Options for Network Charge Back

Version 2.3 - November 21, 2000

Scott Baily and Pat Burns

This document outlines potential options to implement a charge-back scheme for network access. When evaluating the options, several things must be considered: flexibility, accuracy, manageability and cost. Based on these criteria, none of the options are perfect. Nevertheless, the University needs to move forward to assure the continued availability and utility of the network resource.

The usage and cost of Internet access have risen dramatically, beyond ACNS' ability to fund. Projected costs of networking for FY's 00-02 are shown in Table 1 below. In FY 01, the costs are being covered centrally, using one-time funds. Beginning July 1, 2001, it is planned to implement a charge-back scheme to recover these networking costs. In FY's 02 and 03, the projected networking costs will be approximately offset by reductions in the cost of basic telephone service (savings) for all units on campus. Both costs and savings will be identified at the departmental level. For non self-funded units (e.g. colleges, departments and administrative units, excluding enterprises), budget adjustments will be done in FY's 01 and 02 to rectify disparities between reductions in basic service telephone costs and newly instituted network costs.

Table 1 Projected Annual Costs for Networking			
Item	**FY 01**	**FY02**	**FY 03**
Networking	$373,159	$580,003	$803,676
Databases	$0	$100,000	$100,000
Total	$373,159	$680,003	$903,676

The situation of significant increases in networking costs is not unique to Colorado State University. All major research universities are facing this problem at this point in time. At the October 2000 EDUCAUSE meeting, an ad hoc "birds of a feather" session on network charge back attracted 40 Universities, 10 of which are already charging back, and 30 of which are planning to implement network charge back. In the Westnet region, comprising major research universities in the states of Arizona, Colorado, Idaho, New Mexico, Utah and Wyoming, three-quarters are planning to implement charge-back for networking. CSU is fortunate and apparently unique in that, as it will pay off the debt associated with its telephone switch in November 2001, and the savings from that debt payoff will approximately offset the networking costs over the next several years. This document presents options for partitioning the costs of network access.

I. Option 1: Charge by the connection into CSU's backbone network

Currently, ACNS manages the University's central backbone network to which units and departments connect to receive networking services. Units pay the one-time costs of the connection, including all costs at their end of the connection and central costs that ACNS must recover to accommodate new connections. The one-time central connection costs paid to ACNS are summarized below in Table 2. Note that the cost for connection at 1.5 Mbps appears aberrant because it is a more expensive Wide Area Network (WAN) connection, while all other connections are Local Area Network connections.

Table 2 Current one-time connection costs		
Connection Speed	**No. of Connections**	**One-time cost**
1.5 Mbps	7	$4,919.00
10 Mbps	35	$1,176.74
100 Mbps	24	$3,158.58

1,000 Mbps	6	$9,407.49
Total	72	N/A

Currently, there are 72 separate physical connections into the University's backbone. For those units that share backbone connections (for example, multiple departments in a single building aggregated onto a single backbone network connection), ACNS would partition the backbone charge to these units in proportional to their connections into the building backbone switch, thereby eliminating the possibility of recharge by various units. In order for this to be manageable and controllable, ACNS must assume responsibility for and control of all building network switches. In this option, all large auxiliary units would be required to maintain their existing separate connections into the backbone. Small units that are not centrally funded would be required to connect using their own edge network switches. Individual connections that are not centrally funded would have to be paid for by their department.

Pros:

- All connections are easily identifiable and countable. Further, connections are manageable as ACNS operates the backbone, and must be involved when units plug in.

- This option preserves the current point of demarcation between ACNS and departments, allowing units to continue to operate and manage their own networks.

- This is by far the simplest of the options technically. Technical staff opine that all other solutions will be extremely difficult to support – both centrally and within the units.

- This model is perhaps the best at achieving a balance between maintaining adequate overall capacity and allowing units to manage their costs. Units can control their costs by ordering the speed of service. Sufficient capacity can be planned for centrally in aggregate, and costs can be controlled by units by adjusting the speed of their connection.

