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## 차별화된 서비스 네트워크를 위한 two rate Three Color Maker에 관한 연구

### A Study of Two Rate Three Color Maker for Differentiated Service Network

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요 약 본 논문은 RFC2698에서 제안하고 있는 trTCM(Two Rate Three Color Marker)를 디자인 한 것이다. 그것은 trTCM을 AF PHB (Assured Forwarding Per Hop Behavior)을 제공하는 DS 네트워크에서 사용할 것을 권고하고 있다.

trTCM은 미터링 기능을 가진 마커이며, 토큰 갱신 기능과 마킹 기능으로 구성되어 있다. 토큰 갱신 기능은 듀얼 토큰 버킷을 가지고 있다. 마킹 기능은 토큰 값을 입력 패킷의 길이와 비교한 후 그 결과를 IP QoS 필드에 마킹 한다. 본 논문에서는 trTCM 기능을 디자인 하였고, FPGA를 이용하여 그 기능을 구현하는 방안을 언급하였다.

**Abstract** This paper addresses the design of trTCM (Two Rate Three Color Marker) described in RFC2698. It has proposed for trTCM to be used in Differentiated Service network that provides AF PHB (Assured Forwarding Per Hop Behavior). trTCM is the marker with the metering function, and consists of the token updating function and the marking function. The token updating function uses the dual token bucket. The marking function compares the token values with the length of input packet and then marks the result into IP QoS field (ToS field). In this paper, we design trTCM function and then addresses the scheme to implement it using FPGA technology.

**Key Words** : TCM, PHB, QoS, IP, Marker

#### I. Introduction

These days, as new application services requiring QoS guarantee, such VoIP, VPN, and so on in Internet, has appeared. So IP QoS problems has become one of the most important issues. Delay time, delay variation (jitter), and loss of packet in Internet can be the requirement according to diverse services. But As Internet is based on only best effort service that treats

all packets in same method, it cannot guarantee the requirement for delay, delay variation, and loss according to service. Therefore, a new service model unlike best-effort service model has been appeared to guarantee QoS in Internet.

In IP network, to use the network resources efficiently and provide all users with the diverse QoS, the traffic condition function is needed at network edge. The traffic conditioner consists of the four elements, such a meter, a marker, a shaper and a dropper. It need not have all four elements according to the requirement of DS node and service. In RFC 2698, the traffic

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conditioner trTCM for DS network consists of marker and meter<sup>3[4]</sup>.

In trTCM, the meter measures the instantaneous characteristics of selected packet according to the traffic profile specified in TCA (Traffic Conditioning Agreement), and then passes the packet and the metering results to marker. The marker marks the packet into green, yellow, and red according to the metering results. It can mark in-profile or out-profile for the selected packet by setting DS field of packet into specific codepoint value.

In this paper, we have designed trTCM proposed in RFC2698 for implementing its function using FPGA and its related technology. This paper consists of following: Chapter 2 addressed marking scheme in DS network. Chapter 3 addressed trTCM architecture, token updating algorithm, and marking algorithm. Chapter 4 addresses the implementation scheme of trTCM using FPGA and its related technology, and simulation results. And in chapter 5, we addresses the conclusion.

## II. Marking Scheme in DS Network

In DS network, Marker in traffic conditioner marks the standardized DS byte of the packet such that it receives a particular forwarding treatment, or PHB (Per-Hop Behavior), at each network node. After a service is defined, a PHB is specified on all a PHodes of the network offering this service, and DSCP(Differentiated Service Ce CePoint) is assigned to the PHB. PHB is an externally observable forwarding behavior given by a network node to all packets carrying a specific DSCP value. assDS Networkhavbesides the existing BE (Best-Effort) service, there are two others kind of service, AF(Assured Forwarding) service and EF(Expedited Forwarding) service. IETF(Internet Engineering Task Force) has addressed the difference between Best-Effort service and two services using the specific

byte in IP header.

