ITU Seminar

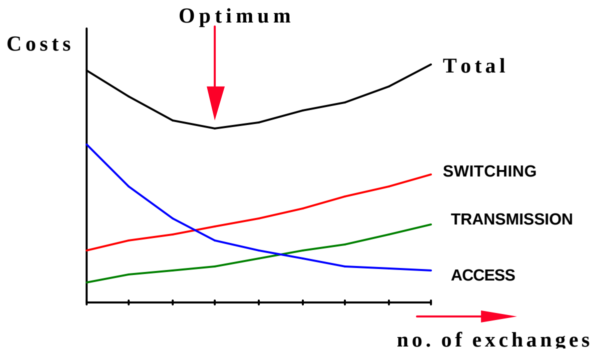
Warsaw, Poland , 6-10 October 2003

Session 3.4

Network optimization and costing

Network optimization

Cost components of telecom network



Network optimization

Optimization task -

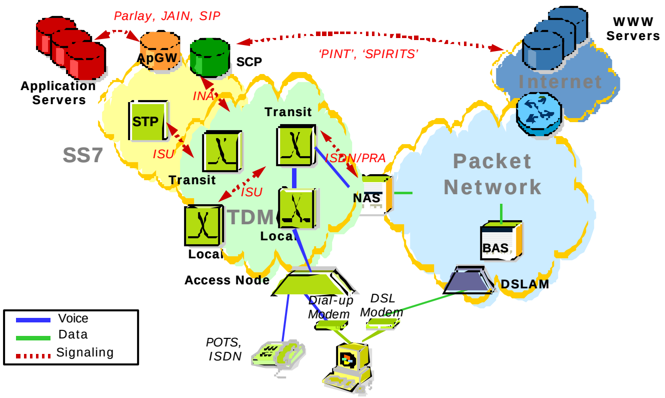
find minimum network cost solution for given (forecasted) demand for services and specified (requirements) quality of service

Owing to the complexity and size of the typical telecom network, it is not possible to treat all aspects of the network simultaneously

Network optimization

complexity of the typical telecom network

Network topology on the evolution states from PSTN to NGN



Network optimization

size of the typical telecom network

Partitioned to:

Metropolitan

Rural

Regional

National

International

Network optimization

Iterative procedure for optimizing a telecom network

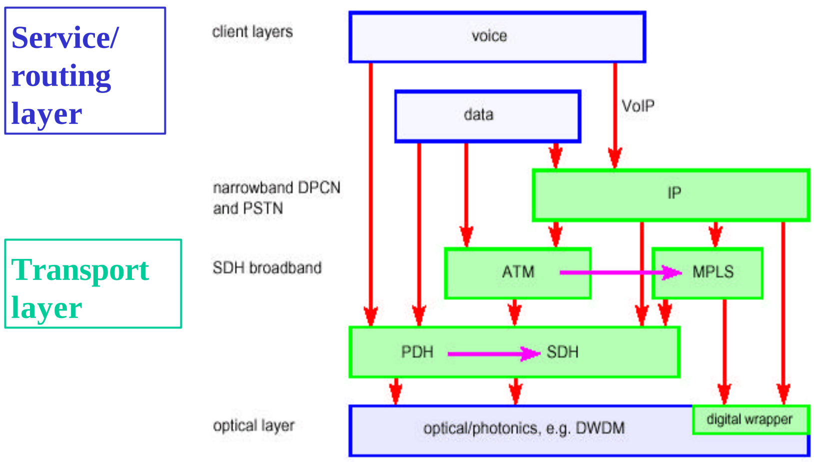
Network optimization problem to be solved has to be divided into a number of suitable **sub-problems, these to be treated iteratively in a certain order**

For the solution of any of these sub-problems, we assume that the rest of the network has been correctly optimized and/or dimensioned

Initially, of course, this will not be the case, and the necessary data will then have to be estimated

