ITU / BDT- COE workshop

Nairobi, Kenya,
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Network Planning

Lecture NP-4.2

Switching/routing planning
Transmission planning

Switching planning:

- **BOUNDARY (SERVICE AREA) OPTIMIZATION**

<u>**GRID MODEL**</u>

Boundary optimization, i.e. finding exchange area boundaries in such a way that total network costs are minimized, is based on the following assumptions :

- exchange locations are fixed (temporarily) ;
- the backbone network cost of any subscriber, of a given traffic zone, *K*, belonging to a given exchange, *E*, is known : $C_j(K,E)$
- the average cost, per subscriber, of exchange and building, is known for any given exchange, *E* : $C_b(E)$
- the cost of connecting a subscriber to any exchange can be calculated from
  - the distance subscriber to exchange, D_E
  - the transmission plan
  - the available transmission media costs,

  and can be written as $D_E \cdot C_s(D_E) + C_f$

The cost of connecting a subscriber at location *(x,y)*, belonging to traffic zone *K*, to an exchange *E* at (X_E, Y_E) can thus be expressed as

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

where $D_E = D(x,y,X_E,Y_E)$

The decision to which exchange, *E*, a given subscriber grid element should belong can be made simply by comparison.
E should be chosen so that *C(E)* is minimized.

So, for every grid element *(i,j)* the value *C(E)* is calculated for every exchange *E* , and the lowest *C(E)* then determines *E*.

The only remaining problem is to find the distance from the exchange in (X_E, Y_E) to the grid element

NODE MODEL

Find the distance from an exchange to subscriber cluster in graph model.

Shortest path problem and corresponding shortest-path algorithms.

- **LOCATION OPTIMIZATION**

GRID MODEL

For any given exchange, *E*, the 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.

As *C* is dependent on all exchange coordinates, and we want to find the overall minimum of *C*, we must find a set of exchange coordinates (X_E, Y_E) for *E* = 1,2,..., so that

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

Different methods for solving this 2*E equation system could be employed depending upon the methods of measuring the distances in the network.

In the most complicated case we get a system of 2*NEX non-linear equations.
We can, however, expand $\partial C/\partial X_E$ and $\partial C/\partial Y_E$ into a Taylor-series, Which leads to a system of 2*NEX linear equations in ΔX_F and ΔY_F , Δ denoting improvement, which can easily be solved by standard methods.

NODE MODEL

If the network model is presented with nodes and links connecting these nodes to the local network cost function, *C*, is a discrete function over all node locations, i.e. it is not possible to use partial derivatives of *C*.

One possibility is to calculate the total network cost, *C*, for all combinations of exchange locations and to find the smallest $C = Cmin$. The exchange locations for *Cmin* are the optimal.

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 of exchange locations.

Two ways of solving the problem are possible :

- to eliminate the obvious senseless combinations and to investigate the rest; there will still be too many left

- to investigate some of the combinations, which could give the optimum exchange locations

Routing planning:

Subject of teletraffic engineering – reference in TTE Handbook.

Tasks:

- DIMENSIONING/OPTIMIZATION OF ROUTES

- CALCULATION OF OVERFLOW TRAFFICS

The task is to providing necessary equipment, e.g. circuits, channels, between the various exchanges/nodes in the network in such a way that the overall cost of the network is minimised, taking into account

the grade of service desired;

the properties of traffic offered;

the technical properties of the switching equipment;

the costs of the switching and transmission equipment.

Considering the traffic case from $i \rightarrow j$, there are 3 possibilities of routing the traffic, ie

- all traffic is carried on the route from i to j - Direct routing
- all traffic is carried through the tandem/transit exchange – transiting of traffic
- part of the traffic is carried on the route i -> j , and the rest of the traffic overflows to the routes $i \rightarrow T \rightarrow j$ - High-usage route.

Dual homing (load sharing) routing is a case when exchanges could be connected to two different tandems.

Overflowing traffic is divided with predefined coefficient α :
α * Overflowing traffic - traffic to the first tandem
- (1-α) * Overflowing traffic - traffic to the second tandem

Coefficient α is defined through input file with routing data.

Non-hierarchical routing as option to the hierarchical routing .

The methods for non-hierarchical routing optimize routing and simultaneously optimally dimension link capacities.

For each OD-pair a direct link and a number of two-link overflow paths are selected.

The following types of routing are possible:

- FSR/OOC (Fixed Sequential Routing with Originating Office Control). This is routing with crank-back, i.e. the call blocked in a transit node is transferred back to the originating one and continues to try consecutive paths. All the overflow paths are tried before call is rejected;
- FSR/SOC (Fixed Sequential Routing with Successive Office Control). The call blocked in a transit node is rejected;
- DAR (Dynamic Alternative Routing). Direct path is tried first, as usual. Then there is one, single currently active overflow path. If the direct path is blocked the call is offered to the current overflow path, and if this is also blocked the call is rejected and new overflow path is selected at random.

In all cases Dynamic Circuit Reservation has to be used.

Transmission planning:

Optimization of Ring/Mesh SDH/SONET transport network.

