

Description

Switching device and method for assignment of time slots to a multi-channel link in a switching device

5 The invention relates to a switching device and a method for assignment of time slots to a multi-channel link.

10 Switching devices in communication systems are used to set up, control and clear down connections for transmission of useful information. In the simplest case, the switching device comprises a coupling stage which connects a subscriber A to a subscriber B. The connections of the subscribers A and B may in this case be located at one port or different ports.

15 It is furthermore known that a switching device can implement a plurality of connections, using the so-called time division multiplex mode, via a single connecting line. Such a physical connecting line can transmit a plurality of channels which are formed by time slots in the time division multiplex mode. In consequence, there is no hard-wired physical connection in a coupling stage in a switching device which is operated using this principle, time slots being assigned for a connection, instead.

25 If a connection is considered from a subscriber A to a subscriber B via a switching device, the connection being regarded for simplicity as being unidirectional, then incoming time slots from the subscriber A must be assigned in the switching device to outgoing time slots from the switching device to the subscriber B. The information which is transmitted during the time slots is thus switched. In the case of the time division multiplex mode, the time slots are organized on the basis of frames, that is to say one frame contains K time slots, which can each be assigned to different connections. The same time slot in each case designates an existing connection, from frame to frame.

35 A bit rate, for example 64 kbit per second for B

channel in ISDN switching devices is assigned to each of the channels formed by a time slot. If a connection from the subscriber A to the subscriber B now requires a higher bit rate, then a multi-channel link is required.

- 5 This just means that a plurality of time slots must be assigned to the connection within a frame. However, in this case, it is not necessary for these time slots to be transmitted on the same physical connecting line.

10 In comparison with single-channel links, additional difficulties occur in the case of multi-channel links. Normally, a continuous information stream is produced by the subscriber A. The information elements in this information stream are arranged in accordance with a specific sequence. This sequence must also be ensured
15 at the subscriber B, after transmission of the information. The subscriber's communications terminals and the switching device satisfy this requirement. It is desirable that such problems be kept away from the communications terminals and that the handling of multi-channel
20 links in accordance with the requirements be provided in the switching devices, instead.

The invention is based on the object of guaranteeing the sequence of the information elements in the incoming time slots for the outgoing time slots when time
25 slots are being assigned to a multi-channel link in a switching device. This object is achieved by the method according to Claim 1 or 2, and by the switching device according to Claim 9 or 10. Advantageous refinements can be found in the subclaims.

30 The multi-channel link is formed by at least two incoming and two outgoing time slots. The specific number n in this case designates the number of incoming time slots for the multi-channel link within an incoming frame having a total of K time slots. An equal number (n) of
35 outgoing time slots in an outgoing frame are now each intended to be assigned an incoming time slot. A first unambiguous identification is assigned to each incoming time slot on the multi-channel link in order to identify the sequence of the incoming time slots within an incom-

ing frame. All the information within the incoming time slots on the multi-channel link form the multi-channel information to be switched.

In the same way, a second unambiguous identification, which defines the sequence, is assigned to the outgoing time slots. A first auxiliary variable is determined, taking account of the position of the incoming and outgoing time slots within the respective frames. This first auxiliary variable indicates the maximum difference between a number of outgoing time slots and incoming time slots for the multi-channel link within the respective frames, up to a time which includes an outgoing time slot. This first auxiliary variable can then be used as an assignment offset for all outgoing time slots for assignment to in each case one incoming time slot. An assignment offset of, for example, three in this case means for the multi-channel link that the fourth outgoing time slot is assigned to the first incoming time slot, the fifth outgoing time slot is assigned to the second incoming time slot, etc. If, as above, an incoming or outgoing frame comprises, for example, five time slots, then the third incoming time slot is assigned to the first outgoing time slot of the next outgoing frame. The assignment offset may thus be regarded as a form of indexing.

Alternatively, or in addition to the first auxiliary variable, a second auxiliary variable may also be determined, however, to achieve the object according to the invention. This second auxiliary variable designates a value which defines the addition of a minimum difference between a number of outgoing time slots and incoming time slots for the multi-channel link within the respective frames, before a time which is formed by an outgoing time slot, with the number of time slots to be assigned. The incoming time slot is, however, also counted for this point. This second auxiliary variable can also be used as an assignment offset for all outgoing time slots for assignment to in each case one incoming time slot. However, any other value between the first

auxiliary variable and the second auxiliary variable is also suitable as an assignment offset.

