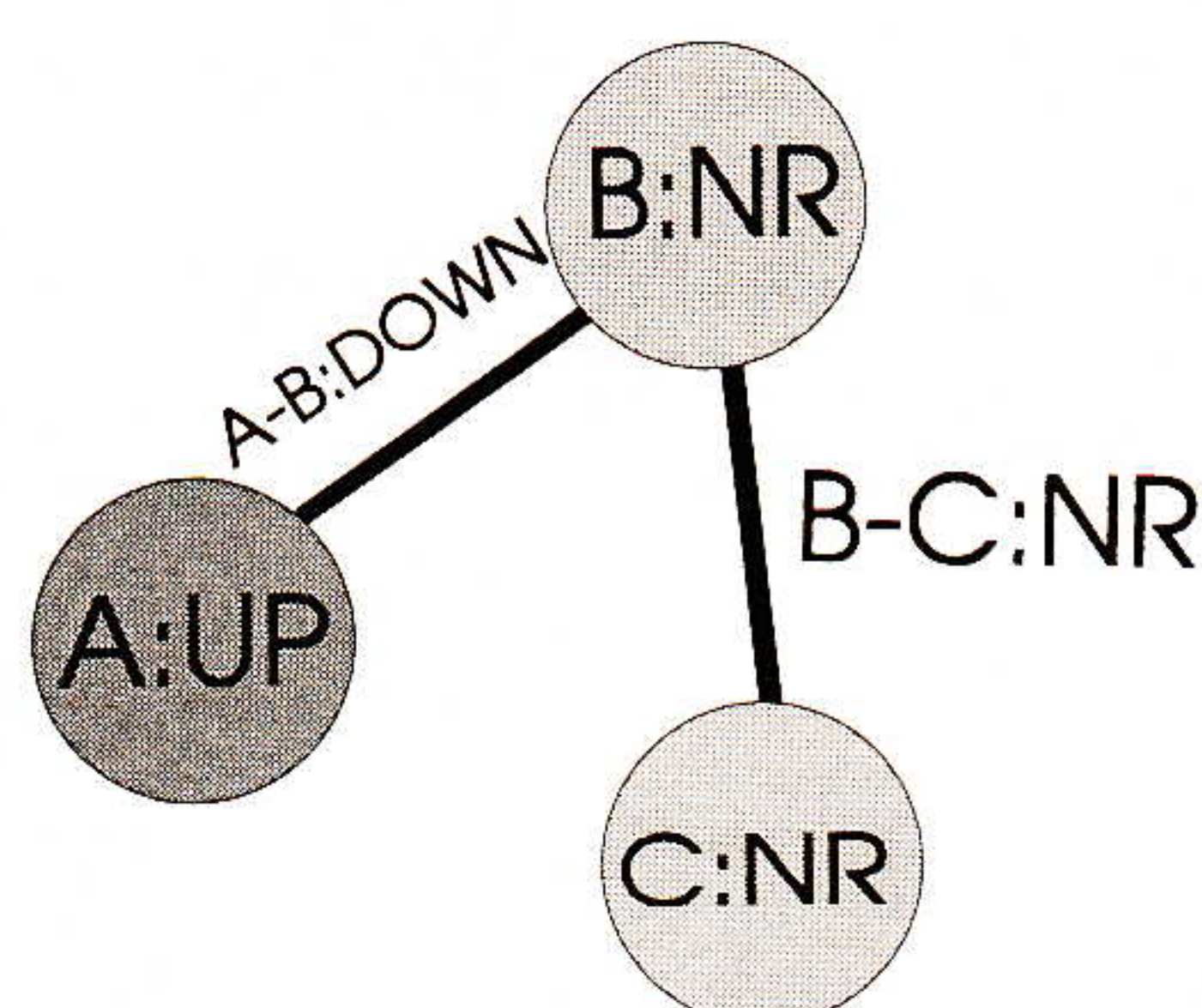| Node	State	Link	State
A	UP	A-B	UP
B	BUSY	A-C	UP
C	BUSY	B-C	NR

Figure 5: Incomplete information: The NR Link State

In fact, during the management and operation of the NSFNET we have found that incomplete information is returned more often then one might think. Routing updates occasionally require great node resources. Phone company lines experience intermittent glitches perhaps corrupting traffic. Using certain vendors equipment, these events may cause the network management system to erroneously alert the NOC and declare the node to be DOWN or unreachable. This algorithm is relatively tolerant of these faults, since it bases the determination of node and link state on both the reachability information and the neighbors' notion of the network state.

