# Why Not RSVP over DTM ?

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**Abstract.** This paper suggests the use of the DTM technology as a solution to the transmission of applications with strict need of bandwidth, instead of the use of the traditional ATM technology. The DTM is a broadband network architecture based on synchronous fast circuit switching solution with a constant delay, perfect to the telephony network which is optimized for the characteristics of voice communication, that is, fixed-sized channels and provision of QoS real-time guarantees. Furthermore, the users require access to new services like audio, video and data which is discussed in this paper by proposing the IETF IntServ and the DTM integration supporting dynamic allocation of resources in a circuit switching network. An overview of the integration of the IntServ guaranteed service/RSVP protocol with the DTM technology on the signalling, reservation and management of the allocated bandwidth before the DTM channel establishment is presented.

## 1 Introduction

Since its first publication in 1988 the ATM technology has been seen as a good cell switching solution. Moreover it has the support of different categories of QoS (*Quality of Service*) services (CBR, rt-VBR, nrt-VBR, ABR). Actually it has been asked if the facilities offered by this technology continue to bring great advantages as a solution for real-time applications with strict needs of throughput, delay, jitter, etc. The inefficiency of the 5 bytes of cell overhead and 4 bytes of the AAL3/4 overhead (SN/MID parameters) results in a maximum use of 91% for ATM when the traffic is not varied. Furthermore, many solutions for attribution, management and control of QoS were designed in the network level, where the applications can have easier and more specific use of the QoS facilities than with the direct use of ATM QoS solution. Others problems are: (1) the cells are small and have fixed size, so ATM is more oriented to the packet switching solution. This means that many of the deficiencies of the packet switching technology are in the cell-switching technology, particularly about the guarantees of QoS. As a consequence, many mechanisms have to be implemented: admission control, shaping, scheduling and resynchronization in the receptor, all at a good effective cost; (2) problems of the CDV (Cell Delay Variation) occur frequently in ATM, as the cells from many transmitters have to be multiplexed in the switch, multiplexer or in other intermediary system. Accumulated delay can be critical if the application doesn't tolerate delays (e.g., video and audio); (3) the lack of

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applications that use directly the ATM classes of service with distinct QoS; (4) high operational cost.

Nowadays some solutions, like the DTM (Dynamic Synchronous Transfer Mode) technology [1], are bringing up the use of antique switching solutions, more simple and with reasonable performance to real-time applications with QoS constraints.

The DTM is an architecture based on the high-speed circuit switching architecture with dynamic resources reallocation. It provides multicast services, channels with varied bit-rates and low circuit configuration time.

As any other circuit switching solution, the DTM isolates the traffics in each circuit, which means that the activities in one circuit do not disturb the activities in the other one. This brings the possibility of the transmission with guaranteed quality, with a constant delay. This architecture can be extended to include a large number of buses using the switching on the nodes. The switching is synchronous, so the delay caused by the switching is constant on each channel.

The channels in DTM are multirate so each channel can have a arbitrary number of data slots and the capacity of each channel is a multiple of 512 Kbps until the maximum capacity of the bus.

The DTM is constructed with fast-circuit switching technology and dynamic resource reallocation. So, if a specific channel does not have sufficient resources for the transmission, it can ask for resources (slots) from the neighbor nodes. Each node maintains a status table that contains information about free slots in another nodes so when it needs more slots, it consults the table to decide where to ask for resources. This approach is the distributed control of the slots. The manager only have to transfer the control of the slots involved from one node to another, if we have the central control of slots, which is the proposed solution here.

As everyone knows the Internet protocols are widely deployed in network architectures, so we can't ignore that there's a enormous number of applications that use them. If we want a wide spread solution, the IP (Internet Protocol) has to be the network layer protocol.