In hybrid ring-mesh SDH network the network is structured into interconnected subnets that can have either ring or mesh topology.

The ring structures provide models for protected SDH rings.

For multi-ring structures it is possible to use the dual homing protection scheme.

The mesh is a network structure of arbitrary topology (regular mesh etc.) that supports the following protection and restoration mechanisms:

- path protection
- link protection
- path diversity

The mesh can be also configured as unprotected.

In the optimization methods are used heuristic algorithms based on the shortest path approach.

Two types of nodes could be distinguished in the network:

- traffic access nodes – these nodes represent the abstract traffic entry points (e.g. telephone exchange etc.)

- transmission nodes – these nodes represent the actual SDH network nodes e.g. ADMs or DXCs.

ANNEX

Example boundaries:

0	0	0	0	0	0	0	0	0	81	326	81	0	0	0
0	0	0	0	0	0	0	0	0	122	407	163	0	0	0
0	0	0	0	0	0	0	0	0	81	366	204	0	0	0
0	0	0	0	0	0	117	156	40	323	284	122	0	0	0
0	0	0	0	0	0	195	391	236	323	323	326	41	43	43
0	0	0	0	0	43	121	234	235	194	150	132	190	222	188
0	0	0	0	0	175	218	38	208	326	310	240	283	317	317
0	0	0	0	0	190	263	263	125	332	155	141	36	61	69
0	0	0	0	76	381	264	224	0	133	142	84	74	77	87
0	0	0	0	229	381	305	300	270	57	192	47	74	35	60
0	0	0	17	140	267	341	271	203	0	112	51	55	61	88
0	0	0	102	339	170	226	86	164	0	187	96	69	61	87
0	0	0	106	203	204	427	192	204	0	201	192	190	51	83
0	0	20	356	267	79	400	192	204	0	328	235	338	99	142
0	0	88	212	356	267	253	97	85	0	178	200	338	99	142
0	0	300	300	257	264	528	190	213	0	322	177	169	113	140
0	0	300	344	300	131	276	189	213	0	402	215	234	112	112
0	110	173	172	344	172	417	184	268	0	299	183	84	142	28
0	115	376	290	133	155	417	261	304	0	392	56	142	56	0
0	150	303	361	193	306	200	217	77	246	238	142	70	0	0

Example locations:

0	0	81	326	81	0	0	0	*R1*
0	0	122	407	163	0	0	0	*R2*
0	0	81	366	204	0	0	0	*R3*
156	40	323	284	122	0	0	0	*R4*
391	236	323	323	326	41	43	43	*R5*
234	235	194	150	132	190	222	188	*R6*
38	208	326	310	240	283	317	317	*R7*

R1 = 81 + 326 + 81 = 488 **S1 = R1 = 488**

R2 = 122 + 407 + 163 = 692 **S2 = S1 + R2 = 1180**

R3 = 81 + 366 + 204 = 651 **S3 = S2 + R3 = 1183**

R4 = 156 + 40 + 323 + 284 + 122 = 925 **S4 = S3 + R4 = 2756**

R5 = 391 + 236 + 323 + 323 + 326 + 41 + 43 +43 = 1726
S5 = S4 + R5 = 4482

R6 = 234 +235 +194 +150 + 132 + 190 + 222 + 188 = 1545
S6 = S5 + R6 = 6027

R7 = 38 + 208 + 326 + 310 + 240 + 283 + 317 + 317 = 2039
S7 = S6 + R7 = 8066

$S_{TOT} = S7$

$S_Y = S_{TOT} /2 = 8066/2 = 4033$

Shortest path problem

Given the lengths of cable runs, the problem is to determine the "shortest path" between any two nodes. This problem is often encountered in different other ways. Instead of dealing with length of cable runs, we can assign cost of link to every cable run; then the problem is to determine the minimum cost path between two nodes.

