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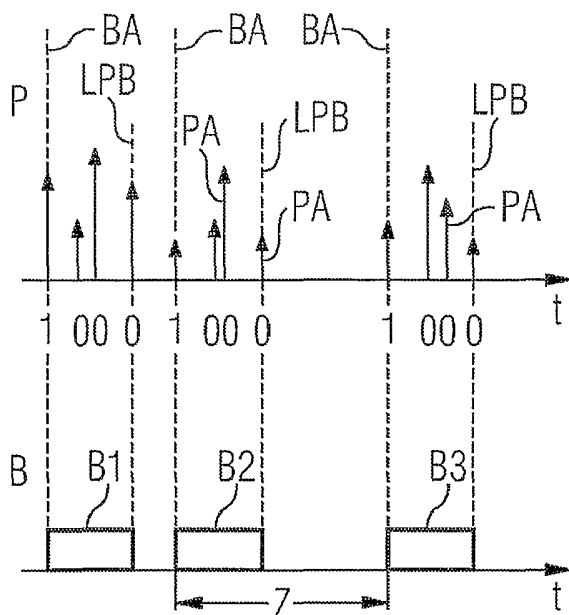
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A METHOD FOR AND APPARATUS FOR AGGREGATING INCOMING PACKETS INTO OPTICAL FOR AN OPTICAL BURST SWITCHED NETWORK



(57) Abstract: Incoming packets are aggregated into optical bursts in an edge node of an Optical Burst Switched Network. This comprises the following steps. Storing the incoming packets to generate an optical burst. Associating each incoming packet with a generated random binary digit with a probability for a first and a second value of the binary digit. A packet with a binary digit having the first value indicates a transition between optical bursts. Sending the optical burst with the aggregated packets when a transition is indicated by the first value.

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Description

A METHOD AND APPARATUS FOR AGGREGATING INCOMING PACKETS INTO OPTICAL
BURSTS FOR AN OPTICAL BURST SWITCHED NETWORK

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In Optical Burst-Switched networks, or so called OBS networks, packets, e.g. Internet Protocol (IP) packets, Asynchronous Transfer Mode (ATM) cells or protocol data units
10 (PDUs), are aggregated into optical bursts in order to be transferred through the OBS network or respective optical network. The conversion of packets into optical bursts takes place in the edge nodes of an OBS network according to a certain aggregation strategy. The solutions so far provide two
15 main aggregation strategies: the aggregation strategy with timeouts and the aggregation strategy with a buffer limit.

First we will discuss the aggregation strategy with timeouts. A schematic example is shown in Figure 1. In this scheme,
20 packets 102 are added or padded to the burst 104 which is being generated in a buffer 106 until a certain timer T expires. Then the burst 108 is sent.

The second, Aggregation strategy with buffer limit will be
25 discussed with reference to Figure 2. In this scheme, packets 202 are added or padded to the burst 204 which is being generated in a buffer 206 until the buffer is full. Then the burst 208 is sent.

30 Once the packets are transformed into bursts and sent into the OBS network, they travel in the OBS network through a series of optical switches to a certain destination. At best, these optical switches have limited storage capabilities, e.g. fiber delay lines, and at worst, no storage capabilities
35 at all in the normal case. Therefore, collisions among optical bursts occur. Major performance parameters of an OBS net-

work are thus the burst blocking probability, the throughput and the delay.

5 The two main aggregation strategies timeout and buffer limit have the disadvantage of a certain blocking probability and maximum achievable throughput.

10 It is an object of the invention to reduce the blocking probability and increase the throughput of an OBS network.

This object is achieved by the features recited in claim 1, 4 and 8.

15 The novel inventive aggregation strategy is based on the following widely accepted assumption for highly multiplexed traffic (core networks): the packet arrival rate process is determined according to a Poisson distribution. With this assumption, the idea is to consider the random selection property of any Poisson process, in order to obtain a Poisson
20 process of a lower arrival rate.

This lower-rate Poisson process will mark the beginning of a new optical burst or the end of an optical burst. So it is possible to assure that the burst send and arrival process is
25 Poisson. In addition, the inter-arrival times between bursts will be negative-exponential distributed, as the inter-arrival times of any Poisson process.

30 It shall be appreciated that advantages of the invention are:

- A lower blocking probability in the optical switches is provided, as compared to the standard aggregation strategies.
- Predictability of the blocking probability. The blocking
35 probability can be calculated with the Erlang-B formula. Whereas for the other aggregation strategies no analytical formula is known.

- Due to the lower blocking probability a higher throughput in optical switches of the OBS network is achieved.
- Predictability of the throughput. The throughput, unlike with the prior art strategies, can be calculated with the help of the Erlang B formula.
- It is easier to calculate waiting times for bursts and/or headers of bursts.
- A lower waiting time for the optical headers in the optical switches.
- In the case burst buffering is available, e.g. by the use of fiber delay lines, a lower waiting time for bursts in the optical switch is achieved.

