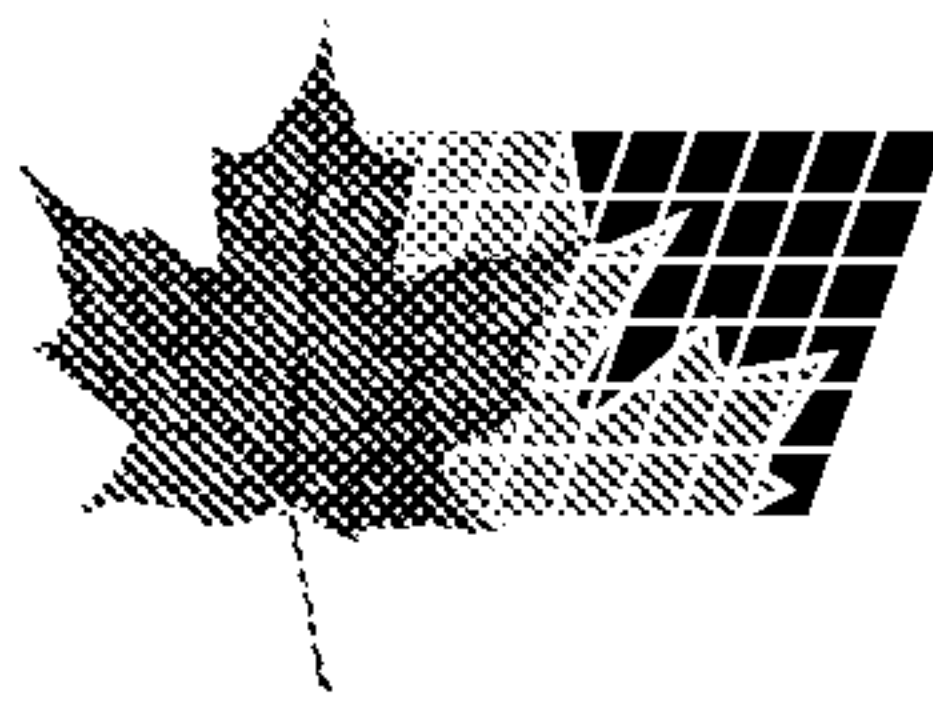


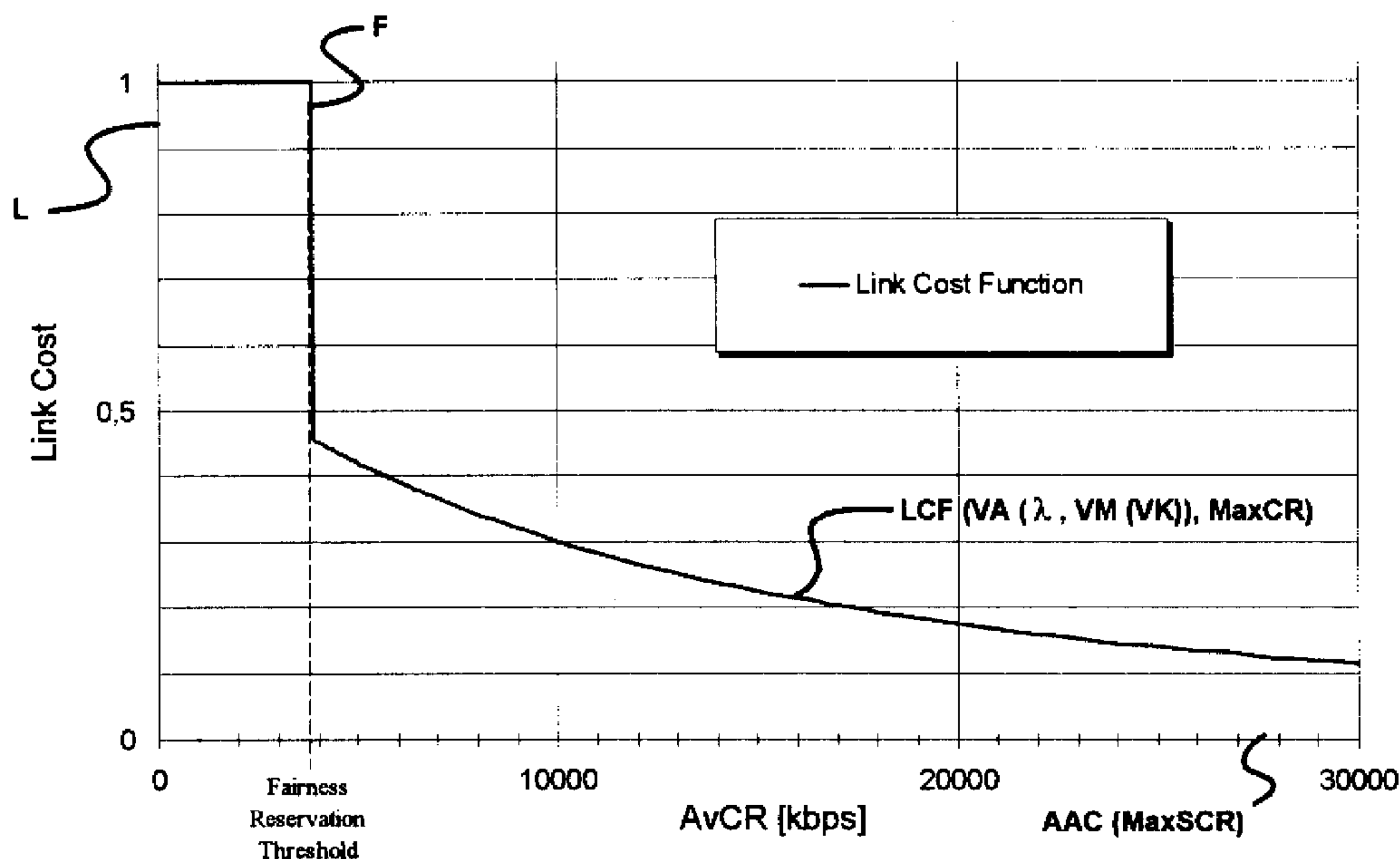


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(54) **METHODE POUR PONDERER LES VOIES DE TRANSMISSION
D'UN RESEAU DE TELECOMMUNICATIONS**
(54) **METHOD FOR WEIGHTING TRANSMISSION PATHS IN A
COMMUNICATIONS NETWORK**



(57) The weighting of transmission paths (U) of a communications network KN in which information is transmitted at different data rates is carried out in accordance with a weighting rule whose weighting work has an essentially linear dependence on the capacity MaxCR of the respective transmission path U. The weighting work thus remains limited even for transmission paths U with a high capacity MaxCR.

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Abstract

Method for weighting transmission paths in a communications network

The weighting of transmission paths (U) of a communications network KN in which information is transmitted at different data rates is carried out in accordance with a weighting rule whose weighting work has an essentially linear dependence on the capacity MaxCR of the respective transmission path U. The weighting work thus remains limited even for transmission paths U with a high capacity MaxCR.

Figure 2

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Description

Method for weighting transmission paths in a communications network

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Communications networks are usually embodied either as packet-oriented or as circuit-oriented networks. In this context, packet-oriented networks are better suited for transmitting information without
10 real-time character, for example data, e-mail or files, while circuit-oriented networks are well designed for transmitting information with real-time character such as voice or moving images. However, in the course of the convergence of circuit-oriented and packet-oriented
15 networks, voice information and moving image information is also increasingly being transmitted in packet-oriented networks. Examples of packet-oriented networks are the Internet or ATM (= Asynchronous Transfer Mode), the designation ATM being occasionally
20 also used as a synonym for B-ISDN (=Broadband Integrated Services Digital Network). Packet-oriented network technology will be explained further below with reference to the example of ATM.

Packet-oriented transmission of information is
25 characteristic of packet-oriented networks. In ATM networks, the information is divided up, for example, into packets of equal length - also referred to as "ATM cells" - which have a header comprising 5 bytes and an information part (payload) comprising 48 bytes. Here,
30 the individual cells are assigned to information streams - also referred to as "virtual connections" - which are determined by the headers. In contrast to, for example, a circuit-oriented TDMA method in which time slots are assigned in advance to different types
35 of data traffic, the incoming information streams on an ATM interface are segmented into the aforementioned 53 byte cells and these cells are then transmitted onward sequentially in the order in which they were generated. The multiplex method which is used in the

