# From SWITCH to SWITCH∗ - extrapolating from a case study

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## Abstract

*The Swiss national network has, like most of its partner networks, observed a yearly growth of its national and international traffic by factor of about 2.5. This corresponds to an exponential growth of user demand. Providing for the necessary funds has become a major challenge.*

*Extrapolating to tomorrow's network load makes several points clear : (1) substantial financial efforts will be necessary, and this in a period of negative growth of average university budgets, (2) the substantial increase of the volume of services and of the required funding result in the need for some re-thinking of service provision strategies.*

*This paper presents an outline of the considerations SWITCH is pursuing in preparation of the next period of service provision.*


## I. Introduction

Like many partner networks in Europe, SWITCH is presently completing a very important milestone - it is concluding a phase that might be characterised as "2 megabit networking". One important condition still needs to be fulfilled before the present phase can be considered a full success : it is necessary to make sure that there will be a next phase, and that this next phase start with a fair chance to be just as successful as its predecessor. SWITCH is therefore involved in heavy planning activities, trying to assess tomorrow's user requirements and to find the means to cope with them. Defining a strategy for funding the corresponding services and growth of expenditure is evidently a major preoccupation.

This situation is by no means specific to SWITCH. No more specific is the challenge SWITCH is facing when it plans for substantial growth in a period, where the average growth of university and research funding corresponds to a factor smaller than one. Hence, the present reflections of SWITCH can be regarded as "typical", and it is worthwhile to consider the ongoing planning exercise as a case study of interest for fellow networks in a similar situation. This paper presents some salient points noted during the process of establishing a formal plan for the period until 1999.

## II. SWITCH : some facts and figures

The approach of SWITCH to service provision is quite straightforward. Transport services use a network of 2 Megabit leased lines and CISCO routers (lower-speed lines for attaching pending nodes at small institutions). International connectivity is provided by purchasing services from DANTE. Application services are principally based on IP technology, with some very dynamic development in the domain of information services. The user community consists of universities (10 sites, about 80 % of the load), other institutions of public research and education (10 %) and industrial research sites (10 %).

In the past, growth of national traffic has been accommodated by mobilising spare capacity in the leased line infrastructure and some minor developments without serious impact on overall costs. However, by the end of 1994, the 2 megabit infrastructure will be saturated and the consequently needed enhancements will have a severe impact on communications costs. Expenses for international traffic already experienced a severe increase during the past few months, due to the combined effect of increasing volume and the recent transition to fully charged and commercially managed services; this item now occupies a substantial position (1994 : about 20 %) in the overall budget of SWITCH.

Funding is essentially obtained by charging the user organisations, applying two basic mechanisms : universities are charged by splitting the overall academic share according to a key (composed of three fractions with equal weight : traffic, access bandwidth, size of the institution - i.e. student population), with a substantial fraction of these user fees being contributed by the federal government; users from outside the domain of universities are billed according to a price list and services consumed.

SWITCH is organised as an independent nonprofit organisation (a "foundation"), and access to services is provided subject to the respect of an "acceptable use policy" very similar to that of most partner networks. There are only few "Swiss peculiarities" to be mentioned, the most important one being the federal structure of Switzerland and its universities. This does not mean that SWITCH does not need to deal with central bureaucracy, but rather that this bureaucracy is difficult to grasp and to motivate; due to the relatively large amount of federal money involved the potential role of the federal authorities is quite important. The federal structure also means, that support for important decisions must be created in eight cantonal ministries and one federal ministry.

## III. Planning for tomorrow's user requirements

### III.1. Planning methodology

When the initial set of services of SWITCH - and, in fact, SWITCH itself - were designed, there was no past experience to be used as a starting point. The initial plans therefore were based on the drafting and costing of a series of hypothetical services and the estimation of the related infrastructure - communications, equipment and staff.

This procedure produced the specification of a series of sub-projects, where it was difficult to map the specifications on a forecast of the traffic to be expected. Since expenses for traffic represent the most important fraction of overall costs (at present about 40 % and increasing to more than 60 % during the next years), this procedure was considered inadequate for the planning of the next phase of SWITCH.

