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Network Design for WAN Traffic and Cost Generator

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Abstract— Wide Area Network (WAN) is an interconnected network round the world to share such as voice, data and video. So there are many types of traffic flow in and out of all directions and much type of data is transferring such as email (internal email, external email), Web Access, Database Access, file transfer and Video Conferencing or Online Meeting or Online Learning during the Covid-19. Those types of data can cause more traffic loading during the busy hours or days. As a network designer must optimize the traffic of network flow to avoid the congestion and cost much money. In this research paper focus on the way how to design the best Wide Area Network. To become an expert Network Designer we need a sample problem to study the algorithms and to hone our skills. Real networks carry real traffic and cost real money. If you can't get the actual tariff and traffic, you will have to fill in the missing information. The generators here can be used to create a simple scenario. Solving such problems is the only way to learn the effective network design.

Keywords— Traffic, Traffic generator, Site, population, Traffic Normalization, node.

I. INTRODUCTION

The main idea to design the best network for WAN or LAN, we must clearly define the scope of our network goal and what applications will be used to handle the services to our customers and estimate the traffic that will flow in and out through nodes. We have to use the mathematical formula to calculate the amount of that traffic caused by applications server such as Web server, Database Server, Mail server and File server. Among those application servers, applications servers which cause a large traffic and can cause congestion are Database server.

The most traffic of network is corrected to population and distance. The population may be the number of service users, number of computers, etc. while the distance is the length between two sites which can be in a country or other countries.

To carry out network design, we need certain inputs: the locations of (candidate) sites (nodes), the traffic demand, and the costs and capabilities of possible links and node equipment .This information may be measured, estimated or a combination of both .It is unlikely that complete information will be available, as both traffic and costs are commercially sensitive (they could be very useful to a competitor company).

Even with access to an existing network, we may only be able to measure the total traffic into and out of a node, not the actual traffic between node pairs; consequently, we will need to estimate the traffic between node pairs, whilst making sure this adds up to the known traffic in and out of the nodes

- In addition, we may need to examine a range of possible traffics or costs
- Consequently, we need to consider traffic and cost generators i.e. mathematical models to estimate traffic and costs from partial information

Section I describes on how to design the best WAN by calculating the traffic in and out from each node and application servers involve the traffic loading of network. Section II describes site, site location, application servers and terminology. Section III describes traffic generators, uniform traffic, random traffic, population& distance. Section IV describes traffic normalization, generating unbalance traffic, sensitive analysis, type of tariff, distance-based costing, and linear based costing, piecewise-linear distance-based costing, piecewise-constant distance-based costing, cost generators & using Delite tool to generate network. Section V describes

II. RELATED WORK

1. SITES

The list of sites - candidate node locations - is a vital input to network design .In many cases, site locations are obvious, as the company has existing buildings it needs to interconnect, or the sites correspond to centers of population or user communities .In some network design scenarios, however, there is a choice of sites at which to place the network nodes, and the network designer must choose the best to obtain the best final network .This is a very difficult problem, and we will only consider the situation where the node locations are fixed, and it is the network between them that must be designed.

For each site we will need:

- A name
- A location (latitude & longitude), allowing calculation of intermodal distances, an important input to link cost
- The population (number of e.g. people, service users, computers), for use in the traffic generator
- Traffic leaving the node (T_{out}), if known
- Traffic entering the node (T_{in}), if known
- The node level, a way of accounting for unbalanced traffic (see later)
- Any restrictions on node interconnections e.g. must be adjacent to a given node

2. Application Servers
   a. Web server: used to host web services such as Apache Server, IIS etc.
   b. Database Server: used to store and handle the query services from clients.
   c. Mail Server: used to store and delivery email message to email client.
   d. File Server: used to store and sharing resources to clients
   e. External Email: Email message sent and received from the Internet.
   f. Internal Email: Email message sent and received in the internal network (LAN).
3. Terminology:
   a. Tariff: The price of using telecommunication service or service charge of using telecommunica-tion channel or PSTN.
   b. Traffic: Data flows in and out from node to node or from node to PSTN.
   c. Population: number of people, services, computers for use in the traffic generator.
   d. Traffic Normalization: is a process of calculating the traffic of each node by recalculating ∝ until all the scaling factors converge to arbitrarily close to 1.0.
   e. Site: location of population
   f. Traffic generator: traffic matrix, i.e. the traffic from $node_i$ to $node_j$ for all nodes in network.
   g. Uniform traffic: it is traffic from one node to another with constant C.
   h. Nodes: referred to site.