For guaranteed resources the applications need to reserve them, so it's necessary to have mechanisms to provide this. In the Internet, there's a lot of resource reservation signalling solutions: (1) CoS (Class of Service), (2) CBQ (Class-Based Queuing), (3) ST-II (Revised Internet Stream Protocol), (4) IntServ/RSVP (Resource reservation Protocol) and recently, Differentiated Service (DiffServ). The IntServ[2]/RSVP protocol[3] seams to be the most appropriate solution to work with DTM as it provides a strict specification of the bandwidth. This parameter requires reserving slots in the DTM technology and in many others aspects they are compatible. On next section they will be indicated. Others solutions like DiffServ are appropriate if you want to classify a provider's customers group and define the QoS level that will be offered to this group. Moreover there is not a better protection against complex QoS solution and there isn't any suggestion about properly dimensioning of the network solution for this. The ST-II has some overhead in their control mechanisms, so it doesn't have good performance. The CoS doesn't have a flexible QoS specification in their classes of services and the CBQ is static in the reservation of resources.

There are many interoperability problems between the ATM technology and the RSVP protocol: (1) the renegotiation of the QoS parameters during the lifetime of the connection is forbidden; the ATM Forum TM-4.0 specifies the ability of the renegotiation of some specific data rate bits, but no one knows if this is enough to provide the requirements of the RSVP protocol; (2) dynamic participation of the members of a multicast group causes serious problem in VC (Virtual Circuit) control; (3) the ATM technology is oriented to the sender and the RSVP protocol to the receiver. The ATM Forum UNI 4.0 proposal defined the LIJ (Leaf Initiated Joint), which is a technique trying to minimize this problem; (4) the ATM signalling Q.2931 is so complex; (5) there's a need of some policy to prevent the resources abuse; (6) the lifetime of the ATM VCs is controlled by inactivity and the RSVP protocol has a soft-state or a timeout control; (7) how to send the RSVP messages in a best-effort VC? (8) the dynamic reservations of RSVP bring a great problem to VC management.

The DTM can be integrated perfectly with the RSVP protocol, as many of the capabilities of RSVP is easy to be supported in the DTM architecture: (1) dynamic reservation: the DTM uses a dynamic reallocation of slots; (2) like as in RSVP, the reservation in DTM can be done by the receptor; (3) in DTM the access medium is shared, so it inherently supports the multicast transmission; (4) guaranteed reservation: the DTM uses a strict scheme of reservation; if there isn't enough resources, it can't establish the channel; (5) in DTM there isn't any specification of the lifetime of the channel; it has to be controlled by the application and the RSVP with its soft-state characteristic can adapt perfectly; (6) the signalling scheme of the DTM is simple; (7) there isn't a need to prevent abuse of resource use because DTM has a token control to the use of the data and control slots; (8) the RSVP messages can be transported in the control slots.

Below there's a table with the principal characteristics of the RSVP protocol and the solution to provide them in both the ATM and DTM technologies.

**Table 1.** Confrontation between ATM and DTM in the Support of the RSVP Protocol.

| Characteristic | ATM | DTM |
|---|---|---|
| Dynamic Reservations | There's only a theoretical suggestion | Dynamic reallocation of slots |
| Orientation | Sender | Sender/receiver |
| Multicast | Complex members control | Inherent multicast support |
| Lifetime of reservation | Controlled by the inactivity of ATM VCs | Controlled by RSVP protocol |
| Styles of reservation | The suggestion is to use a unique VC to the support of each RSVP reservation [4] | Slot sharing (SE or WF styles), slot exclusive (FF style) |
| Policy Control | Need policy control from abusive use of resources | Token slot owner control |

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## 2 Requirements and Objectives

In this section we describe the functions and facilities related to the admission control, reservation and administration of bandwidth in a RSVP/DTM environment, that are supported in this proposal.

a. Resource reservation: the capacity of resource reservation in a unique segment or multiple segments.
b. Admission control: estimation of resource availability.
c. Soft-state: dynamic and automatic lifetime control of the reservations by the soft-state characteristic of the RSVP protocol.

