# Effect of Context Transfer during Handoff on Flow Marking in a DiffServ Edge Router

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## ABSTRACT

*When a mobile node moves and changes its connectivity from one RER to another, the new RER does not have the context unless it is transferred from the old RER. We conducted a study considering a diffserv domain where RERs run TSW scheme to meter the flows and mark the packets. In this paper we present the results of this study, which shows that by transferring the estimated average bandwidth during handoff marking of packets reach stability quickly. If the context is not transferred, then the marking at the new RER takes a while to reach stability. The instability period is proportional to the window size setting. The initialization of window size limits the context transfer latency.*

**Keywords:** Wireless, Mobility, Context transfer, QoS, DiffServ, TSW marking

## 1 INTRODUCTION

In a wireless access network an edge router connected to one or more base stations, called Radio Edge Router (RER), provides connectivity to a mobile node. The RER that provides connectivity to the mobile builds contexts for the flows communicated between the mobile and the correspondent nodes (CN). A correspondent node is a node that communicates with the mobile. When a mobile node moves from one RER to another, then the new RER lacks the context maintained by the previous RER. The context needs to be transferred to new RER to provide same services to the mobile node [1].

In a DiffServ domain an edge router performs MF classification [3] and maintains per flow profile. The profile contains metering information. For example, in case of Time Sliding Window based marking scheme [8], the flow profile keeps the average bandwidth estimate, i.e. the diffserv context. Figure 1 illustrates the situation when a mobile node moves from one RER to another.

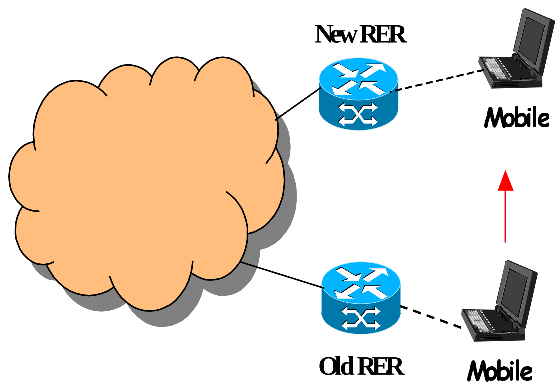


Figure 1: Mobile Node mobility from old to new RER

There are two possible choices to deal with the problem of transferring diffserv context.

1. The new RER builds the flow profile from scratch. For example, the new RER computes the average bandwidth estimate afresh.

2. Alternatively, during handoff (transfer of mobile node from one RER to another) the flow profile may also be transferred to the new RER.

Our objective is to study the benefit of context transfer during handoff. Let *HL* be the time taken by a mobile node to move from one RER to another, called handoff latency. We want to understand what are the benefits of transferring context and what is the window of opportunity, that is what is the time period after which the benefits diminish. Furthermore, what are the factors determining the window of opportunity. It is important to know the window of opportunity as it constrains the context transfer latency, and also in a way affect the handoff latency.

We need to first define a performance metric. One possible metric we used in this paper is the number of packets that are colored green, yellow, and red. For example, we gather the statistics of the packets that are marked green, yellow, or red in both cases in some intervals, and compare the results. In this paper we are reporting results only for the Time Sliding Window metering/marking scheme (RFC 2859) [8]. We also derive the window of opportunity by studying the effect of window size of the stability of estimating average bandwidth.

# 2 TREATMENT OF TRAFFIC ENTERING A NETWORK

In this section, we take a look at the treatment of traffic as it enters a network. The Diffserv architecture is introduced and various traffic marking schemes are considered.

## 2.1 DiffServ

Treatment of various types of traffic in the Internet affects the QoS (Quality of Service) offered to different network applications. Diffserv (Differentiated Services) has been developed as a way to distinguish different traffic types and offer the most suitable service to each stream [2,3,4]. With the deployment of Diffserv in intervening routers and subnet, it has become possible for the users to label their traffic streams for faster forwarding. When the users connect to the Diffserv enabled network, they are able to choose the type of service desired and they are charged accordingly. EF (Expedited Forwarding) is the most expensive "premium" service available under Diffserv. Other services include AF (Assured Forwarding) and DF (traditional Best Effort or Default Forwarding). Diffserv enabled routers typically use class based queuing to offer differentiated services to Diffserv coded traffic. For example, a Diffserv enabled router expedites the EF (Expedited Forwarding) labeled packets and discards DF (Default Forwarding) packets in case of congestion.

