

Congestion Avoidance with Random Early Detection in Packet Switching Gateways : A Generic Simple Simulator

by

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0. Introduction

In this small project aiming to introduce and make short investigation on one of the most efficient congestion algorithm called Random Early Detection (RED) in packet switching networks. I have found this type of queuing strategy while working in the Internet Service Provider [0] to reduce effects of high load in the high end router, in Cisco Systems web site and I found some supporting articles [1] to realize this small term project.

Briefly, basic constituent of communication in computer networks is packets. And to carry (route) those packets over different networks we need gateways, which are nothing but an end point in the graph which regulates and forwards packets between source and destination networks. Using simple queuing for arriving packets into gateway such as first in first out (FIFO) may not be convenient for busy networks that have a congestions or high traffic load, at least for the packet switching purposes.

Written code is based on the paper [1], and an improvement is simulation code can handle arbitrary number of hosts that max packet rate pre-determined in an input file for a particular host.

1. Congestion Avoidance Algorithm

Algorithm given in [1] has been implemented in C with improvements in generic manner. For the sake of simplicity only packet rated per second for hosts that connected to the gateway considered. Here is the modified-algorithm that is implemented in a simple C code;

```

Read in Network packet rates
Loop time steps
    Randomly decide which hosts are sending packets
    initialization
        avg =0
        count=1
    for each packet arrival
        if avg != 0
             $avg = (1-wq)avg + wq q$ 
        else
             $m = t - q\_t$ 
             $avg = (1-wq)^m avg$ 
        end if
        keep tract of avg
    if minth <= avg < maxth
        count ++
         $pb = \max p (avg - minth) / (maxth - minth)$ 
         $pa = pb / (1 - count pb)$ 
        with pa
            drop the arriving packet
            keep track of drops
            count=0
    else if maxth <= avg

```

```

                                drop the arriving packet
                                count=0
else
                                count=-1
if q= =0
                                q_time=time

```

Description of symbols;

```

avg= average queue size
q_time=start of the queue idle time
count=packet since last dropped packet
wq= queue weight
minth=minimum threshold for queue
maxth=maximum threshold for queue
maxp=maximum value for pb
pa= current packet marking probability
q=current queue size
time=current time

```

2.Simulation Code

Simulation code has been written in ANSI C using gcc compiler on XP. Complete code is given in 2.1. Input file “network.ntw” contains a column which the first number indicated number of host connected to this gateway, rest of the numbers are packet rates of each host per second. Output files are “traffic.ntw”, “hostdrops.ntw” and “queues.ntw”. Output file traffic.ntw : contains columns at which time hosts sends packets which is randomly determined during simulation. Hostdrops file gives information that at what times packets are drop from a particular host. And finally queues file gives time evolution of average queue size and the actual queue size.

2.1 Complete Code

```

/*
Simple generic RED gateway simulator
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(c) 2005
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*/
#include <stdlib.h>
#include <stdio.h>

/* Prototypes */
/*****
int main();
void get_randoms(int *numbers, int upper);
void get_bin_randoms(int *numbers2, int upper);
int read_network(int *hostrate);
*****/

```

```

int main()
{
    FILE *fp1,*fp2,*fp3;
    int
i,j,q,numhost,count,minth,maxth,time,simtime,m,qtime,*q_time;
    int *nran,*nran2,*hostrate,**hostdrops,zero,rcount;
    char line1[90];
    double wq,avg,maxp,pa,pb,*avg_time;
    zero=0;
    numhost=0;
    simtime=100;
    wq=0.002;
    minth=5;
    maxth=15;
    maxp=0.02;
    printf(" \n");
    printf("                Simple genericRED gateway simulator
\n");
    printf(" \n");
    hostrate=(int *) malloc(sizeof(int));
    numhost=read_network(hostrate);
    avg_time=(double *) malloc(simtime*sizeof(double));
    q_time=(int *) malloc(simtime*sizeof(int));
    nran=(int *) malloc((simtime+1)*(numhost+1)*sizeof(int));
    nran2=(int *) malloc((numhost+1)*sizeof(int));
    hostdrops=(int **) malloc((simtime+3)*sizeof(int));
    for(i=0;i<=simtime;i++){
        hostdrops[i]=(int *) malloc((numhost+3)*sizeof(int));
    }
    for(i=1;i<=numhost;i++) {
        printf("%d th hostrate = %d packets/second
\n",i,hostrate[i]);
    }

    /* initilize hostdrops and avg_time */
    for(time=0; time <= simtime; time++) {
        avg_time[time]=0;
        for(i=0;i<=numhost;i++) {
            hostdrops[time][i]=0;
        }
    }
    /* core RED algorithm */
    avg=0;
    count=-1;
    qtime=0;
    fp3=fopen("traffic.ntw","w");
    /* Find current queue size or hosts sending packet
*/
    rcount=0;
    /* randomly pick which hosts are sending packets*/
    get_bin_randoms(nran,(numhost+1)*(simtime+1));
    for(time=1;time<=simtime; time++) {
        q=0;
        sprintf(line1,"%d ",time);
        for(i=1;i<=numhost;i++) {
            nran2[i]=nran[rcount];