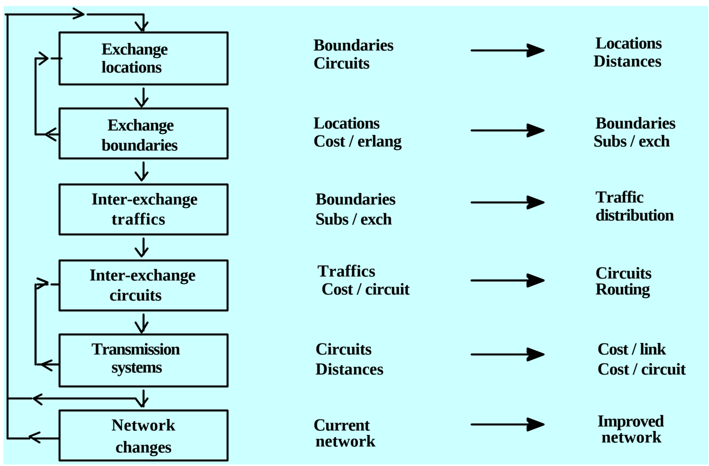
Network optimization

Iterative procedure :



Network optimization

Iterative procedure :



Network optimization

Cost structure :

Cost subscriber – exchange: $D_E \cdot C_s(D_E) + C_f$

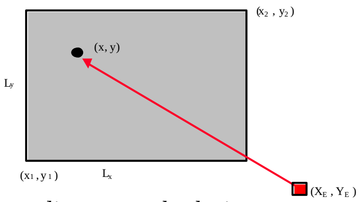
per subscriber, service

Cost exchange – exchange: $D_{EF} \cdot C_c(D_E) + C_d$

per circuit, channel

Cost of exchange equipment (including the switch)

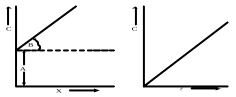
Cost of building, container, etc.



distance calculation

Network optimization

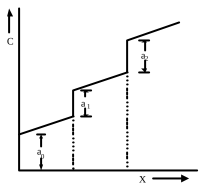
Cost models for the telecom equipment



$D_E \cdot C_s(D_E) + C_f$

Typical cost functions : linear, step function, combination linear-step function (simple, but enough accurate)

$$C(E) = C_j(K,E) + C_b(E) + D_E \cdot C_s(D_E) + C_f$$



Model for individual (sub. line, user port) or group (tr.system, exchange, router) equipment

Function of distance, number of users, required capacity

Network optimization

Cost structure :

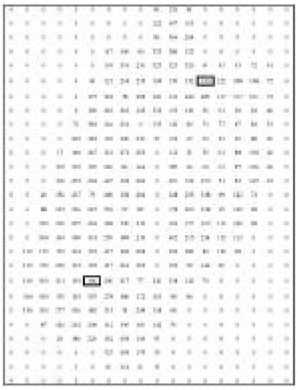
Total network cost function, C, could be expressed, e.g. in the model with subscriber zones (grid), as

$$C = \sum_{E=1}^{NEX} \sum_{(i,j)\in E} sub(i,j)\cdot\left[C_s(D_E)\cdot D_E + C_f\right] + \sum_{E=1}^{NEX}\left[C_a(E)+C_b(E)\right] +$$
$$+ \sum_{E=1}^{NEX} \sum_{F=1}^{NEX} N_{EF}\cdot\left[C_c(D_{EF})\cdot D_{EF} + C_d\right]$$

Network optimization

Cost structure TDM network:

$$C = \sum_{E=1}^{NEX} \sum_{(i,j)\in E} sub(i,j)\cdot\left[C_s(D_E)\cdot D_E + C_f\right] + \sum_{E=1}^{NEX}\left[C_a(E)+C_b(E)\right] +$$
$$+ \sum_{E=1}^{NEX} \sum_{F=1}^{NEX} N_{EF}\cdot\left[C_c(D_{EF})\cdot D_{EF} + C_d\right]$$



Network optimization

Cost structure ATM network:

Total ATM network cost :

$$C_{ATM} = \sum C_{ATM\ Node} + \sum C_{ATM\ Trunk\ Group}$$

Cost of a relation in the SDH network :

$$C_{Relation} = \sum (n_{Path} \bullet c_{Path})$$

On each path, the ATM requirement passes the two SDH end nodes and possibly several SDH transit nodes and links :

$$c_{Trans\ Path} = c_{End\,1} + \sum c_{Transit} + \sum c_{STM-1} + c_{End\,2}$$

$$c_{STM-1} = \frac{P_{Fibre}}{n}$$

Network optimization

E.g. theoretically optimal location (X_E, Y_E) has the property that the partial derivatives of the total network cost function, C, with regard to X_E and Y_E are equal to zero :

$$\left.\begin{aligned} \partial C/\partial X_E &= 0 \\ \partial C/\partial Y_E &= 0 \end{aligned}\right\} \quad for\ E = 1,2,\ldots$$

Standard condition for continues space – location could be anywhere in the area
If not satisfied (locations could be only in particular places) – becomes combinatorial problem

Network optimization

Model with subscriber nodes - combinatorial problem

calculate the total network cost, *C*, for all combinations (solutions) and find the smallest *C = Cmin*

for ***n*** nodes and ***N*** equipment items $\frac{n!}{(n-N)!\,N!}$ combinations

e.g. n=200, N=10, Comb=200!/(190!x10!)