III. METHODOLOGY

1. Introduction to Traffic Generators

The output of a traffic generator is a complete traffic matrix, i.e. the traffic from node *i* to node *j*, $T(i,j)$, for all nodes in the network. In the event that e.g. the traffic from node *i*, $T_{out}(i)$, is known, then the traffic generator should aim to ensure

$$\sum_j T(i,j) \cong T_{\text{out}}(i)$$

Fig.1 traffic out

Similarly, for the overall traffic, the traffic generator should aim to ensure

$$\sum_{i,j} T(i,j) \cong T_{\text{total}}$$

Fig.2.total traffic

2. Uniform Traffic

The simplest traffic model is uniform traffic; for a constant *C*, the traffic from node *i* to node *j* is:

$$T(i,j) = C$$

Fig.3. Uniform Traffic

However, this is not a realistic traffic distribution, and is not often used in real network design.
Nevertheless, it can be useful to test the sensitivity of a design algorithm to changes in cost whilst keeping the traffic uniform.

3. Random Traffic

An alternative is to generate a random level of traffic from node *i* to node *j* between upper and lower limits *maxReq* and *minReq*

```
 for (i=0; i<numNodes; i++)
    for (j=0; j<numNodes; j++)
  traffic[i][j]=minReq+Math.random()*(maxReq-minReq);
```

Although still simple, this generator is of practical use: WWW traffic, where no measurement data exists, can be modeled this way; as such traffic may be uncorrelated with distance or population. However, it should only be used for part of the overall traffic matrix; most traffic shows some correlation to distance and population.

4. More Realistic Traffic: Population & Distance

We need to develop a more realistic traffic generator. Between two sites N_1 and N_2, two of the key factors that can influence the traffic between them are their populations, Pop_1 and Pop_2, and the distance between them, Dist(1,2)

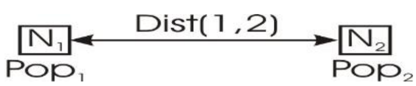


Fig.4. Traffic between two sites

The populations may be the number of people, the number of service users, the number of computers, etc., as the network designer determines. Note: we have already used population to estimate traffic in our earlier examples
More Realistic Traffic: Population & Distance (2)
The traffic from node *i* to node *j* is thus

$$T_\alpha(i,j) = \alpha \times \frac{(\text{Pop}_i \times \text{Pop}_j)^{\text{PopPower}}}{\text{Dist}(i,j)^{\text{DistPower}}}$$

Fig.5. Traffic depend on distance and population

The factors PopPower and DistPower allow us to vary the dependency on population and distance; e.g. if the traffic is heavily distance dependent, DistPower may be 2.0 or even 3.0; whereas if it is not so dependent on distance, DistPower may be 0.5 or even 0.0

The constant α allows us to adjust the relative traffic level to match the expected total traffic.

