Differentiated Services over Shared Media

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Abstract. The growing use of multimedia communication applications with specific bandwidth and real time delivery requirements has created the need for a new Internet in which traditional best effort datagram delivery can coexist with additional enhanced *Quality of Service* (QoS) transfers. There are many aspects in QoS control. In this article, we address the problem of the support of Expedited Forwarding over shared media. Shared media can be found in broadcast networks operating in packet mode. One problem in this environment is unsteady bandwidth. On these networks, the total bandwidth which is used depends on the offered load. In case of excess load, the total bandwidth decreases when it should be reaching its maximal value. Therefore, it is difficult to manage the bandwidth since it does not remain at the same level. In this article, we propose a distributed algorithm to manage the bandwidth efficiently and which enables QoS for a DiffServ environment.

1. Introduction

The current Internet consists of a multitude of networks built from various link layer technologies which rely on the *Internet Protocol* (IP) to interoperate. IP makes no assumption about the underlying protocol stacks and offers an unreliable, connectionless network layer service which is subject to packet loss and delay, all of which increase with the network load. Because of the lack of guarantees, the IP delivery model is referred to as best-effort. However, some applications may require a better service than the simple best effort service. It is the case for many multimedia applications which may require a fixed bandwidth, a low delay and little jitter. There are various aspects in *Quality of Service* (QoS) management. In this article, we address the problem of bandwidth allocation and guaranteed bandwidth over shared media also known as broadcast networks (e.g. an Ethernet network or a wireless LAN). The push for inclusion of wireless capabilities in laptop computers becomes unstoppable. However, bandwidth in wireless networks is still limited and it is thus necessary to manage it in order to provide a good level of QoS to the users. The work which is presented in this paper can be applied to any shared medium, but it is rather clear that wired environments do not have the same requirements since bandwidth is not limited in the same way as it is on a wireless link.

The article is organized as follows : we present related work in section 2. Then, section 3 describes and evaluates a new scheme for bandwidth management for

Differentiated Services over shared media. Finally, we conclude and describe future work in section 4.

2. Related work

2.1. QoS on shared media (Intserv)

Asynchronous shared media (like Ethernet or IEEE 802.11 for example) do not guarantee any type of quality of service. When the network load increases, the total bandwidth decreases when it should be reaching its maximal value. Moreover, it is impossible for a specific flow to have a fixed throughput since Ethernet guarantees some kind of fairness.

In the Intserv context, many works have been carried out to handle these limitations. Yavatkar, Hoffman and Bernet [9] propose a centralized architecture for subnet bandwidth management using a centralized algorithm. Their approach uses a dedicated manager per LAN and depends highly on *Resource Reservation Protocol* (RSVP) [3]. Moreover, [9] does not deal explicitly with best effort traffic related issues.

The *Controlled Load Ethernet Protocol* (CLEP) described in [2] is an implementation of the Controlled Load service over Ethernet defined by Wroclawski in [8]. It provides the client data flow with a quality of service approximating the quality of service this flow would receive on an unloaded network. This service is obtained by incorporating an access controller on the outgoing interfaces of the nodes. This allows to control the load of the broadcast network. As in *Medium Access Protocol* (MAC) layer, CLEP's bandwidth management is distributed. The mains principles used are: (1) flow control of all the streams, (2) protocol to exchange states between access controllers. Access controller is built around token bucket filters. Specific packets can be provided with a guaranteed quality of service. These packets are organized in different privileged flows. Traffic without guaranteed QoS is handled as best effort traffic. All the flows (best effort and privileged flows) use the controlled-load service to control packets admission in the Ethernet network. Packets are admitted only if there is enough bandwidth for them. CLEP provides the shared medium with the following properties:

- a steady bandwidth in overload condition,
- a guaranteed bandwidth for streams which have a reservation,
- a fair share of bandwidth for best effort streams (requires no QoS),
- an isolation of the streams which have QoS requirements

However, this solution requires some QoS signaling before transmitting any data. In some cases, bandwidth usage can be low.

2.2. DiffServ

Recently, DiffServ was proposed by the Internet community to support various services [1]. The key aspects of differentiated services concern scaling [7]:

- traffic streams are reduced to a small number of traffic aggregations. Each aggregation is identified by a single *Per-Hop Behavior* (PHB) on the routers,
- signaling and all the inherent costs are eliminated.