If the first auxiliary variable is selected for the assignment offset, then there is a minimal delay in the multi-channel information in the switching device. However, any other value up to the second auxiliary variable also provides an assignment which guarantees the maintenance of the sequence of the information elements and ensures a minimal frame offset. A critical advantage of the method according to the invention is the fact that the sequence of the information elements (also called the bit integrity in digital switching systems) is achieved for each individual assignment. This renders superfluous any other correction which would be necessary if this bit integrity were not ensured in coupling stages of a switching device. Furthermore, it has been found to be advantageous to be able to select any desired number of outgoing time slots within outgoing frames, and the method according to the invention nevertheless produces an assignment of outgoing time slots to incoming time slots which guarantees the bit integrity.

For assignment, it has been assumed until now that incoming and outgoing frames start at the same time and comprise the same number of time slots. If the multi-channel information is buffer stored in the switching device, then a buffer storage delay can be taken into account in that, for the assignment of the outgoing time slots, the start of an incoming frame is defined as being offset by at least the buffer storage delay before the start of an outgoing frame, the assignment of the first identification being retained. The method sequence can be retained as such if the offset corresponds precisely to the buffer storage delay. An individual buffer storage delay can be taken into account for each coupling stage in a switching device.

If the multi-channel information to be switched is buffer stored, a plurality of time slots are also combined to form a word. In this case, all the incoming time slots of a word are counted for the determination of

the auxiliary variables for the first incoming time slot of the respective word. As the result of this advantageous measure, it is in turn possible individually to match the algorithm to the special features of the individual coupling stages, which are normally governed by the design of the corresponding coupling circuits, as when taking account of the buffer storage delay.

According to a further advantageous refinement, time slots which are present at the same time on different connecting lines are counted together for the determination of the auxiliary variables, if the incoming and/or outgoing time slots of a frame are distributed between different connecting lines. In consequence, the method according to the invention can also be used in switching devices which combine time slots from a plurality of connecting lines and can distribute information from different time slots between a plurality of outgoing connecting lines.

If a switching device comprises a plurality of coupling stages, the assignment offset or the total of the assignment offset of the individual coupling stages is advantageously selected to be equal to the product of the number of the time slots to be switched, using a natural number. In addition to guaranteeing bit integrity, this also ensures frame integrity, since, not only is the information in the time slots contained in the correct sequence, but also the time slots of the multi-channel link of an incoming frame are contained together in one outgoing frame.

According to a further embodiment, the assignment of the time slots in both directions is separated in the case of bidirectional traffic conditions.

The method according to the invention and the switching device according to the invention are explained in more detail in the following text, using exemplary embodiments and with reference to the figures, in which: Figure 1 shows a switching device having three coupling stages, Figure 2 shows a schematic illustration of the assign-

- ment of outgoing time slots to incoming time slots on one connecting line in each case,
Figure 3 shows a schematic illustration of the assignment of outgoing time slots to incoming time slots on two connecting lines in each case,
5 Figure 4 shows a schematic illustration of the assignment of outgoing time slots to incoming time slots, taking account of a buffer storage delay in the case of word-by-word buffer storage,
10 Figure 5 shows a schematic illustration of the assignment of outgoing time slots to incoming time slots over a plurality of coupling stages,
Figure 6 shows a switching device having three coupling stages and the guarantee of frame integrity in each individual coupling stage,
15 Figure 7 shows a switching device having three coupling stages, the frame integrity being reproduced in the last coupling stage, and
Figure 8 shows a schematic flow chart of the calculation of the first and the second auxiliary variable.
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The example of a switching device VE according to Figure 1 comprises three coupling stages K1, K2, K3, the second coupling stage K2 in each case being connected via a highway Hwy, which is composed of connecting lines, to
25 the first coupling stage K1 and to the third coupling stage K3. The coupling stage K1 produces a link via a highway Hwy to a subscriber A, and the third coupling stage K3 produces a link via a further highway Hwy to the subscriber B.

