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As requested -
Salutations distinguees -
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AN AFFORDABLE APPROACH TO NETWORKING AMERICA'S SCHOOLS

As the Clinton Administration approached Inaguration Day, with promises of making a large number of inititatives in the first 100 days, its Transition Team had to get specific on lots of its policy promises. One promise, personified by Senator, Vice-President Elect Al Gore, was to use Technology, and in particular Telecommunications to attack a wide range of US problem, including education.

On December 5th, a member of that team, who had been Senator Gore's chief staff assistant on the billion dollar National Education and Research (NREN) legislation, e-mailed me with the following question.

>Subject: Networking schools
>Date: Sat, 05 Dec 92 10:03:02 EST
>I'd be interested in talking to you about your best guess
>on the costs of networking the nation's public schools using
>cheap, low-tech solutions. Is there anyone else you'd suggest
>I talk who has some solid numbers?

Mike Nelson
Senate Commerce Committee

My Answer

Dear Mike:

There are lots of implications to your question. But these are the thoughts I have on the subject of 'cheap, low tech' solutions to networking the nation's public schools.

My answers here are based on 7 years of dealing with networking schools precisely on the lowest cost, low tech initial strategy - which seems to be a very unpopular approach when discussing the subject with higher education types, especially with those on the Internet, where the dominant belief is that the only acceptable rock-bottom aim is 'every school on the Internet at the telnet/ftp level' from the git go. Which I estimate would cost over $2 billion, and with running annual costs, I believe of at least $1 billion, ($680 million just in the salary of one competant TCP/IP network manager for each of 17,000 shcool districts, which is what it would take to put them all at the

TCP/IP level with district wide equipment). I doubt the schools or their districts would cheerfully bear these kinds of costs.

So I developed a paper about a year ago called "Appropriate and Distributed Networking" which I am sending you seperately, in which the 'low cost, low tech - relatively' solution is elaborated, not just for dollar cost of hardware, software, and connectivity services, but for the CRITICAL issues of political (at school administration and elected board levels) acceptability oftechnology and distance learning in education, school district orstate technological support, of teacher training to use the devices, the network, and most importantly and generally overlooked, the radically different educational methodologies required to effectively (COST-effectively) teach by telecom, which should be formally learned, and rarely are, anywhere. The 'soft'costs may be more, in the initial years, than the hard costs.

My point being that one of the main values of approaching the whole subject on a 'low cost, low tech' basis has as much to do with gradually and progressively 'educating and acclimatizing' public school decision makers, including the local, parents, public and press, to the comparative VALUE (cost/benefit) of distance learning, as well as giving the teachers and administrators a chance to LEARN progressively how to use, themselves learn by, and teach students with, in the 'telecom culture' - comparatively low end tools, rather than assume if we plunged 40,000,000 K-12 students directly into high end and costly-equipment/support networks we would be better off.

66% of all the radically different methodologies and 'virtual student-teacher relationships' required for effective distance learning can be learned on local lan, e-mail, and interconnected computer bulletin-boards by teachers - and even this takes more than a year with real application - before the whiz bang virtues of rlogin can be exploited.

One does not teach the theory of flight by putting students into an F-16 the first day. Even at the Air Force Academy. They start with gliders.

So the merit of 'low cost, low tech' solutions, is sound, not just because of budget constraints, but because if one goes - and many have - into high end Internet, school-server, workstation solutions from the beginning, one is paying for a lot of unused (for a long time) hardware, software, and network capabilities - which will be obsolete by the time its full potential is realized, (2 years is a whole telecom development cycle today), and will force the educational model into 'school centered only' - rather than 'learn from home too, and for the rest of your life' forms - the built-in technical support requirements at the school, district, or state level go up tremendously, and the whole goal of universal, reasonably egaletarian benefits of distance learning - which it inherently promises to the poorest, most remote, or least talented schools in the country.

So now to specifically address your question.

The rough figures I have are that there are 17,000 school districts, 83,000 public schools (22,000 non-public schools), in 50 states.