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case of TDMA is also referred to as "static multiplexing" and the multiplex method which is used in the case of ATM is referred to as "statistical multiplexing". As a consequence of the flexibility of statistical multiplexing, the information streams in the case of ATM can have any desired data rates, whereas in the case of static multiplexing the data rate of the individual information streams - also referred to as "connections" - is fixed, for example at 64 kbit/s in the case of ISDN - owing to the fixed assignment of the timeslots to the information streams.

As a consequence of this difference, in packet-oriented networks the routing of a requested connection is dependent on the residual capacity available on a route, while in circuit-oriented networks it is, by virtue of the principle, independent of the capacity utilization rate of the individual transmission paths. For example, on a route in a circuit-oriented network, along which, for example, 30 connections can be routed in permanently assigned timeslots with 64 kbit/s capacity each, using, for example, a TDM method, it is possible to set up a further connection in all cases even if 29 connections have already been set up because, owing to its constant data rate, the further connection does not require a higher data rate than the still available residual capacity of 64 kbit/s. However, only connections for which a data rate lower than 30 Mbit/s has been requested can be set up along a route in a packet-oriented network with an assumed residual capacity of 30 Mbit/s. Connections with a higher data rate are, however, rejected. If alternative routes exist, they can be set up on a replacement basis along an alternative route with sufficient residual capacity. However, renewed routing is necessary to determine an alternative route.

Various routing methods which can be used to determine routes in networks are known. One possibility is so-called "source routing" in which the entire route

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to a destination switching node is determined starting from an originating switching node. For ATM networks, source routing is required, for example, by the ATM forum in the so-called PNNI (=Private Network-Network Interface) specification. Here, the route is determined by the originating switching node, and subsequently during the connection setup the calculated route is communicated to the switching nodes along the route by means of signaling. A further possibility is so-called "hop-by-hop routing", in which the remainder or the next part of the route is newly calculated by each switching node along a route. This method is applied, for example, in the Internet or in ATM networks without source routing.

In order to exclude, during routing, those routes which would use the overloaded or interrupted transmission paths, the PNNI specification proposes so-called flooding methods. Here, all the switching nodes measure, at defined times, the traffic values of the transmission paths connected to them, and pass them on to all the other switching nodes within a group. This information forwarding is referred to as "flooding". The flooding can additionally also be initiated if the traffic values of the transmission paths change significantly - for example if the present capacity utilization rate of a transmission path with an overall capacity of 150 Mbit/s deviates by more than 10 Mbit/s from the last capacity utilization rate passed on. For example, in ATM networks, methods are proposed which make available to a routing algorithm the traffic values, measured respectively last in the switching nodes of the ATM network, of the transmission paths directly connected to said switching nodes.

