Case study 9

Using videoconferencing at the Engineering Faculty of the Politecnico di Milano/Italy

The Politecnico di Milano[1]consists of two Faculties: the Engineering Faculty with about 30 000 students and the Architecture Faculty with 15 000 students.

The large number of students enrolling at the main campus ('Leonardo da Vinci') in Milano led to the decision in the early 1990s to decentralise the university by adding another campus at Como, about 40 km from Milan. Further campuses were added in Lecco, Cremona and Mantova.

In order to use the same staff without losing valuable staff time for travelling, a distance-teaching system based on videoconferencing was designed. Prof. Brofferio (1998) describes the system as having three levels:

- "the classroom, with audio-visual equipment (TV cameras –TVC and TV displays – TVD), computers (PC, CD-ROM, etc.) and other facilities as videotape recorder (VTR) connected by the classroom matrix switch for source destination selection and external communication;
- the intracampus network, based on a star analogous to commercial TV quality connection for intracampus communication and intracampus interfacing (campus switch);
- the intercampus network, which uses an FM radio and the public telephone network ISDN."

In this case study we do not report the cost of a specific course but describe the cost structure of videoconferencing. The cost structure of videoconferencing is similar to the cost structure of lecturing in so far as that the cost per videoconference per hour is known, the cost of a course can be inferred from the number of contact hours the course requires. Hence we report after a discussion of the general cost structure of videoconferencing the cost data for the Politecnico di Milano and estimate the cost per hour of videoconferencing as well as the average cost per student in videoconferencing based on these data.

[1] This case study is based on personal communications with Prof Brofferio (email and videoconference) and his article S.C.Brofferio *A University Distance Lesson System: Experiments, Services, and Future Developments* in: IEEE Transactions in Education, Vol41 NO 1, February 1998.

The cost structure of videoconferencing

Videoconferencing is designed to allow lecturing at a distance, even at different sites simultaneously. There are two types of set-up of videoconferencing: the symmetrical (or peer) case and the asymmetrical (or master/slave) case. In the symmetrical case the sending and receiving stations are all identically equipped for sending as well as receiving.

In the asymmetrical case only the teacher station is equipped for sending and the other stations are equipped only for receiving. The asymmetrical setting is cheaper in terms of equipment requirement but lacks flexibility. In any case, to calculate the cost of one hour of videoconferencing we need to know: (i) the depreciated costs of equipment per hour or DEC (ii) the cost of the technical support per hour or TSC, (iii) the line costs per hour or LIC, (iv) the lecturer cost per hour or LEC and finally, (v) the number of sites to be connected or S.

The depreciated equipment cost is the initial cost depreciated over the lifetime of the equipment, i.e. divided by the number of hours the equipment is in use. Though the initial costs are quite high, the cost impact on the cost per hour depends to a large extent on the rate of usage.

The line costs vary with the quality requirement. The quality which can be achieved depends on the type of pictures to be sent (e.g. fast moving, multicoloured), the type of connections used (e.g. switched circuits or packet switching) and the codec qualities (i.e. the compression algorithms available). Very common are ISDN lines of 128Kbps or 384 Kbps.

The symmetrical or peer case

In the symmetrical case with two sites (S = 2) the cost per hour of teaching using a videoconference system (VCS) can be calculated as:

C/SLH(VCS) = (DEC + TSC) x 2 +LIC + LEC

This means that we have at each site equipment costs and costs of technical staff. We have one line to pay for and one lecturer.

To find the average cost per student we only have to divide the cost per student by the number of students N:

$$(2) \qquad AC/SLH(VCS) = \frac{C/SLH(VCS)}{N} = \frac{[(DEC + TSC) \times 2 + LIC + LEC]}{N}$$

Since N, the number of students, can be considered as a product of the number of sites S and the average number of students per site G, we have for S = 2, N = 2 x G:

$$AC/SLH(VCS) = \frac{[(DEC + TSC) \text{ x } 2 + LIC + LEC]}{2 \text{ x } G}$$

(3)

$$= \frac{[DEC + TSC + \frac{(LIC + LEC)}{2}]}{G}$$

The general case S=>2 is:

C/SLH (VCS) = (DEC + TSC) x S + LIC x (S – 1) + LEC

$$AC/SLH(VCS) = \frac{[(DEC + TSC) \text{ x } S + LIC \text{ x } (S\ 1) + LEC]}{S \text{ x } G}$$

(5)

$$= \frac{[DEC + TSC + \frac{LIC \text{ x } (S\ 1)}{S} + \frac{LEC}{S}]}{G}$$

In fact, since (S-1)/S = 1-(1/S) approaches 1 when S gets larger, we may simplify the above formula and write:

(6) $$AC/SLH(VCS) = \frac{[DEC + TSC + LIC + \frac{LEC}{S}]}{G}$$

This formula reflects the fact that the average cost per student declines if the number of sites increases.

The asymmetrical case

In the asymmetrical case we have sites which are differently equipped. Generally they are not equipped with the same sending facilities and do not require a sophisticated teacher station. Consequently the depreciated equipment cost (SEC) in the slave classrooms are lower.