4.1. Even More Realistic Traffic: Scaled Population & Distance

There are two difficulties with the previous model

- Firstly, the population and distance may be measured in very different numerical ranges, causing numerical accuracy problems
- This is greatly eased by normalizing them with the maximum population, Pop_{max}, and maximum intermodal distance, $Dist_{max}$

$$\mathrm{Pop}_{\max} = \max_i\{\mathrm{Pop}_i\}$$

$$\mathrm{Dist}_{\max} = \max_{i,j}\{\mathrm{Dist}(i,j)\}$$

Even More Realistic Traffic: Scaled Population Distance (2)

Secondly, the traffic between nodes that are very close together can become unrealistically large. This can be solved by introducing small offsets for both population, Pop_{off}, and distance, $Dist_{off}$

The new traffic generator thus becomes

$$T_\alpha(i,j) = \alpha \times \frac{\left(\dfrac{\mathrm{Pop}_i \times \mathrm{Pop}_j}{\mathrm{Pop}^2_{\max}} + \mathrm{Pop}_{\mathrm{off}}\right)^{\mathrm{PopPower}}}{\left(\dfrac{\mathrm{Dist}(i,j)}{\mathrm{Dist}_{\max}} + \mathrm{Dist}_{\mathrm{off}}\right)^{\mathrm{DistPower}}}$$

Fig.6. Traffic depends on distance and population

IV. RESULT AND DISCUSSION

1. TRAFFIC NORMALIZATION

Given the expected total traffic, T_{total}, the traffic should be normalized by setting

$$\alpha = \frac{T_{total}}{\sum_{i,j} T(i,j)}$$

Fig.7. calculation of α

In practice, the traffic generator is run for all $T(i,j)$ with $\alpha = 1$, then the required value of α calculated, and finally the $T_\alpha(i,j)$ calculated.

1.1. Traffic Normalization (2)

If, in addition, the traffic from each of the nodes is known, we can calculate a different normalization factor for each node

$$\alpha_i = \frac{T_{\mathrm{out}}(i)}{\sum_j T(i,j)}$$

Fig.8. calculation of α for each node

This procedure is called **row normalization**, as it normalizes the row totals of the traffic matrix

If the traffic from only some of the nodes is known, then the value of α_i for the other nodes can be estimated by e.g. the average of those nodes with known traffic.

1.2. Traffic Normalization (3)

If the traffic to and from all the nodes is known, then an attempt can be made to normalize the rows and the columns of the traffic matrix

However, this will not be possible if

$$\sum_i T_{\mathrm{in}}(i) \neq \sum_i T_{\mathrm{out}}(i)$$

Fig.9.Totall traffic in and out is different

It can also be difficult if there are many 0s in the traffic matrix (Cahn p114).We can use an iterative algorithm; first normalize the overall traffic matrix.

$$\alpha = \frac{T_{total}}{\sum_{i,j} T(i,j)} \qquad T_\alpha(i,j) = \alpha \times T(i,j)$$

Fig.10.Formula to normalization the overall traffic matrix

Traffic Normalization (4)

Next calculate row and column based scaling factors

$$\beta_i = \frac{T_{\mathrm{out}}(i)}{\sum_j T_\alpha(i,j)} \qquad \gamma_j = \frac{T_{\mathrm{in}}(j)}{\sum_i T_\alpha(i,j)}$$

Fig.11. formula for calculating the β_i and γ_j

Then rescale the individual traffic requirements

$$T'_\alpha(i,j) = \beta_i \times \gamma_j \times T_\alpha(i,j)$$

Fig.12. Rescale the traffic

Continue by recalculating α and so on until all the scaling factors converge to arbitrarily close to 1.0 (see Cahn pp109-112).

Traffic	N1	N2	N3	N4	N5		alpha
N1		2070	1444	1843	4666		1.000
N2	2070		3150	2659	2081		
N3	1444	3150		3873	1507		
N4	1843	2659	3873		1705		
N5	4666	2081	1507	1705			
Traffic	N1	N2	N3	N4	N5	beta	
N1		2070	1444	1843	4666	**0.998**	
N2	2070		3150	2659	2081	**1.004**	
N3	1444	3150		3874	1507	**1.003**	
N4	1843	2659	3874		1706	**0.992**	
N5	4666	2081	1507	1706		**1.004**	
gamma	**0.998**	**1.004**	**1.003**	**0.992**	**1.004**		