For routing in circuit-oriented and connection-oriented networks, K.R. Krishnan, Huebner-Szabo de Bucs, "Admission Control and State-Dependent Routing for Multirate Circuit-Switched Traffic", ITC-15, pages 1043-1054, 1997 discloses a dynamic routing method for

broadband networks, in which the transmission paths of said networks are weighted as a function of their loading by information transmissions. For this purpose, seizure probabilities are calculated for the transmission paths as a function of offered loads fed to them, their present capacity utilization rate and the data rate necessary for an additional information transmission along a further connection. A largely completely interlinked communications network is required, which is customary in the top hierarchy level of hierarchically structured, circuit-oriented telephone networks. Thus, each transmission path on the top hierarchy level is seized, with a few exceptions, by connections which merely require a single hop from their originating switching node at the top hierarchy level to their destination switching node at the top hierarchy level. Consequently, during the determination of the seizure probabilities of the individual transmission paths, only the offered load, which is transmitted directly between the two switching nodes which are connected to the transmission path, is considered for each of the transmission paths. The link costs are determined using dynamic programming and by solving a linear equation system. Here, the matrix of the transition rates of the possible capacity utilization rates is defined as $\hat{A} = (\hat{a}_{ij})$, the matrix element $\hat{a}_{ij}$ describing the rate of the transition from the capacity utilization rate i to the capacity utilization rate j . The link cost functions $v(i,j)$ of the transition from the capacity utilization rate i to the capacity utilization rate j are calculated as $v(i,j) = z_j - z_i$, the values z_i and z_j being obtained from the equation system

$$BR = w_i + \sum_{j=0}^{MaxCR} \hat{a}_{ij} z_j, i = 1, \dots, MaxCR.$$

The value w_i is the blocking rate of the transmission path in the state i , BR is the entire blocking rate of

the transmission path which is calculated from the matrix $\hat{A}$. The work involved in solving the equation system arises here overproportionally in comparison with the increase in the capacity as the capacity of the transmission paths increases. The equation system thus quickly becomes very complex for large-capacity transmission paths. For example, even a transmission path with a capacity of 155 Mbit/s and a minimum average data rate of 64 kbit/s requires an equation system with approximately 2422 equations to be solved. The weighting rules are based here merely on bidirectional, symmetrical connections. When unidirectional connections are considered, the number of equations increases further.

The invention is based on the object of improving the weighting of transmission paths. The object is achieved by means of the features of patent claim 1.

The essential aspect of the invention consists in a method for weighting transmission paths of a communications network in which information is transmitted at different data rates, in which the weighting is carried out in accordance with a weighting rule whose weighting work has an essentially linear dependence on the capacity of the respective transmission path. The essential advantage of the invention is the fact that the work involved in weighting transmission paths with a high capacity is limited. In addition, the invention is particularly suitable for use in contemporary packet-oriented networks, for example ATM networks, IP networks or the Internet, which are characterized by information transmissions with flexible data rates.

According to one refinement of the method according to the invention, the weightings are each carried out as a function of at least one variable weighting parameter - claim 2. According to one variant of the method according to the invention, there is

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provision that the weightings are each carried out as a function of a single variable weighting parameter, and all the further weighting parameters are constant - claim 3. According to one refinement of the method
5 according to the invention, the variable weighting parameter is embodied in each case as the capacity utilization rate of the transmission path - claim 5. The invention can thus be used particularly satisfactorily in networks with flooding methods.

10 According to a further refinement of the method according to the invention, the variable weighting parameter is independent of a given information transmission request - claim 4. According to one
15 development of the method according to the invention, there is provision that whenever there are capacity utilization rates which are greater than the threshold capacity utilization rate of the transmission path, the weighting of the transmission path is embodied in such
20 a way that no additional information transmissions take place along said transmission path - claim 6. According to one development of the method according to the invention, the threshold capacity utilization rate of a transmission path here is in each case equal to its capacity minus the maximum average data rate which are
25 most necessary for the information transmissions in each case - claim 7. As a result, a fairness policy is advantageously implemented, according to which the same rejection probability is obtained for all the information transmissions, irrespective of the data
30 rates which are required for them, because each of the information transmissions takes place before the threshold capacity utilization rate is exceeded, and none of the information transmissions take place after the threshold capacity utilization rate has been
35 exceeded.

According to one refinement of the method according to the invention, the weighting is carried out according to a given weighting rule, at least as a

function of capacity utilization rate probabilities, given capacity utilization rates and capacities, a cell rate margin and probabilities that a data rate of j bit/s is necessary for an information transmission - claim 8. Thus, different request profiles of the users of the communications network are advantageously taken into account in the weighting. In addition, the time period and temporal distribution of the information transmissions is advantageously included in the weighting. Because only weighting rules relating to probability theory are used, the weightings are determined in a very easy and efficient way by the summing, usually associated with this, of weighted probability values, i.e. neither approximation methods nor the calculation-intensive solution of a large linear equation system is necessary for the weighting. In particular, the "sum", "multiplication" and "division" operations which are applied are generally supported very efficiently by modern processors. Furthermore, the frequently differing characteristic of the individual transmission paths is advantageously included in the weighting. Thus, the weightings advantageously take into account whether a transmission path is utilized by frequently changing information transmissions - for example data traffic - whose data rates are subject to severe fluctuations or whether instead it is loaded very uniformly with information transmissions - for example telephone traffic - which last a long time and often require very similar data rates.