### Traffic costs

SWITCH decided to forecast the traffic costs on the basis of an extrapolation from traffic statistics. An analysis of traffic measurements has shown that the average traffic increases with a remarkably stable growth rate, corresponding to a yearly factor of about 2.5. Similar values have been observed by the partner networks of SWITCH. There is a high degree of probability that this factor will remain stable during the next few years.

A model was then developed, forecasting the evolution of each of the principal leased lines and taking into account the increments of the line speeds available from Swiss PTT (in fact, several such models were studied in order to assess the costs of alternatives with growth rates above and below 2.5). The prices of the lines were then estimated on the base of present tariffs and their expected evolution.

### Staff, equipment and running expenses

It would be fallacious to treat the other expenses, mainly staff and investments, on the hypothesis that they are directly proportional to the evolution of the traffic volume - they are not.

In order to provide a realistic forecast, the present and future activities of SWITCH have been grouped into a series of work-items : transport services, network management and directories, electronic mail, information services[1], user support and education, new (e.g. "multimedia" based) services, administration and management.

For each item, an analysis was made of the evolution to be expected during the planning period; the amount of staff necessary for (1) supporting the expected steady evolution of the activity, and (2) promoting and engineering innovation, was then estimated. Running expenses and investments were treated in a similar fashion.

#### Forecast of overall costs

The result of this planning operation is the prediction that the overall operational costs of SWITCH will be subject to a yearly increase of about 35 %. Some detailed information on this forecast is provided in Section V.1 ("Services tomorrow").

1. the term "information services" refers to an application service, while the "directory" work-item relates to the management of elements of the basic infrastructure, such as domain name servers.

## III.2. Assumptions implied

The described approach relies on a series of assumptions which must be validated in order to assess the reliability of the corresponding forecasts.

Probably the most important assumption is the hypothesis of a *constant growth of traffic*. It has already been mentioned that this factor has practically not varied during the last years and that this observation also holds for the partner networks of SWITCH.

A reflection on the nature of this growth reveals another remarkable fact : the services causing the growth have not always been the same. Growth has initially been due to the evolution of e-mail and remote interactive sessions; in a second phase, the bulk of the growth was caused by the volume of data transported by file-transfer; today, yet another mechanism is taking over, the use of distributed information services. In spite of the very different nature of these services, the growth factor has remained constant. Recognising that the motor for tomorrow's growth will yet be quite different - services based on multimedia technology - and needing to predict its impact on traffic growth, this reflection provides the basis for confidence that a change of the growth pattern is not to be expected.

For the period considered, there is also reason to assume that the increase of the number of users, of the number of connected machines and of the volume of data accessible over the network will continue and will not yet hit a ceiling.

The proposed break-up of the operational costs in staff, the leasing of lines, investments etc. relies on a specific *model for the production of services* : the forecast assumes that a relatively large fraction of services will be directly provided by the staff employed by SWITCH. The production costs for some services have been compared with those of other national networks, which base their production to a relatively large degree on outsourcing their services. It appears that the costs are very much at the same level. It is therefore legitimate to estimate the future costs under the assumption that the present production model is maintained. It is evident that this does not prejudice the effective choice of production methods. There is, in fact, a tendency for SWITCH to increase the fraction of services produced by outsourcing; but this will only result in a shift of emphasis between different items of the forecast without having a major impact on overall costs.

This reflection is particularly important, given the expected evolution of the offer in the domain of commercial transport services, respectively the impact of the maturing ATM technology on these services, and realising that there is an important degree of uncertainty in the present assessment of this evolution.

Another extremely important factor is the *tariff for transport services* that must be applied in order to map the expected traffic onto costs. The forecast of the traffic costs assumes that the present tariff structure will essentially remain stable until 1997 or 1998, with a continuing yearly decrease by a few percent; this applies both for the rental of leased lines at the national level and for the purchase of international communication capacity.

