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(54) **Method of controlling access of devices to communication medium in distributed networks**

Verfahren zur Kontrolle des Zugangs von Einrichtungen zu Kommunikationsmedium in verteilten Netzwerken

Procédé de contrôle d'accès de dispositifs à un support de communication dans des réseaux distribués

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Description

[0001] The subject of the invention is a method of controlling the access of devices to the communication medium in distributed networks applied especially in monitoring and control systems in various industrial processes, among others in chemical industry, and also in control systems installed in buildings.

[0002] A solution known from US 5,297,143 as well as from "LonTalk Protocol Specification", Version 3.0, Echelon Corporation, 1995, presents a method of controlling the access of devices to the communication media in distributed networks of CSMA (Carrier Sense Multiple Access) type during communication of a group of devices, each of which is a node of a distributed network and generates data sent in packet cycles with the use of the communication medium in a system with or without acknowledgment of a message reception while before the attempt of a packet transmission a state of the communication medium is sensed each time using the state detectors of particular nodes connected to this medium.

[0003] When the communication medium is sensed idle, in each packet cycle the prespecified fixed time interval called the minimum interpacket space is timed out by the use of a clock in every node, while during the minimum interpacket space a number of available time slots of equal width is changed depending on the current state of the counter residing in a node where this number is defined as the product of a number of slots in a basic contention window and the current state of the counter. Afterwards, the random numbers of time slots that define the order of media access are selected from the currently available number of slots using the pseudorandom number generator where the probability distribution of sampling the time slots is uniform, and the random time interval defined as the product of the random number of the previously selected time slot reduced by one and the prespecified width of a single time slot is assigned.

[0004] Subsequently, after the minimum interpacket space the phase of sequential priority access starts consisting in timing out concurrently the time delay assigned in the priority phase by the use of a clock residing in each node where this delay equals the product of the number of a priority slot assigned to a particular node reduced by one and the prespecified width of a single priority slot, and the state of the communication medium is sensed again, and if the communication medium is still detected to be idle, it is made available to the node with the lowest number of the assigned priority slot. When a given node starts a transmission, by the use of signals generated by the detectors of the communication medium state, the timing out of time delays of priority slots is terminated in the other nodes with higher numbers of the assigned priority slots, and simultaneously the receiving inputs in all the nodes in the network segment are activated.

[0005] After completing the priority packet reception, the state of the communication medium is sensed again by all the nodes in the network segment, and if the medium is detected to be idle, the time interval equal to the minimum interpacket space is timed out, and the cycle is repeated for the successive number of a priority slot. Next, if during the prespecified maximum number of the priority time slots, the medium is sensed to be idle by the detectors of a communication medium state, or if the prespecified number of the priority slots equals zero, the random delay assigned previously is timed out, and at the same time the state of the communication medium is sensed again. If the communication medium is still detected to be idle, it is made available to the node with the lowest number of the slot randomly selected.

[0006] When the transmission starts, the timing out of the time delays is terminated by the use of the detectors of the communication medium state in the other nodes with higher numbers of slots randomly selected and the receiving inputs in all the nodes are activated at the same time. After completing a given packet transmission, the states of the counters in all the nodes in a given network segment are changed by the increment defining the number of expected packets generated as a result of the reception of a transmitted packet reduced by one, and the state of the communication medium is sensed again by all the nodes. If the medium is detected to be idle, the minimum interpacket space is timed out and simultaneously the number of available time slots is changed in each node depending on the current state of its counter, and the random numbers from the sets of currently available slots are selected, and afterwards, the random delay is assigned, and finally, the assigned random delay is timed out after the minimum interpacket space, and the cycle is repeated.

[0007] During the data packet transmission the collisions are detected optionally by the collision detectors, and afterwards, the states of the counters residing in the nodes are increased by one with the use of the corresponding control signals obtained from the collision detectors. If the communication medium is still idle after the time equal to the sum of the minimum interpacket space and the time delay defined by the prespecified number of time slots included in the basic contention window, the state of the counters in all the nodes in a given network segment is decreased by one with the use of the corresponding control signals obtained from the communication medium state detectors.

[0008] In the other solution known from the technical literature (K. Jamieson, H. Balakrishnan, Y. Tay, "Sift: A MAC protocol for event-driven wireless sensor networks", Technical Report, Massachusetts Institute of Technology, LCS-TR-894, 2003) introducing a method of controlling the access to the communication medium of CSMA-type each time before the attempt of packet transmission the state of the communication medium is sensed using the state detectors in each node connected to this medium, and if the medium is detected to be idle, in each packet cycle the prespecified fixed time interval called the minimum interpacket space is timed out by the use of a clock residing in every node, and at the same

time the numbers of slots determining the order of the medium access are randomly selected in each node from the prespecified fixed number of time slots of equal width by the use of the pseudorandom generators, while the probability of a random selection of a given slot is geometrically distributed with a characteristic parameter defined as the ratio of the probability of a selection of a given slot to the probability of a selection of the next slot, the value of which is greater than zero and at the same time smaller than or equal to one, and afterwards, the random delay is assigned as the time interval equal to the product of the time slot number selected previously reduced by one and the prespecified width of a single time slot.