The method according to the invention is explained in more detail below with reference to a plurality of figures, in which:

Figure 1 shows a communications network with switching nodes and transmission paths in a block circuit diagram,

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Figure 2 shows a weighting embodied as a link cost function in a diagram.

Figure 1 illustrates a communications network KN with four switching nodes K_i , $1 \leq i \leq 4$. The switching node K_1 is connected to the switching node K_2 by a transmission path U_{12} , and to the switching node K_3 by a transmission path U_{13} ; the switching node K_4 is connected to the switching node K_2 by a transmission path U_{24} , and to the switching node K_3 by a transmission path U_{34} ; in addition, a transmission path U_{14} , which is illustrated by a dotted line in the drawing, is provided between the switching nodes K_1 and K_4 . This indicates that transmission paths U - for example the transmission path U_{14} - may be temporarily overloaded and/or interrupted. In addition, an arrow pointing to the switching node K_1 indicates that an information transmission request A is transmitted to this switching node K_1 - for example in a connection-oriented communications network KN along a connection V - for a connection destination VZ - for example the switching node K_4 .

The weightings which are obtained for a specific type of transmission path as a function of its capacity utilization rate AAC are illustrated in Figure 2, in a diagram using a weighting rule embodied, for example, as a link cost function LCF . Here, a type of transmission path is characterized, for example, by its offered load VA and its capacity $MaxCR$. The offered load VA will be assumed, for example, to be determined by its offered load rate λ and its characteristic traffic mix VM of information transmissions which are assigned, if appropriate, to different traffic classes VK . The currently available cell rate $AvCR$ of the corresponding transmission path U is plotted on the abscissa of the diagram - also referred to as "x axis" - and the weightings which are embodied as link costs L are plotted on the ordinate - also referred to as "y

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axis". In addition, a threshold capacity utilization rate F - also referred to as "Fairness Reservation Threshold" is indicated on the x axis. The capacity utilization rate AAC - also referred to as link seizure - can be expressed, using the available cell rate $AvCR$ and the link capacity $MaxCR$ as follows, for example: $AAC = MaxCR - AvCR$. When the threshold capacity utilization rate F is taken into account, the following derivation is obtained: $AAC = MaxCR - F - AvCr$.

According to the exemplary link cost function LCF , higher link costs L result as the capacity utilization rate AAC increases. Starting from the threshold capacity utilization rate F , significantly increased link costs L are provided in comparison with the link costs L for capacity utilization rates AAC lower than the threshold capacity utilization rate F . The link cost function LCF is determined, for example, by the following weighting rule relating to probability and traffic theory:

20

$$\text{cost}(AAC) = \begin{cases} \infty, & AAC > MaxCR - CRM - F \\ \sum_{n=MaxCR-CRM-F+1}^{MaxCR-CRM-F} \alpha_n \cdot P(n, MaxCR - CRM - F) \cdot \left[\sum_{k=AAC-MaxSCR+1}^{AAC} \beta_k(AAC) \cdot P(k, AAC) \right]^{-1}, & AAC \leq MaxCR - CRM - F \end{cases}$$

the following applying to the parameters in this equation:

$$\alpha_n = \sum_{k=MaxCR-CRM-F+1-n}^{MaxSCR} p_k \cdot \left[1 + \sum_{j=MaxCR-CRM-F+1+k-n}^{MaxSCR} \left(p_j \cdot \frac{P(n, MaxCR - CRM, F)}{P(n+k, MaxCR - CRM, F)} \right) \right]^{-1},$$

$$\beta_k(AAC) = \sum_{j=AAC-k+1}^{MaxSCR} p_j,$$

- 25 $MaxCR$ (= Maximum Cell Rate) Capacity of the transmission path U ,
- AAC (= Actual Allocated Capacity) Capacity utilization rate of the transmission path U ; in networks with flooding, the capacity

utilization rate AAC is regularly determined by all the switching nodes K for the transmission paths U connected to them, and is subsequently communicated to all the other switching nodes K,

5 *MaxSCR* (= Maximum Sustainable Cell Rate) Maximum average cell rate which is required for an information transmission; a maximum average data rate can be derived from this by

10 multiplication by the number of bits per cell, for example in the case of ATM cells by multiplication by 424 bit/s (= 53 bytes per cell * 8 bits per byte),

F (= Fairness Reservation Threshold) Threshold

15 capacity utilization rate of a transmission path U starting from which no further information transmissions are permitted, not even if the requested data rate is lower than the one which is still available,

20 *P(x;y,F)* Capacity utilization rate function with steady-state probabilities, a capacity utilization rate AAC being used for x, y being assumed to be a given capacity MaxCR and *F* being assumed to be a given threshold

25 capacity utilization rate *F*,

P(x;y) Capacity utilization function with steady-state probabilities, a capacity utilization rate AAC being used for x, and y being assumed to be a given capacity MaxCR,

30 *CRM* (= Cell Rate Margin) is a buffer capacity which is requested by the ATM forum for a transmission path U, where the sum of average cell rates SCR (= Sustainable Cell Rate) of all the information transmissions which are

35 carried out along a transmission path U plus the buffer capacity CRM should be less than the maximum capacity MaxCR of the transmission path U. The buffer capacity CRM

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5 is used to compensate for cell rate fluctuations and is usually determined at least as a function of the peak cell rates PCR of the information transmissions and the variance factor VF which is dependent thereon,

10 P_j Request function with probabilities that a connection with a data rate of j bit/s is requested, a standardized connection request histogram being given by $(p_1, \dots, p_{\text{MaxSCR}})$.