In IPv4, packets have always contained a Type of Service (ToS) byte to allow simple, per-hop packet classification. Fig 1 shows the ToS and DSCP format. In ToS format in left side, the lower 3 bits present the packet's precedence, the upper 4 bits present the desired type of routing metric information, and the last bit is set to zero for reserved use. DS (Differentiated Service) field shown in right side of Fig 1 has replaced these functions. DSCP (DS Code Point) is an extension to 3bits used by IP precedence. Like IP precedence, DSCP can be used to provide differential treatment to the appropriately marked packets. DSCP field is part of the IP header, similar to IP precedence. In fact, the DSCP field is a superset of the IP precedence field. In right side of Figure, Two bits are currently unused and set to zero. Six bits (bit 0~5) is used as DS Code-Point. DSCP defines the service type of packet within network and its treatment within routers. DSCP consists of three code point spaces. One is for standards and the other two are for experimental or local use.

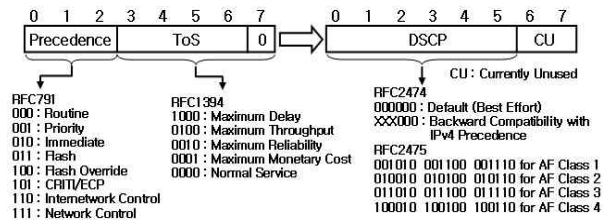


Fig. 1. ToS and DSCP Format

In case of the AF PHB, the color can be coded as the drop precedence of the packet. AF codepoint value is recommended in RFC2597 as shown in Tab 1. It defines four AF traffic classes, with each service class having three-drop precedence levels. Each AF traffic class is services in its own queue, enabling independent capacity management like WFQ(Weighted Fair Queuing) for the four traffic classes. Within each AF class, there are three-drop precedence levels having queue management like RED(Random Early Detection). AF codepoint has 6 bits in xxxyyy, where xxx presents

class and yyy presents drop precedence level.

Table 1. AF Codepoint and Their Color Code [9][10]

Dropping Precedence	Class1	Class2	Class3	Class4	Color
LOW	001010	010010	011010	100010	Green
Medium	001100	010100	011100	100100	Yellow
High	001110	010110	011110	100110	Red

### III. trTCM Architecture and Algorithm

Fig 2 shows trTCM architecture described in RFC2698. The trTCM consists of meter and marker functions. The trTCM is configured by setting its mode and assigning values to four traffic parameters, such as PIR, PBS, CIR, and CBS. Meter consists of two token buckets, C and P with token generation rates CIR and PIR, respectively. PIR and CIR are measured in bytes of IP packets per second, i.e., it includes the IP header, but not link specific headers. PIR must be equal to or greater than the CIR. The maximum size of the token bucket P is PBS and the maximum size of the token bucket C is CBS. PBS and CBS and are measured in bytes.

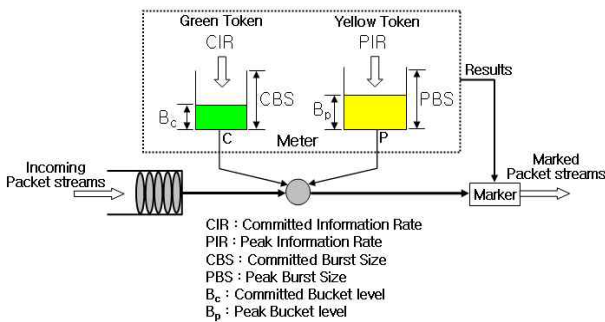


Fig. 2. trTCM architecture

trTCM consists of meter and marker. The meter receives the parameters from classifier and compares it with reference value, and then sends the metering result to marker. Meter operates in one of two modes, such as color-blind mode and color-aware mode.