30 The switching device VE is operated in the time division multiplex mode, so that the transmitted information can be assigned on the connecting lines to time slots within frames. The switching device VE is controlled by a control device SE. The program-controlled
35 control device SE may have memory areas to which, inter alia, a databaseDB [lacuna] for recording outgoing and incoming time slots e_i , a_j which are available for links. When setting up a connection from the subscriber A to the subscriber B, the control device SE makes a selection of

time slots e_i , a_j on the connecting lines Hwy, by accessing the database DB.

The connection from the subscriber A to the subscriber B is set up as a multi-channel link. This means that a plurality of time slots e_i , a_j must be used within a frame R_e , R_a for the transmission of multi-channel information. An algorithm, which will be explained with reference to the following figures, is used for this purpose in the control device SE of the switching device VE.

Reference should also be made to Annex A, for definition of the auxiliary variables for the assignment of the outgoing time slots to the incoming time slots.

According to Figure 2, the multi-channel information comprises, for example, 8 incoming time slots e_0 to e_7 within an incoming frame R_e having a total of K time slots. The outgoing frame R_a having the same number of K time slots likewise comprises 8 outgoing time slots a_0 to a_7 which are selected from the database DB. The incoming time slots e_0 to e_7 and the outgoing time slots a_0 to a_7 have been designated in accordance with their sequence within the frame R_e , R_a with an unambiguous first identification i and second identification j . The position of the outgoing and incoming time slots e_i , a_j can in this case be selected freely within the incoming and outgoing time frames R_e , R_a .

The result of the calculation of the first auxiliary variable d_0 and the second auxiliary variable d_1 has already been illustrated in Figure 2. The difference between a number of outgoing time slots a_j and incoming time slots e_i for the multi-channel link within the respective frames R_a , R_e is determined by the control device SE for each time in an outgoing time slot a_0 to a_7 . The outgoing time slot a_j of the time of the determination is also included in this case. In Figure 2, the maximum difference, that is to say the first auxiliary variable d_0 , has been defined as 3 for the seventh outgoing time slot a_6 .

The second auxiliary variable d_1 is determined in

that the difference between a number of outgoing time slots a_j and incoming time slots e_i for the multi-channel link is determined within the respective frames R_e , R_a , before a time which is formed by an outgoing time slot a_j , for each time in an incoming time slot e_0 to e_7 . The minimum value has in this case been determined using - 1 for the time of the eighth incoming time slot e_7 . The number of time slots a_j to be assigned is then added to this value - 1 (this number is equal to 8), which results, for example, in the value 7 for the second auxiliary variable d_1 .

The calculation procedure for the first auxiliary variable d_0 and second auxiliary variable d_1 can be quoted, using a general notation, by the following equations:

$$d_0 = \max \left(\left| \{a_j | a_j \leq z\} \right| - \left| \{e_i | e_i \leq z\} \right| \right)$$

$$d_1 = \min \left(\left| \{a_j | a_j < z\} \right| - \left| \{e_i | e_i \leq z\} \right| \right) + n$$

z_1 being the time of a time slot and n the number of the incoming time slots e_i on the multi-channel link. $\{m|E\}$ is a set whose elements m have the property E . The operator $|\cdot|$ in this case indicates the number of elements in the set.

The first auxiliary variable d_0 (3) has been selected for assignment in Figure 2, so that the fourth outgoing time slot a_3 is assigned to the first incoming time slot e_0 , etc. The black solid arrows in this case indicate this assignment. The dashed arrows likewise designate this assignment, but these are the assignments which lead to an offset in the frame and replaced the solid arrows for the corresponding incoming time slots e_5 to e_7 .

The schematic illustration of the assignment according to Figure 3 is based on the same principle as the assignment according to Figure 2. However, it should be noted that both the incoming time slots e_0 to e_7 and

the outgoing time slots a_a to a_7 are distributed between in each case two connecting lines (highways) Hwy. Time slots e_i , a_j which are present at the same time are included in the determination of the auxiliary variable $d0$, $d1$, but are counted together. The value 3 thus results once again for the first auxiliary variable $d0$, and the value 7 for the second auxiliary variable $d1$. An assignment of time slots e_i , a_j to a multi-channel link is once again achieved, while guaranteeing the bit integrity, by using the method sequence according to the invention.