Now the lowest cost, lowest tech option that makes any sense to me in terms of networking schools, is to base the lowest-level of deployment on store and forward school based dial-up (or packet radio) systems (single or multi-user BBS), using intermittent connections to each other, (uucp, fidonet protocol, fredmail protocol) and to larger, continuously connected networks (X25, Lans, Bitnet, TCP/IP protocols). If a school has, or can, enter the network at higher levels, fine, but by using the power of distributed e-mail, bbs/conferencing/maillisting, and file transfer, with standard protocols at the core, it just doesn't make any difference what platforms or OS's are involved.

Using UUCP protocols, native to any Unix system, and the overwhelming majority of Internet hosts and servers, any PC running BBS software, or any small unix system running conferencing software, can be fitted with the ability to exchange e-mail, conference comments, and binary files with any other system. Even while, as in the case with both Fidonets (basically MSDOS machines), Frednets (basically AppleIIs and GSs) or Apple nets (Macs), the same box can talk both on its own protocol 'net' as well as via UUCP, to the Usenet, Bitnet, Internet.

Thus new 386 MSDOS machines with hard disks, sufficient ram, built in COM1, COM2 ports, (permitting 2 line systems without added hardware), costing from $600 to $1,000 each (hardware), can be the basis for local, linked multi-user networks for a school. With software (OS, BBS, Editor, 'fredgate or uucp modules', fidonet utilities) costing another $300-$500, including registration of shareware where it is superior to commercial products. Which, at this level, it usually is). So, without printer, and not counting modems, a single MSDOS system that can go from 1 to 16 or so dialin or, locally connected hard wired lines, and exchange data via UUCP with Vax's, Unix servers, Internet, and each other, will run from $1,000 to $1,500 - all new equipment.

Mac's with comparable capabilities cost now in the $1,000 to $1,500 range. The comparable software costs from $500 to $1,000. So the range is from $1,500 to $2,500 per 'BBS' system.

Any larger school, such as urban high-schools which can handle the horsepower - or at the District level where there are few schools - may opt for a small Unix machine. Which, on either an Intel 80386/486 base running Dell, SCO, or Interactive Unix, can come in at under $6,000 for hardware, and $3,000 for software (including TCP/IP).

With over 75% of ALL public schools still equipped with Apple IIs or GS's, especially for the Elementary school level, the Fredmail software which, which now can, and does talk UUCP directly to the Internet, the 'lowest cost' option exists to depend on existing hardware - upgraded at costs of $300 to $600 - to provide a solution for that installed-base schools.

One of the main decisions for any program of every-school implementation of telecom nationally, would be whether to assume all schools have, or could acquire at their own local expense as part of their 'match' the basic platform hardware - PC - to a minimum technical specification. Or to provide in all cases the complete machines. I would guess that 75% of all the schools in the US have now, and could commit, such a platform, accounting for more than 50% of the cost of a total solution. (Only 217

school districts in the US out of 17,000, in 1991, did not have computers in their district schools).

The cost of quite high-speed modems, using, again standard CCITT protocols of V32 (9,600 baud) and V32bis (14,400) baud have dropped below $300. The economy here is not as obvious, but significant. When a BBS of any type can, using store-and-forward Fidonet, Frednet, or UUCP protocols, automatically dial up remote systems at 9,600 baud or higher, they can exchange a complete days' data in one call per night of from 1 to 10 minutes duration. Even involving a long distance call, this is so much more economical than 'continous connection' telecom, or 'every person calls long distance with a modem at brain speed, not system speed' that it is the basis for global, 17,000 node Fidonet, and Frednet. Which does not rule out the use of subsidized 800 numbers within states to reach the most remote school district - not on a rather costly'individual dial up' basis - but on the use of 800 numbers to carry the intermittent, high speed, compressed-data, calls from localschool, or school district, BBSs.

These same modems are quite capable of handling the emerging use of 'intermitent TCP/IP' on Macs and PC, using the SLIP protocol. Which enables a small system to be 'temporarily' connected' by direct dialup modem lines to an Internet IP server, with full telnet/ftp protocol capabilities while connected. $140 worth of Mac software, together with some public domain utilities, can turn any Mac into a node on the Internet while connected.