Dependencies

Dependency, in the context of network management, means the ability to differentiate between network outages and the side-effects of those outages. Obviously, the notion of dependencies is critical to the effective management and operation of an internet. NMS platforms without this ability will likely create many alerts for a single outage, and provide no indication of the real problem. Consider the following different topology and scenario:

Node	State	Link	State
A	UP	A-B	DOWN
B	NR	B-C	NR
C	NR		

Figure 6: Dependencies: Hiding Side Effects

The link between A and B is severed (probably by a backhoe fiber-detector), and as a side effect, both B and C are isolated. Naturally B and C will not respond to queries, but A will report the link to B as DOWN, and the rest of the nodes and links as NR (Not Reachable). Thus, the algorithm correctly identifies the real and direct cause of the outage (A–B: DOWN) distinctly from the side effects of the outage (B: NR, B–C: NR, C: NR)

The significance of the benefits of this algorithm becomes more apparent when one considers isolation faults in larger environments. The more unreachable nodes on the "other" side if the partition, the more the NOC needs to quickly repair the cause of the isolation. Most currently available NMS platforms would present the cause of the fault along with the side effects of the fault to the operator, failing to distinguish between the two types of information. Network management software is unlike normal application software in that network management software must work its best when the network is at its worst. Our experience has been that this algorithm has successfully met that criteria and effectively focus the network operators' attention on the closest proximate cause of the network fault.

Note that if there had been a prior outage beyond B, the store will not save that previous outage state information, but does save the topology information.

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NSFNET Network Discovery Algorithms *(continued)*

This is keeping with the philosophy of maintaining "correct" information in the store. The outage in C may or may not still exist, but the true state is unknown until the node or the neighbor respond. So the information in the store is accurate.

Multiple monitor points

All along we have been assuming that the monitoring is done through node A. Thus, dependencies are determined based upon the availability of information along paths through A. The end effect of this strategy is that, during network partitions, a whole portion of the network will be in the NR state, and only the nodes and links in known states (A: UP, A–B: DOWN) are addressed to solve the network outage (see Figure 7).