The assignment of outgoing time slots a_j to incoming time slots e_i will be explained with reference to Figure 4, taking account of a buffer storage delay $dt_{sl}=6$ and buffer storage which combines 2 time slots e_i to form a word. The time of the start of an incoming frame Re in this case precedes the start of an outgoing frame Ra for example by the buffer storage delay $dt_{sl}=6$. This offset in the start of an incoming frame Re takes account of the buffer storage delay dt_{sl} . At the same time, two time slots e_i are in each case stored together, in the case of this buffer storage.

The seventh and eighth incoming time slots e_6 , e_7 are stored together, in the same way as the fifth and sixth incoming time slots e_4 , e_5 . As the result of the joint buffer storage, these time slots in each case act like a single incoming time slot e_i . This situation must be taken into account in the determination of the first auxiliary variable $d0$ and the second auxiliary variable $d1$. This is done by incoming time slots e_6 , e_7 and e_4 , e_5 being counted together for the time of an outgoing time slot a_j . According to Figure 4, the value 5 was determined for the first auxiliary variable $d0$, and the value 8 (0) for the second auxiliary variable $d1$. A value (the assignment offset 1) can then be selected from the value range of the assignment offset 1 between 5 and 8, by means of which outgoing time slots a_j are assigned to incoming time slots e_i .

The assignment of the outgoing time slots a_j to

incoming time slots e_i according to Figure 5 relates to the three coupling stages K1, K2, K3 according to Figure 1. Four outgoing time slots a_j in the third coupling stage K3 are assigned, with the assistance of the second coupling stage K2 to four incoming time slots e_i in the first coupling stage K1. The buffer storage delays dt_{sl} in the coupling stages K1, K2, K3 are in this case different. The buffer storage delay dt_{sl} in the first coupling stage K1 is = 6, that in the second coupling stage K2 = 10, and that in the third coupling stage K3 is = 4. The first coupling stage K1 and the third coupling stage K3 store two time slots word by word. The second coupling stage K2 carries out the buffer storage, related to time slots. It can be seen from Figure 5 that the sequence of the information elements in the time slots is maintained on each individual coupling stage K1, K2, K3, that is to say the bit integrity is guaranteed. The assignments which are drawn by solid lines have no frame offset, and those which are drawn by dashed lines have a frame offset of 1. The information in time slot A0 is received, for example, by the subscriber B one frame later in the time slot B2. The time slot A2 is received by the subscriber B two frames later, in the time slot B0.

Figures 6 and 7 show that frame integrity TSSI can also be achieved using a plurality of coupling stages K1, K2, K3 by suitable selection of the assignment offset 1. In this case, in accordance with Figure 6, it is possible to produce the frame integrity TSSI in each individual coupling stage K1, K2, K3. However, according to Figure 7, this can also be done by a correction not being carried out and the frame integrity TSSI not being produced until the last coupling stage K3. The frame integrity TSSI is ensured in that a value is selected from the value range for the assignment offset 1 from the first auxiliary variable d_0 to the second auxiliary variable d_1 , which value is equal to the product of the number n of time slots to be switched in the multi-channel link, using a natural number. In the assignment

examples in Figures 2, 3 and 4, this means that the assignment offset 1 or the total of the assignment offsets 1 of the individual coupling stages K1, K2, K3 is equal to 0, 8, or a multiple of 8.

5 If it is intended to correct the frame integrity TSSI in the last coupling stage K3, it is in this case advantageous to select specific outgoing time slots a_j within an outgoing frame for the multi-channel link. For example, if the pattern of the outgoing time slots a_j corresponds to that of the incoming time slots e_i , it is possible to correct the frame integrity TSSI in every case.

10 If it is intended to produce the bit integrity BSI and/or the frame integrity TSSI in both directions in the case of a bidirectional link, then the method according to the invention can be applied separately for both switching directions. The method can be used if any required outgoing time slots a_j are selected from the databaseDB. However, it may be advantageous if a specific prior selection, which optimizes the algorithm, is made for the selection of outgoing time slots a_j . This measure allows the switching delay to be reduced and a minimal frame offset to be achieved.