d. Central control of resources: the switch DTM in each segment is the resources controller and administrator, which is not a completely centralized approach of DTM slot management but gives a better interaction with the functionality of the RSVP protocol.
e. Scalability: the scalability problem of the RSVP protocol is greatly decreased in this proposal. Since the reservation is not done on each IP node but on a unique switch that controls the segment that the data have to pass through, only the switch DTM has to control the reservation state.
f. Interaction with the resource control mechanism: the RSVP protocol has interaction with the resource administration control mechanism of the DTM.
g. Support of different styles of filters: the support of FF (Fixed Filter), SE (Shared Explicit) and WF (Wildcard Filter) filters [3].
h. Controlled channel management: DTM channels are created and managed by the higher layers, in this case the RSVP protocol.
i. The routing and addressing take place at the IP layer.
j. At the DTM layer, the network performs the switching, the interaction with the fiber medium and the access control.

As explained above, in the DTM technology has constant delay of around 125 μs in each hop which leaves as the only parameter to be measured and controlled. This is represented by the 'R' parameter of the Integrated Service Guaranteed Service (GS) [5]. Here we call the "DTM cloud" to the region of the network that has the DTM technology implemented. Every node in this cloud that wants to participate in the resource reservation and admission control, using the RSVP protocol, has to implement this protocol. The RSVP protocol is transparent to no-RSVP nodes but we strongly recommend that in this environment of study every node has to be RSVP-like, in order to avoid breaking RSVP signalling in the establishment of DTM channels. The parameters assigned in the IntServ GS are: Tspec, flow specification and Rspec, reservation specification. Inside the "DTM Cloud" the only Tspec parameter that is interesting is 'M', maximum packet length to assembly and reassembly functions. There isn't traffic control in the DTM switches. About Rspec, 'R' is the only parameter. 'S' may be interesting to buffer control in end-systems, but it's out of this document's scope.

## 3 Basic Architecture

In this section we describe the components and mechanisms necessaries for the interaction of the RSVP protocol and DTM architecture. This proposal concerns reservation, control admission and management of bandwidth. We describe the interaction of the RSVP protocol and the DTM technology in a switch DTM node as it is the responsible for the control admission and management of resources. In sections 4 and 5 we discuss how this is provided.

Before entering in the "DTM Cloud" the IP packets have to pass through a classifier, that decides if the packet will be routed hop-by-hop or it will be switched at DTM layer. To avoid the overhead of establishing and tearing down frequently the DTM channels, short lived flows may be routed hop-by-hop and the long ones (e.g., internet telephony) switched in the DTM layer. The network performance depends greatly on this decision, since with the IP switching technology where the IP Switcher Controller decides if the flow is going to be sent hop-a-hop or to be switched. Here we suggest the use of the Logical Interface Handle (LIH) of the PATH messages to indicate if the referenced packet has to be switched in the "DTM Cloud".

Label binding is not necessary in this proposal. The binding of the slots with respective owners will happen intrinsically in the DTM protocols.

In this proposal we are interested in the study of the packets that will be switched in the DTM layer. In this case each IP packet has to be assigned to a DTM channel that has previously been established using the RSVP protocol. In this proposal, each IP flow (IP address + port) has a dedicated DTM channel, which works like a RSVP protocol that assigns a reservation per each IP flow. We can spend a lot of resources without the multiplexing of various IP traffic in a unique channel, but we are discussing here about guaranteed services, which need strict QoS facilities. There's a necessity of a priority police to manage the queue of packets of each channel. A kind of shaper for bursty traffic can be implemented too in case of buffer overflow, for example using the RED (Random Early Detection).