15 It is to be noted that although the link costs L according to this weighting rule depend generally on the data rates of the information transmissions, they depend neither on the requested data rate nor on any other properties of a present information transmission request A. As a result, a fairness policy is advantageously implemented, according to which the same rejection probability is obtained for all traffic classes, i.e. for all information transmissions, irrespective of the requested data rate, if any data transmission is permitted before the threshold capacity utilization rate F is exceeded, and no information transmission is permitted after the threshold capacity utilization rate F is exceeded. It is also to be noted that this weighting rule can be solved only by using parameters and requires only simple addition, multiplication and division operations to calculate the link costs L as a function of a given capacity utilization rate AAC, but does not require any solution of a complex equation system. It is also to be noted that the term "link costs" should not be interpreted literally in the sense of "costs". Thus, to form the link costs L as an extension of the above weighting rule, any desired values which are relevant to the transmission paths U or information transmissions may be used, for example priority values or quality-of-service values.

For the exemplary embodiment it will be assumed that the possible capacity utilization rates AAC of the transmission path are $\{1, 2, \dots, \text{MaxCR}\}$. The weightings - referred to below also as $\text{cost}(i)$ - which are determined by link cost functions LCF are formed as a function of a single weighting parameter i - for example the present capacity utilization rate AAC. According to Krishnan, relationship between the weightings $\text{cost}(i)$ and the costs $v(i,j)$ mentioned at the beginning is as follows:

$$\text{cost}(i) = E[E[v(k,j) + w_k | j \in \{i+1, \dots, k + \text{MaxSCR}\}] | k \in \{i - \text{MaxSCR} + 1, \dots, i\}],$$

$E[f|B]$ constituting a conditional anticipated value of the function f , under the proviso that the event B is given. According to the invention, the weighting $\text{cost}(i)$ is thus equivalent to an average cost value $v(k,j)$ which is produced when the capacity utilization rates AAC which are used as weighting parameters i are exceeded. On this basis, the weighting $\text{cost}(i)$ is determined according to the following considerations:

20

1) The anticipated number of rejected information transmissions is a linear function of time t with a gradient BR . This function is thus embodied as a linear rejection anticipation curve $ZW(t)$, i.e.
 $ZW(t) = BR * t$.

25

2) It will be assumed that at the time t_0 there is an information transmission request. At this time t_0 , it will be assumed that the capacity utilization rate AAC of the transmission path U is given by a capacity utilization rate AAC_0 representing the weighting parameter i .

30

3) If the desired information transmission is permitted, the linear rejection anticipation curve $ZW(t)$ is shifted upward suddenly by a value v , the gradient remaining unchanged, i.e. $ZW(t) =$

35

- (BR * t) + v. The anticipated number of rejections increases because the information transmission instantaneously gives rise to a higher capacity utilization rate AAC. Here, the information transmission which is considered is only a randomly selected information transmission, i.e. the overall equilibrium of the transmission path U remains unchanged.
- 4) If, on the other hand, the information transmission is not accepted at the time t_0 , the anticipated linear rejection anticipation curve $ZW(t)$ remains unchanged. After a time period T , the capacity utilization rate AAC will nevertheless exceed the capacity utilization state AAC_0 . As soon as this occurs, the situation on the transmission path U is the same as if the information transmission had been accepted at the time t_0 . During the time period T , the capacity utilization state is, by definition, always less than AAC_0 , and for this reason no rejections occur in this time interval. Because the situation is the same, the number of rejections is also equal to v.
- 5) The average value of the time period T will be designated by τ_i . $1/\tau_i$ is therefore the transition rate $\ddot{U}R_i$ from the states below AAC_0 to states above AAC_0 . The anticipated number of rejections rises in accordance with the rejection anticipation curve $ZW(t)$ during the time period τ_i by $BR * \tau_i$. Consequently, taking into account 4), $v = \tau_i * BR = BR/\ddot{U}R_i$.
- 6) When an information transmission is routed, those transmission paths U at which the anticipated rejection anticipation curves $ZW(t)$ are displaced upward by the smallest amount v are to be

selected. The variable v is therefore identified using the link costs L , i.e. $\text{cost}(i) := v$, or:

$$\text{cost}(i) = \frac{BR}{\ddot{U}R_i}.$$

- 7) If the information transmission request has to be rejected in the capacity utilization state AAC_0 because capacity is exceeded, the transmission path U must not be selected during routing. In this case, $\text{cost}(i) = \infty$ should be set.
- 10 For a transmission path U with a capacity MaxCR , a fairness reservation threshold F and a cell rate margin CRM , the following is thus obtained for the gradient BR in the capacity utilization state $i = AAC$:

$$BR = \lambda \cdot \sum_{n=\text{MaxCR}-\text{CRM}-F+1}^{\text{MaxCR}-\text{CRM}-F} \alpha_n \cdot P(n; \text{MaxCR}-\text{CRM}-F),$$