At the end of this period, it is expected that the beginning "liberalisation" of the market of communication lines will have an important impact on communication costs. The planning figures provided by SWITCH therefore foresee that the growth of the communication expenses will level off after 1998; unfortunately, only extremely arbitrary assumptions can be made on this evolution.

SWITCH places great hope on a substantial decrease of communication costs by the end of the century. One reason will clearly be the liberalisation of the market of communication lines; but also the important growth to be expected in the domain of entertainment and domestic use of high-bandwidth communications will have an important impact on prices. This evolution will quite probably result in a development comparable to that of the price of CPU power and memory capacity, to a large degree compensating the cost of increasing service demand by a decrease of prices for the production of these services.

That is a very comforting perspective in a situation of exponential growth of the user demand for communication services. Although no end can be foreseen to this growth, its impact on costs will be curtailed. This provides an important argument when talking to funding agencies : the present financial effort necessary for the development of the communication infrastructure can be considered as extraordinary, indications exist that the growth of expenses will sensibly slow down in the foreseeable future.

### III.3. A rule-of-thumb estimation

Before investing in the "solid" planning operation outlined in this paper, SWITCH tried rapidly to obtain a rough estimation of the expected growth of costs by applying a simplified planning method :

Traffic was still forecast by applying the yearly growth factor of 2.5 to the observed traffic figures. The communication costs, however, were obtained by an extrapolation from the present tariffs for 2 megabit lines, scaling these tariffs according to the well established "square root of 2" factor[2]. Expenses for staffing and running expenses were simply doubled over 4 years. The results of this estimation tallies quite nicely with those obtained by the more precise method.

2. Prices for leased lines increase, in a first approximation, with the square-root of the line capacity (bit rate).

## IV. The challenge : funding and charging

### IV.1. Evolution of costs

Using the procedures described above, SWITCH produced a forecast for the evolution of the expenses until the year of 1999 :

- Overall user contributions, not counting the centrally funded costs of pilot projects and innovative efforts, will have an average yearly growth-rate of 35 %.
- This increase might level off to 10 % to 15 % as a result of the expected decrease of prices for communications already in 1998.
- The expenses for national and international transport services alone will even increase by between 50 % and 70 % per year; the impact on the overall operational expenses will rise from initially 40 % to 65 % in 1999.
- Personnel costs will approximately double in five years.
- Investments, not counting those related to pilot projects and innovation, will amount to an average of roughly 10 % of the total operational costs.
- Expenses for pilot projects and the promotion of innovative developments will correspond to an order of magnitude of 10 % of the operational costs.
- The overall yearly budget of SWITCH is estimated to increase from the present 5,8 million Swiss francs to about 25 million in 1999.

It should be noted that the break-down of costs into communications, staff and investments is strongly biased by the underlying production model; purchasing managed communication services from a commercial supplier would provide a very different distribution of costs over these items; but, as already mentioned, this should not have an important influence on the predicted overall costs.

### IV.2. Funding model, charging

The currently applied mechanism supports all costs as operational expenses charged to universities (distribution key) and other users (tariffs). In order to counteract the presently observed reticence to fund innovative developments, SWITCH will suggest to centrally fund "innovative expenses". In addition, user charges for operational expenses in the domain of research and higher education will continue to be centrally subsidised, but at a reduced percentage. By and large, this new mechanism will now be quite similar to the funding methods of partner networks.

The charging procedures used by SWITCH will be subject to a major revision. The principle elements in the corresponding discussion will probably be :

- Shall the present *coexistence of two charging mechanisms* be maintained, calculating university contributions according to a "mixed" distribution key, other contributions being charged in proportion to the services used ?

On the one hand, this complicates the administrative procedures; on the other, it corresponds to the role of universities as the representatives of "entrepreneurship" in SWITCH and practically eliminates all problems related to assuring the necessary cash-flow, providing a predictable and stable income.