[0009] Next, after the minimum interpacket space the random delay assigned previously is timed out and the state of the communication medium is at the same time sensed again, whereas, if the medium is detected to be idle, it is made available to the node that has selected the time slot with the lowest number among the numbers randomly selected by all the nodes. When a given node starts to transmit, the timing out of random delays in the other nodes with higher numbers of selected time slots is terminated by the use of the communication medium state detectors, and simultaneously the receiving inputs of the nodes are activated. After completing the reception of the transmitted packet by all the nodes, the state of the communication medium is sensed again, and if the medium is detected to be idle, the minimum interpacket space is timed out and the numbers of the time slots from the prespecified fixed number of available time slots are randomly selected concurrently, and then, the random delay is assigned, and after the minimum interpacket space the random time delay assigned previously is timed out, and the cycle is repeated.

[0010] The method consists communicating with each other a group of devices connected to a shared communication link, each of which is a node of a distributed network and generates data transmitted in packet cycles to at least one node using acknowledged or unacknowledged message service in a way that at the moment of generation of data by any node in the network, the state of the communication medium is sensed by the use of the medium state detector, and if the medium is detected to be idle, the prespecified fixed minimum interpacket space is timed out in each packet cycle by the use of a clock in each node, and during the minimum interpacket space the numbers of slots determining the order of the medium access are randomly selected from the prespecified fixed number of available time slots of equal width by the use of the pseudorandom generators at each node, and the random delay to every node is assigned equal to the product of the randomly selected time slot reduced by one and the prespecified width of a single slot.

[0011] After the time equal to the minimum interpacket space, the phase of sequential priority access is started consisting in that in each node using a clock the priority time delay concurrently is timed out as the product of the number of the assigned priority slot reduced by one and the prespecified width of the priority time slot, and the state of the communication medium is sensed again, and if the medium is detected to be idle, it is made available to the node with the lowest number of the assigned priority slot, and when a given node starts a transmission, the timing out of time delay of the priority slots is terminated by the use of signals from detectors of the communication medium state in the other nodes of higher numbers of the assigned priority slots, and simultaneously the receiving inputs are activated in all the nodes in the network segment.

[0012] After completing a given priority packet reception, the state of the communication medium is sensed again by all the nodes, and if the medium is detected to be idle, the minimum interpacket space is timed out and then the cycle is repeated for the successive number of the priority time slot, and subsequently, after the timing out of the duration of the prespecified maximum number of priority slots and sensing the medium to be idle by the detectors of the communication medium state in all the nodes, or if the prespecified number of the priority slots equals zero, the random delay assigned previously is timed out and at the same time the state of the communication medium is sensed again, and if the communication medium is detected to be idle after the assigned random delay, the medium is made available to the node with the lowest number of the slot randomly selected, and the states of the counters in all the nodes are changed as soon as every node receives the transmitted packet depending on the packet class or if the collision is detected in the communication medium.

[0013] The essence of the solution consists in that each time before the packet transmission attempt, the state of the communication medium is sensed using the state detectors of particular nodes connected to this medium, and if the communication medium is detected to be idle, the prespecified fixed time interval equal to the minimum interpacket space is timed out by the use of a clock in every node in each packet cycle, while during the minimum interpacket space, the random numbers of time slots defining the order of media access are selected from the fixed number of slots of equal width using the pseudorandom number generator in every node, and the probability of a selection of a particular slot is geometric with a characteristic parameter defined as the ratio of the probability of a selection of a given slot to the probability of a selection of the next slot, which changes from zero to one as a discrete function of the state of the node's counter in a way that a change of the counter state from one to the prespecified maximum number corresponds to a change of the characteristic parameter from the maximum to the minimum value and after that the time interval of random delay is assigned which is equal to the product of the number of a slot randomly selected reduced by one and the prespecified width of a single slot.

[0014] Next, after the minimum interpacket space the phase of sequential priority access is started consisting

in that the time interval assigned to a node is timed out concurrently by the use of a clock residing in each node, and this time interval is equal to the product of the number of a priority slot assigned to the particular node reduced by one and the prespecified width of a single priority slot. Next, the state of the medium is sensed again, and if the medium is detected to be idle, it is made available to the node with the lowest number of the assigned priority slot, and when a transmission starts the timing out of time delay in the other nodes with higher numbers of the assigned priority slots is terminated, and simultaneously the receiving inputs in all the nodes in the network segment are activated.

[0015] After completing a given priority packet reception, the state of the communication medium is sensed again by all the nodes, and if the medium is detected to be idle, the minimum interpacket space is timed out, and the cycle is repeated for the successive number of the priority slot. Subsequently, if the medium is sensed to be idle by the detectors of the communication medium state in all the nodes after the timing out of the duration of the prespecified maximum number of the priority slots or if the prespecified number of the priority slots equals zero, the random delay previously assigned is timed out and at the same time the state of the communication medium is sensed again. If the communication medium is still sensed idle, it is made available to the node with the lowest number of the slot randomly selected. When a given node starts a transmission, the timing out of the time delays is terminated by the use of the detectors of the communication medium state in the other nodes with higher numbers of slots randomly selected, and their receiving inputs in all the nodes are activated at the same time.