In order to avoid any unforeseen congestion, the users have to agree to a traffic profile before using a Diffserv domain. When the traffic enters a Diffserv domain, it may be monitored, marked and shaped at the ingress node. The purpose of marking and shaping at the ingress node is to make sure that the user is not violating the agreed profile. Some of the important parameters of agreed profile include the committed rate and allowed peak rate. Since some flows may be misbehaving and violating agreed profile, it is important to enforce the policing (metering and marking) and shaping (smoothing the bursts over time) mechanisms at the ingress node. Several algorithms have been proposed for metering and marking the user traffic streams [6,7,8]. The purpose of marking is to indicate whether the current packet violates the profile or not. Three color marking is considered sufficient with green indicating a good packet, yellow showing a packet that has exceeded committed profile but falls within the peak rate and red showing a violation. Colors are coded using the drop precedence of the AF (assured forwarding) class [5].

## 2.2 Time Sliding Window Metering And Marking

The Time Sliding Window Three-Color Marker (tswTCM) is designed to mark packets of an IP traffic stream with red, yellow or green color [8]. The marking is performed using the estimated average rate as compared against the Committed Target Rate (CTR) and the Peak Target Rate (PTR). The computation of estimated rate is based on a time window in order to take into account the recent behavior of the stream. Packets that confirm to CTR are marked green. Packets that exceed CTR but do not exceed PTR are marked yellow and packets contributing to the portion of the rate above PTR are marked red. The tswTCM has been primarily designed for traffic streams that will be forwarded based on the AF PHB in core routers [8].

## 2.3 Mobile Computing Requirements

Mobile computing is an integral part of the targeted ubiquitous computing environment. Third generation wireless systems and the Internet are considered two main drivers behind the mobile telecommunications [9]. Mobile users would like to move around and still maintain active communication links. There is a growing need to provide quality of service to the mobile users based on an increase in the number of time-sensitive applications. Significant amount of work has been done to deal with the issue of providing multimedia services in the mobile wireless network [10,11,12]. If a mobile node connects to a Diffserv domain, it is subjected to the same policing and shaping as done for the static nodes. If this node transfers over from one radio edge router to another, while maintaining connection to the same correspondent node, the service offered to this mobile may go through a transitory change. In this paper, the problem of transferring diffserv context during handoff has been investigated and various scenarios are simulated to determine the benefit and the window of opportunity of transferring the context information.

## 3 EXPERIMENTAL SETUP

Figure 2 shows the experimental setup we used for this study. Initially the mobile node (MN) is connected through the Radio Edge Router (RER1) to the network and communicates with the correspondent node (CN). The CN is assumed to be fixed and attached to the Edge Router (ER).

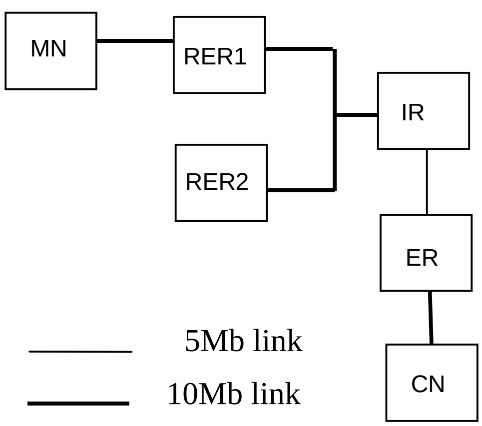


Figure 2: Experimental Setup

The mobile remains connected to RER1 for 40 seconds, and at the 40th second it moves to the coverage area of RER2. Hence, handoff takes place at the 40th second. The handoff latency (HL) is considered zero, thus there is no packet loss during handoff.