- There seems to be consensus that the principle of a *distribution key for charging universities* will be maintained. But there is also agreement that this key needs to be improved in order to reply better to several important criteria : (1) it must be accepted as "just", i.e., formally acceptable to all partners involved, (2) it must, to a certain degree, allow each university to open and close the "service tap" and to control its communication expenses, (3) although university contributions are budgeted according to the distribution key, the delay between a possible change in usage and the effect on the key must be as short as possible, and (4) the implementation must not entail prohibitive administrative or technical overheads.

  In the past, the advocates of a purely bandwidth-based key and of a purely traffic-proportional key have been alternating in predominance. There are strong arguments in favour of both approaches; it is probable that the key will also in future contain both components, but they might appear with different weight. The third factor of the presently used key - student population - will probably disappear.

  Past experience has shown that the negotiation of the algorithm determining the key is an extremely tedious and lengthy process. It is therefore important to create an algorithm which can be used during a substantial period of time and does not need to be changed too frequently.

- A certain amount of *unbundling of services* will be necessary in order to add some flexibility. For instance, a university should have the choice between implementing its own fax gateway and using the central fax gateway of SWITCH; its contributions to SWITCH should be adapted in correspondence.

- The charging mechanism should provide a means for enhancing the cost awareness of the end-user. However, there is agreement that end-user billing is not a viable alternative, and an efficient approach to attain this goal needs still to be found.

## IV.3. Acceptance from funding authorities

The initial recognition of the importance of the required growth of funding represented a shock to SWITCH and caused serious doubts whether a corresponding evolution could effectively be instrumented.

Very rapidly, and this can be considered as the first phase in a "selling process", the responsible body of SWITCH realised that the fundamental facts behind this growth are of paramount importance and that it imperatively had to take up the challenge to develop a strategy for making the funding available.

SWITCH is presently occupied with the next step, promoting the evolution recognised as necessary and preparing the formal decisions relative to multi-annual planning and yearly budget allocations. It must be admitted that this procedure should have begun earlier, the entire process now needing to be completed during a period of a few months.

In parallel to these studies and planning activities, a process which might be called "lobbying" had to be started. The important amount of funding obtained from universities made it imperative to convince each university individually about the necessary priorities and to prepare the necessary local funding (which, in today's no-growth situation, practically everywhere is only possible by taking the money from some other budget line considered of lower importance). This process went through a two-step approach, an initial "early warning" and a second phase of clarifying the precise implications for each university.

It would be difficult to convince the funding agencies and user institutions to invest into a "hole without a bottom" and to cater for exponential growth for an unlimited time. The argument in reply to this consideration has already been mentioned : SWITCH expects the costs for transport services to level off in a couple of years.

## IV.4. Service policy

The decision of SWITCH to support continuing exponential growth does not represent a policy of promoting consumption. It responds to user demand and fulfils the role of a service provider (evidently within the limits decided by the user institutions and formalised in the annual budgets of SWITCH agreed by these institutions). However (and the present planning operation is an illustration) SWITCH must avoid a purely and naively passive role, it must participate and consult the user institutions in assessing the necessary priorities. Here lies one of the important differences between an "ordinary" commercial company and an organisation like SWITCH.

There is a certain preoccupation that the estimation of the growth presented might be too conservative and that, as a consequence, it might be difficult to fully face the increase in user demand. SWITCH is aware of this risk, but has decided that the proposed planning represents the only reasonable and possible compromise between two extremes, both implying failure : (a) planning for costs which cannot be funded and therefore make the project be rejected even before it is started, and (b) planning for insufficient services, entailing saturation effects and user dissatisfaction and, as a result, providing an extremely poor return of investment for the substantial amount of money nevertheless spent.

The recognition of the extreme importance of continuity in evolving leading-edge services provides the principle justification for a substantial increase of funding from users and their institutions. There is a second very important argument to mention when discussing central funding with government authorities : the evolution of IT and related services plays an important role as an enabling technology in support of developments in other domains. Competence and early experience with emerging communication services have therefore a signification for national economy and society. A discussion of this topic, however, goes beyond the scope of this paper.