Now the main arguement of those who say the only solution is to have full Internet connectivity for a school, is that if the teachers and student only have UUCP, or Fidonet, Frednet store and forward connectivity they can't use the power of rlogin, telnet, ftp, use wais, gopher and other services generic to TCP/IP. My question has always been, just how many hours of the day, what days, and what months, are such 'advanced' utilities actually to be used in course instruction? With schools in session only perhaps 8 hours a day, 5 days a week, for 9 months, the actual amount of telnet/ftp 'connect time' for a given school can be pretty small for a complete, dedicated circuit, TCP/IP running server or host, with technical support, 24 hours a day, year round, and connectivity costs to the Internet in a state to be factored in. Intermittent SLIP, PPP from PCs when needed, brought right into the classroom by either dial up line with a 14,400 speed modem, or a spread spectrum (no licence) packet radio device, is a compromise, vastly cheaper solution.

The dialup based model, as differentiated from the in-school workstation model has a very important long range characteristic. That is, the school's system can be accessed - by teachers, students, parents and mentors 'after hours.' In fact the Annenburg CPB grant project for math/science education, literally requires that 'parents' be involved technologically, with their children's education. One fault with the high-end workstation approach, is that the ONLY place the network can be accessed is on the school premises. Which effectively cuts out all outsiders from 'distance learning.'

The 'distributed' BBS/conferencing system has another thing, economically, to commend it. And that is, if there are 'continuous' connections to servers and hosts, to serve all simultaneous users at peak load times - i.e. prime time on school

days - one has to have a lot of dial up connections to central, beyond-school,servers, such as the Internet. I once did an analysis of the alternative ways for the 55 public schools with 30,000 students in Colorado Springs main school district to reach highly economical Colorado Supernet. With direct connectivity locally, it would require over 100 modem equipped phone lines on the CS Cisco Servers, to handle a representative daily load during school hours. The alternative to that would be equipping each school with servers which could be used in-school locally, while each of the 55 would be connected to the CSN server. But that would require technical expertise at the school level which is simply very scarce. (In fact it was the revolt of many of the 1,063 Texas School Districts that caused the State to withdraw an RFP that was based on putting a Unix system at each District, to serve District schools, and link with the center, on the basis that the school districts simply didn't have that kind of expertise. So TENET fell back to be based on using the University network system, expertise, and investment. The further down toward K-12 schools you push technical direct Internet connectivity the higher the price you pay for the technical personnel infrastructure to service it. The distributed BBS structure can be designed within the reach of school-level, or at the least, District level, expertise. It only took 1 year for the State of Montana to deploy 26 linked Fido systems called METNET, while it took the University system 5 years to implement TCP/IP just to the college, university level, in spite of their full time DP staffs) One of the other arguements given for high bandwidth (and corresponding higher cost than low tech, low bandwidth) connectivity for K-12 education, is that without it schools can't handle graphics, or sound. That is true only if you assume that the graphics have to be huge bitmaps in TIFF or comparable formats, or sound in large data files. But this is simply not necessary. I seem to have been one of the few people in the US who has felt that there were graphical technical counterparts to low bandwidth, PC based, telecom. I have long advocated resorting to NAPLPS (North American Presentation Level Protocol Syntax) an international, vector (algorithms in the target computer draws the graphics), rather than raster (bit mapped), standard. Which was important enough for a 'low bandwidth' solution that IBM and Sears use it in their 1.5 million person Prodigy service. And there simply has to be the provision for graphics - from photographic and scanned-in image level, to abstracted diagrammatic, map, chart, foreign language or math symbolic, and animated process representations - for K-12 telecommunications education. (NAPLPS is being used in Colorado also by public television stations for vertical blanking interval - VBI - standard for its state-wide, public-access government information network)

I believe we have demonstrated a decisive solution to that problem,which is also economical. One could call it 'low tech' but I think it is more 'high intelligence' :-) When none of the educational operations I support could interest any of their grant resources to fund them, so we could develop the necessary new software tools with more advanced concepts implemented for end users, with our own private funds we hired, through telecommunications, two Russian software engineers and a scientist in Moscow, and developed it ourself. The long and the short of it is that it works. We are now routinely sending graphics, animated graphics, and foreign language fonts transarently through any e-mail, or computer conferencing, bbs system, globally which can be viewed and responded to by any

MSDOS, or Mac PC. And can be adapted to any other low end PC, and exists for X-Windows at the work station end.