Fig 3 shows the token bucket update algorithm of

meter in trTCM. Initially, the levels of two buckets, B<sub>c</sub> and B<sub>p</sub>, are assigned to B<sub>c</sub>(0)=CBS and B<sub>p</sub>(0)=PBS respectively. The updated value (B<sub>c</sub> + CIR\*S) of committed bucket level is compared with CBS. If the updated value is less than CBS, marker marks this packet with green, and then updates committed bucket level(B<sub>c</sub>). If the updated value is greater than CBS, the updated value (B<sub>p</sub> + PIR\*S) of peak bucket level is compared with PBS. If the updated value in B<sub>p</sub> is less than PBS, marker marks this packet with yellow, and then updates peak bucket level(B<sub>p</sub>). If the updated value in B<sub>p</sub> is greater than PBS, marker marks DS field with red.

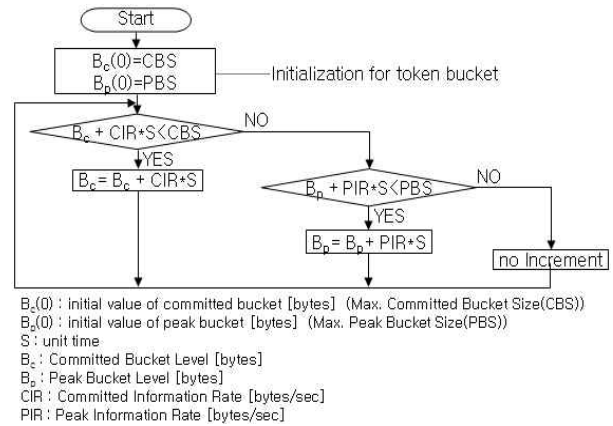


Fig. 3. Updating Algorithm for token bucket

Tab 2 shows these algorithm in two mode, such as color blind mode and color award mode. The meter operates in one of two modes: color-blind mode and color-aware mode. In color-blind mode, the meter assumes that the incoming packet stream is uncolored. Therefore, the traffic conditioner does not check or reflect the color of the incoming packets in metering and marking process. In this mode, all packets are processed in the same method. This mode applied to mainly edge system. In the color-aware mode, the meter assumes that the incoming packet stream has been pre-marked as green, yellow, or red. In this mode, the packet is additionally processed through the different methods based on its color. color-aware mode applied to mainly core system.

Table 2. Color Mode Algorithm in trTCM

Color-Blind Mode	Color-Award Mode
if L <= Bc then packet is marked green Bc = Bc - L; else if L <= Bp then packet is marked yellow Bp=Bp-L; else packet is marked red end if; end if;	if((L<=Bc) and (green)) then packet if marked green Bc=Bc-L; else if((L<=Bp) and (green or yellow)) then packet is marked yellow Bp=Bp-L; else packet is red end if; end if;

### IV. trTCM Design and Simulation

Fig 4 shows trTCM overall block diagram for implementing its function using VHDL and FPGA. This block diagram has a CPU interface, Tx/Rx MII, decoder block, bucket block, meter block, token generation block having two token generation rate. CPU interface assigns the initial values of trTCM, such as CIR, CBS, PIR, PBS, unit time, and clock speed. Two queues are FIFO buffers for input and output respectively. trTCM function has two MII interfaces to connect a device with a standard interface, such as an Ethernet switch chip.

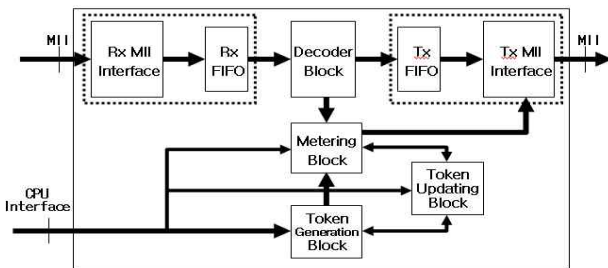


Fig. 4. Overall Block Diagram of trTCM

Fig 5 shows the Tx\_MII transmit packet process. This operation has thirty one states, that are S0~S30. In S0, this operation checks transmit trigger. In state S1, this block checks packet drop. If there is drop signal and FIFO has read enable signal, it will be changed to state S22. If FIFO does not have read enable signal, it can be changed to next state S2. State S2 bypass the packet. If there is packet pass signal, it would be changed to state S17. In another case, this

block is changed to state S3. This block checks packet tag and untag type and then is changed to next state S4. This block start to transmit the packet.