Further developments of the invention are identified in sub-claims.

An exemplary embodiment of the invention is described in greater detail below with reference to a drawing.

Shown in the drawing are:

FIG 1 the initially cited prior art.

FIG 2 the initially cited prior art.

FIG 3 an schematically example for the aggregation and random selection process.

FIG 4 a graph with the blocking probability as a function of the load for different aggregation strategies.

Figure 3 shows two associated timelines P and B. On the first timeline P packets PA, pictured as arrow line, are received in chronological order, e.g. IP packets, ATM cells or PDUs.

Every packet is associated with a generated random binary digit. A binary digit has a first and a second value, e.g. 1 for the first value and 0 for the second value or opposite.

So, every packet is associated either with a 1 or a 0. The random binary digits can be generated by a Bernoulli random generator, according to a Bernoulli probability distribution. The probability for every value of the random binary digit, thus the probability (p) for the 1's and ($1-p$) for the 0's, is determined by a certain probability distribution, e.g. $p(1)=0,01$ and $p(0)=0,99$. These packets are aggregated in a buffer to accumulate an optical burst. A packet with an associated first value, e.g. with a 1 indicates a transition between optical bursts, e.g. the beginning of a new burst. In figure 3 this is labeled with BA. The chronological last packet with a 0 before a packet with a 1, is the last packet of the burst, marked with LPB in figure 3. On the second timeline B in figure 3 the resulting Bursts B1, B2 and B3 are shown. The time difference Z between the beginning of two successive bursts is called inter-arrival time. The aggregation delay is the delay experienced by a packet in the edge node until the burst to which it belongs is completed. After appearance of a packet with a 1, a new burst begins and the old burst is send into the OBS network.

The used probability distribution determines the average number of packets per burst. E.g. the average number of packets per burst is equal to $1/p(1)$. For the example, if $p(1)=0,01$, the average number of packets per burst is $1/p(1)=100$ packets per burst.

The method can also be realized, that the second value indicates a transition between optical bursts.

Also the first value indicates, instead of the beginning of a new burst, the end of the aggregated packets and by that the end of the aggregated burst. The main idea is, that a generated random digit with a certain probability indicates the beginning or the end of a burst, which consists of aggregated packets, e.g. IP packets.

The invention can be implemented by the following steps/algorithm:

- Every time the edge node receives a packet, e.g. an IP
5 packet, it sends it to the buffer.
- Then the edge node reads the generated associated random
binary digit / random number corresponding to the next
packet.
- If the associated random binary digit / random number for
10 the next packet is a first value, e.g. a 1, the accumu-
lated burst in the buffer is sent.
- Otherwise, do nothing.

A simulation has been done with Matlab® in order to calculate
15 the blocking probability in an optical switch with no wave-
length conversion available as a function of the load. The
results are presented in figure 4. In figure 4 AT means ag-
gregation strategy with aggregation timer, AB means aggrega-
tion strategy with aggregation buffer, Erl B means theoreti-
20 cally possible load according to Erlang B formula and RS
means inventive aggregation strategy with random selection.

It can be observed that the inventive random selection strat-
egy leads to the lowest blocking probability and furthermore
25 it matches the Erlang-B formula predictions.

Patent Claims

1. A method for aggregating incoming packets into optical bursts in an edge node of an Optical Burst Switched Network,
5 comprising the steps of:

storing the incoming packets to generate an optical burst;

associating each incoming packet with a generated random binary digit with a probability for a first and a second value
10 of the binary digit; and

wherein, a packet with a binary digit having the first value indicates a transition between optical bursts,
15 sending the optical burst with the aggregated packets when a transition is indicated by the first value.

2. The Method as claimed in claim 1,
20 characterized in that,
wherein the transition is a beginning of the new optical burst.

3. The Method as claimed in claim 1,
25 characterized in that,
wherein the transition is an end of the optical burst.

4. A method for aggregating incoming packets into optical bursts in an edge node of an Optical Burst Switched Network,
30 whereby every time a received incoming packet is stored and a random binary digit, with a probability for the first and the second value of the binary digit, is generated and compared with the first value of the binary digit and, if equal, the stored packets are sent as an optical burst.
35

5. The Method as claimed in one of claims 1 to 4,
characterized in that,

7

where said optical burst is sent through the Optical Burst Switched Network.

6. The Method as claimed in one of claims 1 to 5,
5 c h a r a c t e r i z e d i n t h a t,
where said random binary digit is generated according to a Bernoulli probability distribution.

7. The Method as claimed in one of claims 1 to 6,
10 c h a r a c t e r i z e d i n t h a t,
that IP packets are used as incoming packets.