[0016] After completing a given packet reception, the states of the counters in all the nodes in a given network segment are increased by the increment defining the number of expected packets that will be generated in a result of the reception of the transmitted packet reduced by one. Afterwards, the state of the communication medium is sensed again by all the nodes and if the communication medium is detected to be idle, the minimum interpacket space is timed out. Concurrently with the timing out of the minimum interpacket space, the random numbers are selected from the prespecified fixed number of available slots and the random delay is assigned to each node, and subsequently after the minimum interpacket space the random delay assigned previously is timed out, and at the same time the state of the communication medium is sensed again, and the cycle is repeated.

[0017] Besides, during the data packet transmission the collisions are detected optionally in the communication medium by the collision detectors, and after the collision detection the states of the counters are changed in the nodes with the use of the corresponding control signals obtained from the collision detectors. In case the communication medium is detected to be idle after the time equal to the sum of the minimum interpacket space and the time delay defined by the prespecified fixed maximum number of slots, the states of the counters in all the nodes in a given network segment are decreased by one with the use of the corresponding control signals obtained from the communication medium state detectors. After the detection of a collision in the communication medium, the state of the counters in the nodes are increased by a constant increment N, where N is a natural number, or the current states of the counters are doubled. The method enables an increase of the network throughput and its optimization for various levels of load of the communication medium by the use of slot random selection from the geometric probability distribution with the characteristic parameter changing as a discrete function of a state of a node's counter, and also enables the reduction of message transmission time because of a constant number of available time slots which is independent of the state of the counter. Furthermore, the method, according to the invention, excludes the possibility of incorrect identification of a packet cycle as idle, that is, without any transmission in a situation when the nodes competing for the communication medium access have selected the numbers of slots beyond the set of slot numbers defining the size of the basic contention window which causes the decrease of the state of the node's counter by one after the time equal to the duration of the basic contention window.

[0018] The solution according to the invention is presented by independent claim 1.

[0019] The method consists in that each time before the packet transmission attempt in a system of packet cycles, the state of the communication medium is sensed using the state detectors of particular nodes connected to this medium, and if the communication medium is detected to be idle, the prespecified fixed time interval equal to the minimum interpacket space is timed out by the use of a clock in every node in each packet cycle. During the minimum interpacket space, the random numbers of time slots defining the order of media access are selected from the prespecified fixed number of slots equal to sixteen using the pseudorandom number generator in every node where the probability of a selection of a particular slot is geometric with a characteristic parameter defined as the ratio of the probability of a selection of a given slot to the probability of a selection of the next slot, which changes from zero to one as a discrete function of the state of the node's counter in a way that a change of the counter state from one to the prespecified maximum number corresponds to a change of the characteristic parameter from the maximum to the minimum value, and after that the time interval of random delay is assigned which is equal to the product of the number of a slot randomly selected reduced by one and the prespecified width of a single slot.

[0020] Next, after the minimum interpacket space the phase of sequential priority access is started consisting in that the time interval assigned to a node is timed out concurrently by the use of a clock residing in each node,

and this time interval is equal to the product of the number of a priority slot assigned to the particular node reduced by one and the prespecified width of a single priority slot, and next, the state of the medium is sensed again, and if the medium is detected to be idle, it is made available to the node with the lowest number of the assigned priority slot. When a given node starts a transmission, the timing out of time delay in the other nodes with higher numbers of the assigned priority slots is terminated, and simultaneously the receiving inputs in all the nodes in the network segment are activated.

[0021] After completing a given priority packet reception, the state of the communication medium is sensed again by all the nodes, and if the medium is detected to be idle, the minimum interpacket space is timed out, and the cycle is repeated for the successive number of the priority slot. Subsequently, if the medium is sensed to be idle by the detectors of the communication medium state in all the nodes after the timing out of the duration of the prespecified maximum number of the priority slots or if the prespecified number of the priority slots equals zero, the random delay assigned previously is timed out, and at the same time the state of the communication medium is sensed again, and if the communication medium is still sensed idle, it is made available to the node with the lowest number of the slot randomly selected.

[0022] When a given node starts a transmission, the timing out of the time delays is terminated by the use of the detectors of the communication medium state in the other nodes with higher numbers of slots randomly selected, and their receiving inputs in all the nodes are activated at the same time.

[0023] After completing a given packet reception, the states of the counters in all the nodes in a given network segment are increased by the increment defining the number of expected packets that will be generated in a result of the reception of the transmitted packet reduced by one, and afterwards, the state of the communication medium is sensed again by all the nodes and if the communication medium is detected to be idle, the minimum interpacket space is timed out, and at the same time the random numbers are selected from the prespecified fixed number of available slots and the random delay is assigned to each node, and subsequently after the minimum interpacket space the random delay assigned previously is timed out, and at the same time the state of the communication medium is sensed again, and the cycle is repeated.