Fig.13. Traffic Normalization

1.3. Generating Unbalanced Traffic

All the traffic generators so far produce symmetric traffic, i.e. $T_\alpha(i,j) = T_\alpha(j,i) \quad \forall i,j$

However, data traffic is often asymmetric e.g. Web traffic, database queries, and terminal sessions. We need to introduce different traffic levels, L_i for each node; for example, a Web server i, with outgoing traffic 3 times normal, would have $L_i = 3$

$$T_\alpha(i,j) = \alpha \times \frac{\text{Level}(L_i, L_j) \times \left(\frac{\text{Pop}_i \times \text{Pop}_j}{\text{Pop}^2_{\max}} + \text{Pop}_{\text{off}}\right)^{\text{PopPower}}}{\left(\frac{\text{Dist}(i,j)}{\text{Dist}_{\max}} + \text{Dist}_{\text{off}}\right)^{\text{DistPower}}}$$

Fig.14. Formula for unbalanced traffic

1.4. Generating Unbalanced Traffic (2)

Finally, real traffic never entirely fits an artificial model, so it is necessary to introduce a level of random variation in the traffic levels. For a random number generator Rand(), with values in the range 0 to 1, we can use the following traffic generator.

$$T_\alpha(i,j) = \alpha \times \frac{\text{Level}(L_i, L_j) \times (1 - r + 2r \times \text{Rand}()) \times \left(\frac{\text{Pop}_i \times \text{Pop}_j}{\text{Pop}^2_{\max}} + \text{Pop}_{\text{off}}\right)^{\text{PopPower}}}{\left(\frac{\text{Dist}(i,j)}{\text{Dist}_{\max}} + \text{Dist}_{\text{off}}\right)^{\text{DistPower}}}$$

Fig.15. Random variation in the traffic level

With $0 \le r \le 1$ used to adjust the amount of randomness; with $r = 0$, there is no randomness; with $r > 0$ increasing amounts of randomness are introduced.

2. Sensitivity Analysis

If we generate just one traffic matrix to use in the design process, this may not be enough. There are uncertainties in setting the parameters for the generator, so the real traffic may be slightly different from our initial traffic matrix .In addition; a single traffic matrix takes no account of the likely growth (or fall) in the traffic levels. Consequently, we should generate a suite of traffic matrices, reflecting the range of uncertainty and/or change in traffic levels, and design for all of them (or design for one, but at least check the design against the others). The resulting design will be far more robust to changes in traffic level.

Additional Considerations

Cahn devotes a full section (§4.7) to a case study on traffic generation, but time does not allow us to examine this in detail in the paper.

Please read this carefully, considering which generator is needed for each type of data traffic

- terminal sessions (on remote hosts)
- e-mail, both internal and external
- web pages, both internal (intranet) and external (internet)
- database (client/server) traffic, with partitioned or replicated data

3. Cost Generators

3.1. Types of Tariff

Here are many different types of tariff (cost) for voice and data networks. In general, the cost of the nodes, when depreciated over several years, is much less important than the link and usage costs. For voice networks, calls on the PSTN result in usage charges for (usually) the calling party, related to distance, time of day and administrative or national borders; in addition a monthly access fee (line rental) may be paid; often there will also be an initial fee (setup fee) when first obtaining a telephone line. For leased lines, there are only access charges, again relating to distance and administrative or national borders, plus a setup fee.

3.2. Types of Tariff (2)

In data networks, some calls are charged in a similar way to telephony (including modem and ISDN calls), but often the cost is simply access charges for a given bandwidth, rather than usage charges .Overall, tariffs may include:

- Access fees
- Setup fees
- Teardown fees
- Usage fees, relating to
    - channel capacity
    - committed information rate (a given % of channel capacity)
    - distance
    - time of day
    - administrative and national borders

4. Distance-based Costing

Focusing on access fees for links, one possibility would be to have the tariff simply related to the distance (length of the link).However, in practice this is almost never the case. For example, the cost of the link will be fixed by the PTT (telephone company) providing it; if they operate only within a given region or country, they will have to markup the cost they in turn must pay to another company if they provide a link partially outside their coverage area.