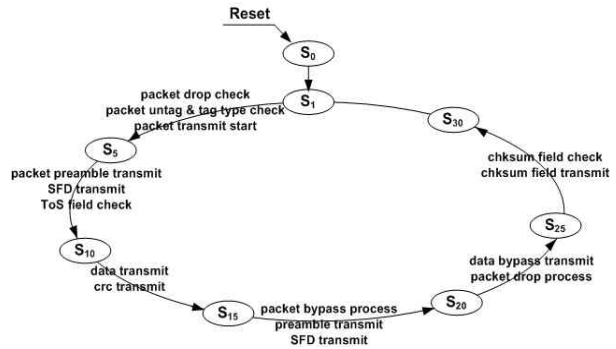


Fig. 5. Tx\_MII State Diagram

Fig 6 shows simulation result of Tx\_MII. The Tx\_PHY\_MII uses CRC generation function(eth\_crc\_gen). The input has to be asserted as active high to indicate that TXD is valid and is clocked at rising edges of Tx\_CLK. The Tx\_MII inputs are rstn, txclk, tx\_fifo\_rdat, tx\_fifo\_empty, pkt\_tx\_trig, pkt\_tx\_tos, pkt\_tx\_chksum and pkt\_tx\_type. The output values are txd and txen. This figure shows Tx\_MII signals meets MII standard.

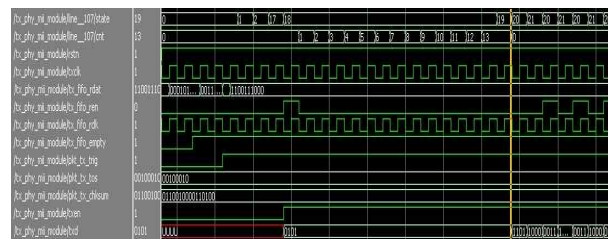


Fig. 6. Simulation result of Tx\_MII

Fig 7 shows the Rx\_MII state transition diagram. This operation has ten states, that are S0~S9. In state S0, Rx\_MII is ready to receive the packet. When Rx\_MII receives the incoming data at Rx\_DV=1, it does not change state. But it can be changed to the next state when Rx\_DV is equal to low level. State S1 also checks whether the incoming data is valid or not. It is changed to the next state when the incoming data is valid. In state S2, this block checks whether Rx FIFO

signal is full or not. If it is full signal( $fifo\_full\_sig=1$ ), it will be changed to state S0. If it is not full signal ( $fifo\_full\_sig=0$ ), it can be changed to the next state S3. On other hand, Rx\_MII checks the pream Ie field of Ethernet frame in S0~S3. In state S3, SFD field is examined to find frame ate S. After finding SFD field, it will process Ethernet frame from deatination address. State S4 coedinius t thid. In smnb Ie data RXD[3:0] and checks ate S2p ied '01'(fifowdat\_sig(9 dowed t8)<=ate S\_p ied). State S5 further tid. In ssnnb Ie data RXD[3:0]. The State S6tchecks whether incoming data is valid or not. it will be changed to state S7 when incoming data is valid ( $Rx\_DV=1$ ). The State S7 is changed to state S6 when FIFO write enable signal is active( $fifo\_wen\_sig<=1$ ). In state S8, this block receives end field of frame( $fifowdat\_sig(9\ downto\ 8)<=end\_point$ ) and active FIFO write enable signal( $fifo\_wen\_sig<=1$ ), and then changed to state S9. In state S9, if FIFO write enable signal is not active, it will be changed to state S0.