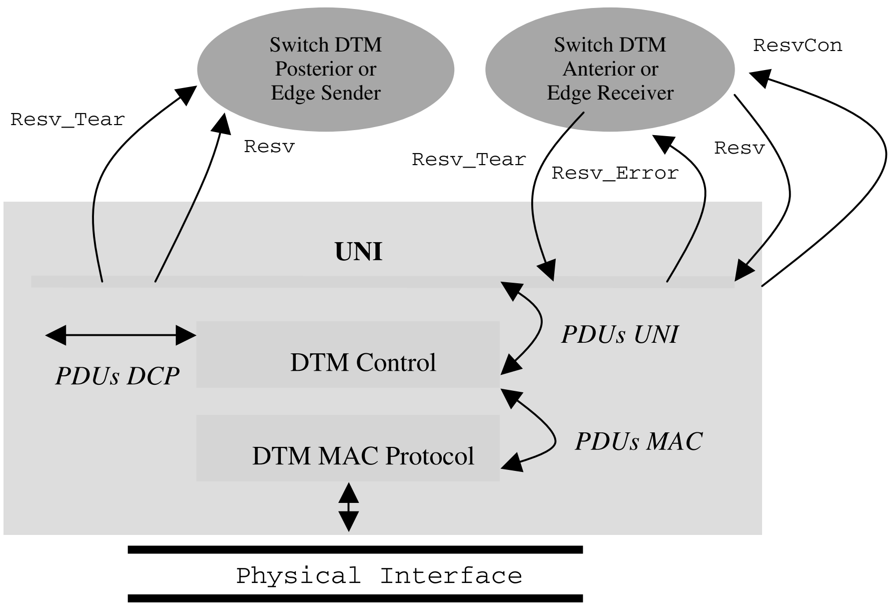


**Fig. 1.** Upstream Interaction of RSVP/DTM in a Switch DTM in the Reservation and Admission Control of Resources.

The switch DTM architecture proposed here is very simple. It doesn't have any function about IP routing nor RSVP controls. It only has a mechanism to detect the RSVP PATH and Resv messages, send them to DTM UNI level and forward them to the next/prior switch DTM or IP node. For the interaction of RSVP protocol with DTM architecture, the RSVP Resv message has to have a new object that is called DTM_Channel_Controller. This object defines the node that has initiated the establishment of the channel, the edge receiver of the "DTM Cloud". We have to remind that in DTM technology the node that establishes the channel is the transmitter, here the edge transmitter of the "DTM Cloud". The RSVP messages

ResvTear, ResvErr and ResvConf formats have the same format as the specification of the RSVP protocol [3]. About the Error_spec object of the ResvErr message, the important error here is the code error 01, "Failure in the admission control" [3].

**The DTM UNI level.** One of the functions of this level is to provide a interface between the applications or the protocols in higher level (RSVP, STII, SNMP, etc.) and the DTM Control Protocol (DCP). To start a reservation the application or protocol has to send the following parameters: the desired service (guaranteed or controlled load), description of the traffic (Tspec) and the quantity of resources (Rspec). Here we are only interested in the IntServ GS service. The DTM technology only specifies a strict and deterministic resource reservation, which means that if there isn't enough resources, the admission control fails. This is very compatible with the QoS strict necessity of QoS of the GS services. Moreover, in this proposal the DTM Level UNI has the function of the object translation of RSVP messages to an adequate format, which is to the others components of the switch DTM model. The DTM UNI level is responsible too to return the results of the RSVP messages processing in the DTM DCP level to the posterior or anterior RSVP process. This processing concerns reservation, control admission and management of resources. The RSVP accesses the DTM DCP services using UNI primitives are translated from the RSVP messages by the UNI level. For example, the UNI_create primitive indicates a node to allocate a defined number of slots in a new channel. [3] suggests the following call from the RSVP protocol to the Traffic Control module; here it's represented by the DTM DCP, that uses the DTM UNI as an interface.

**Call:** TC_AddFlowSpec (Interface, TC_Flowspec, TC_Tspec, TC_Adspec, Police_Flags) -> Rhandle, [Fwd_Flowspec].

The parameter interface has to be changed to specify the object DTM_Channel_Controller. The process Police_flags is out of the scope of this proposal, so it will no be mentioned. In the actual specification of the RSVP protocol [3], the admission control service can modify the flowspec and this returns the updated object in the Fwd_Flospwec. Here this doesn't provide any facility because the GS services need a strict QoS. The others primitives: UNI_remove, UNI_change and UNI_indication work in the same manner. The RSVP protocol suggests a call and this call is translated by the DTM UNI and forwarded to the DTM DCP level.