15 Figure 8 shows the calculation of the first auxiliary variable d0 and the second auxiliary variable d1 using a flow chart. This sequence represents one implementation of the equations quoted above. The time slots e_i and a_j are indexed from 0 to n-1. An auxiliary variable ixin is set in a first loop such that an incoming time slot e_i which is indexed with this auxiliary variable ixin arrives before the end of the incoming frame R_e , reduced by the buffer storage delay dt_{s1} . An output variable d for the further calculation of the first auxiliary variable d0 and the second auxiliary variable d1 is determined by means of the second loop, taking account of the buffer storage delay dt_{s1} and of any word-by-word buffer storage, in that the set of incoming and outgoing time slots e_i and a_j is considered and compared for different times within a frame R_e , R_a .



Patent Claims

1. Method for assignment of time slots to a multi-channel link in a switching device (VE),

- the multi-channel link comprising at least two incoming and two outgoing time slots (e_i , a_j),
- a specific number (n) of incoming time slots (e_i) within an incoming frame (Re) being assigned a first unambiguous identification (i) which defines the sequence, and the incoming time slots (e_i) forming the multi-channel information to be switched, and
- the same number (n) of outgoing time slots (a_j) in an outgoing frame (Ra) being assigned a second unambiguous identification (j) which defines the sequence, and the outgoing time slots (a_j) being available for the multi-channel link,

in which

- a first auxiliary variable (d_0) is determined, which indicates the maximum difference between a number of outgoing time slots (a_j) and a number of incoming time slots (e_i) for the multi-channel link within the respective frames (Re, Ra) up to a time which includes an outgoing time slot (a_j),

and

- this first auxiliary variable (d_0) being used as an assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).

2. Method for assignment of time slots to a multi-channel link in a switching device (VE),

- the multi-channel link comprising at least two incoming and two outgoing time slots (e_i , a_j),
- a specific number (n) of incoming time slots (e_i) within an incoming frame (Re) being assigned a first unambiguous identification (i) which defines the sequence, and the incoming time slots (e_i) forming the multi-channel information to be switched, and
- the same number (n) of outgoing time slots (a_j) in an outgoing frame (Ra) being assigned a second unambigu-



ous identification (j) which defines the sequence, and the outgoing time slots (a_j) being available for the multi-channel link,

in which

- 5 - a second auxiliary variable (d1) is determined which designates an addition of the minimum difference between a number of outgoing time slots (a_j) and a number of incoming time slots (e_i) for the multi-channel link within the respective frames (R_e , R_a)
10 before a time which is formed by an outgoing time slot (a_j), with the number (n) of time slots to be assigned, the incoming time slot (e_i) which is assigned to the time of the outgoing time slot (a_j) being included,
- 15 and
 - this second auxiliary variable (d1) being used as an assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).
- 20 3. Method according to Claim [sic] 1 and 2, in which,
 as an alternative to the use of the first or second auxiliary variable (d0, d1)
 - a value between the first auxiliary variable (d0) and
25 the second auxiliary variable (d1) is used as the assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).
- 30 4. Method according to one of the preceding claims, in which a buffer storage delay (dtsl) of the switching device (VE) is taken into account for buffer storage of the multi-channel information to be switched, in that, for the assignment of the outgoing time slots (a_j), the start of an incoming frame (R_e) is defined as being
35 offset by at least the buffer storage delay (dtsl) before the start of an outgoing frame (R_a), the assignment of the first identification (i) being retained.
5. Method according to one of the preceding claims, in which, for a switching device (VE) which combines a



plurality of time slots (e_i, a_j) to form a word if the multi-channel information to be switched is being buffer stored, all the incoming time slots (e_i) of a word are counted for the first incoming time slot (e_i) of the
5 respective word for the determination of the auxiliary variable ($d0, d1$).

6. Method according to one of the preceding claims, in which at least the incoming and/or outgoing time slots (e_i, a_j) of a frame (Re, Ra) are distributed between
10 different connecting lines (Hwy), and time slots (e_i, a_j) which are present at the same time on different connecting lines (Hwy) are counted together for the determination of the auxiliary variable ($d0, d1$).