We conducted experiments with the Time Sliding Window (TSW) [8] marking scheme. Both RERs implement the same scheme. We consider a single flow of traffic from MN to CN.

CIR= 1 Mbps
PIR = 2 Mbps
AVERAGE_INTERVAL
(Window Size) = 1 second

Figure 3: Values for TSWTM

We used Nortel's DiffServ patch for ns-2 simulator for the experiments reported in this paper. In the Nortel DiffServ patch, there is a counter for each queue that records the total number of packets and how many of them are colored green, yellow, and red. Our experimental results contain the total number of packets arriving to the queue from the beginning at t = 0 until t = 40s. We computed the statistics for one second (between 40 to 41 second) by the difference of the statistics gathered until 41st and 40th second.

## 4 RESULTS

In this section we present the results of the effect of transferring the context information on packet marking. We show the packet distribution for green, yellow, and red packets for the case where the context information was transferred and the case where that is not transferred. When context information is not transferred during handoff, then the packet marking starts from initial state.

### 4.1 Time Sliding Window

A TSW meter estimates average packet arrival rate by including both the rate of newly arrived packet and the rate estimated within a window of history, as explained in Section 2.2. The context information for TSW is thus the current average estimated rate. In this section we present the results obtained by running three experiments as described below:

1. In the first experiment packet statistics are collected for three seconds at RER1 without moving the MN to RER2, hence this case shows the data without handoff. Table 1a shows the statistics during a period of 1 second from 40th to 41st second for the total

packets arrived at RER1, their breakdown into green, yellow and red packets, and also the packets dropped.

Table 1: The packet statistics at RER1 without handoff during 40th and 41st second

| 40 < t < 41 | Total Packets | TR packets | Drops |
|---|---|---|---|
| Total | 750 | 628 | 122 |
| Green | 128 | 128 | 0 |
| Yellow | 121 | 121 | 0 |
| Red | 501 | 379 | 122 |

2. In the second experiment, packet statistics are collected for three seconds at RER2 without handing over the estimated average rate computed at RER1 to RER2, hence this case shows the data without context transfer. The handoff takes place at 40th second and the handoff latency is assumed to be zero. Table 2 shows the statistics during a period of 1 second from 40th to 41st seconds for the total packets arrived at RER2, their breakdown into green, yellow and red packets, and also the packets dropped in the queue.

Table 2: Packet statistic at RER2 for duration of one second (40 < t < 41)

| 40< t < 41 | Total Packets | TR packets | Drops |
|---|---|---|---|
| Total | 746 | 565 | 181 |
| Green | 402 | 397 | 5 |
| Yellow | 217 | 168 | 49 |
| Red | 127 | 0 | 127 |

3. In the third experiment, packet statistics are collected for three seconds at RER2 with handing over the estimated average rate computed at RER1 to RER2 at 40th second (handoff time), hence this case shows the data with context transfer. The handoff takes place at 40th second and the handoff latency is assumed to be zero, context is transferred in zero time. Table 3 shows the statistics during a period of 1 second from the 40th to 41st seconds for the total packets arrived at RER2, their break down into green, yellow and red packets, and also the packets dropped in the queue.

Table 3: Packet statistic at RER2 for the duration of one second (40 < t < 41)

| 40< t < 41 | Total Packets | TR packets | Drops |
|---|---|---|---|
| Total | 746 | 590 | 156 |
| Green | 127 | 127 | 0 |
| Yellow | 129 | 129 | 0 |
| Red | 490 | 334 | 156 |

### 4.2 Analysis

Figures 4 to 6 show the packet distribution for green, yellow, and red packets that we plot by collecting statistics at the interval of 0.2 second within a period of 3 seconds from the 40th to 43rd seconds. In these figures X axis is the time represents time from 40th to 43rd second, while Y-axis shows the packet distribution for green (G), yellow (Y), and red (R) packets.