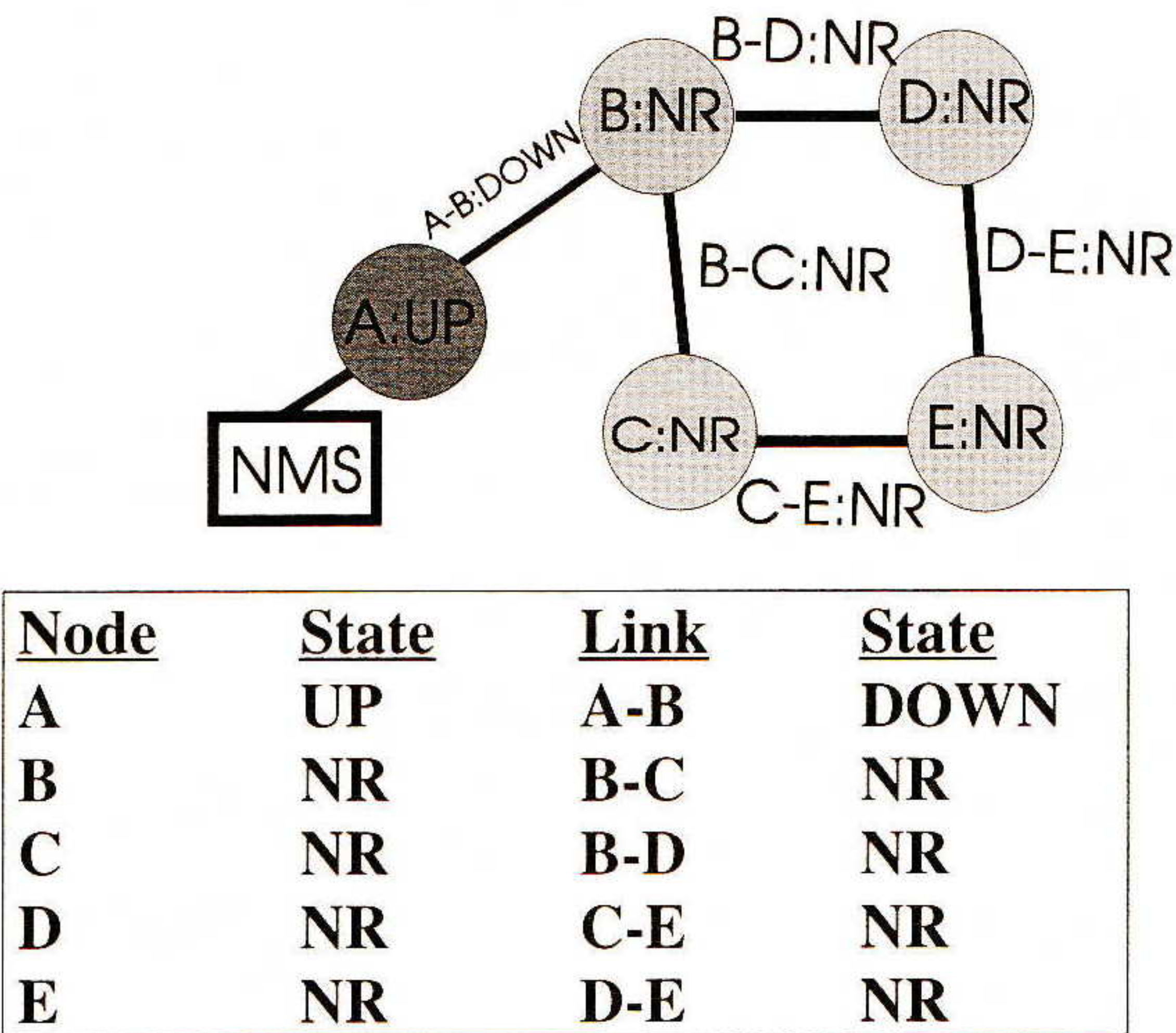| Node	State	Link	State
A	UP	A-B	DOWN
B	NR	B-C	NR
C	NR	B-D	NR
D	NR	C-E	NR
E	NR	D-E	NR

Figure 7. Single Monitoring Point

Assume that a second NMS was installed, with out-of-band communication facilities to the first NMS. The two views of the network, when combined, will provide a more accurate picture of the network (see Figure 8.) In this case, what was previously unknown (the state of the network behind the A–B isolation) is now known. We now know that node B is UP, so one problem must be in the link between A and B. Further, C and D are both UP, and we also know that the node E is isolated behind links D–E and C–E. The wonderful thing about this distributed management approach is that simplicity of the algorithm is maintained, and greater information results from the shuffling of the two network views.