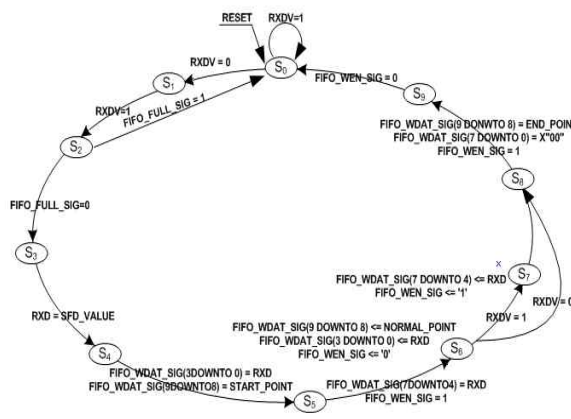


Fig. 7. Rx\_MII State Transition diagram

Fig 8 shows simulation result of Rx\_MII block of trTCM. This result shows the start of Ethernet frame. Input signals are rest, MII Rx signals(rxclk, rxdv, rxd), FIFO read enable, and FIFO clock signal. This shows normal Rx\_MII interface operation.

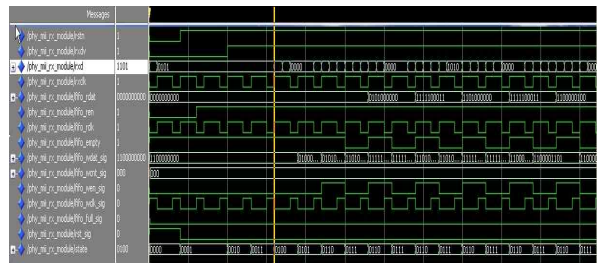


Fig. 8. Simulation result of Rx\_MII

Fig 9 shows state diagram of decoding block. There are seven states in this operation. State S0 checks whether receive FIFO is empty or not. S0 continue to be in S0 if there is not read enable signal when receive FIFO empty signal is not active. if read enable signal is active when receive FIFO is not empty, state S0 will be changed to state S1. In state S1, this block starts to send frame. if write enable signal is active in receive FIFO, state S1 will be changed to state S2. Otherwise, state S1 will be changed to state S0. state S2 will be changed to state S3 when trigger signal is generated and read enable signal is active in receive FIFO. state S3 checks the end of frame, and then it changed to state S4. state S4 checks packet error. If there are packet errors in state S4, state S4 will changed to state S5. state S5 will be changed to state S6 when  $pkt\_trig\_force\_sig$  is active.

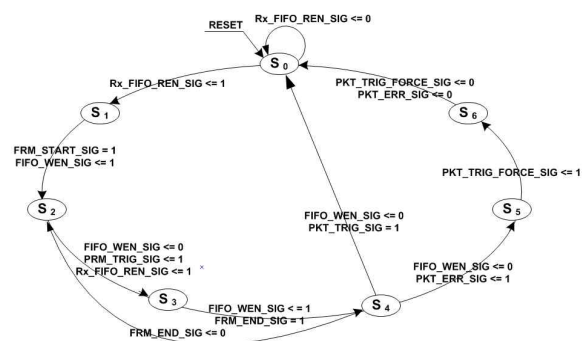


Fig. 9. Decoding Operation State

Fig 10 shows the main operation state of metering block in trTCM. There are five states in this operation. In state S0, this block checks whether there are incoming packets. State S0 will be changed to state S1



when if are incoming packet(pkt\_rx\_trig\_clr\_sig=1). State S1 passes the incoming packet without any condition and then will be changed to state S2. State S2 checks packet delay. state S2 will be changed to state S3 when count value is equal to 4. Otherwise, state S3 continue to be in state S3 until it become 4. State S3 checks the update request signal for Bc and Bp. state S3 will be changed to state S4 when count value becomes 0 and packet transmit trigger signal become active. State S4 will be changed to S0 when bucket update request signals (Bc\_update\_req\_sig, Bp\_update\_req\_sig) and packet transmit trigger signal (pkt\_tx\_trig\_sig) are not active.