8. An edge node apparatus for an Optical Burst Switched Net-
work for aggregating incoming packets into optical bursts,
15 comprising:

a buffer to accumulate the incoming packets as an optical burst; and

20 a random generator to generate a sequence of binary digits with a probability for a first and a second value of the binary digit, such that every incoming packet is associated with a generated binary digit,

25 wherein an packet with the first value of the binary digit indicates a transition between optical bursts; and

wherein the optical burst with the aggregated packets is sent when a transition is indicated by the first value.

30

9. The apparatus as claimed in claim 8,
c h a r a c t e r i z e d i n t h a t,
wherein the random generator is a Bernoulli random generator that generates a sequence of binary digits in accordance with
35 a Bernoulli probability distribution.

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FIG 1

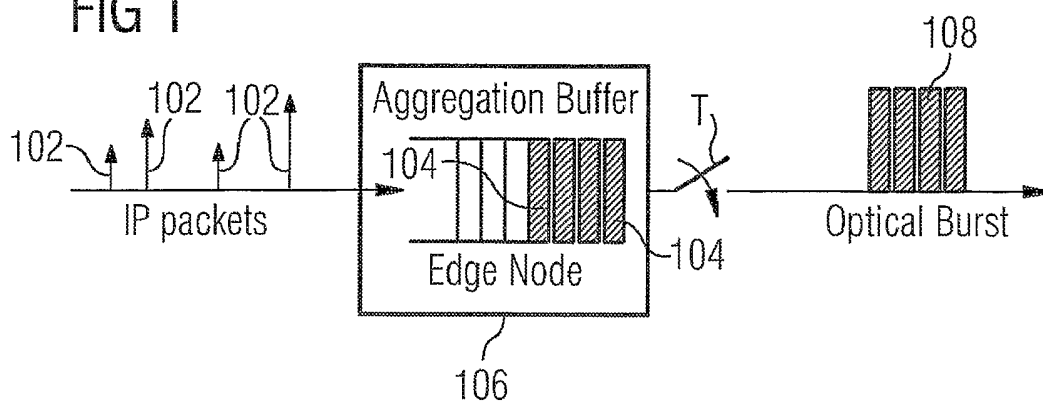


FIG 2

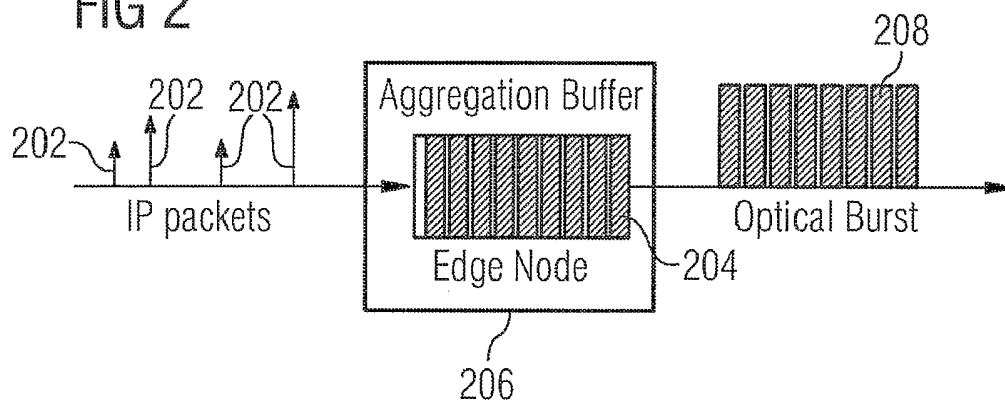
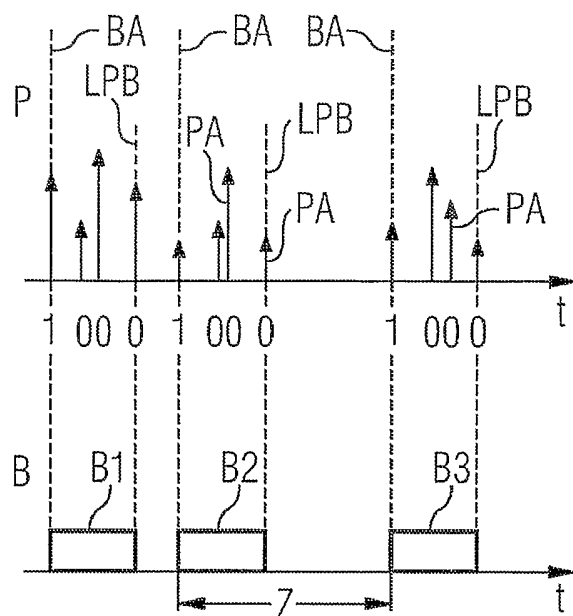