Figure 4 shows the packet distribution collected during experiment 1 (without handoff). The marking is almost stable, and it shows stability right from 40th second (starting point of the graph), because of the effect of prior estimated average rate. The red packets is roughly 100 packets every 0.2 second, the yellow packets is roughly 25 packets every 0.2 second, and the green packet is about 25 packets every 0.2 second

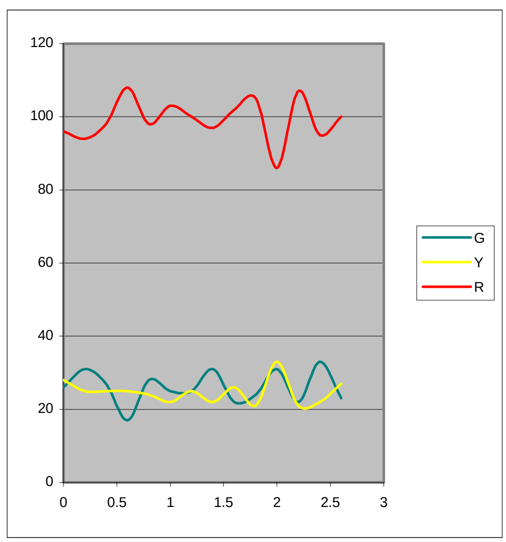


Figure 4: Marking of a flow from MN to CN at RER1 without handoff

In Figure 5 the handoff takes place at t = 40th second. In this case the estimated average rate is not transferred from RER1 to RER2 during handoff. As a result the TSW start marking the incoming traffic from the initial window setting, that is using CTR as the past estimated average rate. The average rate is updated at the arrival of each packet as described above. It takes a while for the average to reach a stable value that is reflective of the close approximation of the actual arrival rate. The instability time seems to have some correlation with the initial window setting, but these warrants further study that is discussed in Section 4.2.

As long as the average rate is less than CTR all the packets are marked green, hence we see the number of the green is high at the beginning and then tapers off later (around one second later) to its stable value. Similar patterns are shown by the distribution of yellow and red packets as well.

The graph shows that the rate estimate improves with time and consequently TSW marking reaches some sort of stability.

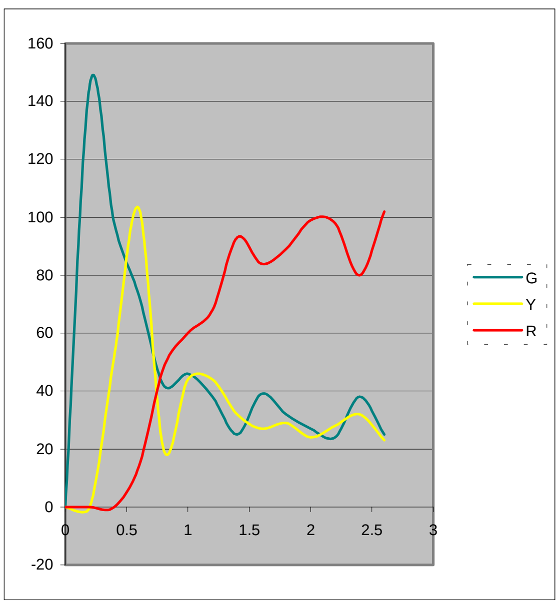


Figure 5: Marking of a flow from MN to CN at RER2 after handoff without transferring the estimated average

The packet distribution in Figure 6 shows that the marking reach stability earlier than what it takes for the experiment 2 (as shown in Figure 5). This is because the estimated average rate computed at the 40th second (handoff time) is transferred from RER1 to RER2 during handoff. This calibrates the meter at RER2 to estimate the average rate closer to accuracy.