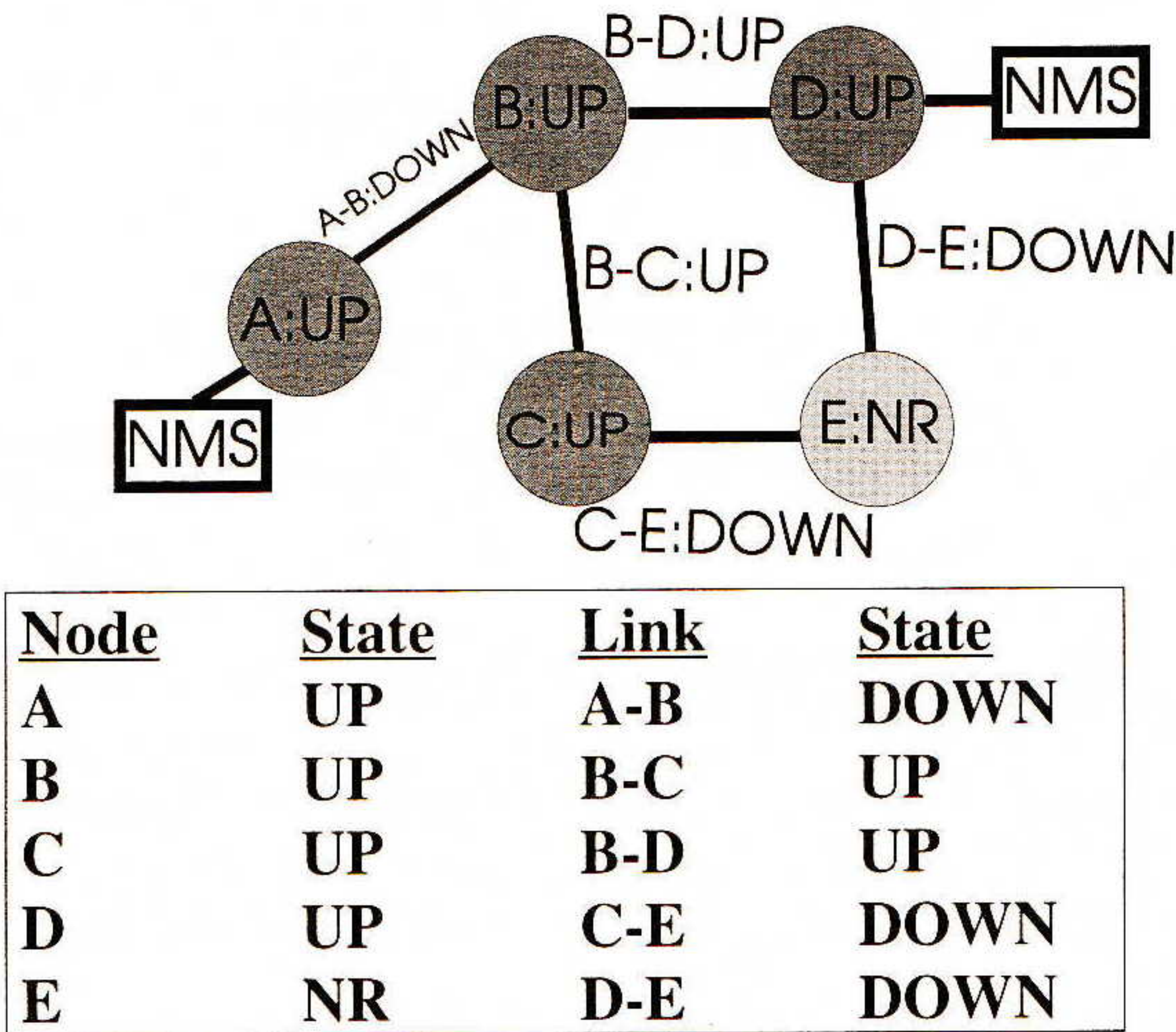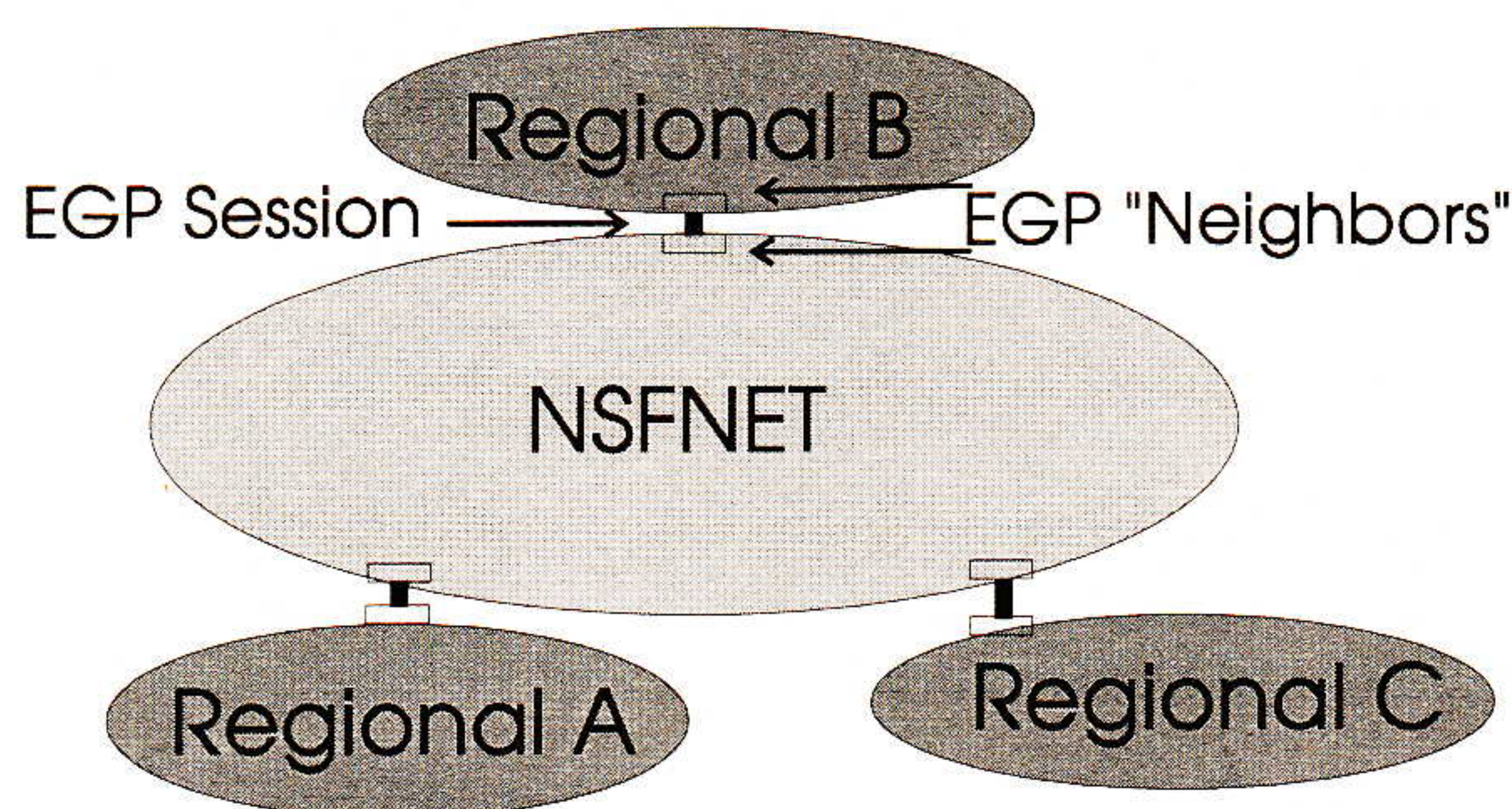| Node	State	Link	State
A	UP	A-B	DOWN
B	UP	B-C	UP
C	UP	B-D	UP
D	UP	C-E	DOWN
E	NR	D-E	DOWN

