

Alternative Routing Networks

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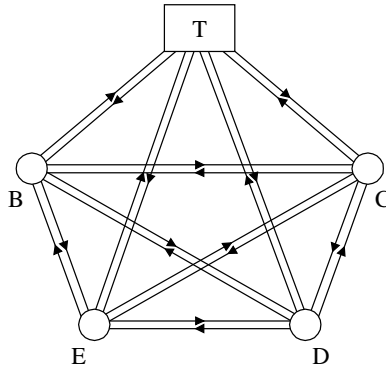


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Example:

A small network.
4 terminal exchanges.
1 tandem.



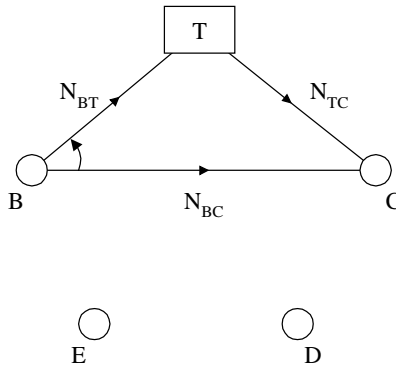
	B	C	D	E	T
B					
C					
D					
E					
T					

Consider the traffic case

B→C!

Tasks:

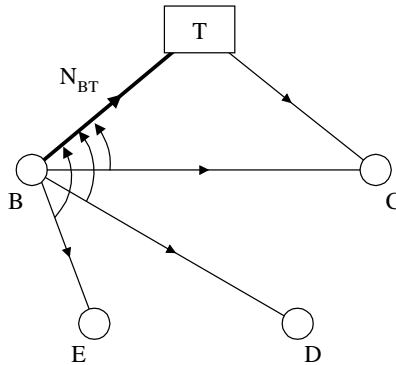
- 1) Optimise N_{BC}
- 2) Dimension N_{BT}
and N_{TC}



	B	C	D	E	T
B		X			X
C					
D					
E					
T		X			

But N_{BT}
carries also
overflow traffic
(background traffic)
from traffic
cases

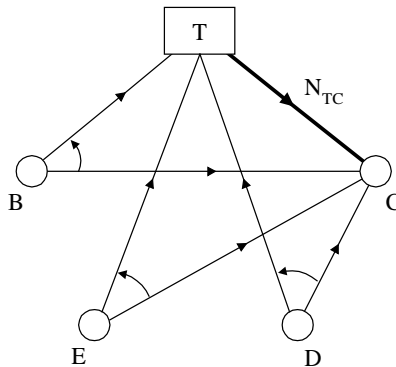
- B→D
- and
- B→E!



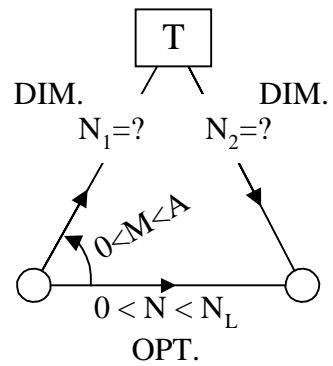
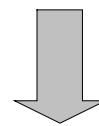
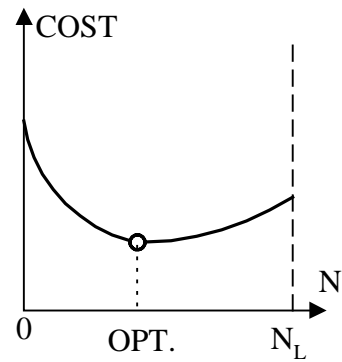
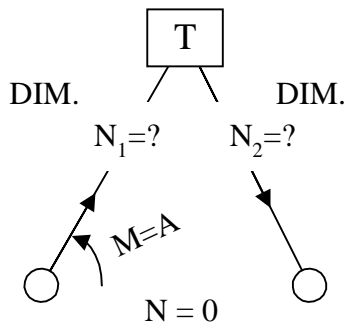
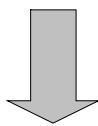
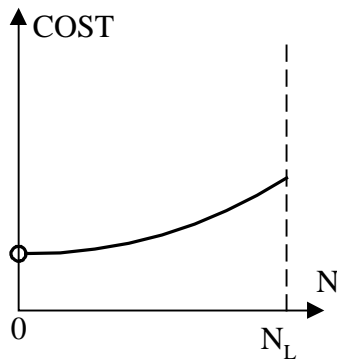
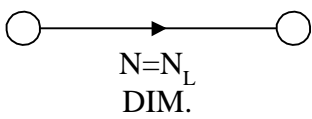
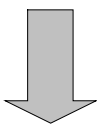
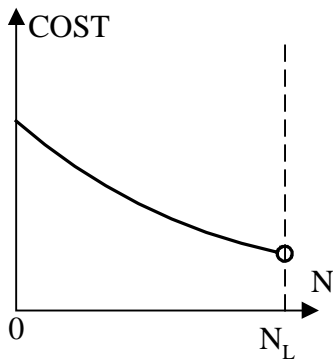
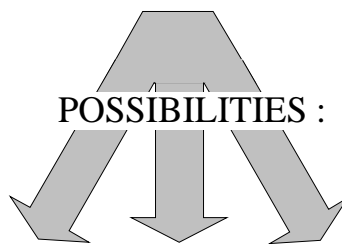
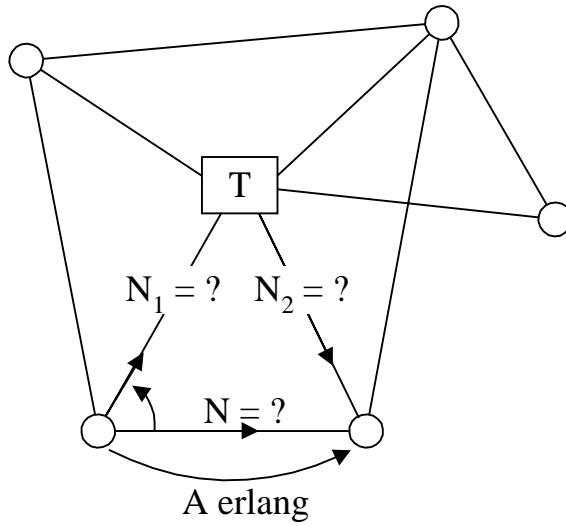
	B	C	D	E	T
B		X	X	X	X
C					
D					
E					
T					