We introduce immediately the general case. At all sites we require technical support (hence TSC x S). At all but one site we have to account for the depreciated equipment costs for the slave classrooms. This is the same number as the number of lines which link the teacher station to the other classrooms. The lecturing costs and the depreciated cost for the master classroom are to be counted only once:

(7) C/SLH(VCS) = TSC x S + (SEC +LIC) x (S – 1) + LEC +DEC

The average cost per student is:

$$(8) \qquad AC/SLH(VCS) = \frac{[TSC + (SEC + LIC)\,x\,\frac{(S\ 1)}{S} + \frac{(LEC + DEC)}{S}]}{G}$$

The cost behaviour can be seen better if we assume that S is big and therefore (S-1)/S = 1-(1/s) ≈ 1

$$(9) \qquad AC/SLH(VCS) = \frac{[TSC + SEC + LIC + \frac{(LEC + DEC)}{S}]}{G}$$

The above analysis suggests an interesting conclusion can be drawn. We might be interested to know in which case videoconferencing promises lower average cost per student than conventional. The average cost of a lecture being the cost of the lecturer and the number of students in the group:

(10) AC/SLH(lecturing) = LEC/G

We are interested to know for which case the following relationship applies:

(11) AC/SLH(VCS) < AC/SLH(lecturing)

We demonstrate the case only for the symmetrical case. For S = 2 and using (3) we get:

$$(12) \qquad \frac{DEC + TSC + \frac{(LIC + LEC)}{S}]}{G} < \frac{LEC}{G}$$

Since G can be cancelled, it follows that the break-even point is independent of the group size. From (12) we can derive a criterion for the lower average cost of videoconferencing as compared to lecturing:

(13) 2 x DEC + LIC LEC – 2 x TSC

The general case follows from the substitution of (6) into (11) and yields using 1-(1/s) ≈ 1:

(14) DEC + LIC < LEC -TSC

The formula allows us to make the following observations: for videoconferencing to achieve lower average costs, the difference between the cost of technical support staff and the cost of the lecturer must be substantial. On the other hand, line costs and depreciated equipment costs should be low. In order to achieve low depreciated costs of equipment a reasonably high usage rate is essential.

Costs of videoconferencing at the Politecnico di Milano

The costs do not refer to a specific course. However, general information on equipment cost, depreciation time, line cost and personnel costs were obtained which allow us to calculate cost per hour of videoconferencing as well as the average cost per student of videoconferencing.

Cost of equipment

The equipment costs fall broadly into two categories: costs of display equipment and network related equipment. The display equipment includes the equipment of the teacher station. A summary of equipment costs is presented in table CS 9.1. It was suggested that the equipment costs should be depreciated over five years at a usage rate of 1 300 hours per year (5 years x 26 weeks per year x 5 days per week x 10 hours per day =6 500 hours).

Line costs

For intercampus connection, ISDN lines were used. The line costs depend on bandwidth: 128 Kbps cost £17 per hour and 384 Kbps cost as much as £52 per hour.

Personnel costs

The personnel costs consist of costs for technical support and the cost of the lecturer. The cost of technical support per hour was specified as £13. The cost of the lecturer seems to depend on the number of students taught: £1 per student. Since the average group size was specified as varying between 25 and 50 students, we assume that the cost of a lecturer is about £38. This allows us to calculate the cost per hour of videoconferencing.

Cost analysis

The cost analysis includes the calculation of the cost per student learning hour and the average cost per learning hour per student and a comparison between the average cost per student of videoconferencing to the average cost per student of lecturing.

Table CS 9.1: Equipment costs

Type of equipment	costs
Display Equipment	
Overhead camera	1 672
Teacher Tracking Camera	1 003
Monitor 11"	1 003
Backprojectors (n.2)	14 716
Video Matrix (16:4)	468
Presentation manager	836
PC+VGA/PAL	1 338
Audio Mixer	468
Wireless Microphone	334
Sliding Blackboard	1 003
Subtotal	22 841
Network/connections	
Videodec (compression lab)	53 512
Videodec (Aethra)	6 689
Inverse Multiplexer(Teleos)	3 344
Subtotal	63 545
Total	86 386

Source: Politecnico di Milano

Cost per student learning hour
Depreciating the equipment cost over five years at the indicated usage rate we get:

$$DEC = \frac{£86\,386}{6\,500} = £13$$

Therefore (using (1)) we get:
Cost/SLH (VCS) = (£13 + £13) x 2 + £17 + £37 = £106

If we require higher bandwidths (384 Kbps at £52) we get:
Cost/SLH (VCS) = (£13 + £13) x 2 + £52 + £37 = £141

If more than four sites are linked we get, other things being equal, the following figure:
Cost/SLH (VCS) = (£13 + £13) x 4 + £17 + £37 = £158

Average cost per student

Using equation (3) and the above data and a group size of G = 30, we get:

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + \frac{(£17 + £37)}{2}]}{30} = \frac{[£26 + £27]}{30} = £1.77$$

Higher line cost increases average costs. Using the 384 kbps rate at £52 per hour, we get:

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + (£52 + £37)/2]}{30} = \frac{[£26 + £44.5]}{30} = £2.35$$

However, increasing sites reduces average costs (using (5)):

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + (3/4)\text{ x }£17 + (1/4)\text{ x }£37]}{30} = \frac{[£26 + £12.75 + £9.25]}{30}$$

$$= \frac{£48}{30} = £1.6$$

Cost comparison with lecturing

We may use the above criterion to determine if under this condition videoconferencing achieves lower average cost per student than conventional lecturing. The above condition for S = 2 was:

DEC + LIC < LEC –2 x TSC

13 + £17 < 37 – 2 x 13 this is equivalent to 30 < 11 which is not the case

For bigger S the condition is only

DEC + LIC < LEC – TSC

But even then 13 + £17 < 37 – 13 this is equivalent to 30 < 24 which is not the case even independent of the number of sites. To argue for the use of videoconferencing as opposed to lecturing we would have to take account of the opportunity savings of not having to travel.