- This option can be constructed to avoid recharge by units by making ACNS the only entity on campus that charges and receives payment for this service. However, this will require either ACNS staff time that will have to be funded or time of local staff in the units to identify and partition the costs when the backbone connection is "fanned out."

Cons:

- End-user connections that are mixed in with other connections, such as individual computers intermingled with academic computers (for example in colleges and departments) will be difficult to identify and impossible to control. As these individual connections are supported behind a unit's aggregate connection, by default they may be funded by the unit that pays for the aggregate connection. It may be worthwhile to consider an explicit prohibition against charge back for these situations.

- This option might encourage units to aggregate their networks across buildings, for which there may be insufficient fiber available.

A. Charge back based upon speed of the connection into the backbone

In this option 1.A, ACNS would distribute the recurring monthly costs according to the speed of the connection into the backbone network.

Pros:

- This model is easy to plan and budget for, as the charges are predictable.

- This model is also easy to account for; accounting and billing can easily be done monthly.

Cons:

- This option discourages backbone connection speed upgrades that may be required to accommodate emerging applications such as training on demand, video conferencing, etc. However, this issue exists for all models to some degree, as any model involving charge-back would permit units to choose to reduce costs by reducing services.

- Furthermore, this option may result in unacceptably high costs for some units, such as for the classrooms that have multiple Gigabit connections into the backbone, yet generate very little traffic.

- To minimize cost, units may desire to disconnect their networks from or reduce the speed of their connections into the backbone. The variation in revenue resulting from this may impair central planning for capacity. Effecting multiple connects and disconnects also would require more technical staff to support. This situation may be able to be managed by introducing an appropriate one-time charge per connection to discourage this "churn."

Cost Estimates

It is proposed to use as a cost model the costs in Table 2 above, where each upgrade in speed results in an increase in cost by a factor of 2.8, as this represents an acceptable balance between price and performance. (Note that the magnitude of this number, 2.8, may better emerge from the campus – 2.8 is suggested as a starting point.) Using the numbers of connections in Table 2 above and the cost factor of 2.8 yields the cost partitioning detailed in Table 3 below. Provided ACNS could enlist unit support personnel in performing cost partitioning for their building, ACNS does not anticipate needing any additional support personnel to implement this option. If ACNS is required to maintain the networks to the building switch and perform the cost partitioning within buildings, ACNS anticipates needing one additional network engineer to perform the additional work associated with this option. Funding for this person has not been included in the overall costs in Table 1, and, and therefore is not reflected in Table 3 below.

Table 3 Cost estimates for option 1.A, 72 connections

Backbone Speed (Mbps)	**No.**		**FY 01**	**FY 02**	**FY 03**
1.5	7	Annual	N/A	$1,600.49	$2,126.94
		Monthly	N/A	$133.37	$177.24
10	35	Annual	N/A	$4,481.37	$5,955.42
		Monthly	N/A	$373.45	$496.29
100	24	Annual	N/A	$12,547.83	$16,675.19
		Monthly	N/A	$1,045.65	$1,389.60
1,000	6	Annual	N/A	$35,133.94	$46,690.52
		Monthly	N/A	$2,927.83	$3,890.88

The costs in Table 3 above assume that there is no erosion in the numbers or speeds of connections. It is likely that an erosion will occur, and this ought to be planned for in the model. Specifically, adequate capacity for the entire University needs to be funded by the revenue deriving from the charge back. If insufficient revenue to fund adequate total capacity into the University is not realized, then all at the University will experience inadequate Internet service.

Finally, the current deployment of networking has individuals from separate units sharing individual switches. In order to partition units onto individual switches, it will be necessary to procure additional network switches. A very rough estimate of the potential one-time cost of this is about $80,000 one time. How these one-time costs would be covered has not been determined, but is a subject of continued discussion.

B. <u>Charge back based upon measured traffic over the connection</u>

In this option 1.B, all traffic into and out of each backbone connection would be metered, and units would be charged in proportion to the total (in plus out) traffic. This metering would be done monthly. The total monthly cost would then be prorated according to this measured traffic.