Figure 8: Second Monitoring Point

The other important benefit of discovering topology as well as state in each poll is that topological changes as well as state changes are recognized immediately after polling. As additional neighbors are attached to the NSFNET, the IS–IS neighbor table increases. Node additions and subtractions are therefore discovered every poll. One problem that occurs is that nodes may be attached, discovered and monitored automatically prior to being operational. Thus alerts for non-operational nodes need to be dealt with. Similarly, the issue of automated subtractions needs to be addressed (i.e. do you want to automatically remove nodes that are no longer attached, if so, do you want the software to do so without operator acknowledgment?, etc.)

Algorithm expanded to monitor National and Regional Networks

Over the years, regional networks have attached to the NSFNET backbone using a variety of *External Gateway Protocols* (EGPs), from EGP to the current version of the Border Gateway Protocol, BGP-4. These protocols maintain their sessions by using "keepalive" packets, much like the HELO packets described earlier under the IS–IS link state protocol. Therefore, if one abstract the notion of an attached network into the notion of a "neighbor," and one can poll the session state to determine the state of the link to this network neighbor, then this algorithm can be applied to network peer attachments as well.

Node	State	Link	State
NSFNET	UP	NSFNET-A	UP
A	UP	NSFNET-B	UP
B	UP	NSFNET-C	UP

Figure 9: Regional Networks as Adjacencies

At Merit, this algorithm has been applied to monitor the nodes and links within the NSFNET cloud, as well as the regional network attachments to the NSFNET cloud (see Figure 9). During the early days of the project, the External Gateway Protocol was the only EGP used, and MIB-2 defined adequate instrumentation for monitoring the connections between the backbone and the regionals.

However, networking technology changes frequently, and in this case, the routing protocols changed. EGP was replaced with the *Border Gateway Protocol* (BGP). Unfortunately, too often the instrumentation lags behind that which should be instrumented. This was the case in the NSFNET, where the lack of BGP instrumentation crippled the ability for the algorithm to effectively monitor the regional neighbors.

A "temporary" kludge was invented to get around this lack of instrumentation. Since Merit maintains a database mapping regional networks to EGP peers to *Autonomous Systems* (ASs), and we can determine which ASs are being announced to the backbone, we can infer the state of the attached regional.

NSFNET Network Discovery Algorithms *(continued)*

This hack however, negates the intrinsic dependency and incomplete information benefits described in the algorithm, because this reachability information is not retrieved directly from the neighbors. To finish the story, several years later, BGP, now in version 4, is finally being installed on the NSFNET (along with instrumentation!), and this "temporary" kludge can finally be dismantled. It is interesting to see how long temporary kludges live!

Summary

This simple algorithm discovers both the topology and state of a data network, and this article has described its application to the NSF-NET. The algorithm uses both declarative states (UP, DOWN) and inferred states (NR, BUSY) to accurately describe the state of the network at any point in time. Dependency and incomplete information are dealt with through the semantics of the state information of the store and the application of the algorithm. The network store is accurate in the context of a single view, but can be made more accurate through the use of multiple network monitoring points.

This algorithm is by no means a network discovery panacea, however. While it has successfully been applied to the NSFNET for many years and other (non-IS–IS) environments, the requirement that a node *must* be able to infer the state of its neighbors is not met in many environments. For example, on a Local Area Network (LAN), neighbors do not necessarily communicate, and therefore one cannot directly infer one's neighbors' state. Further, as in the case of the NSF-NET, even if the routing protocols support discovery, the instrumentation must also exist to perform the algorithm efficiently. For this algorithm to work, the routing algorithms must support the notion of neighbors and neighbor state intrinsically, and the appropriate instrumentation must be available.

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The Future of DECnet at the University of Minnesota
by Craig A. Finseth, University of Minnesota

Introduction

At this time, we support four network protocols on the University of Minnesota's data network: IP, AppleTalk, DECnet Phase IV, and Novell IPX. This list of protocols came from two sources. The first three protocols were called for in a report issued by a 1987 campus-wide committee and the last one was added after a user survey identified a number of areas for improvement. (The committee was headed by Dr. Russell Hobbie and the report is usually referred to as the "Hobbie Report." This report set many of the directions of our campus network including the creating of University Networking Services in 1990.)

Note that by "DECnet," we mean just that. Non-DECnet protocols such as MOP and LAT are not supported on our network.

Status of the protocols

Due to its nature as a vendor-independent, open protocol, we consider IP to be the "flagship" protocol. This status also comes from IP's use on the worldwide Internet. Further, its requirement of fixed address assignments helps make it the basis of our network management system. At this time, virtually all hosts on our network can use IP for communication and we have assigned over 20,000 IP addresses.

AppleTalk is closely tied to the Macintosh architecture. And, as we have several thousand such computers on our network, it is clear that there is a large demand for this protocol. At this time, AppleTalk is a more-or-less frozen protocol. We will continue to support it on a legacy basis. Apple has not announced plans for a replacement protocol, and it is by no means clear that we would ever support such a replacement protocol should one ever be announced.

There are currently many thousands of computers on our network using the Novell IPX protocol. With the advent of Novell 4 and the use of IP as an alternate transport protocol, we are looking to extend the use of Novell to the Internet as a whole. After this change, we will offer basic naming and related services, but otherwise be "out" of the IPX routing business at the network level. (Our department will, of course, be involved with the protocol at the application level.)