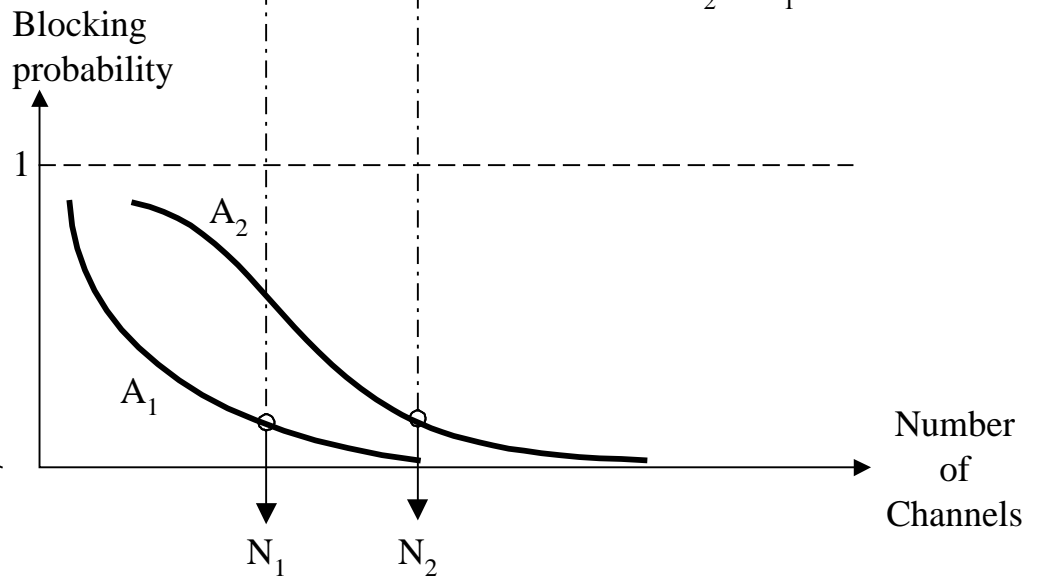
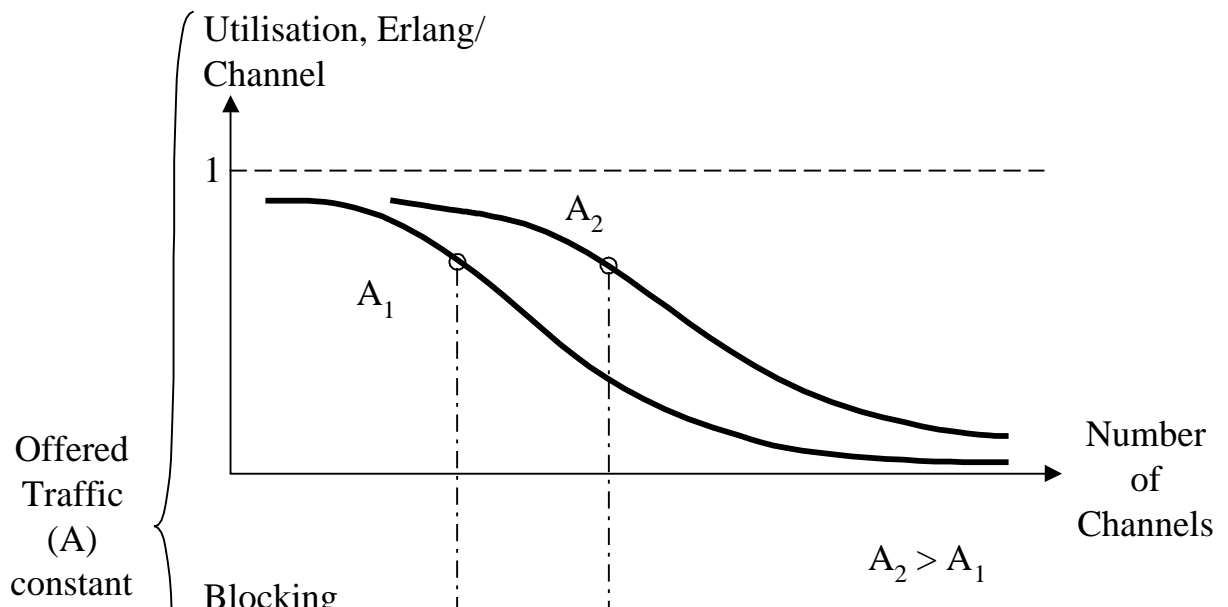
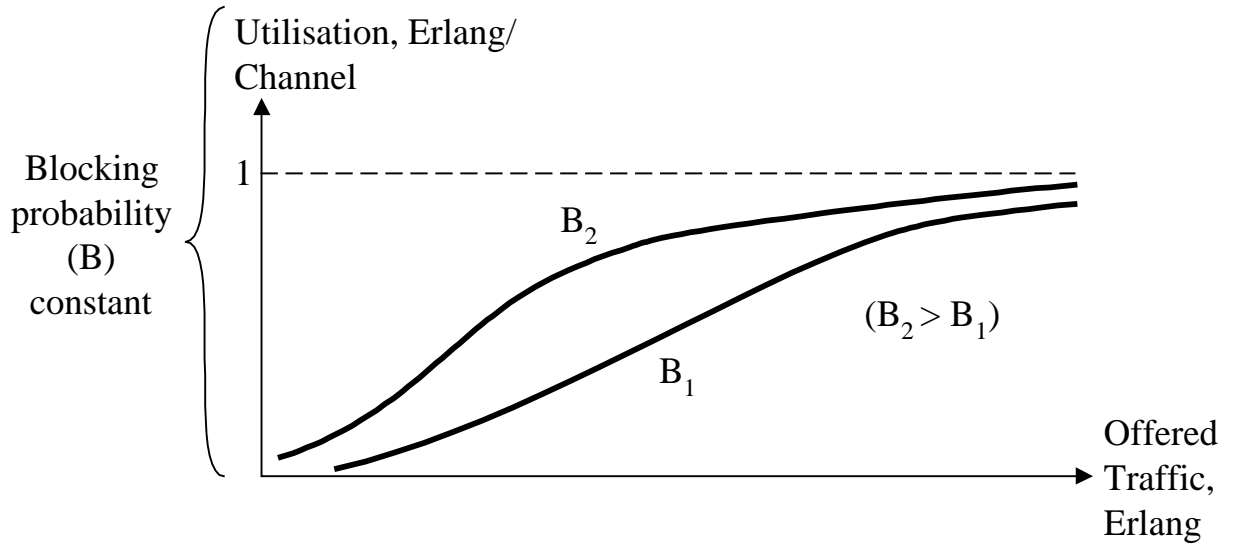
And N_{TC}
carries also
overflow traffic
(background traffic)
from traffic
cases