<u>Pros:</u>

- This model is relatively easy to account for; accounting and billing can be done monthly.

- This is perhaps the "fairest" model that is technically feasible, as it is traffic based. Ideally, the measured traffic would, in aggregate, reflect the load each backbone connection puts on the Internet connection. Currently, it is technically infeasible to measure only the off-campus traffic into and put of each backbone connection.

<u>Cons</u>:

- This model is not easy to plan and budget for. Costs would vary every month, depending on capacity. Specifically, this model poses difficulties in making budget adjustments, that would have to occur monthly, as that is when the networking costs would be determined.

- The traffic that would be measured would include both on-campus and off-campus traffic. Units that have a large proportion of on-campus versus off-campus traffic would pay more than those units that do not.

II. Option 2: Charge back by individual connection

For this model to be effective, ACNS feels that it would have to have responsibility and authority for the network to the wall jack, and provide support to the wall jack. This would require additional staffing.

<u>Pros:</u>

- This would allow individual projects to be charged for service, as we do now for basic telephone service.

<u>Cons:</u>

- This option would require a massive accounting effort. Option 2.B is especially problematic in this regard.

- Units that pay for central network support may expect ACNS to be responsible for equipment upgrades over time. This is not currently planned for in this document.

- Individual charge back will present significant hardship for certain situations, including large, open computer labs.

A. <u>Charge back based upon the connection into the switch</u>

In this option, costs are partitioned by the active switch port. This would be determined by counting all connections to switches in communications closets.

<u>Pros:</u>

- This would implement the change and reform recommendation to provide central network support to the wall jack. This would result in a higher quality network, tending more toward the operation of the network as a basic "utility," that is sufficiently robust and reliable so it becomes assumed that it will always "work."

- This option avoids the need to identify, count and locate individual computers in order to associate them with an account.

<u>Cons:</u>

- This option would require central control over the communications closets, which is a reversal of a model where ACNS has granted some subnet managers access to secure communications closets. There is very strong opposition to central control in some areas of campus- the University may not be ready to absorb such a cultural shift.

- The accounting and administration of this option would be extremely labor intensive. Central support to the wall jack would require additional personnel, increasing the total costs that must be recovered.

- Central support to the wall jack would require equipment upgrades in several areas, further increasing the total costs by an unknown amount.

- A transition period would be required to attain a position (preparing building LANs, obtaining and training personnel, etc.) where this would be possible, requiring subnet managers to share the support burden for their networks during this period.

- This option presents difficulties for central planning in that, to save money, units will likely disconnect users from their networks on an ad hoc basis, even monthly. This will make it difficult to set costs as they will likely be predicated upon the current numbers of users.

- Departments desiring to activate all switch ports, increasing convenience and tending closer to providing the network as a "utility," will be discouraged from doing so due to increased costs.

- This option is rife with issues of an appropriate time frame for charging. For example, the residence halls are occupied only about 9 months per year. Some faculty do not work over the summer. Some student labs are not open over the summer. The temptation will exist for individuals to disconnect their computers from the network to avoid charges. Telecom has instituted a connection charge for basic service, and thus avoids frequent disconnects and connects. This may be an option that deserves some consideration for network charges.

- To minimize their cost, Departments would be inclined to build their own networks behind wall jacks, including even wireless networks. Wireless networks, although providing the convenience of mobility, are especially slow, extremely insecure and are very difficult to support. This situation is not manageable. This would result in reduced performance and security, and is contrary to the directions we have been implementing in CSUIITE as mandated in Change and Reform.

- A policy is required to define acceptable topologies and configurations that would be allowed connected to the wall jack. ACNS may be expected to support non-standard hubs/switches that are behind the wall jack, and this is an untenable situation.