Network optimization

Model with subscriber nodes - combinatorial problem

It is obvious that it is not possible to use such a method in practice, except for some very small networks.
Moreover, it is pointless to investigate many of the combinations.
Solution:

- to eliminate the obvious senseless combinations and to investigate the rest
- to investigate some of the combinations, which could give the optimum

Network costing

Evaluate :
- **capital expenses(CAPEX)**
- **operational expenses (OPEX)**

CAPEX

- **Material: Purchasing of all material used in the construction of the plant, freight costs, sales taxes, and supply expenses**
- **Installation: All direct labour costs as well as incidental expenses**
- **Miscellaneous: Supervision, tool expenses, general expenses, social security taxes, and relief and pensions**

Network costing

CAPEX

- **Engineering: Cost of all engineering time and associated costs**
- **Costs occurring during construction, which are added to the plant investments accounts**

OPEX

- **The cost of material and labour associated with the upkeep and re-arrangement of the plant (maintenance costs)**
- **The cost of labour associated with day-to-day operation of the plant**
- **Miscellaneous expenses, such as workshop repairs, tool expenses, caretaker, utilities, etc**

Network costing

Economy Study Techniques

The basic economic study methods are:

- **The present worth method**
- **The annuity method**
- **The rate of return method**

The choice of method to be employed for a certain study is rather arbitrary and the ease of calculation and the simplicity of presentation are factors which should always be considered when making the decision

Network costing

Present Worth (PW) method

This method refers to all the events in an economy, both incomes and expenditures , as one figure at one point in time

When comparing different alternatives for a given revenue or cost saving, the alternative with the least present worth of all expenditures or annual charges should be selected

There are two methods of present worth:

- the present worth of expenditures (PWE), and
- the present worth of annual charges (PWAC)

Network costing

Present Worth of Expenditures (PWE)

The present worth of expenditures (PWE) method measures how attractive an alternative is based on the capital costs conversion

The PWE does not require any estimate of revenues

If a difference in revenues is anticipated, revenues must be taken into consideration in order to maintain comparable conditions

Network costing

Present worth of annual cost (PWAC)

The present worth of annual costs (PWAC) method is essentially the same as the PWE method, except that capital costs are converted to equivalent annual costs (AC) before their worth is found

Network costing

Example for PWE of transmission Systems

Item	Purchasing Cost	Taxes	Installation	Total Investment	Replace-ment	Mainten-ance	Total Present Worth
Terminal equipment	15980.0						
Repeater	14780.0						
Cable per km	153.6						

Taxes = 20% of purchasing cost

Installation = 10% of purchasing cost

Replacement = $\frac{\text{(Total investment)}}{(1+i)^{T}-1}$

Maintenance = $\frac{u}{i} \times$ (Purchasing cost)

Network costing

The annuity method

Initial capital costs are converted to equivalent annual costs and then constant annual receipts and/or operating costs are subtracted and/or added to the annual capital costs

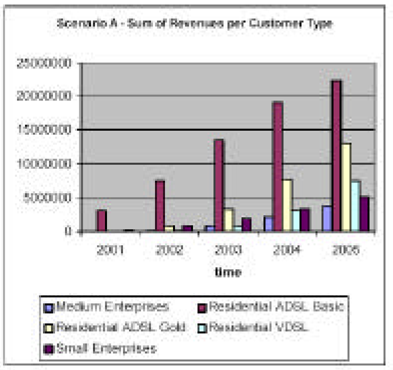
The application of the annuity method is limited by the assumptions and conditions:

- all investments have to be made at one time, at the beginning of the calculation period
- operating expenses and receipts have to remain constant during the calculation period

Network costing

The rate of return method

- This method has to guaranty profitable for the operator network
- In the time of monopoly the method of rate of return was rarely used in network planning applications, instead technical planning was followed by feasibility study



Network costing

Overall economic results –

Revenues, Cost, Cash-flow and Net Present Value