[0024] Besides, during the data packet transmission the collisions are detected optionally in the communication medium by the collision detectors, and next, by the use of the corresponding control signals obtained from the collision detectors, the states of the counters in the nodes are increased by a constant increment *N*, or the current states of the counters are doubled where *N* is a natural number. In case the communication medium is detected to be idle after the time equal to the sum of the minimum interpacket space and the time delay defined by the prespecified fixed maximum number of slots, the states of the counters in all the nodes in a given network segment are decreased by one with the use of the control signals obtained from the communication medium state detectors.

Claims

1. Method of controlling access of devices to communication medium in distributed networks consisting in communicating with each other a group of devices connected to a shared communication link, each of which is a node of a distributed network and generates data transmitted in packet cycles to at least one node using acknowledged or unacknowledged message service in a way that at the moment of generation of data by any node in the network, the state of the communication medium is sensed by the use of a medium state detector, and if the medium is detected to be idle, the prespecified fixed minimum interpacket space is timed out in each packet cycle by the use of a clock in each node, and during the minimum interpacket space the numbers of slots determining the order of the medium access are randomly selected from the prespecified fixed number of available time slots of equal width by the use of the pseudorandom generators at each node, and the random delay to every node is assigned equal to the product of the randomly selected time slot reduced by one and the prespecified width of a single slot, and after the time equal to the minimum interpacket space, the phase of sequential priority access is started consisting in that in each node using a clock the priority time delay concurrently is timed out as the product of the number of the assigned priority slot reduced by one and the prespecified width of the priority time slot, and the state of the communication medium is sensed again, and if the medium is detected to be idle, it is made available to the node with the lowest number of the assigned priority slot, and when a given node starts a transmission, the timing out of time delay of the priority slots is terminated by the use of signals from detectors of the communication medium state in the other nodes of higher numbers of the assigned priority slots, and simultaneously the receiving inputs are activated in all the nodes in the network segment, and after completing a given priority packet reception, the state of the communication medium is sensed again by all the nodes, and if the medium is detected to be idle, the minimum interpacket space is timed out and then the cycle is repeated for the successive number of the priority time slot, and subsequently, after timing out the duration of the prespecified maximum number of priority slots and sensing the medium to be idle by the detectors of the communication medium state in all the nodes, or if the prespecified

number of the priority slots equals zero, the random delay assigned previously is timed out and at the same time the state of the communication medium is sensed again, and if the communication medium is detected to be idle after the assigned random delay, the medium is made available to the node with the lowest number of the slot randomly selected, and the states of the counters in all the nodes are changed as soon as every node receives the transmitted packet depending on the packet class or if the collision is detected in the communication medium, is **characterized in that** each time before the packet transmission attempt, the state of the communication medium is sensed using the state detectors of particular nodes connected to this medium, and if the communication medium is detected to be idle, the prespecified fixed time interval equal to the minimum interpacket space is timed out by the use of a clock in every node in each packet cycle, while during the minimum interpacket space, the random numbers of time slots defining the order of media access are selected from the fixed number of slots of equal width using the pseudorandom number generator in every node, and the probability of a selection of a particular slot is geometric with a characteristic parameter defined as the ratio of the probability of a selection of a given slot to the probability of a selection of the next slot, which changes from zero to one as a discrete function of the state of the node's counter in a way that a change of the counter state from one to the prespecified maximum number corresponds to a change of the characteristic parameter from the maximum to the minimum value, and after that the time interval of random delay is assigned which is equal to the product of the number of a slot randomly selected reduced by one and the prespecified width of a single slot, and next, after the minimum interpacket space the phase of sequential priority access is started consisting **in that** the time interval assigned to a node is timed out concurrently by the use of a clock residing in each node, and this time interval is equal to the product of the number of a priority slot assigned to the particular node reduced by one and the prespecified width of a single priority slot, and next, the state of the medium is sensed again, and if the medium is detected to be idle, it is made available to the node with the lowest number of the assigned priority slot, and when a given node starts a transmission, the timing out of time delay in the other nodes with higher numbers of the assigned priority slots is terminated, and simultaneously the receiving inputs in all the nodes in the network segment are activated, while after completing a given priority packet reception, the state of the communication medium is sensed again by all the nodes, and if the medium is detected to be idle, the minimum interpacket space is timed out, and the cycle is repeated for the successive number of the priority slot, and subsequently, if the medium is sensed to be idle by the detectors of the communication medium state in all the nodes after timing out the duration of the prespecified maximum number of the priority slots or if the prespecified number of the priority slots equals zero, the random delay assigned previously is timed out and at the same time the state of the communication medium is sensed again, and if the communication medium is still sensed idle, it is made available to the node with the lowest number of the slot randomly selected, and when a given node starts a transmission, the timing out of the time delays is terminated by the use of the detectors of the communication medium state in the other nodes with higher numbers of slots randomly selected, and their receiving inputs in all the nodes are activated at the same time, and after completing a given packet reception, the states of the counters in all the nodes in a given network segment are increased by the increment defining the number of expected packets that will be generated in a result of the reception of the transmitted packet reduced by one, and afterwards, the state of the communication medium is sensed again by all the nodes, and if the communication medium is detected to be idle, the minimum interpacket space is timed out, and at the same time the random numbers are selected from the prespecified fixed number of available slots and the random delay is assigned to each node, and subsequently after the minimum interpacket space the random delay assigned previously is timed out, and at the same time the state of the communication medium is sensed again, and the cycle is repeated, and besides, during the data packet transmission the collisions are detected optionally in the communication medium by the collision detectors, and after the detection of a collision the states of the counters are changed in the nodes with the use of the corresponding control signals obtained from the collision detectors, and in case the communication medium is detected to be idle after the time equal to the sum of the minimum interpacket space and the time delay defined by the prespecified fixed maximum number of slots, the states of the counters in all the nodes in a given network segment are decreased by one with the use of the corresponding control signals obtained from the communication medium state detectors.