4.1. Distance-based Costing (2)

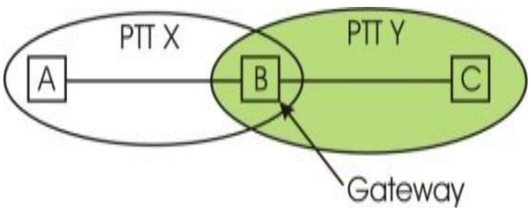


Fig.16.Distance-based Costing

Cost of a link (A,C) to a customer of PTT X is

$$C_X(A,C) = C_X(A,B) + M_X C_Y(B,C)$$

Where M_X is the markup PTT X applies to the cost, $C_Y(B,C)$, it must pay to PTT Y for the (B,C) link.

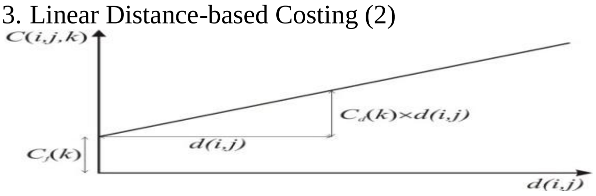
4.2. Linear Distance-based Costing

The simplest form of distance-based link cost is **linear distance-based costing**. The cost of a link of type *k* from node *i* to node *j* is

$$C(i,j,k) = C_f(k) + C_d(k) \times d(i,j)$$

Where, for links of type *k*, $C_f(k)$ is the fixed cost, $d(i,j)$ is the distance between node *i* and node *j* (in km), and $C_d(k)$ is the cost/km. If a PTT issues a large tariff table, with an entry for (nearly) every city pair and link type, it may be possible to approximate this by using **linear regression** to fit a linear-distance based cost generator to the table (Cahn pp130-131).

4.3. Linear Distance-based Costing (2)



4.4. Piecewise-linear Distance-based Costing

A slightly more complicated form of distance-based link cost is **piecewise-linear distance-based costing**

A piecewise-linear function P on $\Re$ with breaks at (d_1, d_2, ..., d_n) is continuous on $\Re$ and is linear on the intervals $(0,d_1)$, (d_1,d_2), ...(d_n,∞)

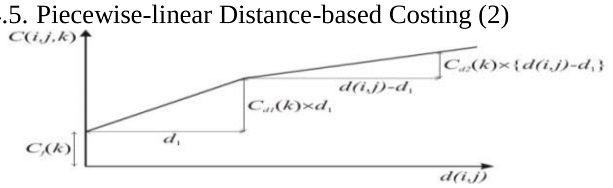
The cost of a link of type k from node i to node j with one break at d_1 is

$$C(i,j,k)=\begin{cases} C_f(k)+C_{d_1}(k)\times d(i,j) & \text{for } d \le d_1 \\ C_f(k)+C_{d_1}(k)\times d_1+C_{d_2}(k)\times\{d(i,j)-d_1\} & \text{otherwise}\end{cases}$$

Fig.17.Piecewise-linear distance-based costing

Where, for links of type k, $C_f(k)$ is the fixed cost, $d(i,j)$ is the distance between node i and node j (in km), and $C_{d1}(k)$ and $C_{d2}(k)$ are the cost/km before and after the break at d_1, respectively.

4.5. Piecewise-linear Distance-based Costing (2)



4.6. Piecewise-constant Distance-based Costing

Some PTTs provide tariffs where the cost of a link is fixed for any length within a given range i.e. **piecewise-constant distance-based costing**

The cost of a link of type k from node i to node j with two breaks at d_1 and d_2 is

$$C(i,j,k)=\begin{cases} C_{d_1}(k) & \text{for } 0<d\le d_1 \\ C_{d_2}(k) & \text{for } d_1<d\le d_2 \\ C_{d_3}(k) & \text{for } d_2<d\le\infty\end{cases}$$