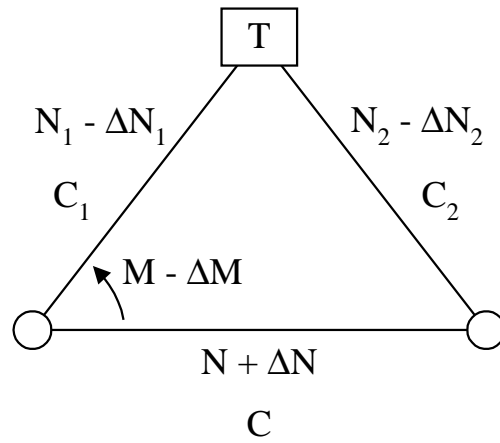
- D→C
- and
- E→C



	B	C	D	E	T
B		X			
C					
D		X			
E		X			
T		X			







$$N + \Delta N \Rightarrow C_{TOT} + \Delta C_{TOT}$$

$$\Delta C_{TOT} = C \cdot \Delta N - C_1 \cdot \Delta N_1 - C_2 \cdot \Delta N_2$$

$$\Delta C_{TOT} = 0 \text{ when :}$$

$$C \cdot \Delta N = C_1 \cdot \Delta N_1 + C_2 \cdot \Delta N_2$$

Divide by ΔM :

$$C \cdot \frac{\Delta N}{\Delta M} = C_1 \cdot \frac{\Delta N_1}{\Delta M} + C_2 \cdot \frac{\Delta N_2}{\Delta M}$$

or:

$$\frac{\Delta M}{\Delta N} = \frac{C}{C_1 \cdot \frac{\Delta N_1}{\Delta M} + C_2 \cdot \frac{\Delta N_2}{\Delta M}}$$

$$\frac{\Delta M}{\Delta N} = \frac{C}{C_1 \cdot \frac{\Delta N_1}{\Delta M} + C_2 \cdot \frac{\Delta N_2}{\Delta M}}$$

If $\Delta N = 1$ then :