2. Method as claimed in claim 1 **characterized in that** the states of the counters in the nodes are increased after detection of a collision in the communication medium by a constant increment N where N is a natural number.

3. Method as claimed in claim 1 **characterized in that** the state of the counters in the nodes are doubled after detection of a collision in the communication medium.

Patentansprüche

1. Verfahren zur Kontrolle des Zugangs von Einrichtungen zum Kommunikationsmedium in verteilten Netzwerken, beruhend auf dem Kommunizieren unter einander zwischen einer Gruppe von Einrichtungen, die an ein gemeinsames Kommunikationsmedium angeschlossen sind, von denen jede einen Knoten des verteilten Netzwerkes darstellt und Daten generiert, die in Paketzyklen an zumindest einen System-Netzwerkknoten ohne bzw. mit der Bestätigung des Paketempfangs auf solche Weise ausgesendet werden, dass der Besetzungszustand des Kommunikationsmediums im Moment der Hervorbringung von Daten durch irgendeinen Netzwerkknoten mit Hilfe eines Detektors des Besetzungszustands des Kommunikationsmediums geprüft wird und der konstante Zeitabschnitt des minimalen Zwischenpaketabstands nach Feststellung des Nichtbesetzungszustands in jedem Paketzyklus mittels des Taktgebers des jeweiligen Knotens angegeben wird und während dessen Dauer die Nummern der Zeitspalten, welche die Reihenfolge des Zugangs zum Kommunikationsmedium bestimmen, unter der verfügbaren Anzahl der Zeitspalten mit gleicher Breite mittels eines Pseudo-random bit-stream-Generators des jeweiligen Knotens ausgelost werden und ein Zeitabschnitt der Schicksalsverzögerung als eine Zeitspanne, die dem Produkt der ausgelosten Nummer der Zeitspalte, vermindert um eins, und der vorgegebenen Breite der Zeitspalten entspricht, festgesetzt werden, wonach nach Ablauf der Zeitspanne, die dem Abschnitt des minimalen Zwischenpaketabstands gleich ist, die Ausführung der Etappe der aufeinanderfolgenden Prioritätszugänge beginnt, die darauf beruht, dass der Abschnitt der vorgegebenen Zeit der Prioritätsverzögerung, die dem Produkt der Nummer der vorgegebenen Prioritätszeitspalte, vermindert um eins, und der vorgegebenen Breite der einzelnen Prioritätszeitspalte gleich ist, mittels des Taktgebers des jeweiligen Knotens gemessen wird und danach der Besetzungszustand des Kommunikationsmediums erneut geprüft wird, wobei das Kommunikationsmedium nach Feststellung der Nichtbesetzung für den Knoten mit der niedrigsten Nummer der erforderten Prioritätsspalte zugänglich gemacht wird und die Zeitangabe der Prioritätsverzögerungen in den übrigen Netzwerkknoten mit höheren Nummern von Prioritätszeitspalten nach Beginn der Übertragung durch den jeweiligen Knoten mittels der Signale aus den Detektoren des Besetzungszustands des Kommunikationsmediums unterbrochen wird und gleichzeitig die Empfangseingänge sämtlicher Knoten des gegebenen Netzsegmentes aktiviert werden, und der Besetzungszustand des Kommunikationsmediums nach Beendigung des Empfangs des gegebenen Prioritätspakets durch alle Netzwerkknoten erneut geprüft wird und der Zeitabschnitt des minimalen Zwischenpaketabstands, falls das Kommunikationsmedium nicht besetzt ist, gemessen, und dieser Zyklus für die folgende Nummer der Prioritätsspalte wiederholt wird, und dann, wenn nach der Abmessung der Dauer der festgesetzten maximal zugänglichen Anzahl der Prioritätszeitspalten und Feststellung der Nichtbesetzung des Kommunikationsmediums mittels der Detektoren des Besetzungszustands des Kommunikationsmediums in allen Netzwerkknoten, oder falls die Anzahl der Prioritätszeitspalten gleich Null ist, der vorher vorgegebene Zeitabschnitt der Schicksalsverzögerung gemessen und gleichzeitig den Besetzungszustand des Kommunikationsmediums erneut geprüft werden, und das Kommunikationsmedium nach Ablauf des gemessenen Zeitabschnitts der Schicksalsverzögerung und nach Feststellung der Nichtbesetzung des Kommunikationsmediums für den Netzwerkknoten mit der niedrigsten Nummer der ausgelosten Spalte zugänglich gemacht wird, und der Stand sämtlicher Knotenzeitgeber bei dem Empfang des ausgesendeten Pakets in Abhängigkeit von dessen Art durch den jeweiligen Netzwerkknoten sowie im Fall der Feststellung einer Kollision im Kommunikationsmedium verändert wird, **dadurch gekennzeichnet, dass** der Besetzungszustand des Kommunikationsmediums jeweils vor der Aussendung des Pakets mittels der Detektoren des Zustands der einzelnen Knoten, die an dieses Kommunikationsmedium angeschlossen sind, geprüft wird, und der konstante Zeitabschnitt des minimalen Zwischenpaketabstands nach Feststellung des Nichtbesetzungszustands in jedem Paketzyklus mittels des Taktgebers des jeweiligen Knotens angegeben wird, wobei während dessen Dauer unter der verfügbaren Anzahl der Zeitspalten mit gleicher Breite mittels eines Pseudo-random bit-stream-Generators des jeweiligen Knotens die Nummern der Zeitspalten, welche die Reihenfolge des Zugangs zum Kommunikationsmedium bestimmen, ausgelost werden, an deren Verlosung die Wahrscheinlichkeit der Auslosung der gegebenen Spalte eine geometrische Verteilung aufweist, deren charakteristischer Parameter das Verhältnis der Wahrscheinlichkeit der Auslosung der gegebenen Spalte zur Wahrscheinlichkeit der Auslosung der darauf folgenden Spalte darstellt, der sich innerhalb der Grenzen von Null zu eins in der diskreten Funktion der Zustandsveränderungen des Taktgebers des jeweiligen Knotens verändert, nämlich in der Weise, dass der Änderung des Zustands des Taktgebers von eins bis zur definierten maximalen Zahl eine Veränderung des Wertes des charakteristischen Parameters innerhalb einer Spanne vom maximalen Wert bis zum minimalen Wert entspricht, wonach ein Zeitabschnitt der Schicksalsverzögerung als eine Zeitspanne, die dem Produkt der ausgelosten Nummer der Zeitspalte, vermindert um eins, und der vorge-