```

```

        /* printf("count nran2=%d\n",nran2[i]); */
        if(nran[rcount] == 1) {
            q=q+hostrate[i];
            sprintf(line1,"%s%d ",line1,hostrate[i]);
        } else {
            sprintf(line1,"%s%d ",line1,zero);
        }
        rcount++;
    }
    fprintf(fp3,"%s\n",line1);
    q_time[time]=q;
    /* loop over each host sending packet */
    for(i=1;i<=numhost;i++) {
        /* printf("here nran2=%d\n",nran2[i]); */
        if(nran2[i] == 1) {
            for(j=1;j<=hostrate[i];j++) {
                if(q != 0) {
                    avg=(1-wq)*avg+wq*q;
                    avg_time[time]=avg;
                } else {
                    m=time-qtime;
                    avg=pow((1-wq),m)*avg;
                    avg_time[time]=avg;
                }
            }
            if(minth <= avg && avg < maxth ) {
                count++;
                pb=maxp*(avg-minth)/(maxth-
minth);

                pa=pb/(1-count*pb);
                if(pa >= 0.015) {
                    hostdrops[time][i]++;
                    count=0;
                }
            }
            if(maxth <= avg) {
                hostdrops[time][i]++;
                count=0;
            } else {
                count=-1;
            }
            if(q ==0) {
                qtime=time;
            }
        }
    }
}

}

close(fp3);
/* Report Host Drops */
fp1=fopen("hostdrops.ntw","w");
for(time=1; time < simtime; time++) {
    sprintf(line1,"%5d",time);
    for(i=1;i<=numhost;i++) {
        sprintf(line1,"%s %5d",line1,hostdrops[time][i]);
    }
    fprintf(fp1,"%s\n",line1);
}

```

```

    }
    close(fp1);
    /* Report average and current queue size */
    fp2=fopen("queues.ntw","w");
    for(time=1; time <= simtime; time++) {
        fprintf(fp2,"%d  %f  %d\n",time,avg_time[time],q_time
[time]);
        /* printf("time=%d avg_time=%f\n",time,avg_time[time]);
*/
    }
    close(fp2);
    /* Free Dynamic Arrays */
    free(nran);
    free(hostrate);
    free(hostdrops);
    free(avg_time);
    free(q_time);
    exit(0);
}

/*****
RED simulator  Functions
*****/
/* Get random sequence over upper*/
void get_randoms(int *numbers, int upper) {
    int i,where;
    srand( (unsigned int)time( NULL ) );
    for(i =upper-1; i > 0; i -= 1 ){
        numbers[i] = rand() % i;
        /* printf("numbers=%d i=%d \n",numbers[i],i);*/
    }
}

/* Get random sequence of 1s and 0s of uppers*/
void get_bin_randoms(int *numbers2, int upper) {
    int i,where;
    srand( (unsigned int)time( NULL ) );
    for(i =0; i < upper; i++ ){
        where=rand();
        /* printf("where = %d\n",where) */;
        numbers2[i] = where % 2;
    }
}

/* Read Network Data */
/* First line number of hosts */
/* other lines packets/sec perline */
int read_network(int *hostrate) {
    FILE *fp;
    int i,numhost;
    char line[4];
    fp=fopen("network.ntw","r");
    i=0;
    while(!feof(fp)) {
        if(i == 0) {
            fscanf(fp,"%s",line);
            realloc(hostrate,2*sizeof(int));
            sscanf(line,"%d",&numhost);
            /* printf("numhost=%d \n",numhost); */