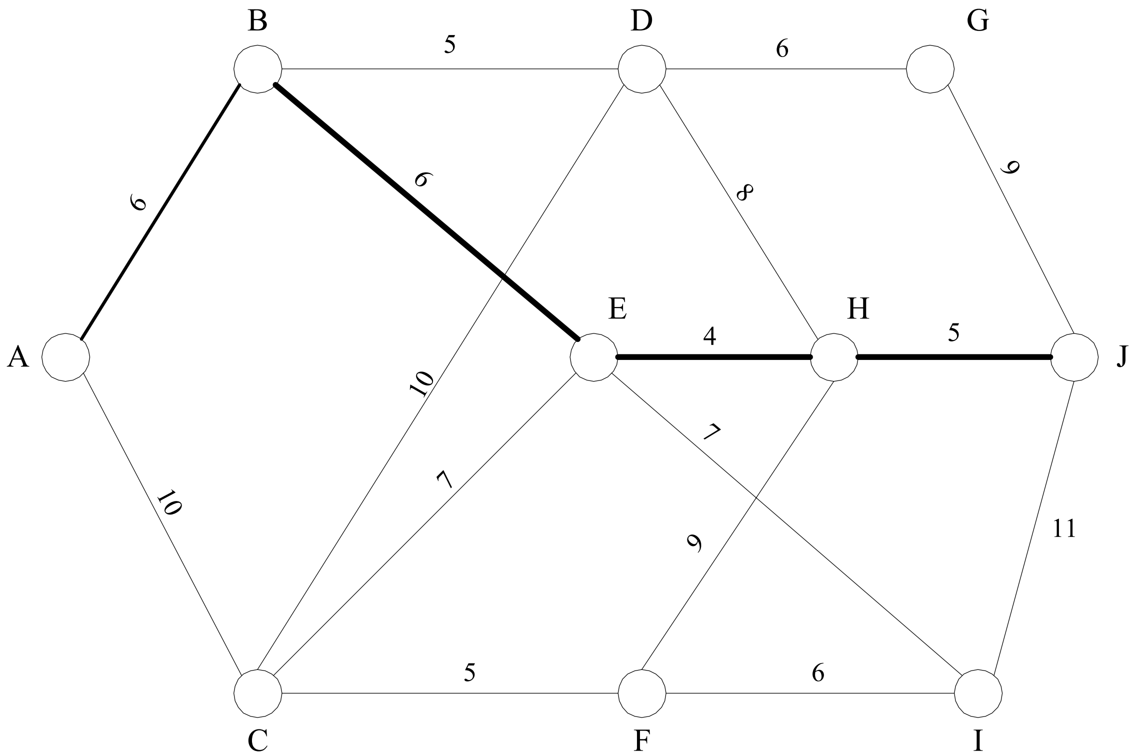


Figure 1

This problem can be tackled as a linear mathematical program, but it is more efficient to use other algorithms. The simplest method is due to Dantzig and the procedure is as follows:

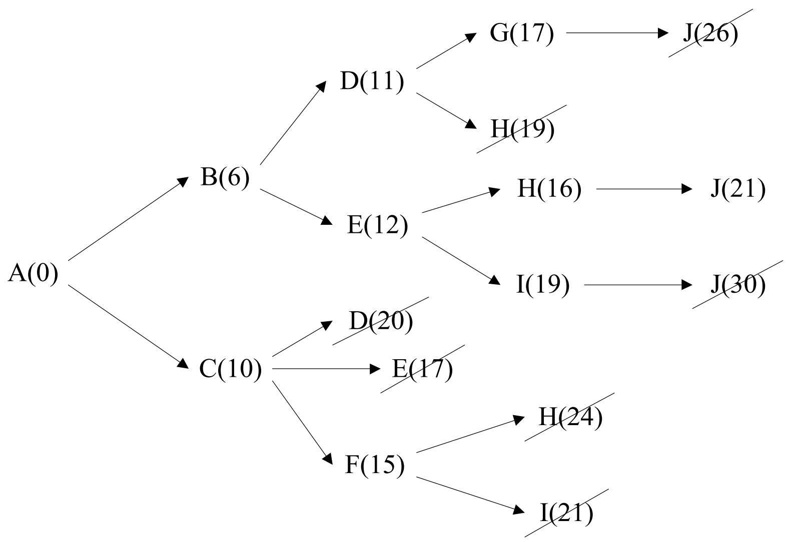
a) Label the source node as “0”.

b) Examine the adjacent nodes and label, each one with its distance from the source node.

c) Examine nodes adjacent to those already labelled. When a node has links to two or more labelled nodes, its distance from each node is added to the label of that node. The smallest sum is chosen and used as the label for the new node.

d) Repeat *(C)* until either the destination node is reached (if the shortest route to only one node is required) or until all nodes have been labelled (if the shortest routes to all nodes are required).

Let us try to find the shortest path from node *“A”* to node *“J”* for the network of Figure 1. In Figure 2, all steps to determine the shortest path are illustrated. We label the source node *“A”* with 0.



Shortest path procedure
Figure 2

The adjacent nodes to *A* are *B* and *C*. For those nodes we find the distances by adding the label of *A* with the distance of nodes from *A*. Thus, we get for *B* $0+6=6$, and for *C* $0+10=10$.

These figures are used as labels for *B* and *C* respectively. The next step is to find the adjacent nodes to *B* and *C* and then the labels to these nodes. For *B*, we have the node *D* with the label *11 = (6+5)* and the node *E* with the label *12 = (6+6)*. For *C*, we have the node *D* with the label *20 = (10+10)*. But the node *D* is also reached through *B*. Now we keep the smallest distance, which is *11*, via *B* and eliminate *D(20).* We continue this procedure until the remaining nodes *(E, F)*, adjacent to *C*, are examined. We keep *F(15)* and eliminate *F(17)*. Continuing this way, we stop the procedure when the examination of node(s) we are concerned with is reached. In Figure 1, the shortest path from *A* to *J* is drawn with coarse line.

Consider now all partially paths contained in the path from *A* to *J-(ABEHJ)*. These are: *(AB), (ABE), (ABEH), (BE), (BEH), (BEHJ), (EH), (EHJ), (HJ)*. If we examine these partial paths, we can verify that they are optimal paths. For example, from *B* to *J*, the optimal path is *(BEHJ)*. We can ascertain the fact that every optimal path consists of partially optimal paths.