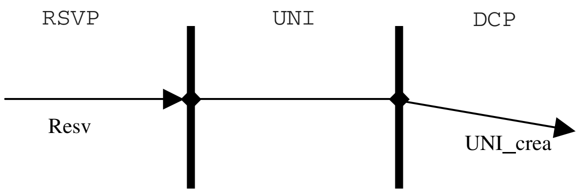


**Fig. 2.** UNI_create Primitive.

**The DTM Control Protocol (DCP) level.** This protocol has four responsibilities: (1) allocation of slots; (2) mapping from slot to channel; (3) transmitter/receiver synchronization and (4) management functions. It provides services to user through the UNI level and communicates with others nodes through DTM PDUs (Protocol Data Units). On this proposal, the DCP will respond for the admission control, reservation and management slots. Applications using the RSVP protocol can ask for various services (bandwidth, change of reservation, information about available resources, etc.). These petitions are processed by the DCP.

**The DTM MAC level.** The DTM MAC (Medium Access Control) defines the access to the medium, in our case the fiber. In the DTM technology the nodes access the medium using the TDM Multiplexing (Time Division Multiplexing). There are three primitives defined to this function: slot_request, slot and slot_indication.

## 4 Resource Management Function

In this section we describe the resources management function in DTM, that consists of two basic principles: resources allocation between nodes in the network and the resource reservation in the channels.

**Allocation of resources.** As resources allocation we prefer the central approach, because it brings a good conformance with the RSVP protocol. Moreover, (1) the clients become simpler as they only contain the information about their own channels; (2) it is easier to have admission control and fairness; (3) the fragmentation of the free slots in the controller is very modest.

The slot controller will be the DTM switch on each physical segment that takes part in a transmission. It has the responsibilities to create and terminate a channel on the reception of RSVP Resv and Resv_Tear messages and the resource management. Each time a user request arrives to a node, it first requests tokens from the slot controller. The delay in finding and allocating free slots is around 100 µs [7]. In this approach the slot controller has to have more signalling capacity, that means that it will have access to a large number of control slots. The main advantage of the distributed approach is that it doesn't depend on the round-trip time on the bus; but in [7] was proven that the central approach performs close to the ideal protocol and is relatively simple. A study [8] demonstrated that in situations of low load (70%), the probability of asking for slots from others nodes is 55%, which is high and means drawback to algorithms like KTH and KTHLR (KTH Ring), since even in situations of normal load nodes need to request slots frequently. There's another algorithm called BCA (Background Channel Allocation) that intents to minimize this problem.

**Resource Reservation.** The RSVP protocol is responsible for the indication of the amount of resources that a host wants using its reservation soft-state characteristic. It also establishes the channel duration. At the starting of the network, the DTM guarantees to each node a certain number of slots in each fiber. If we have *m* nodes, listed v = 0, 1, ..., *m*-1, the number of slots to each node in each fiber 0 and 1 is [9]

$$N_{vo} = (2\,N\,/\,m) * [v\,/\,(m - 1)]$$

$$N_{v1} = (2\,N\,/\,m) * [1 - v\,/\,(m - 1)]$$

being $N$ the number of slots in each cycle defined as $N = B * T / (n + c)$ where $B$ is the bandwidth, $T$ the time cycles length, $n$ the number of data bits in each cycle and $c$ the number of control bits in each cycle.

The DTM uses a strict resource reservation scheme, where a new channel is admitted only if there is enough free slots. The main point in DTM resource reservation is that a host gets a bandwidth in direct proportion to the number of slots [10]. The DTM supports dynamic reallocation of slots between nodes. This means that the network can adapt to traffic variations. Dynamic priorities in resource reservation can be used between the nodes of the same fiber segment. The proposal is using GS service Tspec parameters and the 'D' parameter of the Adspec to infer the traffic characteristics, to assign or modify node's access priority. A future study will describe this suggestion. In DTM a node has to explicitly indicate if it wants to share the use of its channel. From this possibility we can map the three types of filters defined in the RSVP protocol by channels sharing possibilities. For FF filter, DTM doesn't share channels and for SE and WF filters nodes share channels.