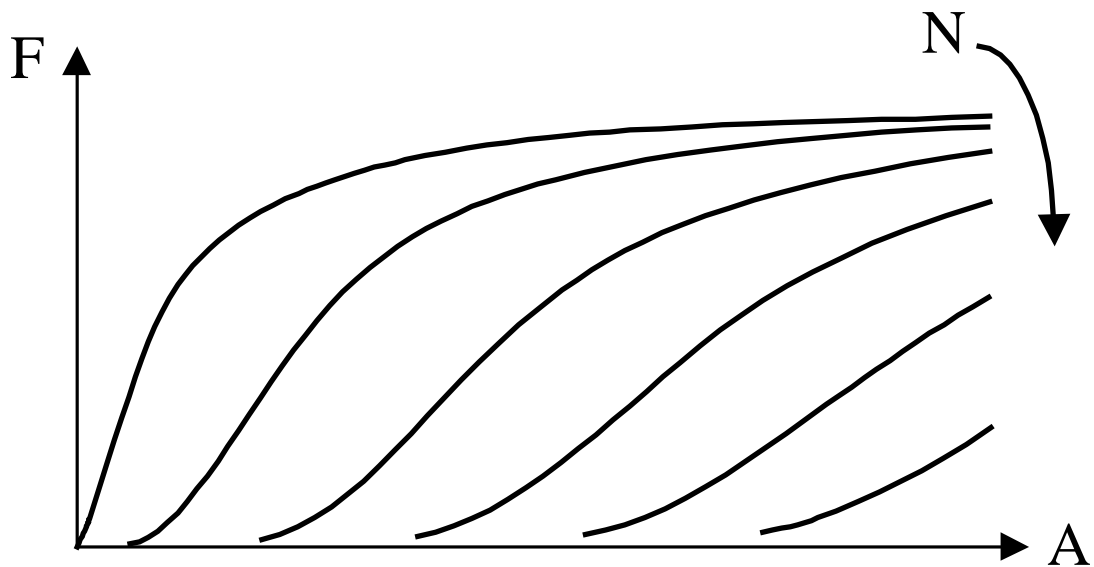
$$\frac{\Delta M}{\Delta N} = F = \text{The Improvement Factor}$$

F is calculated as

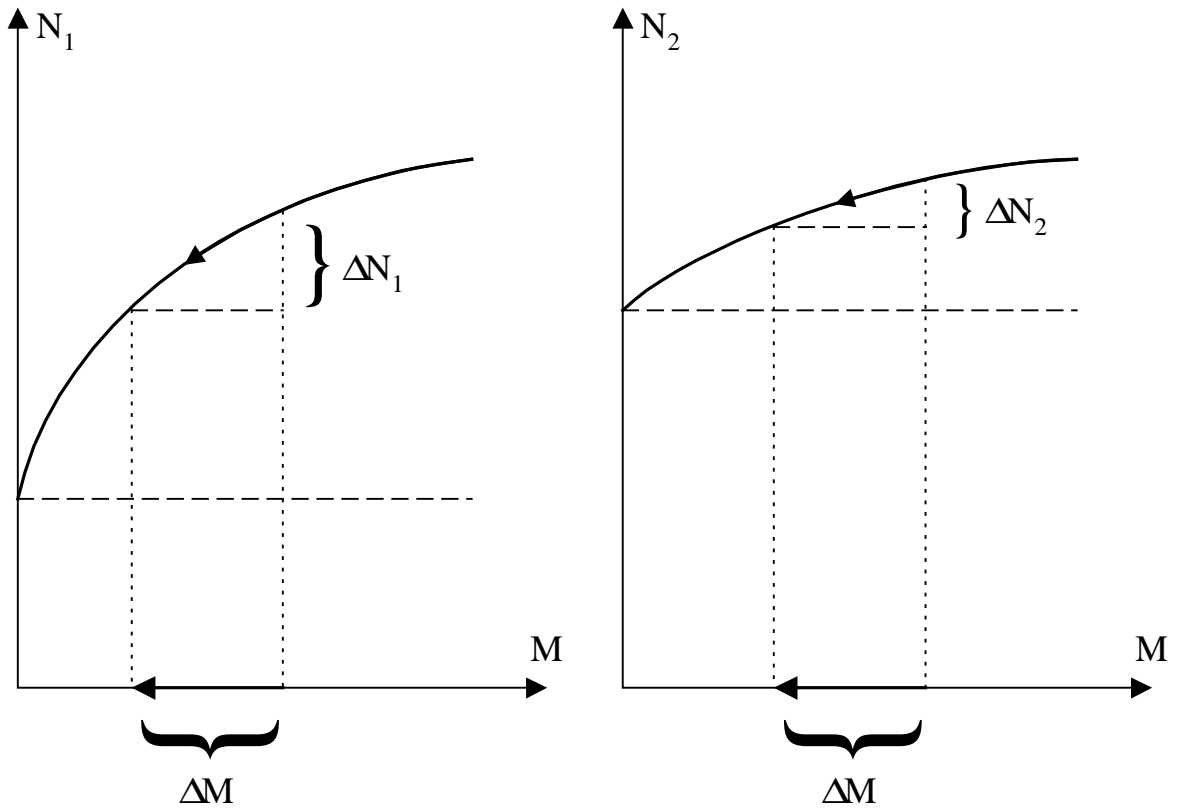
$$F = A \cdot [B_N(A) - B_{N+1}(A)]$$

where $B_N(A)$ is a general expression for the congestion in a trunk group with N trunks and A erl. offered.