```

```

    } else {
        fscanf(fp, "%s", line);
        realloc(hostrate, sizeof(int)+i*sizeof(int));
        sscanf(line, "%d", &hostrate[i]);
    }
    i++;
}
if(numhost >= i) {
    printf("missing host in network.ntw  \n");
    exit(0);
}
close(fp);
return numhost;
}

```

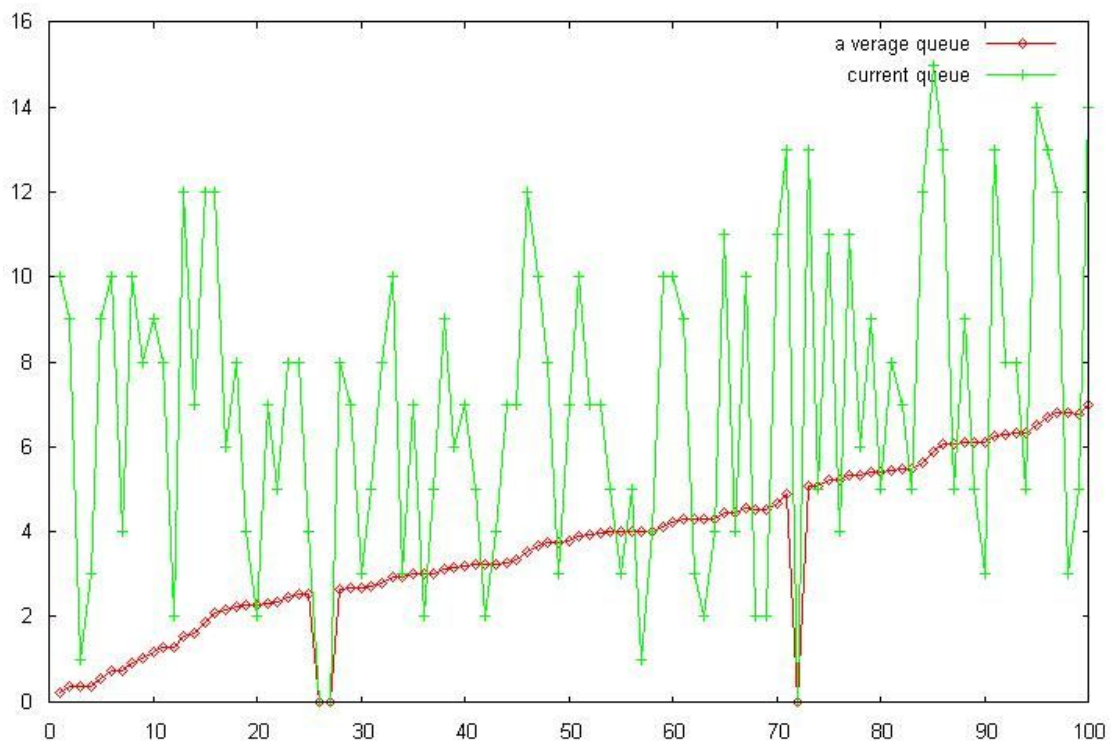
3. Investigation & Simulated Network

According to reference [1] some fixed parameters are used as follows; $wq=0.002$, $minh=5$, $maxh=15$ and $maxp=1/50$. There was 6 hosts in these simulations and three different states. At low, mid-range and busy traffic compare to maximum average queue size limit given above as $maxh$. Output files and other relevant files are given in the CD

With this report. [4]

3.1 Low Traffic

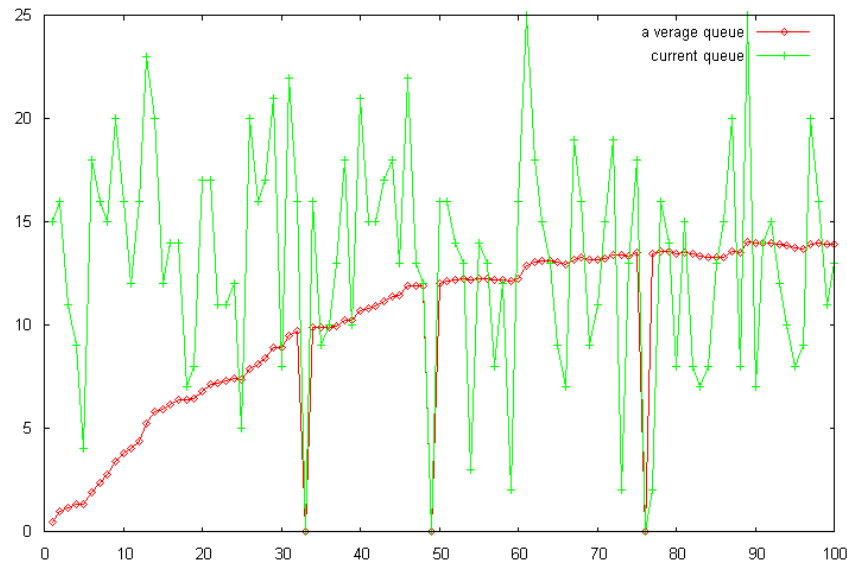
Hostrates used here are 2,5,3,2,2,1 packets per second for 6 hosts. After simulating 100 time step. Queues appear like this;