- 15 and the following is obtained for the transition rate $\ddot{U}R$:

$$\ddot{U}R_{AAC} = \lambda \cdot \sum_{k=\text{AAC}-\text{MaxSCR}+1}^{\text{AAC}} \sum_{j=\text{AAC}-k+1}^{\text{MaxSCR}} p_j \cdot P(k; AAC).$$

- Here, the parameter α_n represents the probability that an information transmission request will be rejected at a jump from a capacity utilization state n into the region protected by the fairness reservation threshold F . This is represented as follows by way of example:

$$\alpha_n = \sum_{k=\text{MaxCR}-\text{CRM}-F+1-n}^{\text{MaxSCR}} p_k \cdot \left[1 + \sum_{j=\text{MaxCR}-\text{CRM}-F+1+k-n}^{\text{MaxSCR}} \left(p_j \cdot \frac{P(n; \text{MaxCR}-\text{CRM}, F)}{P(n+k; \text{MaxCR}-\text{CRM}, F)} \right) \right]^{-1}.$$

- 25 The parameter λ is the overall request rate of the transmission path U ; it is abbreviated in the weighting rule according to the invention.

For an exemplary use of the invention in a connection-oriented communications network KN, i.e. with information transmissions along connections V, it is assumed that the transmission paths U will be utilized as follows: $AvCR(U_{12}) = 20,000$ kbit/s, $AvCR(U_{13}) = 25,000$ kbit/s, $AvCR(U_{14}) = 5,000$ kbit/s, $AvCR(U_{24}) = 30,000$ kbit/s, and $AvCR(U_{34}) = 25,000$ kbit/s. The link costs obtained for these according to the link cost function LCF are $L(U_{12}) = 0.175$, $L(U_{13}) = 0.140$, $L(U_{14}) = 0.421$, $L(U_{24}) = 0.115$ and $L(U_{34}) = 0.140$. In addition, source routing should be applied in the communications network. The setup of a connection V to a connection destination VZ will be requested by the switching node K_1 using an information transmission request A. This connection destination VZ will be assumed to be embodied as the switching node K_4 , and the connection V thus as the connection V_{14} . For this connection V_{14} , three suitable routes R_{14} are obtained:

- 1) route R_{14-1} along the transmission paths U_{12} and U_{24} ,
- 2) route R_{14-2} along the transmission paths U_{13} and U_{34} ,
- and 3) route R_{14-3} along the transmission path U_{14} .

These routes R_{14} are weighted by adding to each of the routes the link costs L determined according to the invention for the transmission paths U. Thus, the route costs $RK(R_{14-1}) = 0.290$, $RK(R_{14-2}) = 0.280$ and $RK(R_{14-3}) = 0.421$ are obtained. Consequently, the route $R_{MIN}(V_{14})$ which is optimum for the connection V is the route R_{14-2} , i.e. the connection V is set up along the route R_{14-2} with 2 hops and not along the route R_{14-3} with one hop. The fact that the route R_{14-2} has a lower level of capacity utilization than the route R_{14-3} is consequently given heavier weighting in the weighting of the routes R_{14} than the fact that the larger number of hops results in a slightly increased delay time. In addition, as a result of the source routing, the optimum route R_{MIN} is determined from the point of view of the entire communications network KN, i.e. a route R_{MIN} is initially set up along transmission paths U which

possibly have heavier loading in comparison with other transmission paths U if this results in particularly "favorable" transmission paths along the rest of the route R_{MIN} . After the routing, the requested connection
5 V_{14} is set up along the route $R_{\text{MIN}} (V_{14})$ which is optimum for the connection.

It is to be noted that the invention can, of course, be applied to any communications networks KN , in particular to connectionless communications networks
10 KN , such as the packet-oriented Internet. In the Internet, each individual packet is, for example, transmitted along a packet-specific route R , i.e. the route of each packet of a virtual connection V is independent of the routes R of the predecessor and
15 successor packets of the same virtual connection V , and the switching nodes K are embodied, for example, as Internet routers, and in this context determine in each case only the next switching node K - also referred to by experts as "hop" - for each packet of a virtual
20 connection V . According to the method in accordance with the invention, each router weights the transmission paths U connected to it. As a function of this weighting, if appropriate, successive packets which are associated with the same virtual connection V
25 are distributed among the transmission paths U in accordance with the link costs L which have been determined. In this process, it is possible, for example, that different propagation times of the individual packets will lead to changes in the original
30 sequence of the packets. In this case, the original sequence of the packets of the virtual connection V is restored in the receiver by a higher protocol layer. A plurality of methods are known for this, for example the Transport Control Protocol TCP.

35 Further attractive advantages are obtained when routing in networks with flooding methods - for example ATM networks with PNNI methods or IP networks with OSPF methods. Here, a re-weighting of the transmission paths

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U occurs, for example, after each flooding into the transmission node K. For this purpose, according to the invention, new link costs L are determined using the link cost functions LCF for the transmission paths U as
5 a function of the capacity utilization rates AAC which have been communicated with the flooding. The routes R are then weighted on the basis of the newly determined link costs L, and requested connections V are set up along the routes RMIN (V) which are optimum for the
10 latter. The work in terms of routing is advantageously reduced further if overloaded and/or interrupted transmission paths U are weighted with infinitely high link costs L, at least during the time period of the overload and/or interruption, causing them to be
15 eliminated from the routing.