gebenen Breite der Zeitspalten entspricht, festgesetzt wird, und dann nach Ablauf der Zeitspanne, die dem Zeitabschnitt des minimalen Zwischenpaketabstands gleich ist, die Ausführung der Etappe der aufeinander folgenden Prioritätszugänge beginnt, die darauf beruht, dass gleichzeitig der Abschnitt der vorgegebenen Zeit der Prioritätsverzögerung, die dem Produkt der Nummer der vorgegebenen Prioritätszeitspalte, vermindert um eins, und der vorgegebenen Breite der einzelnen Prioritätszeitspalte gleich ist, gemessen und der Besetzungszustand des Kommunikationsmediums erneut geprüft wird, und das Kommunikationsmedium nach Feststellung der Nichtbesetzung für den Knoten mit der niedrigsten Nummer der vorgegebenen Prioritätsspalte zugänglich gemacht wird und die Zeitangabe der Prioritätsverzögerungen in den übrigen Netzwerkknoten mit höheren Nummern der Prioritätszeitspalten nach Beginn der Übertragung durch den jeweiligen Knoten mittels der Signale aus den Detektoren des Besetzungszustands des Kommunikationsmediums unterbrochen wird und die Empfangseingänge sämtlicher Knoten des gegebenen Netzsegmentes gleichzeitig aktiviert werden, und der Abschnitt des minimalen Zwischenpaketabstands abgemessen wird, wonach der Zyklus für die folgende Prioritätsnummer wiederholt wird, und dann, wenn nach der Abmessung der Dauer der festgesetzten maximal zugänglichen Anzahl der Prioritätszeitspalten und Feststellung der Nichtbesetzung des Kommunikationsmediums mittels der Detektoren des Besetzungszustands des Kommunikationsmediums in allen Netzwerkknoten, oder falls die Anzahl der Prioritätszeitspalten gleich Null ist, der vorher vorgegebene Zeitabschnitt der Schicksalsverzögerung gemessen und gleichzeitig der Besetzungszustand des Kommunikationsmediums erneut geprüft wird, und das Kommunikationsnetz nach Feststellung der Nichtbesetzung des Kommunikationsmediums für den Netzwerkknoten mit der niedrigsten Nummer der ausgelosten Spalte zugänglich gemacht wird, die Zeitangabe der Prioritätsverzögerungen in den übrigen Netzwerkknoten mit höheren Nummern von Prioritätszeitspalten nach Beginn der Übertragung durch den jeweiligen Knoten mittels der Signale aus den Detektoren des Besetzungszustands des Kommunikationsmediums unterbrochen wird und ihre Empfangseingänge gleichzeitig aktiviert werden, und der Stand des Zeitgebers in sämtlichen Knoten des gegebenen Netzwerksegments nach der Beendigung des Empfangs des gegebenen Pakets sich um die Zahl vergrößert, mit welcher die Anzahl der zu erwartenden Pakete, die infolge des Empfangs des ausgesendeten Pakets, vermindert um eins, generiert werden, bestimmt wird, und der Zeitabschnitt des minimalen Zwischenpaketabstands, in dem Fall, wenn das Kommunikationsmedium nicht besetzt ist, gemessen wird, wobei gleichzeitig die Nummern der Zeitspalten unter der gleichbleibenden Anzahl zugänglicher Spalten ausgelost und die Zeit der Schicksalsverzögerung bestimmt werden, und dann der vorher vorgegebene Zeitabschnitt der Schicksalsverzögerung nach Ablauf des Zeitabschnitts des minimalen Zwischenpaketsabstands gleichzeitig gemessen und der Besetzungszustand des Kommunikationsmediums erneut geprüft wird, wonach dieser Zyklus wiederholt wird, und darüber hinaus die während der Übertragung des jeweiligen Datenpakets allfällig auftretenden Kollisionen im Kommunikationsmedium mithilfe von Kollisionsdetektor aufgedeckt und der Stand der Knotenzeitgeber mittels des erlangten Signals geändert werden, und in dem Fall, wenn das Kommunikationsmedium nach Ablauf einer Zeitspanne, die der Summe des minimalen Zwischenpaketabstands und des Verzögerungszeitabschnitts, der für die maximale gleichbleibende Anzahl der Zeitspalten festgesetzt wurde, gleicht ist, nicht besetzt ist, dann wird der Stand der Zeitgeber in sämtlichen Knoten des gegebenen Netzwerksegments mittels eines Signals, der durch den Detektor des Besetzungszustands des Kommunikationsmediums ausgestrahlt wird, um eins vermindert.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Stand der Zeitgeber sich nach der Aufdeckung einer Kollision im Kommunikationsmedium um einen konstanten Zuwachs N vergrößert, wobei N eine natürliche Zahl ist.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Stand der Zeitgeber sich nach der Aufdeckung einer Kollision im Kommunikationsmedium durch eine Verdoppelung ihrer aktuellen Stände vergrößert wird.