The NAPLPS standard itself has been updated, and now can incorporate JPEG graphic formats also. The Internet Engineering Task Force (IETF) recently entertained a proposal to add NAPLPS as an extention to their MIME (multi-media by e-mail) standard, and it looks at this writing that that will be accepted. So NAPLPS becomes a low-end ANSI standard within a high-end (Internet) standard.

So many graphical software and hardware tools - covering the full range of school subjects - English, foreign languages, geography, history, science, math, art - can be built upon the current NAPLPS standard, by multiple vendors, to work over any network, with any display platform. And even in a store and forward BBS, dial up, local system environment.

NAPLPS is a perfect graphical and symbolics standard-based telecommunications solution to your low cost, low tech question. Cost? Our own commercial Teledraw product (NAPLPS terminal, drawing, symbol processing), because we took advantage of the 400 ruble to 1 dollar situation, will sell in the $150 range. And there already is both limited shareware, freeware, and BBS 'server'software available which can run on the host and make any BBS into dual ASCII, NAPLPS host. But since NAPLPS is a standard, and not a product, there is no reason that many vendors and projects could not follow our lead and produce similar, and specialized versions. In fact there is already the appearance of a variety of implementations.

Other considerations. The above analysis covers the communications model (distributed store and forward based at bottom, but capable of continuous upgrade), the systems required (hard disk, multiple port, any OS, PCs, with fast modems), appropriate software to be used.

There are other considerations.

A Network of Networks: The Internet, provided that Congress and the Administration, insures that the AUP, cost-allocation, and related public-interest issues are handled properly can operate as the principal 'backbone' of the all-connected school network. The problem that exists right now is the widely varying sets of charges, rules of use, and connectivity-conditions that the Federally subsidized mid-levels impose on those connected to them. For example, in Colorado, Colorado Supernet charges ANY Colorado person, or organization only $2.00 an hour to connect on a dial up basis. In Montana, however, and hard as it is to believe, the director of Northwest Net does not want any system connected to the Internet through their service unless they are directly involved with 'education.' Since some systems, even those operated on College Campuses - including Big Sky Telegraph - permit, in limited and controllable ways, the 'public' including parents, to log on, Northwest wants to deny the entire system access to the Internet. Thus low cost, low tech, solutions at the school, school district, state departmental, and associated university level will not be universally 'networked' until clear policies are promulgated from Congress and the Administration on the use of any network subsidized by the US Government.

Training and Adminstration: The biggest obstacle today to the effective use of existing and affordable networks by K-12 schools is the training and preparation for teaching via networks by teachers. Followed by the lack of consistent technical support and adminstration of telecommunicated instruction at the school and school district level.

It took several years, even after grants and buys of microcomputers for K-12 education occurred, before effective instruction using them started to take place. And in many places it never occured. And not only did the equipment not get used for years, but by the time it was when personnel changed, the computers and software were obsolete.

That same scenario can happen again with Telecommunications, unless numerous steps are taken to insure that whatever is subsized is used effectively.

1. There should be some criteria for providing connectivity assistance in the first place. Not only a school, district or state Plan for incorporation BEFORE the award, but auditing DURING the period specified for assistance (like 3 years).

2. With penalties of withdrawal of equipment or services unless the telecom systems are, in fact used, for education of students, not just teachers.