Patent claims

1. A method for weighting transmission paths (U) of a communications network (KN) in which information
5 is transmitted at different data rates,
in which
the weighting is carried out in accordance with a weighting rule whose weighting work has an essentially linear dependence on the capacity (MaxCR) of the
10 respective transmission path (U).
2. The method as claimed in claim 1, characterized in that the weightings are each carried out as a function of at least one variable weighting parameter.
3. The method as claimed in one of claims 1 or 2,
15 characterized in that the weightings are each carried out as a function of a single variable weighting parameter and all the further weighting parameters are constant.
4. The method as claimed in one of claims 1 to 3,
20 characterized in that the variable weighting parameter is independent of a given information transmission request (A).
5. The method as claimed in one of claims 3 or 4,
25 characterized in that the variable weighting parameter is embodied in each case as the capacity utilization rate (AAC) of the transmission path (U).
6. The method as claimed in one of the preceding claims, characterized in that, whenever there are capacity utilization rates (AAC) which are greater than
30 the threshold capacity utilization rate (F) of the transmission path, the weighting of the transmission path (U) is embodied in such a way that no additional information transmissions take place along said transmission path (U).
- 35 7. The method as claimed in claim 6, characterized in that the threshold capacity utilization rate (F) of a transmission path (U) is in each case equal to its capacity (MaxCR) minus the maximum average data rate

(MaxSCR) which the information transmissions request most.

8. The method as claimed in one of the preceding claims, characterized in that the weighting is carried out according to the following weighting rule:

$$\text{cost}(AAC) = \begin{cases} \infty, & AAC > \text{MaxCR} - \text{CRM} - F \\ \sum_{n=\text{MaxCR}-\text{CRM}-F+1}^{\text{MaxCR}-\text{CRM}-F} \alpha_n \cdot P(n, \text{MaxCR} - \text{CRM} - F) \cdot \left[\sum_{k=\text{AAC}-\text{MaxSCR}+1}^{\text{AAC}} \beta_k(AAC) \cdot P(k, AAC) \right]^{-1}, & AAC \leq \text{MaxCR} - \text{CRM} - F \end{cases}$$

the following applying to its parameters:

$$\alpha_n = \sum_{k=\text{MaxCR}-\text{CRM}-F+1}^{\text{MaxSCR}} p_k \cdot \left[1 + \sum_{j=\text{MaxCR}-\text{CRM}-F+1+k-n}^{\text{MaxSCR}} \left(p_j \cdot \frac{P(n, \text{MaxCR} - \text{CRM}, F)}{P(n+k, \text{MaxCR} - \text{CRM}, F)} \right) \right]^{-1}$$

$$\beta_k(AAC) = \sum_{j=\text{AAC}-k+1}^{\text{MaxSCR}} p_j$$

- cost the weighting which is determined,
- 10 - $P(x; y, F)$ a capacity utilization rate probability,
- $P(x; y)$ a further capacity utilization rate probability,
- x a capacity utilization rate,
- y a capacity,
- 15 - CRM a cell rate margin, and
- p_j the probability that a data rate of j bit/s is required for an information transmission.