Diagram for F:



$$\frac{\Delta M}{\Delta N} = F = \frac{C}{C_1 \cdot \frac{\Delta N_1}{\Delta M} + C_2 \cdot \frac{\Delta N_2}{\Delta M}}$$



Rapp's Approximation:

$$F = \varepsilon \cdot [0.7 + 0.3 \cdot \varepsilon^2]$$

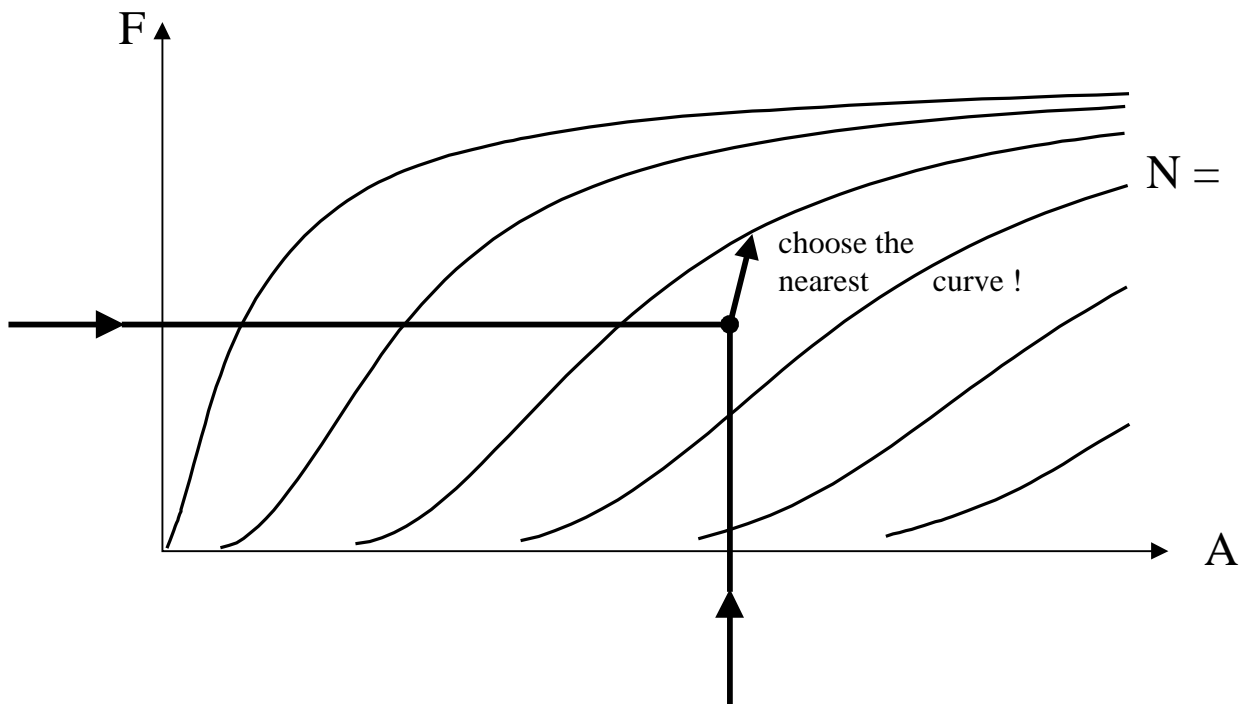
where

$$\varepsilon = \frac{C}{C_1 + C_2}$$

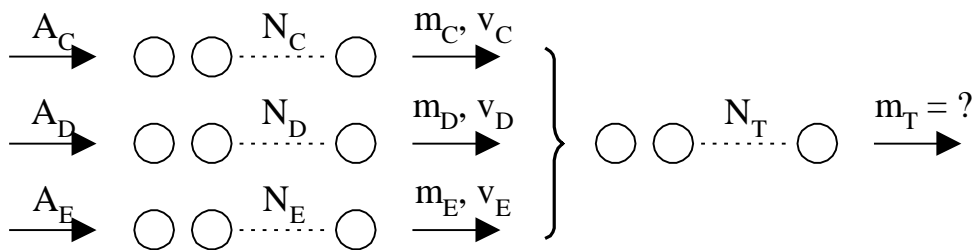
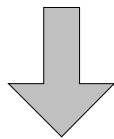
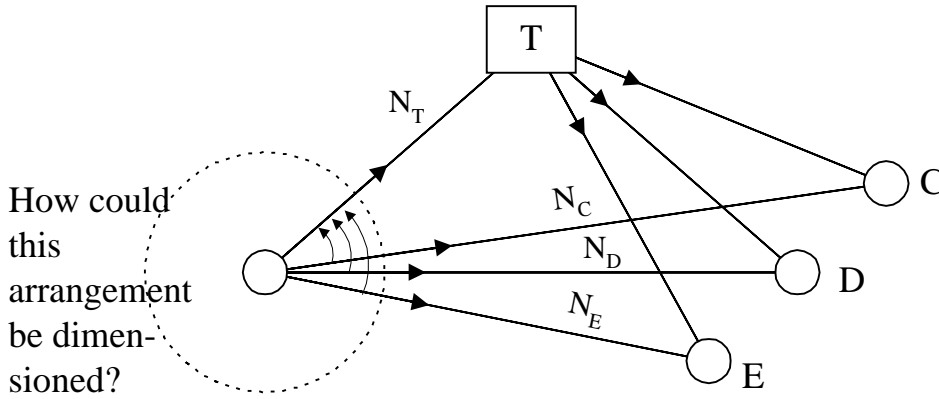
Optimisation Procedure:

- 1) Calculate F e.g. using Rapp's approximation.
- 2) Using the calculated F -value and the total traffic A , enter the appropriate F -diagram and read:

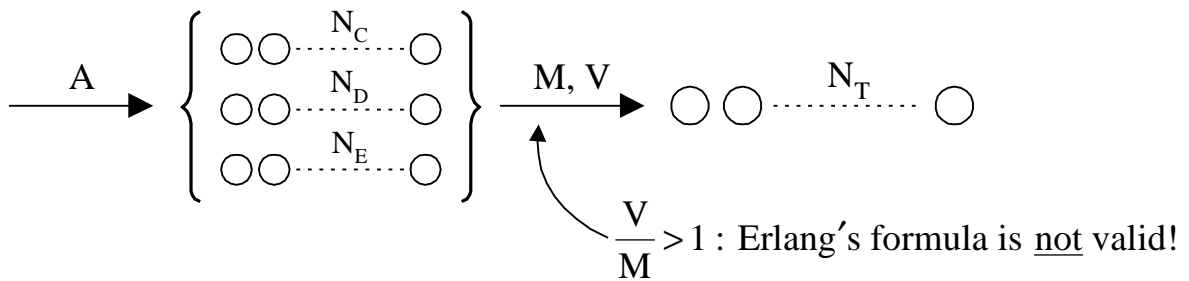
N = optimal number of trunks in the high-usage route.



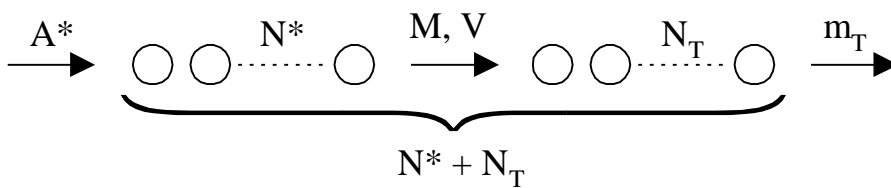
Wilkinson's Method:



We sum up:



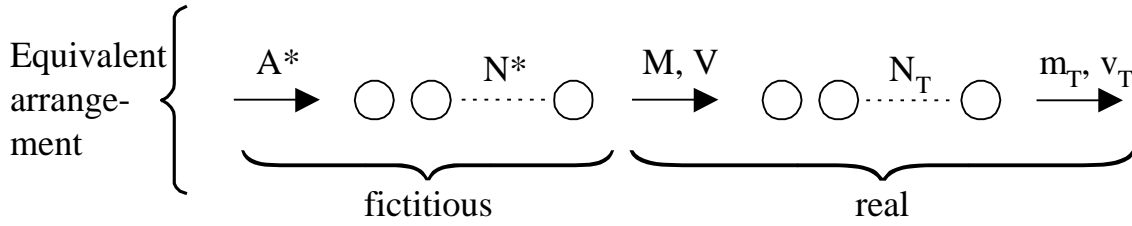
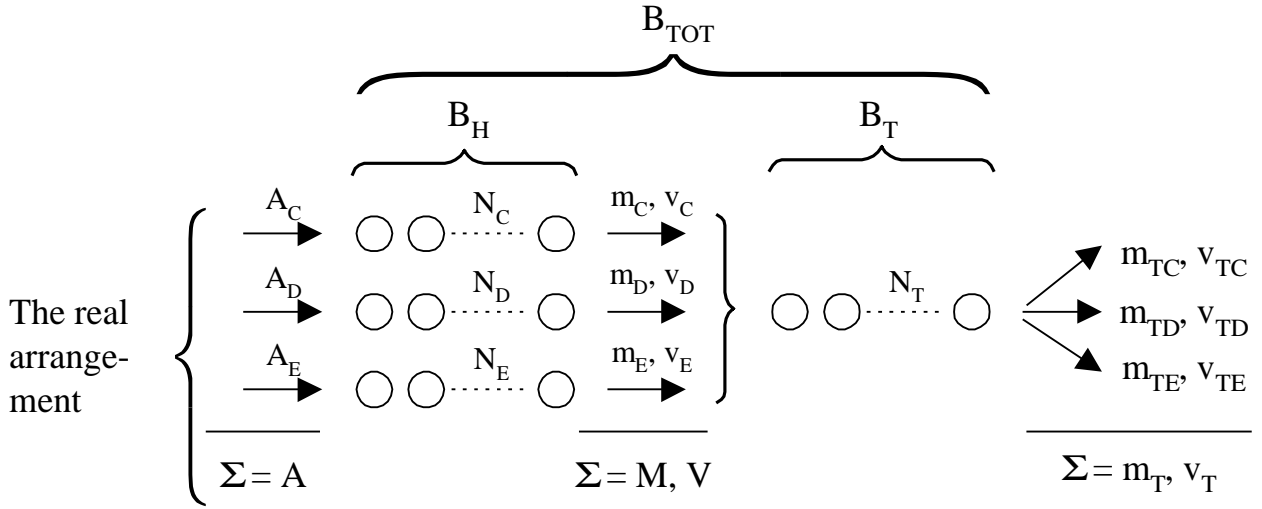
Solution: find fictitious traffic A^* , offered to a fictitious trunk group N^* , so that the mean and the variance of the rejected traffic is exactly equal to M resp. V !