<u>Cost Estimates</u>

In this option, the per unit cost is computed as follows:

$$\text{Per unit cost} = \frac{\text{Total Costs}}{\text{Number of Active Ports}} \qquad \text{Eqn. (1)}$$

In order to compute the costs for this option, the number of active wall jacks, or active connections on network switches and hubs, must be known. Currently, there are about 15,000 unique network devices (including computers, printers, network devices such as switches and routers, and other devices such as experimental apparatus) connected to the network. While it is unknown how many active jacks there are, a reasonable assumption is that there are 10% more active jacks than computers connected to the network, yielding 16,500 as the denominator in Eqn. (1) above. This yields the per unit costs shown below in Table 4 below, assuming all 16,500 jacks are active 12 months per year.

Table 4 Per jack cost estimates for option 2, 16,500 jacks

Term	FY 01	FY 02	FY 03
Annual Costs	N/A	$41.21	$54.77
Monthly Costs	N/A	$3.43	$4.56

Note that it may make more sense to establish differential charges for different speeds of connections, as for option 1.A. However, without knowing the distribution of speeds of jack connections, such costs cannot be computed. The costs in Table 4 above also presume that there is no erosion in the numbers of connections. It is likely that such erosion will occur, and so ought to be planned for in the model.

B. <u>Charge back to individual computers</u>

This option is very similar to option 2.A above, except that here, instead of charging by active ports on switches in communications closets, computers would be “counted” on each of approximately 155 logical backbone interfaces. Each of the approximately 15,000 computers on campus then would have to be associated with an account number. Aggregation of charges over account numbers then would then have to be accomplished. However, even counting the number of computers on the network is difficult – a recent counting in two different ways yielded a discrepancy of about 2,000 computers. This model would require additional staffing in ACNS.

<u>Pros:</u>

- This option embodies the closest association between individualized services delivered and cost, as each computer connected to the wall jack that generates traffic would be charged.

<u>Cons:</u>

- This option presents the greatest technical challenges, that the technical staff currently regard as insurmountable. Technical difficulties abound, including: devices (e.g. firewalls and routers) that exist today on the network that serve to “hide” computers behind them, computers that have power management, go to sleep and “drop off” the network, portable and wireless computers that are transitory, etc.

- The accounting and administration of this option would be even more labor intensive than for option 2.B. Associating a billing account number with each of 15,000 computers on the network is a daunting task.

- Issues remain of when and how often the counting and accounting are to be done. This option requires by far the greatest recurring effort from central and unit staff.

- In order to facilitate associating the computers counted on each backbone with an account, it will most likely be required to partition the network further to make the model easier to implement, elevating the total cost of such a model.

- A lengthy transition period would be required to attain a position (preparing building LANs, obtaining and training personnel, refining counting methodologies and procedures, etc.) where implementing this model would be possible.

Cost Estimates

The costs for this option are computed the same as for option 3, except that the denominator in Eqn. (1) is 15,000, yielding the numbers in Table 5 below.

Table 5 Per computer cost estimates for option 3, 15,000 computers

Term	FY 01	FY 02	FY 03
Annual Costs	N/A	$45.33	$60.25
Monthly Costs	N/A	$3.78	$5.02

Note that it may make more sense to establish differential charges for different speeds of computer connections, as for option 1.A and possibly for option 2.A. However, without knowing the distribution of speeds of computer connections, such costs cannot be computed. The costs in Table 4 above also presume that there is no erosion in the numbers of connections. It is likely that this will occur, and so ought to be planned for in the model.

III. Option 3 – Charge back network costs by telephone line subscriber, accounting for large discrepancies in number

In this option, the goal would be to assume that individual computers can be associated with individual telephones, in an effort to use the telephone billing database as the network charge back billing base. In order for this to occur, areas where the numbers of telephones are widely disparate from the numbers of computers would be accounted for separately. Obvious pockets of significant discrepancy include: the residence halls, the library, and student computing labs.

Pros:

- An existing billing infrastructure already exists, facilitating billing for this option. Pockets of discrepancy can be handled relatively easily, as long as the pockets are “large.”

Cons:

- This option represents the loosest association between services delivered and billing. As such, there may be issues of federal cost accounting standards.

