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# (12) United States Patent
Ye

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(54) **EARLY TRAFFIC REGULATION TECHNIQUES TO PROTECT AGAINST NETWORK FLOODING**

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*H04J 1/16* (2006.01)
*H04J 3/16* (2006.01)
*G06F 11/00* (2006.01)

(52) **U.S. Cl.** ...................... **370/232**; 370/236; 370/468; 726/22

(58) **Field of Classification Search** ..... 370/229–236.1, 370/395.1, 465
See application file for complete search history.

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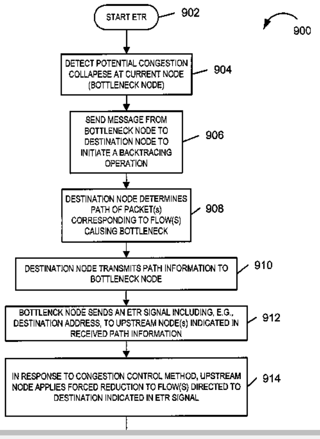
*Assistant Examiner*—Nittaya Juntima

## (57) ABSTRACT

Methods and apparatus for providing an Anti-Flooding Flow-Control (AFFC) mechanism suitable for use in defending against flooding network Denial-of-Service (N-DoS) attacks is described. Features of the AFFC mechanism include (1) traffic baseline generation, (2) dynamic buffer management, (3) packet scheduling, and (4) optional early traffic regulation. Baseline statistics on the flow rates for flows of data corresponding to different classes of packets are generated. When a router senses congestion, it activates the AFFC mechanism of the present invention. Traffic flows are classified. Elastic traffic is examined to determine if it is responsive to flow control signals. Flows of non-responsive elastic traffic is dropped. The remaining flows are compared to corresponding class baseline flow rates. Flows exceeding the baseline flow rates are subject to forced flow rate reductions, e.g., dropping of packets.

**11 Claims, 10 Drawing Sheets**


START ETR
902
900
DETECT POTENTIAL CONGESTION COLLAPESE AT CURRENT NODE (BOTTLENECK NODE)
904
SEND MESSAGE FROM BOTTLENECK NODE TO DESTINATION NODE TO INITIATE A BACKTRACING OPERATION
906
DESTINATION NODE DETERMINES PATH OF PACKET(s) CORRESPONDING TO FLOW(S) CAUSING BOTTLENECK
908
DESTINATION NODE TRANSMITS PATH INFORMATION TO BOTTLENECK NODE
910
BOTTLENCK NODE SENDS AN ETR SIGNAL INCLUDING, E.G., DESTINATION ADDRESS, TO UPSTREAM NODE(s) INDICATED IN RECEIVED PATH INFORMATION
912
IN RESPONSE TO CONGESTION CONTROL METHOD, UPSTREAM NODE APPLIES FORCED REDUCTION TO FLOW(S) DIRECTED TO DESTINATION INDICATED IN ETR SIGNAL
914

