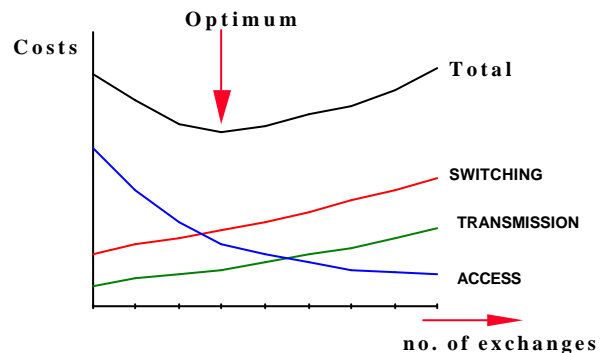# ITU Seminar

Bangkok, Thailand , 11-15 November 2002

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
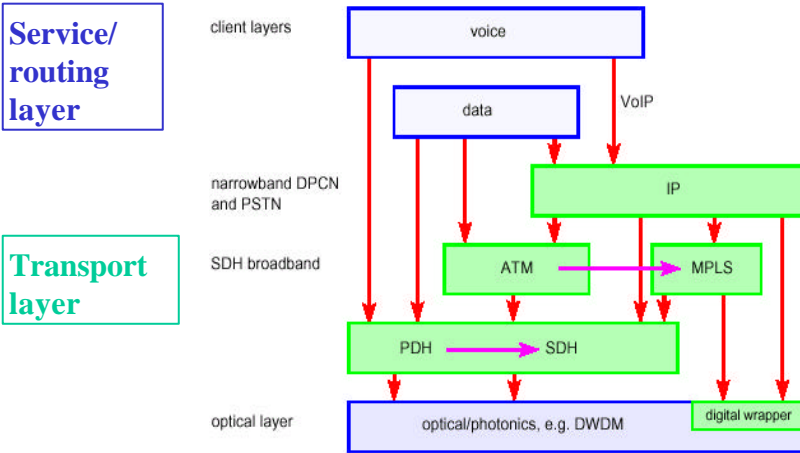aspects of the network simultaneously

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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
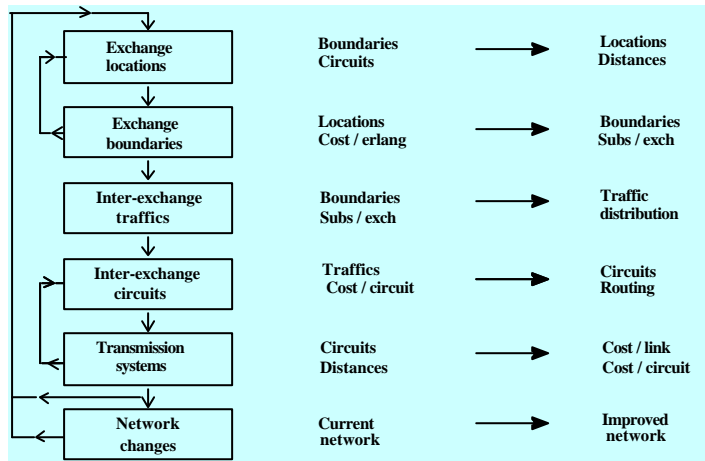to be treated iteratively in a certain order**

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

Service/
routing
layer

Transport
layer

client layers — voice

data — VoIP

narrowband DPCN
and PSTN — IP

SDH broadband — ATM → MPLS

PDH → SDH

optical layer — optical/photonics, e.g. DWDM — digital wrapper

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Network optimization

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Exchange locations	Boundaries Circuits →	Locations Distances
Exchange boundaries	Locations Cost / erlang →	Boundaries Subs / exch
Inter-exchange traffics	Boundaries Subs / exch →	Traffic distribution
Inter-exchange circuits	Traffics Cost / circuit →	Circuits Routing
Transmission systems	Circuits Distances →	Cost / link Cost / circuit
Network changes	Current network →	Improved network

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
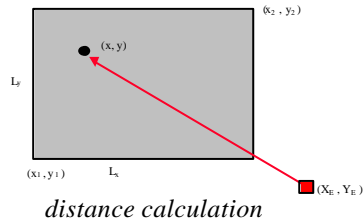
Network optimization
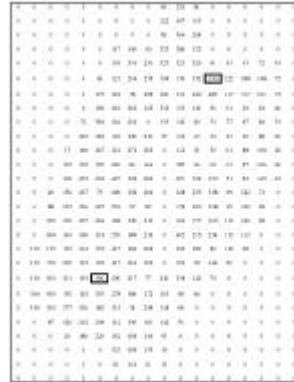
Cost structure :

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 :

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

$$+ \sum_{E=1}^{NEX} \sum_{F=1}^{NEX} N_{EF} \cdot \left[C_c(D_{EF}) \cdot D_{EF} + C_d \right]$$

Network optimization

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 :

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

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 $\dfrac{n!}{(n-N)!\ N!}$ 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

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

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

Maintenance = $\dfrac{u}{i}$ × (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

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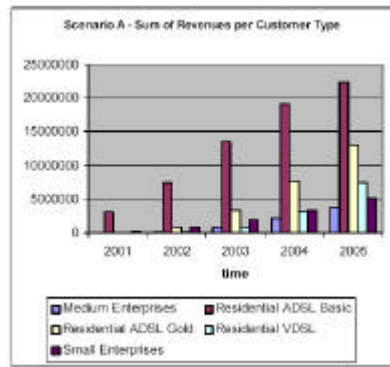
Network costing

Overall economic results –
Revenues, Cost, Cash-flow and Net Present Value