Erlang's formula is now valid:

$$m_T = A^* \cdot E_{N^* + N_T}(A^*)$$

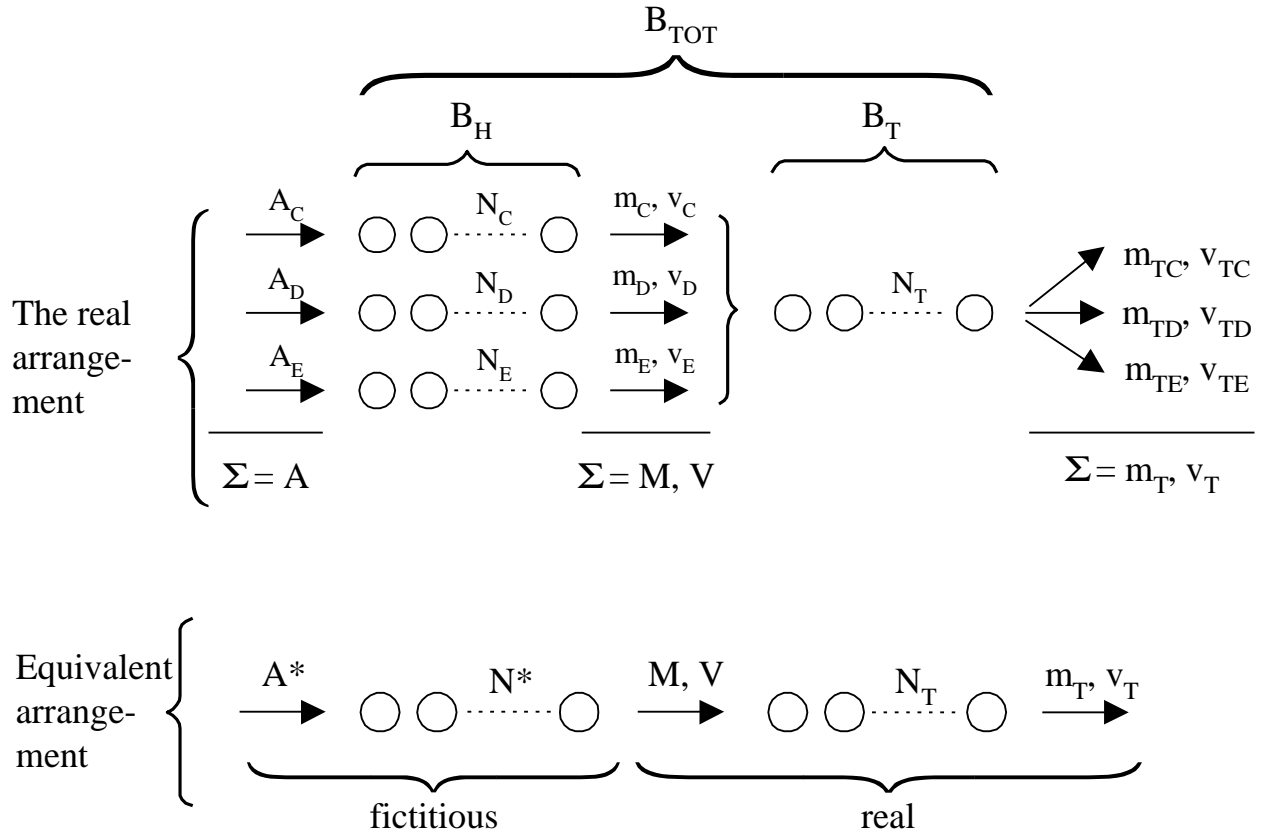
Blocking Probabilities:



$$1. \bar{B}_H = \frac{m_C + m_D + m_E}{A_C + A_D + A_E} = \frac{A_C \cdot E_{N_C}(A_C) + A_D \cdot E_{N_D}(A_D) + A_E \cdot E_{N_E}(A_E)}{A_C + A_D + A_E} = \frac{M}{A}$$

$$2. \bar{B}_T = \frac{m_{TC} + m_{TD} + m_{TE}}{m_C + m_D + m_E} = \frac{m_T}{M} = \frac{A^* \cdot E_{N^*+N_T}(A^*)}{M} = \frac{E_{N^*+N_T}(A^*)}{E_{N^*}(A^*)}$$

$$3. \bar{B}_{TOT} = \frac{m_T}{A_C + A_D + A_E} = \frac{A^* \cdot E_{N^*+N_T}(A^*)}{A}$$



$$4. B_{HC} = \frac{m_C}{A_C} = E_{N_C}(A_C)$$

$$5. B_{TC} = \bar{B}_T = \frac{E_{N^*+N_T}(A^*)}{E_{N^*}(A^*)}$$

$$6. B_{TOTC} = \frac{m_{TC}}{A_C} = \frac{m_C \cdot \bar{B}_T}{A_C} = \frac{E_{N_C}(A_C) \cdot E_{N^*+N_T}(A^*)}{E_{N^*}(A^*)}$$

$$7. B'_{TC} = \frac{v_C \cdot M}{V \cdot m_C} \cdot \bar{B}_T$$

$$8. B'_{TOTC} = \frac{m'_{TE}}{A_C} = \frac{m_C \cdot B'_{TC}}{A_C} = \frac{v_C \cdot M}{V \cdot m_C} \cdot B_{TOTC} =$$

$$= \frac{v_C \cdot M}{V \cdot m_C} \cdot \frac{E_{N_C}(A_C) \cdot E_{N^*+N_T}(A^*)}{E_{N^*}(A^*)}$$