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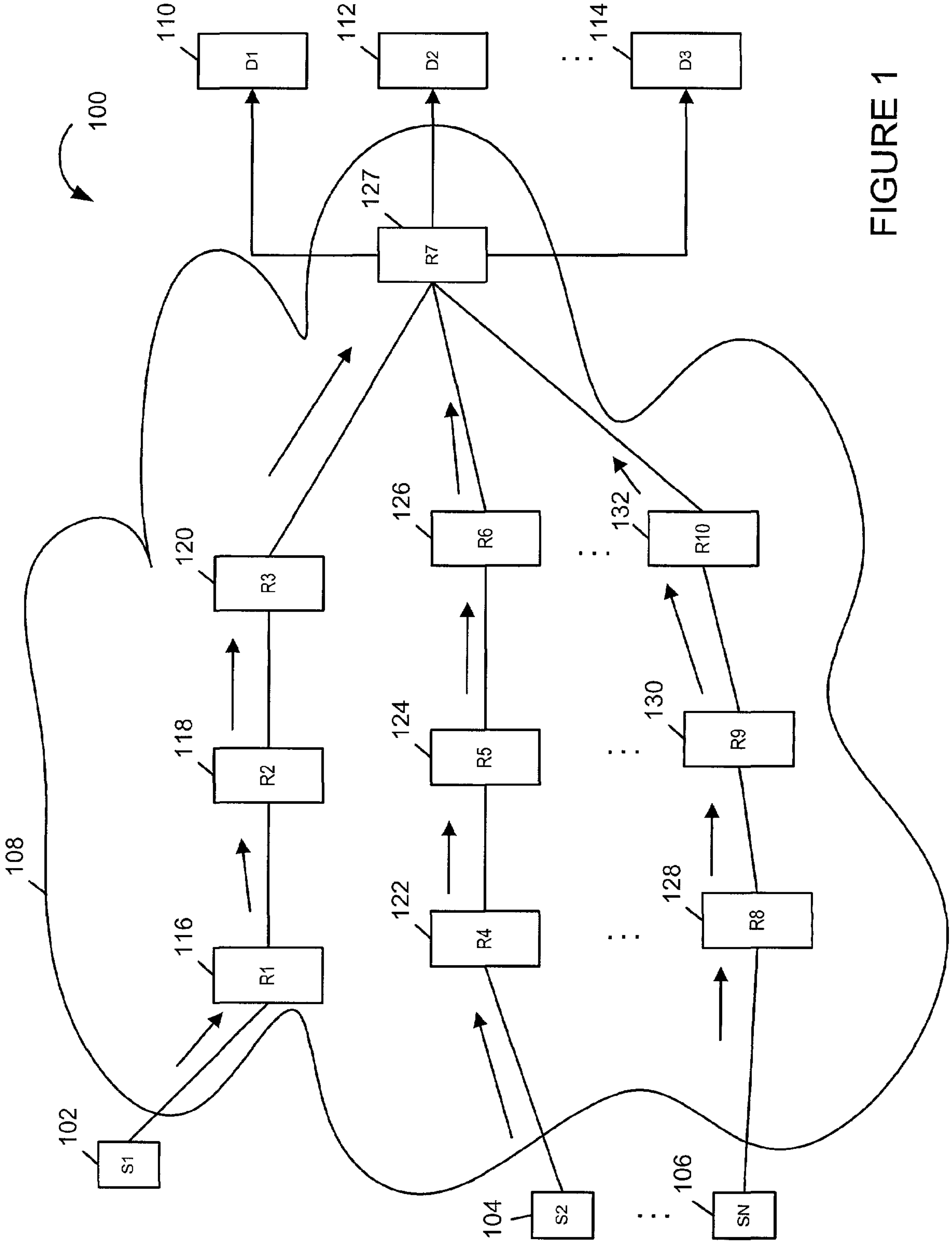
100
110
D1
112
D2
114
D3
127
R7
108
120
R3
126
R6
132
R10
118
R2
124
R5
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R9
116
R1
122
R4
128
R8
102
S1
104
S2
106
SN