Differentiated services paradigm is made by an architecture which separates clearly forwarding from control. Control is executed at the edges of the DiffServ network. Control actions can be policing, shaping, marking and depend of the *Trafic Conditioning Agreement* (TCA). Apart from *Default* (DE) which handles the traffic in a best effort manner, two forwarding behaviors are defined : *Expedited Forwarding* (EF) [4] and *Assured Forwarding* (AF) [5]. The first PHB is dedicated to support a service with a strong QoS requirement about delay. The second PHB allows to use a service for which the average throughput is "guaranteed". Routers of a differentiated services network handle IP datagrams in different traffic streams and forward them using different PHBs. The PHB to be applied is based on mechanisms which process either drop or temporal priorities. These mechanisms are located on the output interfaces.

The DiffServ architecture relies on a centralized processing for each PHB. This means the total amount of bandwidth is dedicated to a single output interface. This is the case of point to point links in switched networks. But in broadcast networks, the link is multipoint i.e. access to the link is distributed. For these types of network, it raises some difficulties to apply coherent PHBs:

- the bandwidth is shared between the output interfaces of all the nodes connected to the link. Moreover, access is fair like in Ethernet networks. It is hard to assign any level of bandwidth to a particular source.
- the bandwidth is unsteady; it depends on the offered load. This is true for Ethernet networks where traffic in overload condition is inversely proportional to the offered load (cf. Figure 2)
- Distributed access prevents from scheduling all the packets like it can be done in single access.

Finally, a source on a broadcast network cannot have any QoS guarantee for any of its streams. As QoS is an end to end concept, the QoS provided to the destination node is that of the network the least efficient on the path from the source to the destination. In corporate environments, broadcast networks are mainly used in the access network to the internet. As for switched networks, it is important for this type of network to support the DiffServ architecture. This paper presents a solution to activate the deployment of DiffServ over broadcast networks. It describes a system to manage bandwidth in order to support different PHBs.

3. Bandwidth management for Diffserv over shared media

3.1. Principle

In the following, we propose a system to control bandwidth in order to support EF on a shared LAN. This system called DS-CLEP (Differentiated Services CLEP) is derived from works on CLEP but it changes by the stream management and the lack of dynamic reservation. The mains objectives are:

– manage QoS streams by aggregation at the network level,
– no dynamic signaling to avoid to manage it by applications (e.g. RSVP),
– get statistical gain in keeping the isolation between streams.

Using this scheme, a network which only has a best effort service can be integrated in a DS domain with two PHBs: DE and EF. EF means that traffic is limited. Excess traffic is dropped and no drop priorities are used. Statistical gain can be accomplished at two levels:

– locally, on each node. The extra bandwidth allocated to EF streams is used to send best effort traffic. However, the gain depends on the best effort load of the node. If it is small, the gain is small. In this article, we propose a solution which provides the nodes with a local statistical gain.
– globally, for a LAN. The extra EF bandwidth is used the best effort traffic of all the nodes. This may however have a negative impact on the EF traffic since the extra bandwidth may need a long time to be recovered when the stream needs it.

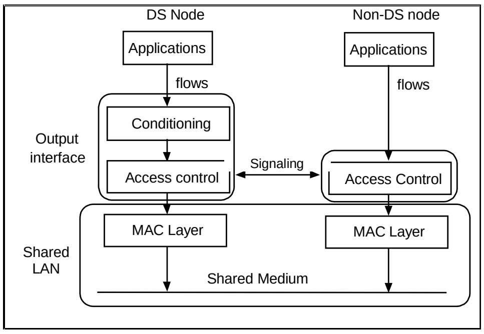

Fig. 1. Functional elements of a DiffServ network on a shared medium

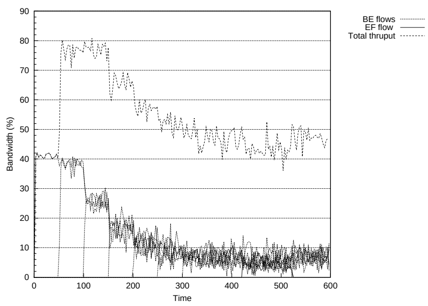

Fig. 2. Classical behavior of an Ethernet under heavy load

As shown on Figure 1, we add an access control module and a conditioning module (for DiffServ nodes only) to the traditional architecture of a node (i.e. in an architecture which does not support QoS). The conditioning module aims at marking and limiting the EF traffic as specified within a TCA. A TCA is set at the nodes by the network administrator. Without conditioning, the node cannot send any EF traffic. Actions between access controllers are synchronized with a signalling protocol which exchanges states for internal purposes and are not seen by the upper layers (e.g. IP).

3.2. Evaluation

The comparison between the different solutions are made by simulation, using NS-2 [6]. All the evaluations involve the same topology and the same scenario. The topology comprises 8 nodes out of which 7 are traffic sources and one is a traffic sink for all the flows. One of the traffic sources has two flows (a DE and an EF flow) whereas all the other sources only have a DE flow.