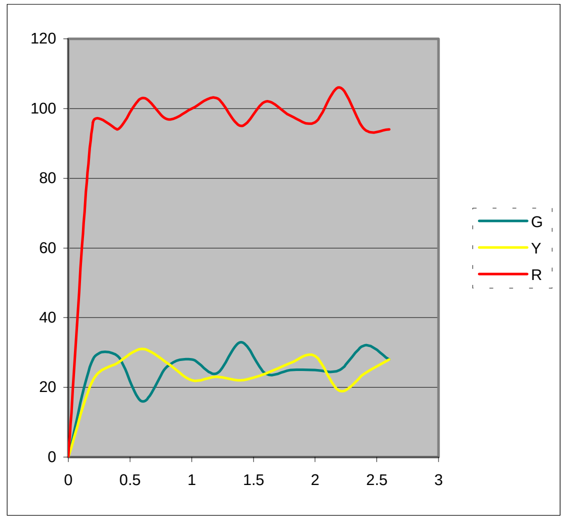


Figure 6: Marking of a flow from MN to CN at RER2 after transferring the estimated average during handoff

### 4.3 Effects of Window Size on Marking Stability for TSW

The following graphs show the effect of the window length on calculating the average rate estimate for the TSW scheme. These graphs are obtained with experiment 2 but with window size of 0.5 second and 0.1 second respectively.

It is evident from Figures 5, 7, and 8 that the instability period is proportional to the value of window size. Hence, the window size is an important parameter whose initial value has an impact on the window of opportunity. The long window size provides more time for transferring the context, but it tends to smooth out bursts for non-CBR traffic. Hence, the initial window size cannot be increased arbitrarily large to derive a longer window of opportunity and in effect relaxing the constraint on transferring the context.

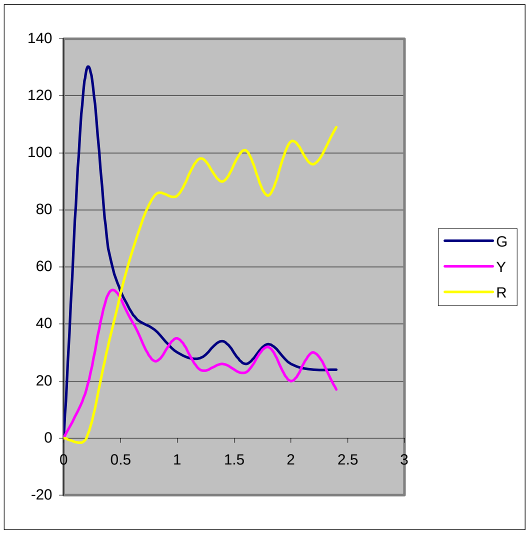


Figure 7: Marking of a flow from MN to CN at RER2 after handoff without transferring the estimated average with window size=0.5 second

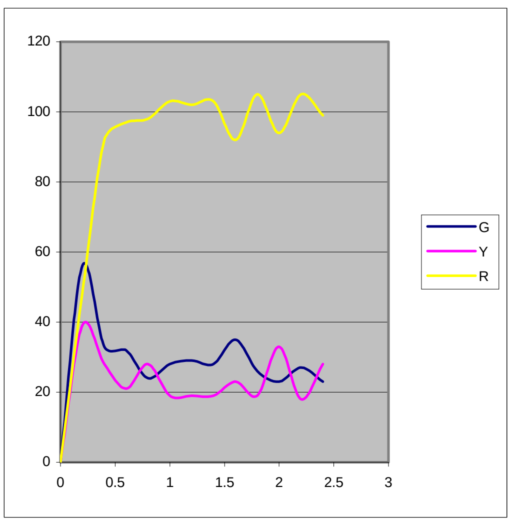


Figure 8: Marking of a flow from MN to CN at RER2 after handoff without transferring the estimated average with window size=0.1 second

## 5 CONCLUSION

When a mobile node is connected to a RER, the RER builds some QoS context related to the communication of the mobile with correspondent nodes. When the mobile moves and changes its connectivity from one RER to another, the new RER does not have that context unless it is transferred from the old RER. We conducted a study considering a diffserv domain where RERs run TSW [8] scheme to meter and mark the packets of a flow. The results indicate that by transferring the estimated average bandwidth during handoff, marking stabilizes quickly. If the context is not transferred, then the marking at the new RER takes a while to stabilize. The instability period is proportional to the window size setting. The window size needs to be initialized to a larger value to derive longer window of opportunity and hence less constraint on context transfer latency. But, it cannot be increased arbitrarily large, as it tends to smooth out bursts for non-CBR traffic.

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