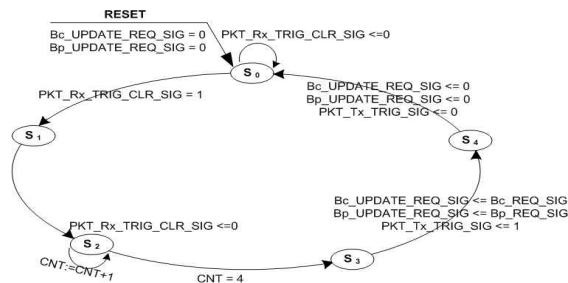
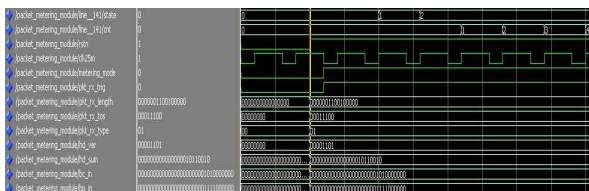
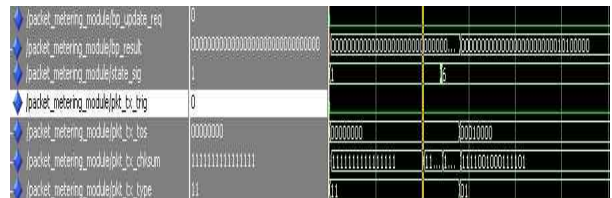


Fig. 10. Metering Operation State

Fig 11 shows simulation result of metering block. This simulation uses color blind mode in configuration of metering mode. It receives each field in IP header from decoder block. The meter input values are set as follows : packet length=100kbytes, metering mode=1, Bc=80bytes and Bp=120bytes. Input and output values are presented on Fig 4-13 (a) and (b) respectively. It is marked yellow color. Bp value updated ((L < Bp) yes Bp = Bp - L) will be 20kbytes.



a) Input data



b) Output data

Fig. 11. Simulation result of Metering Block

Fig 12 shows the token update operation for trTCM. There are four states in this operation.

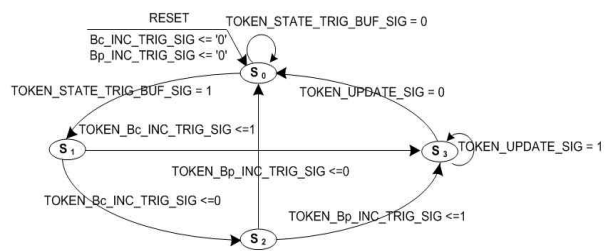


Fig. 12. Token Operation of trTCM

In state S0, this block checks the trigger signal for the token bucket. if there is the trigger signal, state S0 will be changed to state S1. State S1 checks the trigger signal to increase token bucket level Bc. if there is the trigger signal, this state will be changed to S3 to update token bucket level Bc. Otherwise, state S1 will be changed to S2. State S2 checks the trigger signal to increase token bucket level Bp. if there is the trigger signal, this state will be changed to S3 to update token bucket level Bp. Otherwise, state S2 will be changed to S0. Therefore, this block generates the trigger signal to update token bucket Bc or Bp and then sends the signal and the token value for Bc and Bp to the bucket date block.

Fig 13 shows simulation results of token update block. The input parameters of this block are entered by CPU. These initializes trTCM function through parameters, such as CIR, CBS, PIR, PBS, S, Bc and Bp. For simulation, The token update prameters are set as follows : CIR =500kbps, PIR=600kbps, S=1sec, CBS=1000bytes, PBS=2000bytes, Bc=600bytes, Bp=800bytes. Fig 13 (00bshows the oes, PBS=20 of token update



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