Fig.18. Piecewise-constant distance-based costing

4.7. Piecewise-constant Distance-based Costing (2)

5. TARIFF TOOLS

Ideally, we would like to incorporate real tariffs in any network design computer program we create; however, incorporating real tariffs like this can be difficult for a number of reasons. For example, there may be no direct links between two given locations, so there may be no pre-existing tariff; it would have to be requested specifically from the PTT. Tariffs can differ depending on the PTT from which it is requested; different PTTs use different markups. Even if a tariff exists, the delay to provision a link may be too long. Finally, although third-party tariff tools do exist (giving tariffs from several countries), they are enormously expensive.

5.1. Cost Generators

The Delite tool contains a series of five link cost generators

- Each one represents a refinement of the earlier ones
- Moreover, apart from the first generator, each successive generator is used together with the earlier ones
- For any given link, if more than one generator could provide a cost, then the cost returned by the highest-numbered generator is used

5.2. Cost Generator 1: Linear Distance-based

The first generator is a simple linear distance-based generator. The cost of a link of type k from node i to node j is

$$C_1(i,j,k)=C_f(k)+C_d(k)\times d(i,j)$$

Fig.19. Linear Distance-based

Where, for links of type k, $C_f(k)$ is the fixed cost, $d(i,j)$ is the distance between node i and node j (in km), and $C_d(k)$ is the cost/km. This generator will be sufficient for costing links within one country, where the tariff can be approximated by a linear distance-based model.

5.3. Cost Generator 2: Piecewise-linear Distance-based

The second generator is a piecewise-linear distance-based generator. The cost of a link of type k from node i to node j with one break at d_1 is

$$C_2(i,j,k)=\begin{cases} C_f(k)+C_{d_1}(k)\times d(i,j) & \text{for } d \le d_1 \\ C_f(k)+C_{d_1}(k)\times d_1+C_{d_2}(k)\times\{d(i,j)-d_1\} & \text{otherwise}\end{cases}$$

Fig.20. Piecewise-linear Distance-based

Where, for links of type k, $C_f(k)$ is the fixed cost, $d(i,j)$ is the distance between node i and node j (in km), and $C_{d1}(k)$ and $C_{d2}(k)$ are the cost/km before and after the break at d_1, respectively. This generator is again probably limited to one country, but allows us to approximate more complex tariffs than the first.

5.4. Cost Generator 3: Including National Costs

The third generator uses specific tariffs within each country (C_3), where these are known, but uses C_2 for the default cost. In country l, the cost of a link of type k from node i to node j with one break at $d_1(l)$ is

$$C_3(i,j,k,l)=\begin{cases} C_f(k,l)+C_{d_1}(k,l)\times d(i,j) & \text{for } d \le d_1(l) \\ C_f(k,l)+C_{d_1}(k,l)\times d_1(l)+C_{d_2}(k,l)\times\{d(i,j)-d_1(l)\} & \text{otherwise}\end{cases}$$

Fig.21. Nation Costs

where, for links of type k in country l, $C_f(k,l)$ is the fixed cost, $d(i,j)$ is the distance between node i and node j (in km), and $C_{d1}(k,l)$ and $C_{d2}(k,l)$ are the cost/km before and after the break at $d_1(l)$, respectively.

5.5. Cost Generator 4: Including International Half Circuits
For international links, the cost is usually not related to distance, but is instead the sum of two fixed tariffs, one for the half of the link in each country (the so-called **half-circuit cost**). The generator uses C_2 for the default cost, C_3 for links within countries, and C_4 for international links
The cost of an international link of type *k* from node *i* to node *j* is

$$C_4(i,j,k)=C_h(N(i),N(j),k)+C_h(N(j),N(i),k)$$

Fig.22. International Half Circuit

where node *i* is in country $N(i)$, node *j* is in country $N(j)$, and $C_h(l,m,k)$ is the cost of a half circuit from country *l* to county *m* of type *k*.