DECnet

DECnet has very different usage patterns than the above protocols. First, there are a fairly small number of DECnet hosts on our network: something like 125 or so. Second, these computers tend to be multi-user machines, so the small number of computers nonetheless affects many users. Third, DECnet users tend to form visible clumps, where they communicate much more extensively *within* each clump than among the clumps. Fourth, DECnet communication with the "outside world" is available on a limited basis. Many of the clumps communicate extensively with (their own separate) external clumps.

There are a number of issues to our use of DECnet that affect its long-term viability:

- *Scalability:* We have an assigned "block" of 1,024 DECnet addresses. Clearly, it is not feasible to provide DECnet access to all University hosts. Worse, DECnet Phase IV does not provide the equivalent of the Domain Name System and other tools to help manage growth. (Imagine the logistics of keeping a 20,000 entry host table and distributing it regularly to 20,000 hosts.) For the long term, it is not clear that it makes sense to support a protocol on a University-wide basis that only a small number of people can use.

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Future of DECnet at U of Minnesota *(continued)*

- *Effect on vendor choices:* At this time, we support four protocol suites on the network. We must take all of these protocols into account when evaluating network equipment and devising network designs. For the long term, we have a desire to reduce the number of supported protocols as such a reduction would widen the choice of possible vendors and ease constraints on network design.

- *External connections:* At this time, we obtain wide area connectivity to the NSI/D (area 7, via leased line) and HEPNET (area 46, via CICNET) networks. Those networks run DECnet Phase IV.

The NSI/D connection is relatively simple: it is a leased line to the rest of the NSI/D network and affects only a few hosts in the Physics building. While it works quite well for now, in the long term, it should be practical to eliminate this line. Such an elimination would save money, reduce complexity, and improve reliability of the network.

The HEPNET connection is more complex: it uses CICNET as a carrier and requires access to area 46 at a number of University of Minnesota sites, including Tower-Sudan. It is clear that most future wide-area network designs will not include DECnet Phase IV, and so we would like to remove this constraint on our ability of adopt such designs.

DECnet Phase IV requires that all areas be contiguous. This requirement makes it especially difficult to maintain these external connections.

Steps

For these reasons, we would like to work with DECnet users to plan for the eventual elimination of DECnet support from our campus network. We cannot stress enough the phrase "work with users," as we believe that it is very important that users be able to do their work. One set of steps to achieve this goal is:

- Identify all users.

- Work with each user to identify the current DECnet uses. Create a plan for each user that spells out alternate technology to perform the current tasks as well or better than the use of DECnet Phase IV.

- Stop accepting new DECnet host registrations (this is a soft "stop," as we will be willing to accommodate emergencies). We will continue to indefinitely assign names and numbers for host configuration—as opposed to networking—purposes.

- Follow up with each user to ensure that the conversion plan has been followed.

- At this point, all users should be using other network technology such as IP. There should be *no* use of DECnet Phase IV at this time. Therefore, it should be safe to stop routing DECnet Phase IV.

There are many other methods that we could use. In all cases, we place a very high priority on ensuring that all users' needs are met.

We deliberately omitted setting specific dates for these steps. However, it is probably realistic to have achieved the first two within a year.

Phase V

We clearly have a strong preference for using IP as the alternate network technology. However, it is worth discussing DECnet Phase V a little.

Implementations of Phase V network applications are starting to appear. The current implementations use OSI network layers. At this time, we have no intention of supporting OSI as a network layer within our network. While this intention may change, it is unlikely to do so. However, DEC has also promised Phase V support using RFC 1006. In short, this means using IP as a transport layer. The use of DECnet Phase V over IP is a strong candidate for support.

It is only considered a "candidate" as there are a number of related application-layer protocols that we must understand and possibly provide. For example, the Phase V DECnet naming scheme is not compatible with either X.500 or TCP/IP's DNS and we must evaluate what level of support is required for the naming scheme. Also, we support TCP/IP's NTP (*Network Time Protocol*) as a campus-wide timebase. That protocol is not compatible with DECnet's equivalent DTP. Again, we would have to evaluate the required level of support. There are quite likely other such application protocols to consider. We plan to work with DEC and other parties (such as HEPNET and NSI/D) to understand these requirements more fully. After we have such an understanding, we can make an informed decision whether to allow DECnet Phase V.