1. (Approx.) n_v from

$$\begin{cases} F(n_v, A_v) \approx \varepsilon \cdot [1 - 0.3 \cdot (1 - \varepsilon^2)] \\ \varepsilon = C_{ij} / (C_{it} + C_{Tj}) \\ F(n, A) = A \cdot [E(n, A) - E(n+1, A)] \quad (\text{exact}) \end{cases}$$

2. (Exact)

$$m_v = A_v \cdot E_{n_v}(A_v)$$

$$v_v = m_v \cdot \left(1 - m_v + \frac{A_v}{1 + n_v + m_v - A_v} \right)$$

3. (Exact)

$$M = \sum_v m_v \quad V = \sum_v v_v$$

4. (Exact)

A^* and n^* from

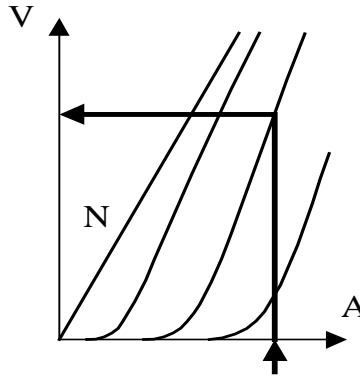
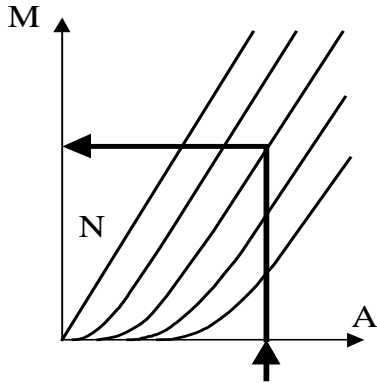
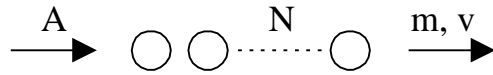
$$\begin{cases} M = A^* \cdot E_{n^*}(A^*) \\ V = M \cdot \left(1 - M + \frac{A^*}{1 + n^* + M - A^*} \right) \end{cases}$$

4. (Approx.)

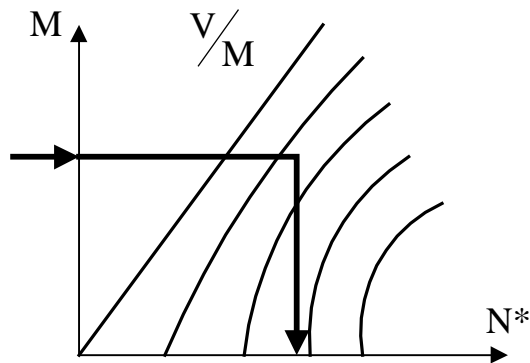
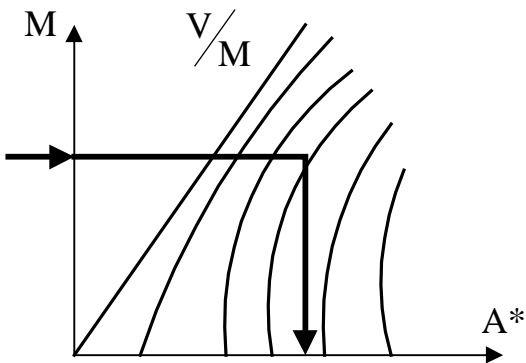
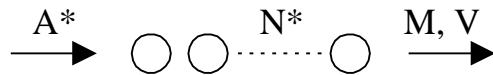
$$A^* \approx V + 3 \cdot \frac{V}{M} \cdot \left(\frac{V}{M} - 1 \right)$$

$$n^* \approx \frac{A^*}{1 - \frac{1}{M + \frac{V}{M}}} - M - 1$$

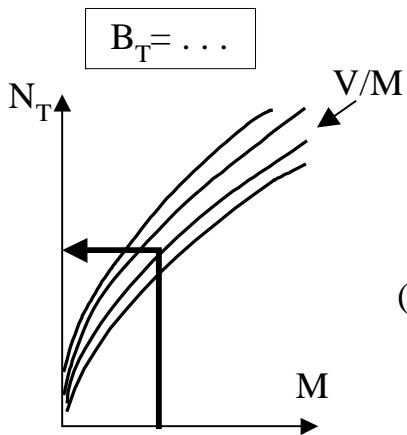
There are diagrams for calculation of m and ν from high-usage trunk groups...



and other diagrams for calculation of fictitious traffic and fictitious trunk group:



If the tandem route is to be dimensioned for a fixed, standard congestion value, these diagrams may be used (instead of calculations) :



(In that case, A* and N* are not needed!)