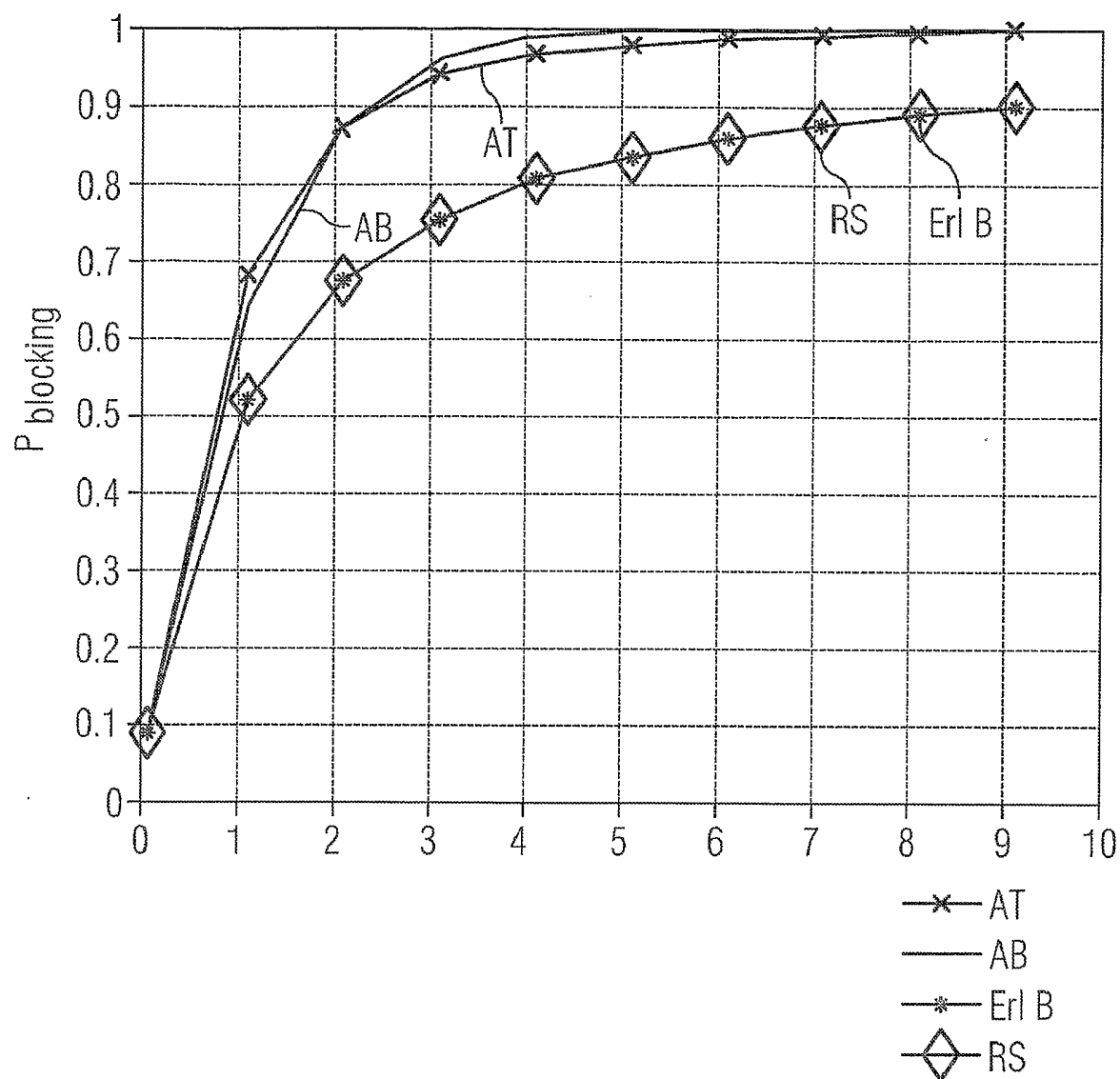


FIG 3



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FIG 4



INTERNATIONAL SEARCH REPORT

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 A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 H04Q11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01/84875 A (NOKIA INC) 8 November 2001 (2001-11-08) page 5, line 30 - page 6, line 8 page 7, line 9 - page 8, line 23 page 10, line 2 - line 11 -----	1-9
A	YOO M ET AL: "NEW OPTICAL BURST SWITCHING PROTOCOL FOR SUPPORTING QUALITY OF SERVICE" PROCEEDINGS OF THE SPIE, SPIE, BELLINGHAM, VA, US, vol. 3531, November 1998 (1998-11), pages 396-405, XP000950072 ISSN: 0277-786X the whole document ----- -/--	1-9



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/099243 A1 (KANG MINHO ET AL) 29 May 2003 (2003-05-29) page 2, right-hand column, paragraph 19 page 4, left-hand column, paragraph 56 page 4, right-hand column, paragraph 63 -----	1-9

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Information on patent family members

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