1/1

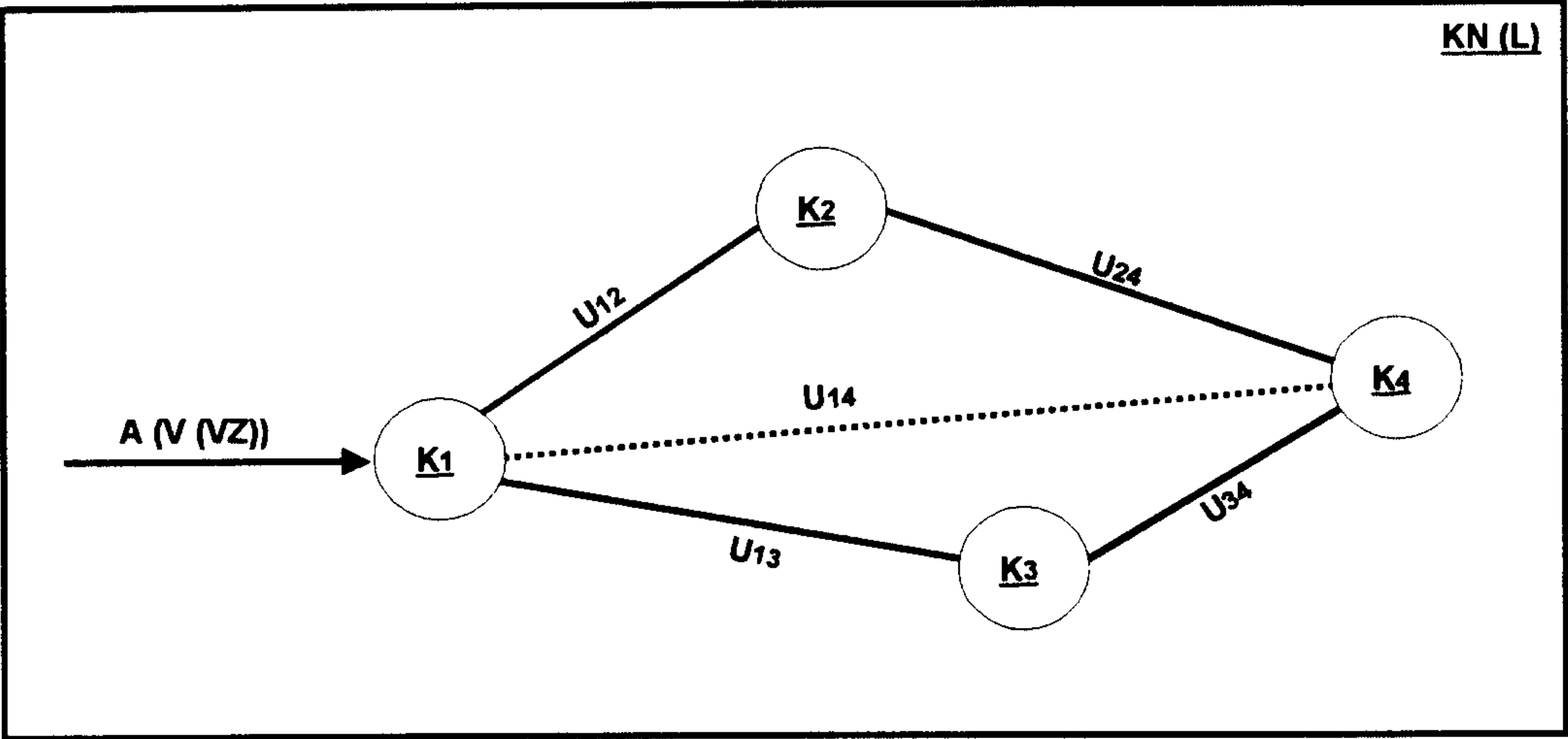


FIG 1

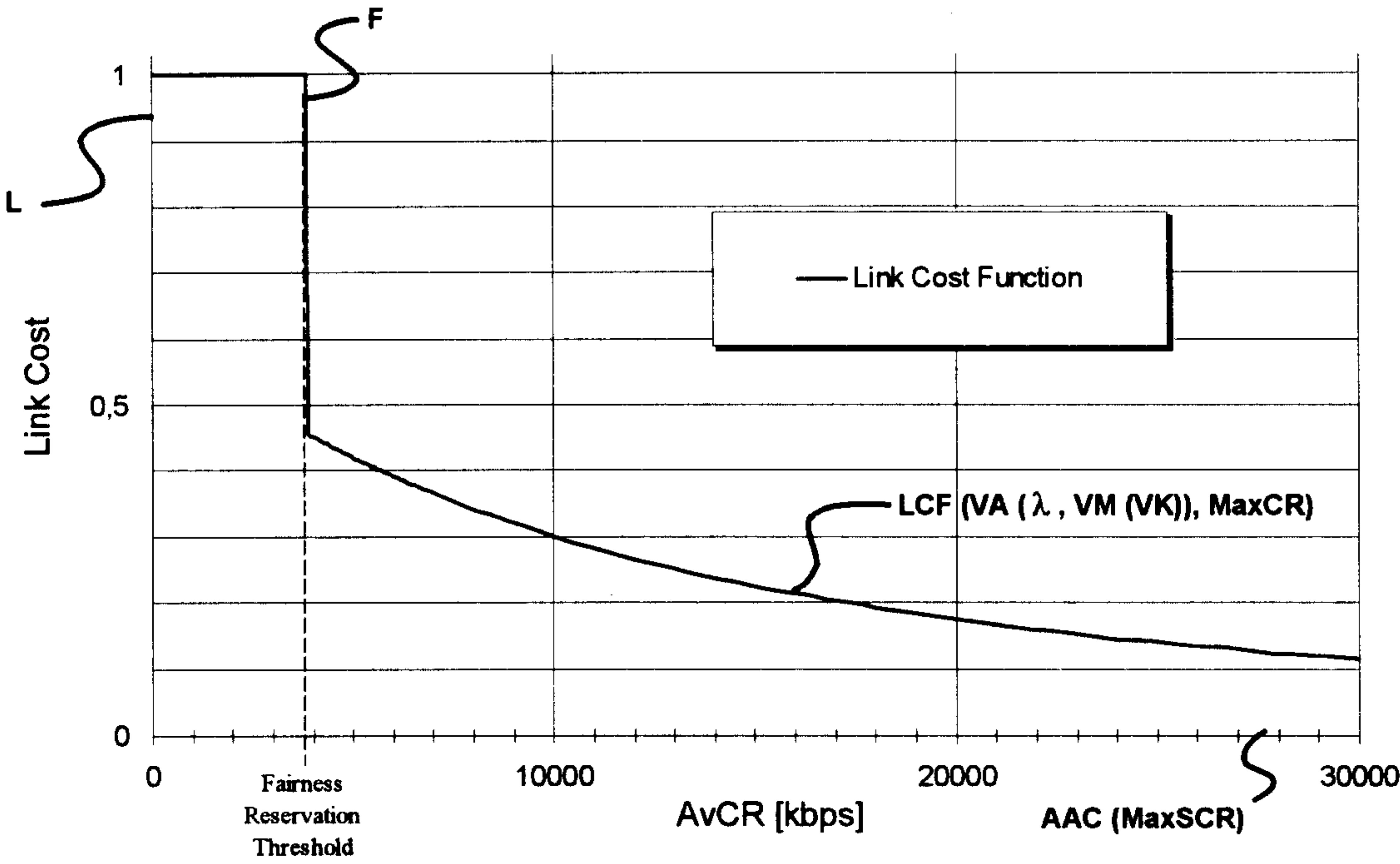


FIG 2