5.6. Cost Generator 5: Including Special Tariffs
The final generator includes the possibility of special tariffs available between certain city pairs e.g. the cost of links into and out of London is different than for any other city in the UK. The generator uses C_2 for the default cost, C_3 for links within countries, C_4 for international links, and C_5 for special tariffs. C_5 simply consists of a table lookup in the program.

5.7. Using Delite to Generate Networks
In the Delite program, a small input file (.GEN) can be used to generate traffic and costs in .REQ and .CST files, referenced by a .INP file

- Run the Delite tool
- Generate a random network in Squareworld using menu *File:Random Net in SqWd* with parameters, say, (10, 1, 0, TEST.GEN, MESH, none)
- Run the network generator using menu *File:Generate Input* on file TEST.GEN, producing TEST.INP, TEST.REQ and TEST.CST
- Experiment with changing parameters, making reference to both Cahn's book and the program documentation.

V. CONCLUSION

As the discussion above and result, we observed that the best way to design the WAN for enterprise network, we must do the traffic normalization to calculate the traffic in and out of each node in order to setup the right bandwidth to handle the demand services. Involving the network design, we also need to calculate the cost and tariff of telecommunications. The cost of telecommunication is based on the distance. There are five types of cost-based distance that we need to consider before we calculate the tariff:

1- Distance-based costing: The costing of a link (A,C) to a customer of PTTX is $C_x(A,C)=C_x(A,B)+M_xC_x(B,C)$
2- Linear Distance-based Costing: The cost of link type k from a $node\ i$ to $node\ j$ is $C(i,j,k)=C_f(k)+C_d(k)\text{x}\ d(i,j)$
3- Piecewise-linear Distance-based Costing: a slightly more complicated form of distance-based link cost is piecewise-linear-based costing. A piecewise –linear function *P* on *R* with breaks at $(d_1, d_2, \dots \dots d_n)$ continue on *R* and is linear on the interval $(0, d_1)$),(d_1,d_2), (d_2,d_3),…..((d_n,∞).
The cost of a link type k from $node_i$ to $node_j$ with one break at d_1 is
$$C(i,j,k)=\begin{cases} C_f(k)+C_{d_1}(k)\times d(i,j) & \text{for } d\le d_1 \\ C_f(k)+C_{d_1}(k)\times d_1+C_{d_2}(k)\times\{d(i,j)-d_1\} & \text{otherwise}\end{cases}$$
The cost of a link of type *k* from node *i* to node *j* with two breaks at d_1 and d_2 is
$$C(i,j,k)=\begin{cases} C_{d_1}(k) & \text{for } 0<d\le d_1 \\ C_{d_2}(k) & \text{for } d_1<d\le d_2 \\ C_{d_3}(k) & \text{for } d_2<d\le\infty\end{cases}$$
4- Cost Generator: National Costs
$$C_3(i,j,k,l)=\begin{cases} C_f(k,l)+C_{d_1}(k,l)\times d(i,j) & \text{for } d\le d_1(l) \\ C_f(k,l)+C_{d_1}(k,l)\times d_1(l)+C_{d_2}(k,l)\times\{d(i,j)-d_1(l)\} & \text{otherwise}\end{cases}$$
5- Cost Generator: International Half Circuits
$$C_4(i,j,k)=C_h(N(i),N(j),k)+C_h(N(j),N(i),k)$$

Least, but not last it can be drown that traffic normalization will adjust traffic in and out of each node to the requirement of bandwidth or channel to be subscribed and to generate the cost of telecommunication network, it really based on the distance which will implement the right formula to be used for calculating the cost from Node i to Node j. The Nodes can be in a country or many countries around the world. But for International link, the cost is not usually related to distance.

There are five types of cost-based distance that we need to consider before we calculate the tariff are Distance-based costing, Linear Distance-based Costing, Piecewise-linear Distance-based Costing, and Cost Generator: National Costs and Cost Generator: International Half Circuits.

For simulation, we use the Delite tool to generate the cost and choose the best network design.

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