Current queue size fluctuates between 1 to 15 packets which is in the range. There is no host drops for this configuration. Average queue size is saturated around 8 packets/sec.

3.2 Mid-Range Traffic

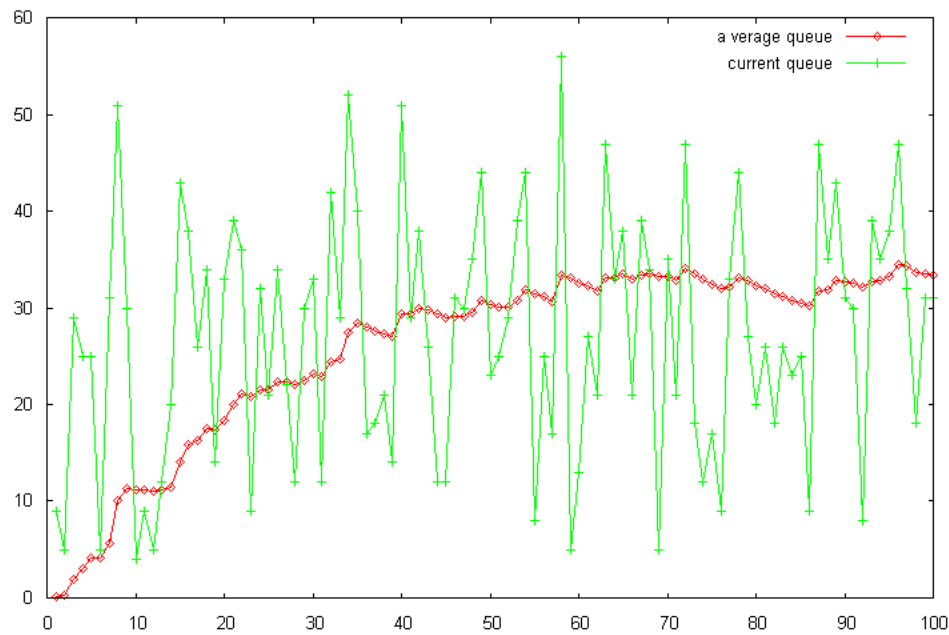
Hostrates used here are 5,7,3,6,2,4 packets per second for 6 hosts. After simulating 100 time step. Queues appear like this;



Current queue size fluctuates between 1 to 25 packets which is sometimes higher than the maximum threshold which leads to some drops. Average queue size is saturated around 13 packets/sec.

3.3. Busy Traffic

Hostrates used here are 12,9,4,8,5,18 packets per second for 6 hosts. After simulating 100 time step. Queues appear like this;



Current queue size fluctuates between 4 to 55 packets which is quite higher than the maximum threshold which leads to extreme drops. Average queue size is saturated around 30 packets/sec.

4. Discussions

Investigation of RED strategy for the congested gateways demonstrates a probabilistic drops based on average queue size leads to more fair traffic distribution and avoids congestion on the gateway. A simple simulator designed and implemented from a very general description of the algorithm given in [1]. Traffic originating from hosts connected to gateway randomly picked to generate traffic in a given rate.

Results shown that even

for the high traffic RED algorithm regulates average queue size around the certain value

which implies a saturation. An improvement of the RED which called weighted RED is a bit more complicated and needs more elaborate and detailed work.

References

- [0] Kibris.Net Internet Services, Nicosia, Cyprus
- [1] Sally Floyd, Van Jacobson August 1993 IEEE/ACM Transactions in Networking
- [2] Andrew S. Tanenbaum, Computer Networks, 3rd Edition Prentice-Hall
- [3] C Programming Language, Dennis Ritchie and Brian W. Kernighan
- [4] CD contains this document, outputs of test examples, source code, compiled binary and the reference [1]