We encourage comments and questions on this document.

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Announcement and Call for Participation

The 8th *USENIX Systems Administration Conference* (LISA VIII) will be held September 19–23, 1994, at the Town and Country Hotel, San Diego, California. The event is co-sponsored by USENIX, the UNIX and Advanced Computing Systems Professional and Technical Association, and SAGE, the System Administrators Guild.

Scope
The annual Systems Administration Conference provides a forum in which system administrators meet to share ideas and experiences. A growing success for the previous seven years, the conference is the only event which focuses specifically on the needs of system administrators. Its scope includes system administrators from sites of all sizes and configurations. "Automation: Managing the Computer of the 90's" is the theme of this year's conference. The conference will focus on tools to help system administrators automate administration tasks and troubleshoot problems.

Tutorial program
The two-day tutorial program at the conference (Monday and Tuesday, September 19–20, 1994) offers multiple tracks, with a total of as many as twelve half-day tutorials. Attendees may move between tracks, choosing the sections of most interest to them. Tutorials offer expert instruction in areas of interest to system administrators, novice through experienced. Topics are expected to include Networking, Advanced System Administration Tools, Solaris & BSD Administration, *Perl* Programming, System Security, and more.

Technical sessions
The three days of technical sessions program will include refereed paper presentations, invited talks, panels, *Works-In-Progress* (WIP) reports, and *Birds-Of-a-Feather* (BOF) sessions. The first track is dedicated to presentations of referred technical papers. Although papers of a traditional technical content are very welcome, the Program Committee is especially seeking papers on areas such as useful tools or solutions to system administration problems. Papers which are tutorial in nature would also be appropriate. The second track of the Technical Sessions will offer invited talks, panels, mini-workshops, and similar presentations, and we seek proposals for these presentation formats as well.

Conference Proceedings, containing all refereed papers and materials from invited talks and workshops, will be distributed to conference attendees. The Conference Proceedings will also be available from the USENIX Association following the conference.

Vendor display
Well informed vendor representatives will demonstrate products and services useful to systems and network administration on Wednesday at the informal table-top display accompanying the USENIX Systems Administration Conference. If your company would like to participate, please contact Peter Mui at 510-528-8649; FAX 510-548-8649; E-mail: pmui@usenix.org

Topics
The Program Committee invites you to submit to the refereed paper track of the technical sessions, as well as to submit informal proposals, ideas, or suggestions for the various presentation formats of the second track, on any of the following or related topics:

- Automating Administration Tasks
- Distributed System Administration
- Problem Tracking
- Predicting problems before they happen
- System Administration standards

- Differences in OSF, Solaris, and ?
- Case studies: "This is the problem we solved & how we solved it."
- Career paths for system admins ("Is there life after support?")
- Applications using emerging technology (**C++**, AI, etc.)
- Performance Monitoring
- Hardware-related topics: all about memory, installing disk drives
- Tools: Programs/solutions you've developed and wish to share

Important dates

Extended Abstract Submission Deadline:	May 23, 1994
Notification to Authors:	June 24, 1994
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Submissions

We strongly urge you to request a sample extended abstract by sending e-mail to `sample-abstract@usenix.org` or telephoning +1 (510) 528-8649. The Program Committee requires that an extended abstract be submitted for the paper selection process. (Full-papers are not acceptable for this stage; if you send a full paper, you must also include an extended abstract for evaluation.) Your extended abstract should consist of a traditional abstract which summarizes the content/ideas of the entire paper, followed by a skeletal outline of the full paper. Submissions will be judged on the following criteria: relevancy of topic, quality of work, and quality of the written submission. Authors of an accepted paper will present their paper at the conference and provide a final paper for publication in the Conference Proceedings. Final papers are limited to 20 pages, including diagrams, figures and appendix and must be in *troff* or ASCII format. We will supply you with instructions and *troff* macros. Papers should include a brief description of the site (if applicable).

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