Revendications

1. Procédé de contrôle d'accès de dispositifs à un support de communication dans des réseaux distribués consistant en communication entre eux d'un groupe de dispositifs, connectés à un support de communication commun, dans lequel chacun des dispositifs constitue un noeud de réseau distribué et génère des données, qui sont envoyées en cycles de paquets à l'un au moins des noeuds du réseau dans le système sans ou avec confirmation de la réception du paquet et au moment de la génération de données par l'un quelconque des noeuds du réseau, est contrôlé l'état d'occupation du support au moyen d'un détecteur d'état de support et s'il est détecté que le support de communication est au repos dans chaque cycle de paquet, au moyen de l'horloge de chaque noeud est temporisé l'intervalle de temps fixe préspécifié de l'espace inter-paquets minimal, durant lequel à partir du nombre de créneaux disponibles

de largueur égale sont sélectionnés, au moyen du générateur de nombres pseudo-aléatoires de chaque noeud, les numéros des créneaux déterminant l'ordre d'accès au support de communication et est défini l'intervalle de temps de retard aléatoire comme temps égal au produit du numéro sélectionné du créneau réduit de un et de la largeur pré-spécifiée des créneaux, et, ensuite, après l'écoulement du temps égal à l'espace inter-paquets minimal est démarrée la réalisation de la phase d'accès séquentiel par ordre de priorité consistant en ce qu'en même temps est temporisé au moyen de l'horloge de chaque noeud l'intervalle de temps de retard prioritaire pré-spécifié, qui est égal au produit du numéro pré-spécifié du créneau prioritaire réduit de un et de la largeur pré-spécifiée du créneau prioritaire particulier et est contrôlé de nouveau l'état d'occupation du support de communication, et s'il est détecté que le support de communication est au repos, il est rendu disponible au noeud avec le numéro le plus faible du créneau prioritaire demandé, et, après le démarrage de la transmission par le noeud donné au moyen de signaux à partir des détecteurs d'état de support de communication est interrompu temporisation de retards prioritaires dans les autres noeuds ayant les numéros prioritaires des créneaux plus élevés et, en même temps, sont activées les entrées de réception de tous les noeuds dans un segment de réseau donné, et après l'achèvement de la réception du paquet prioritaire donné est contrôlé de nouveau l'état d'occupation du support de communication par tous les noeuds et, si le support est au repos, l'espace inter-paquet minimal est temporisé et le cycle est répété pour le numéro suivant du créneau prioritaire, ensuite, si, après la temporisation de la durée du nombre maximal pré-spécifié disponible de créneaux prioritaires, il est détecté, au moyens de détecteurs d'état d'occupation des noeuds du réseau, que le support de communication est au repos ou si le nombre de créneaux prioritaires est égal à zéro est temporisé l'intervalle de temps de retard aléatoire pré-spécifié et, en même temps, est contrôlé de nouveau l'état d'occupation du support de communication, et, après l'écoulement du temps de retard aléatoire temporisé et si le support de communication est toujours détecté au repos, il est rendu disponible au noeud avec le numéro le plus faible du créneau sélectionné de manière aléatoire, et après l'achèvement de la réception par chaque noeud du paquet transmis en fonction de son type, et, aussi, s'ils sont détectées de collisions dans le support, les états des compteurs sont changés dans les noeuds **caractérisé en ce que** chaque fois, avant la tentative de transmission de paquet est contrôlé le support au moyen de détecteurs d'état du support des noeuds respectifs connectés à ce support, et s'il est détecté que le support de communication est au repos, dans chaque cycle de paquet, au moyen de l'horloge de chaque noeud, est temporisé l'intervalle de temps fixe pré-spécifié de l'espace inter-paquets minimal, et durant cet espace inter-paquet minimal à partir du nombre fixe de créneaux disponibles de largueur égale sont sélectionnés, au moyen du générateur de nombres pseudo-aléatoires de chaque noeud, les numéros des créneaux déterminant l'ordre d'accès au support de communication, où la probabilité d'une sélection d'un créneau particulier est géométrique avec un paramètre caractéristique défini en tant que rapport de la probabilité d'une sélection d'un créneau donné sur la probabilité d'une sélection du créneau suivant, qui varie de zéro à un en tant que fonction discrète de l'état du compteur du noeud, et ceci de manière qu'à la variation de l'état du compteur de