FIGURE 1

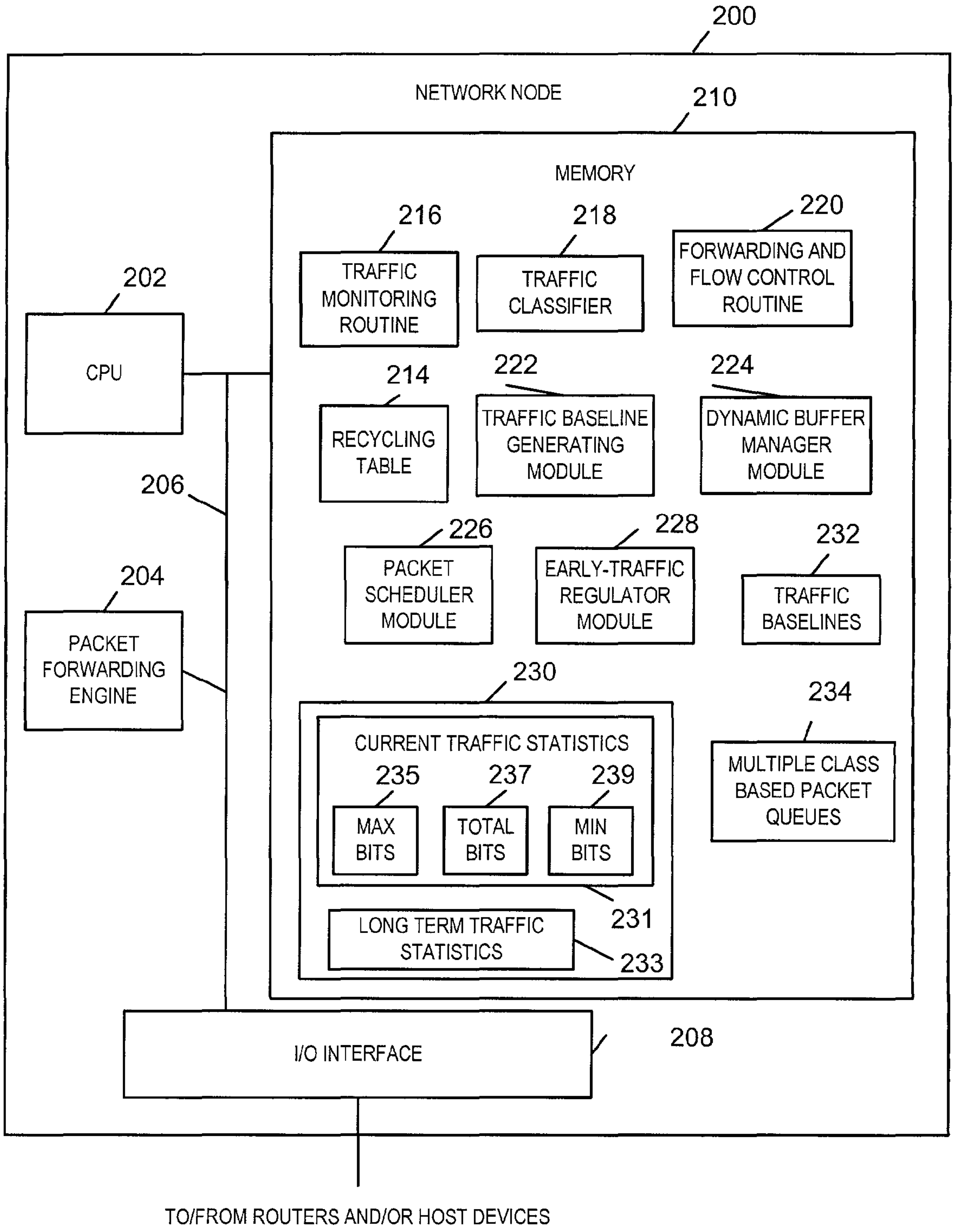
200
NETWORK NODE
210
MEMORY
216
TRAFFIC MONITORING ROUTINE
218
TRAFFIC CLASSIFIER
220
FORWARDING AND FLOW CONTROL ROUTINE
202
CPU
214
RECYCLING TABLE
222
TRAFFIC BASELINE GENERATING MODULE
224
DYNAMIC BUFFER MANAGER MODULE
206
226
PACKET SCHEDULER MODULE
228
EARLY-TRAFFIC REGULATOR MODULE
232
TRAFFIC BASELINES
204
PACKET FORWARDING ENGINE
230
CURRENT TRAFFIC STATISTICS
235
237
239
MAX BITS
TOTAL BITS
MIN BITS
234
MULTIPLE CLASS BASED PACKET QUEUES
231
LONG TERM TRAFFIC STATISTICS
233
I/O INTERFACE
208
TO/FROM ROUTERS AND/OR HOST DEVICES