7. Method according to one of the preceding claims, in which, for one or more coupling stages ($K1, K2, K3$) within the switching device (VE), the assignment offset
15 (l) or the total of the assignment offset (l) of the individual coupling stages ($K1, K2, K3$) is equal to the product of the number (n) of the time slots (e_i) to be
20 switched, using a natural number.

8. Method according to one of the preceding claims, characterized in that, in the case of a bidirectional traffic condition, the assignment of the time slots (e_i, a_j) is carried out separately in both directions.

25 9. Switching device (VE) for switching a multi-channel link,
having a database(DB) for outgoing time slots (a_j) which can be assigned to a number (n) of incoming time slots, and
30 having a control device for assignment of the outgoing time slots (a_j) to in each case one incoming time slot (e_i)

- the multi-channel link comprising at least two incoming and two outgoing time slots (e_i, a_j),
- 35 - a first unambiguous identification (i), which defines the sequence, being assigned in the database(DB) to a specific number (n) of incoming time slots (e_i) within an incoming frame (Re), and the incoming time slots (e_i) forming the multi-channel information to be



switched, and

- a second unambiguous identification (j), which defines the sequence, being assigned in the database(DB) to the same number (n) of outgoing time slots (a_j) in an outgoing frame (R_a), and the outgoing time slots (a_j) being available for the multi-channel link,

in which, by means of the control device (SE),

- a first auxiliary variable (d0) is determined, which indicates the maximum difference between a number of outgoing time slots (a_j) and a number of incoming time slots (e_i) for the multi-channel link within the respective frames (R_e , R_a) up to a time which includes an outgoing time slot (a_j),

and

- this first auxiliary variable (d0) being used as an assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).

10. Switching device (VE) for switching a multi-channel link,

having a database(DB) for outgoing time slots (a_j) which can be assigned to a number (n) of incoming time slots, and

having a control device for assignment of the outgoing time slots (a_j) to in each case one incoming time slot (e_i)

- the multi-channel link comprising at least two incoming and two outgoing time slots (e_i , a_j),
- a first unambiguous identification (i), which defines the sequence, being assigned in the database(DB) to a specific number (n) of incoming time slots (e_i) within an incoming frame (R_e), and the incoming time slots (e_i) forming the multi-channel information to be switched, and
- a second unambiguous identification (j), which defines the sequence, being assigned in the database(DB) to the same number (n) of outgoing time slots (a_j) in an outgoing frame (R_a), and the outgoing time slots (a_j) being available for the multi-channel link,



in which, by means of the control device (SE),

- a second auxiliary variable (d1) is determined which designates an addition of the minimum difference between a number of outgoing time slots (a_j) and a number of incoming time slots (e_i) for the multi-channel link within the respective frames (Re , Ra) before a time which is formed by an outgoing time slot (a_j), with the number (n) of time slots to be assigned, the incoming time slot (e_i) which is assigned to the time of the outgoing time slot (a_j) being included,

and

- this second auxiliary variable (d1) being used as an assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).

11. Switching device (VE) according to Claim [sic] 9 and 10, in which, by means of the control device (SE) as an alternative to the use of the first or second auxiliary variable (d0, d1)

- a value between the first auxiliary variable (d0) and the second auxiliary variable (d1) is used as the assignment offset (l) for all outgoing time slots (a_j , $j=i+1$) for assignment to in each case one incoming time slot (e_i).

12. Switching device (VE) according to one of Claims 9 to 11, in which

a buffer storage delay (dts1) of the switching device (VE) is taken into account for buffer storage of the multi-channel information to be switched, in that, for the assignment of the outgoing time slots (a_j), the control device defines the start of an incoming frame (Re) such that it is offset by at least the buffer storage delay (dts1) before the start of an outgoing frame (Ra), the assignment of the first identification (i) being retained.

13. Switching device (VE) according to one of Claims 9 to 12, the switching device (VE) comprising one or more coupling stages ($K1$, $K2$, $K3$), and the control device



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being designed in such a manner
that the assignment offset (1) or the total of the
assignment offset (1) of the individual coupling stages
(K1, K2, K3) is selected to be equal to the product of
5 the number (n) of time slots (e_i) to be switched, using
a natural number.