un à un nombre maximal pré-spécifié correspond la variation de la valeur du paramètre caractéristique de la valeur maximale à la valeur minimale, et après cela est déterminé l'intervalle de temps de retard aléatoire égal au produit du numéro sélectionné du créneau réduit de un et de la largeur pré-spécifiée du créneau particulier, et, ensuite, après l'écoulement de l'espace inter-paquets minimal est démarrée la réalisation de la phase d'accès séquentiel par ordre de priorité consistant **en ce que**, en même temps, est temporisé au moyen de l'horloge de chaque noeud l'intervalle de temps de retard prioritaire pré-spécifié, qui est égal au produit du numéro pré-spécifié du créneau prioritaire réduit de un et de la largeur pré-spécifiée du créneau prioritaire particulier et est contrôlé de nouveau l'état d'occupation du support de communication, et s'il est détecté que le support de communication est au repos, il est rendu disponible au noeud avec le numéro le plus faible du créneau sélectionné, et après le démarrage de la transmission par le noeud donné au moyen de signaux détecteurs d'état de support de communication est interrompue la temporisation des retards prioritaires dans les autres noeuds ayant les numéros prioritaires plus élevés des créneaux et en même temps sont activées les entrées de réception de tous les noeuds dans un segment de réseau donné, et après l'achèvement de la réception du paquet donné prioritaire est contrôlé de nouveau l'état d'occupation du support de communication par tous les noeuds et si le support est au repos l'espace inter-paquet minimal est temporisé et le cycle est répété pour le numéro prioritaire suivant et, ensuite, après la temporisation de la durée du nombre maximal de créneaux prioritaires, s'il est détecté, au moyens de détecteurs d'état d'occupation des noeuds du réseau, que le support de communication est au repos ou si le nombre de créneaux prioritaires est égal à zéro, est temporisé l'intervalle de temps de retard aléatoire pré-spécifié et en même temps est contrôlé de nouveau l'état d'occupation du support de communication, et s'il est détecté que le support de communication est

au repos, il est rendu disponible au noeud avec le numéro le plus faible du créneau sélectionné et, après le démarrage de la transmission par le noeud donné au moyen de signaux d'état d'occupation du support est interrompu la temporisation des retards aléatoires dans les autres noeuds ayant des numéros sélectionnés plus élevés des créneaux et en même temps sont activées leurs entrées de réception, et après l'achèvement de la réception du paquet donné dans tous les noeuds d'un segment de réseau donné les états des compteurs dans tous les noeuds dans un segment de réseau donné sont augmentés par l'incrément définissant le nombre de paquets attendus qui seront générés en résultat de la réception du paquet transmis réduit de un, et ensuite, est contrôlé de nouveau l'état d'occupation du support de communication par tous les noeuds et si le support est au repos l'espace inter-paquet minimal est temporisé et en même temps sont sélectionnés les numéros des créneaux à partir du nombre pré-spécifié fixe de créneaux disponibles et est déterminé le temps de retard aléatoire, et, ensuite, après l'écoulement de l'espace inter-paquets minimal est en même temps temporisé le retard aléatoire préalablement défini et est contrôlé de nouveau l'état d'occupation du support de communication, et, après cela, le cycle est répété et, durant la transmission de paquet de données, des collisions sont détectées de manière facultative dans le support de communication par les détecteurs de collision, puis les états des compteurs sont changés dans les noeuds, et dans le cas où le support de communication est détecté au repos après l'intervalle égal à la somme de l'espace inter-paquet minimal et du retard de temps défini par le nombre de créneaux maximal fixé pré-spécifié, les états des compteurs dans tous les noeuds dans un segment de réseau donné sont diminués de un à l'aide des signaux de commande obtenus à partir des détecteurs d'état de support de communication.

2. Le procédé selon la revendication 1 **caractérisé en ce qu'**après la détection de collision dans le support de communication, les états des compteurs sont augmentés par l'incrément fixe N, où N est un nombre naturel.

3. Le procédé selon la revendication 1 **caractérisé en ce qu'**après la détection de collision dans le support de communication les états des compteurs sont augmentés par le doublement de leurs états actuels.

REFERENCES CITED IN THE DESCRIPTION

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