3. Systematic teacher training must be provided for. Virtually no School of Education is today teaching teachers how to use telecom for instruction. And it has been my experience as the person scholars credit for teaching the first courses for college credit by telecom in the US (1983), that virtually no 'computer science' degree programs teach any of the level of 'telecom' we are here considering. I have had to teach more of those with Masters Degrees in Computer Science than I care to recount, both the technical and pedagogical details of distance learning. At the minimum, any teacher who engages in distance learning with these tools, should have at least three certified courses of instruction under their belt before being considered fully qualified - a course, taught using the technology, in the technical telecommunciations they will use. A second course in the general principles of education in a 'virtual' classroom using any of many distance learning techniques. And a course, taught, again over the telecommunications medium they will use, on how to teach the particular disciplines, or grade levels they are involved in - discipline specific - including resources. Three such courses for in-service, or college credit, will run in the $200 each range, or $600 to $750 for direct teacher training.

4. Technical support. There has to be clear provisions for technical networking support for schools. Only in recent years has there emerged - usually at the high-school or district level -'computer coordinators' who repair, advise purchases, install microcomputer educational equipment. That does not qualify them to deal with the very different technical world of telecom.

The above matters MUST be dealt with, one way or another, with a high degree of follow through, or any national program to acquire low cost, low tech network access for all 83,000 public schools will give very uneven results and lots of waste. Whether or not the 'costs' for training teachers, and technicans should be

included in the costs you ask for I don't know. But it CANNOT be assumed.

Library Resources: One of the greatest problems that will confront educators using telecommunications for education, will not be in getting the technical links to a resource, but in how to know what or who is available on the vast network, and how to reach them through it. This is a natural function of technologically equipped libraries and librarians. Fortunatley libraries are far more prepared to perform this function now via telecommunications, than schools are to teach by telecom. Their unique and important resource location function - and the necessary funds to support them in this endeavor in specific support of schools - should be provided for in local conjunction with schools acquiring network capabilities. This also cannot be assumed.

Public Readiness: Even if Congress appropriated all the funds necessary to equip all the public schools in the US for networking,a great deal of thought would have to go into how the program would be implemented, taking into account that the legal control of K-12 education rests at the elected school board level, and that about half of all school finance comes from state legislatures. Very little comes from the Federal level. And the functions of school administrators, elected school boards, state school boards and departments, legislatures, and the federal level are all very different. Both public readiness for the wide-scale introduction of telecommunications tools - 'technology based education' - and cooperative planning and implementation along with state and local jurisdictions would be critical to the success of the program. It would probably take a minimum of one specially formed federally organized team for each state to carry off the political, public and elected-official educational, school and district plan-review, and initial support function for districts to get the plan off the ground. That would be a cost.

SUMMARY: With all the above considerations and caveats, my best 'guess' at how much it would cost to provide all schools with a 'Cheap, low tech' network solution would be:

Per School	Low	High
PC, modem, software	1,500	3,500
Dialup lines (2)		
Install	250	500
Annual operation	1,000	2,000
Network Costs	1,000	4,000
	3,750	10,000
83,000 schools	$310 million	830 million
Training 3 teachers per sch at $600/1,200	150 million	300 million
District technical Administrator, 17,000 Dis first year 30,000/50,000	68 million	85 million

50 Implementation Teams, 1 year, 5 persons Admin cost $500,000 Leader $50/60,000 Technical Network 30/50,000 Technical Hd/Soft 30/50,000 Education Advisor 40/60,000 Acquisition Spec 40/60,000	10 million	14.5 million
Supplement Library Nets (kinda arbitrary - on a per district basis $1/3,000)	17 million	34 million
Totals	$555 million	$1,263.5 million

If 50% of the schools had $1,000/3,000 worth of hardware to match with, the totals would be reduced by 83 to 249 million. If 100%, by 166 to 498 million.

So that is my best estimate without using more detailed technical-demographic information about schools, and a more refined interpretation of just what 'networking' is to mean.

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Next	OSS '92 Terry S. Kees, Chair, Advanced Information Processing and Analysis Steering Group (AIPASG), Advanced Information Processing and Analysis (American Intelligence Journal, Summer 1992),

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