FIGURE 2

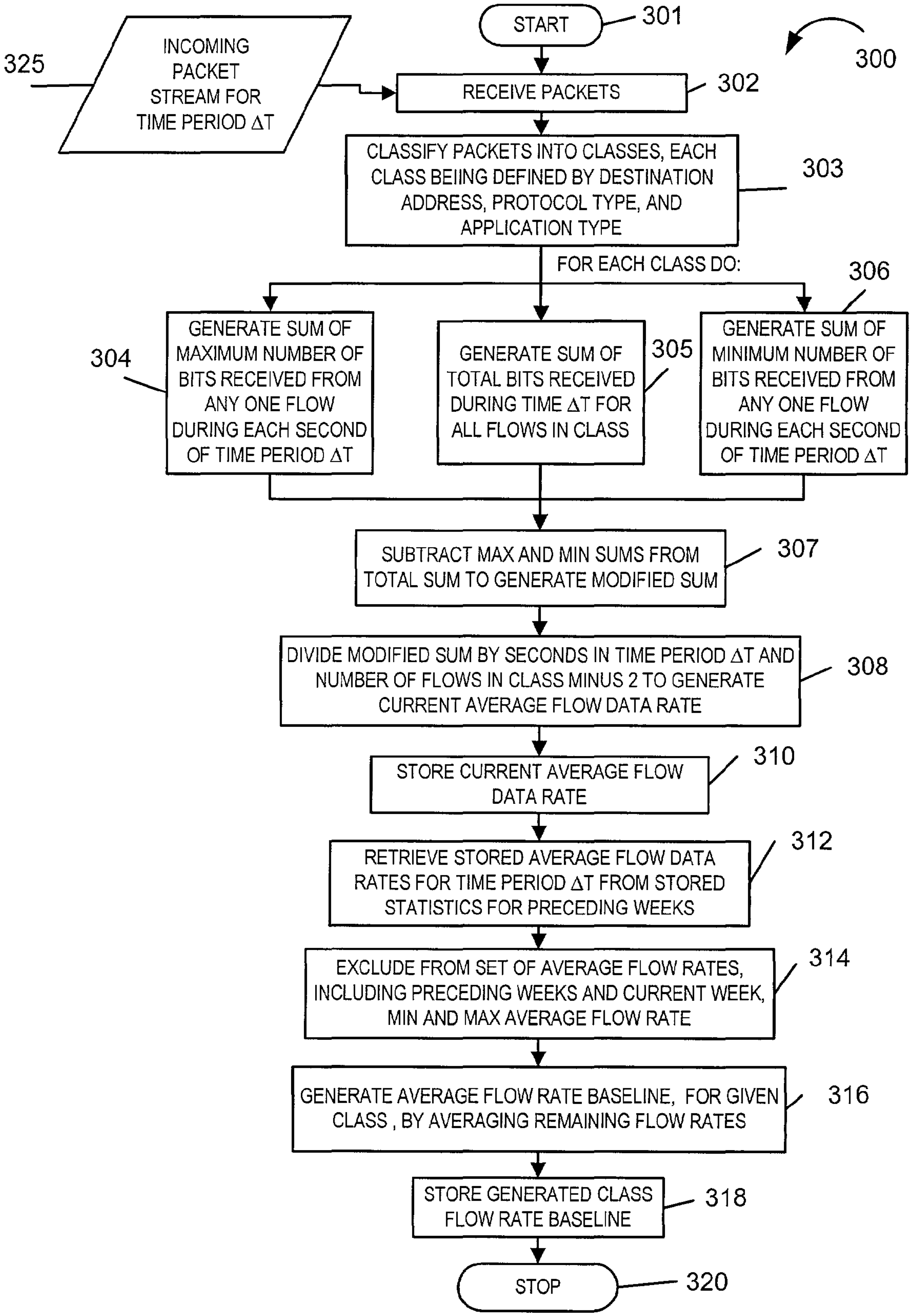
START
301
300
INCOMING PACKET STREAM FOR TIME PERIOD ΔT
325
RECEIVE PACKETS
302
CLASSIFY PACKETS INTO CLASSES, EACH CLASS BEIING DEFINED BY DESTINATION ADDRESS, PROTOCOL TYPE, AND APPLICATION TYPE
303
FOR EACH CLASS DO:
306
304
GENERATE SUM OF MAXIMUM NUMBER OF BITS RECEIVED FROM ANY ONE FLOW DURING EACH SECOND OF TIME PERIOD ΔT
GENERATE SUM OF TOTAL BITS RECEIVED DURING TIME ΔT FOR ALL FLOWS IN CLASS
305
GENERATE SUM OF MINIMUM NUMBER OF BITS RECEIVED FROM ANY ONE FLOW DURING EACH SECOND OF TIME PERIOD ΔT
SUBTRACT MAX AND MIN SUMS FROM TOTAL SUM TO GENERATE MODIFIED SUM
307
DIVIDE MODIFIED SUM BY SECONDS IN TIME PERIOD ΔT AND NUMBER OF FLOWS IN CLASS MINUS 2 TO GENERATE CURRENT AVERAGE FLOW DATA RATE
308
STORE CURRENT AVERAGE FLOW DATA RATE
310
RETRIEVE STORED AVERAGE FLOW DATA RATES FOR TIME PERIOD ΔT FROM STORED STATISTICS FOR PRECEDING WEEKS
312
EXCLUDE FROM SET OF AVERAGE FLOW RATES, INCLUDING PRECEDING WEEKS AND CURRENT WEEK, MIN AND MAX AVERAGE FLOW RATE
314
GENERATE AVERAGE FLOW RATE BASELINE, FOR GIVEN CLASS , BY AVERAGING REMAINING FLOW RATES
316
STORE GENERATED CLASS FLOW RATE BASELINE
318
STOP
320

FIGURE 3

DOCKET ALARM

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