Each traffic source produces a DE flow at a constant bit rate of 410 kbit/s with a packet size of 512 bytes. The starting time for these flows is laid with a step of 50s.

Node 1 also benefits from a high level of QoS. A high priority flow starts at t= 420s and lasts 100s. The rate of this flow is set to 200kbit/s and the packet size is 512 bytes, as for the other best effort flows.

The network model is studied under heavy load condition. Thus, we set the link bandwidth to 1 Mbit/s. This value is very low compared to the actual bandwidth usage in the networks. The motivation is to demonstrate the algorithm behavior and a model for a high speed network changes nothing to the algorithm. In truth, the latter requires more simulation time to process the huge quantity of events produced.

The maximum flow capacity of the network is around 75% of the link bandwidth. The difference is consumed by the MAC layer like collisions resolution, interframe gap, etc. This value has been kept to indicate the available bandwidth with our management system. This scenario is played on 3 different simulations models. We measure the throughput received by the destination. Throughput is expressed as a percentage of link bandwidth.

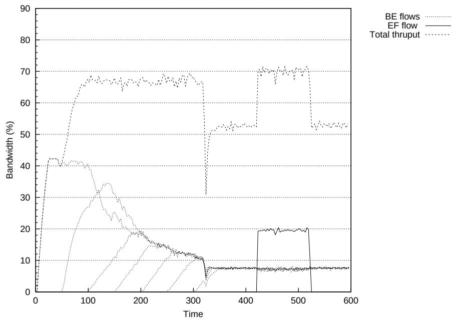

Fig. 3. Bandwidth share with CLEP

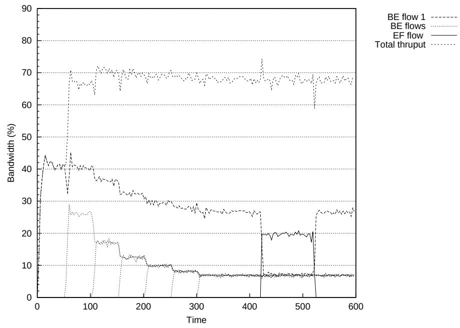

Fig. 4. Bandwidth share with DS-CLEP

The first model involves a classical Ethernet without any bandwidth management. Figure 2 shows the well-known result. In this case, no flow can have any guarantee of throughput. We can see strong variations and an overall throughput decreasing as load increases. The total used bandwidth depends on the offered load. In case of excess load, the total bandwidth decreases when it should be reaching its maximal value. In the second model, Ethernet is extended with the bandwidth management system CLEP presented in [2]. In Figure 3, the overall load increases as a more sources start using the link, but the total bandwidth usage is steady regardless of the load. However, at t=320s the total bandwidth usage decreases because an explicit reservation at 200 kbit/s is set. Until the flow starts at t= 420s, the bandwidth usage is smaller (200 kbit/s less) until the flow with required QoS starts. In a sense, the system is not work conservating, the link can be in the idle state when there are packets awaiting transmission. The second thing to see is that DE flows converge to the fair share. In the last model, we use our proposal of bandwidth management system to enable DiffServ on shared media. Recall, this system wants to be work conservating by searching to assign locally unused bandwidth of EF flows. In the model, node 1 contains a source in DE (noted flow 1 in Figure 4) and a TCA for an EF flow at 200kbit/s. In Figure 4, while the EF flow has not yet started, flow 1 gets its fair share and all the bandwidth unused by the EF flow. The total bandwidth stays nearly the same. At t=320s, the EF flow starts and flow 1 on the same node releases some bandwidth for the EF flow. When the EF flow stops, bandwidth is retrieved by the flow DE on the same node. In this system, a throughput guarantee is given to particular flows without managing any signaling overhead. Unused bandwidth reserved for a PHB is collected by DE flows on the same node.

The latter solution allows the network administrator to distribute TCAs for EF traffic between different nodes of a broadcast network without decreasing DE traffic. A source can transmit a QoS flow at any time without generating any signaling. This behavior is highly desirable in order to support a DiffServ environment.

4. Conclusion

In this proposal, we have shown a control of bandwidth of shared media can be done in a distributed manner in order to activate a deployment of DiffServ paradigm on this type of network. However, our study is made with throughput parameters. Delay and packet losses are the other important parameters which characterize QoS. This study must be extended with the analysis of these parameters.

Moreover, the algorithm can be improved by a global recovery (involving all nodes) of unused EF bandwidth. Our solution must yet be extended with the support of AF PHB i.e. permit to transmit out of profile traffic when the network is in low load condition. But the first step presented here is cheerful for the future. Although this work applies to wired networks, the scope is mainly concerning wireless networks with more limited bandwidth, which seem to have a brilliant future.

5. References

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