## V. SWITCH tomorrow

The implementation of the proposed developments will have an important impact on the services available to the user. But it will also allow the user community to continue to grow, making communication services accessible to an ever larger public more and more from domains not familiar with the use of IT based methods, and it will probably influence the way SWITCH works as an organisation providing these services.

### V.1. The services

As a consequence of the described financial effort, the end user will continue to have high-quality services "at his fingertips", allowing him to maintain his competitiveness at the international level. In particular, he will not have to face sluggish response due to overloaded communication facilities, and he will obtain access to new services as they become feasible.

At present these new services concentrate on the domain of distributed information services (e.g. WWW, Gopher); tomorrow's new services will probably be based on multimedia techniques : for instance tele-teaching, CSCW, but also "document" access, understanding this term in a very general way.

The underlying communication infrastructure will rapidly develop to a 34 Mbit network (1997) and beyond. As the result of innovation funding, these services should also support communications with enhanced requirements on real-time performance, first at a pilot level, but soon also in production.

### V.2. The user community

SWITCH has been created as a network for research and higher education. The corresponding user community will remain the key component of the usership. During the last few years, the scope of institutions served by SWITCH very rapidly grew beyond the initial group of the 10 Swiss universities :

- industry research gained access to SWITCH in support of research projects pursued in common with universities and in response to the need to access resources like high-performance computers connected to SWITCH,
- schools of engineering ("HTL"s) asked to be connected to SWITCH,
- public research laboratories (for instance in meteorology) needed access to SWITCH.

The extension to an enlarged user community is an ongoing process. The presently most important development lies in the domain of public libraries (university libraries, evidently, already having been connected).

SWITCH, just as many partner networks, faces problems of defining limits between acceptable usage, complying with the established acceptable use policy, and purely commercial usage, which is not allowed on SWITCH. Several elements produce a constant pressure from "outside" to gain access and require difficult decisions to be made : (1) there is a general interest to use the excellent services of SWITCH and, in particular, (2) to gain access to the Internet through connectivity provided by SWITCH; (3) there exists a gray zone between industrial usage for research projects and for projects of predominantly commercial nature; but one should also recognise (4) a certain interest of the academic users to lighten their financial burden by gaining some income from commercial users.

There is also some difficulty to assess the effective weight of this problem. It has been the cause of many heated discussions, but the low ratio of industry use might indicate an only relatively low objective importance of this question. In fact, when a university's principle use was based on 64 kilobit full IP access, industry essentially needed mailbox access. Today, universities do "2 megabit networking" and industry contents itself with a couple of 64 kilobit access points. The same reflection might hold when universities take the step to ATM speeds - it appears, that industry use of networking services is, to a certain degree, lagging behind. Since growth is exponential, a lag of a few years may also in future retain industry in the role of a minor entity.

Substantial work will be needed to clarify this situation. The developments in the domain of distributed information services tend to further complicate this matter. These services rely on the availability of information with items distributed over the entire Internet, regardless of limits between commercial and research organisations. Access to these services represents a tremendous potential in support of everybody's daily work. Both information provision and use will increasingly span and blur the frontier between the commercial and non-commercial world; in fact, the mutual sharing of information will make these services still more attractive and be a motor for integration between users from academic and industrial research and the commercial world.

### V.3. The SWITCH organisation

The SWITCH organisation will probably remain more or less as it is. However, it would be a mistake not to realise that some organisational measures will be necessary to adapt the operation of SWITCH to tomorrow's needs and to a substantially increased volume of activities. A discussion of the corresponding considerations would go beyond the scope of this paper, but it may be of interest to mention a few items :

- SWITCH will pursue a policy of "subsidiarity", concentrating on the activities which cannot be efficiently assumed by the user institutions.
- The evolution of the user community might have some impact on organisational issues, for instance in creating the need for enhancing the representation of new user groups. As already discussed, the relation to commercial users will have to be clarified, a process that also might have organisational consequences.
- The increased volume of funds to be handled will require organisational steps to be considered. For instance, SWITCH has recently mandated an expert study, trying to find an improved concept for its internal accounting and account management system.

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