- As users transition to Voice over IP (voice over the network – we are already seeing this type of traffic on our network), they will avoid charges for both telephone and network, yet be receiving networking service.

- The cutoff point in the size of the "pockets of discrepancy" is not well defined. There is great likelihood (in fact, a virtual certainty) that users below the threshold of consideration will want to be dealt with as a discrepancy, causing this model to devolve into the model of Option 2.B that is technically infeasible.

Cost Estimates

The costs for this option would be computed in a manner similar to that of option 2.B above. After the numbers of computers identified in the large pockets of discrepancy are identified, then an association can be made between the number of computers and the number of telephones. The per computer cost assessed to the computers in the large pockets of discrepancy would be the same as that in Table 5 above. An aggregation of all remaining networking costs would then be done over the number of telephones (currently, about 10,000), yielding a unit cost for networking per telephone. However, in this model, all basic service telephone users would be charged this cost, with an offset in the cost of basic telephone service.

IV. Scope of Activities and Oversight

Support to the Wall Jack

The 1996 Change and Reform item 3.AS.12 included a recommendation that central networking support be extended to the wall jack. None of the above models explicitly assume that this model will be implemented. However, any of the models above could support the implementation of this model by including the costs of additional support personnel as an additional line item in Table 1. These costs would be reflected throughout all costing models above as an increase in the numerator of Eqn. (1), for example. Estimates of the steady-state costs for this activity are provided in Table 6 below, along with total costs from Table 1. The costs of this in a relative sense (last line in Table 6) are not too extreme, and will get proportionally lower as the base costs of networking capacity are likely to rise much faster than salaries every year.

Table 6 Annual Support Costs for Networking

Item	FY 01	FY02	FY 03
Base (from Table 1)	$373,159	$680,003	$903,676
Staffing	N/A	$100,000	$105,000
Staffing as % of Base	N/A	15%	12%

The benefits of this are numerous. In most cases, higher quality networking support would result. Staff would be dedicated to this activity, with overlap of responsibilities, backup and economies of scale. Extended hours of support (but not 24x7) would be provided. The network would be centrally configured end-to-end, facilitating the provision of new, important services that are emerging, such as Quality of Service and multicast. End-to-end security could also be implemented.

Fiber Support

Finally, it is worthwhile to consider including fiber costs in the overall model. Underground fiber is currently charged back at $115 per month per connection. This allows users to configure their own networks and their connections to the campus backbone network. There are several problems with this model, especially when considered in the context of the above charge-back models for networking, specifically:

- There is no mechanism to recover costs of in-building fiber, only underground fiber is charged back. Expenses associated with in-building fiber have grown to be very large, and users expect this to be provided to them for free.

- Central subsidy for the fiber activity has been eliminated over the past three years, and the charges have not kept pace with the ramp-down of the central subsidy. Currently, about $115,000 per year of revenue accrues from this charge back, except that Telecom has been expending about $300,000 per year maintaining and expanding the fiber network. This situation can not continue beyond this fiscal year, as the Telecom reserve is expected to be exhausted at the end of FY 01

- Accounting for the central fiber activity is difficult and time consuming for staff.

- Users implement their own fiber networks to minimize their costs, rather than optimize the use of the underground fiber plant and/or maximize the performance of their networks.

- The model is not equitable, as those buildings with central backbone network nodes have fiber supplied to them, and users in those buildings do not have to pay for an underground fiber circuit.

An alternative to the current fiber charge back is to lump the fiber plant costs with the networking costs. This would allow the fiber plant to be managed centrally to its and user's best advantage, and minimize administrative costs.

Oversight of Activity

It is our recommendation that a committee be formed to oversee and manage this activity, just as now is done for the central modem pool. The functions of the committee would be to: 1) plan for capacity for the forthcoming year, 2) establish per unit costs for the next year, 3) set policies for the activity, and 4) adjudicate disputes. That model has worked exceptionally well for the central modem pool, and we strongly endorse it conceptually for this activity. The central networking committee would include many of the same committee members as the central modem management committee.

A committee has been formed and will meet for the first time in early December 2000.