## 5 Admission Control Function

In this section we describe the admission control function that takes place before the connection establishment phase. As the DTM needs strict resources reservation, the RSVP protocol interacts with it in the signalling of the bandwidth necessary for the transmission of a certain flow. If there is enough resources, RSVP will alert the application and automatically the reservations established before for this flow will be turned down.

**RSVP-based Admission Control over DTM.** Here we describe generically a signalling method and procedures for RSVP-based admission control over DTM. This study is based on the SBM (Subnet Bandwidth Manager) specification of IEEE 802-style LANs [11]. The IntServ and RSVP definitions do not depend on the underlying network technologies; so it is necessary to map these specifications onto specific subnetwork technologies, in our case the DTM technology. In section 3 we give a example of how the RSVP message Resv is mapped to UNI_create primitive of DTM.

In this proposal the switches DTM (L2 devices) only implement the link-layer functionality. As was mentioned, these devices only have a simple mechanism to detect, capture and forward RSVP messages, without requiring the L2 device to snoop for RSVP messages. The L3 devices are the IP routers that use the network layer and the RSVP protocol. Here every physical segment is managed, which means that they have implemented the protocol DBM (DTM Bandwidth Manager) on their DTM switches. The EDBM (Entity of DTM Bandwidth Manager) is the protocol entity responsible for managing resources on an L2 segment. Here this entity will be always present in the DTM switch. An extended segment includes members of the same IP subnet but interconnected by a switch DTM. The DBM clients are the IP routers that require resource reservation and support some features of the DBM protocol.

Similar to the SBM algorithm in the procedure of admission control using RSVP in switched Ethernet [11], we present the DBM algorithm:

1. DBM Initialization: The EDBM obtains information of the bandwidth available on each of the managed segment under its control. As we suggested the central control approach, each DTM switch has the information of the free slots in the

segment under its control. A static configuration has to be done to specify the amount of bandwidth that can be reserved.

2. DBM Client Initialization: The DBM client has to communicate with the DTM switch that controls its segment for admission control purposes.
3. DBM Admission Control: To request the reservation of bandwidth the DBM client follows 3 steps:

   a) The DBM client sends/forwards a PATH message to the next IP router only to update the switch DTM with the link layer address and network address of the next IP router for which it will have to send the PATH message and to map the switches DTM that are along the path. The IP routers along the route don't participate in the transmission of the Resv messages. For this purpose, the IP router sends this message using a reserved IP Multicast address called EDBMLogicalAddress (224.0.0.16). The EDBM doesn't have implemented the IP protocol, so it doesn't know how to forward the PATH message. As in [11] a new RSVP object has to be introduced, called DTM_NHOP. When a DBM client sends out a PATH message to the EDBM, it must include in the DTM_NHOP the address of the next IP router or the destination address. When the EDBM receives a PATH message, it can now look at the address in the DTM_NHOP object. We can have a problem if the next IP router is reached through another EDBM. In this case the PATH message is sent to it using a reserved IP multicast address called AllDBMAddress (224.0.0.17) and the DTM_HOP has to follow untouched. The DSBM forwards the PATH message towards the RSVP receiver and puts its L2 and L3 addresses in the PHOP object, with this procedure it inserts itself as an intermediary node between the sender and the receiver. The DTM switch is not expected to have ARP capability to determine the MAC address, therefore the DTM_HOP address has to include both the IP address and the MAC address.

   b) When an application whishes to make a reservation for the RSVP session established, it follows the normal RSVP message processing rules and sends a RSVP Resv to the EDBM of its segment obtained from the PHOP object defined in the PATH message. If there's enough resources and the reservation is granted, the EDBM forwards the Resv message to the next hop based on the PHOP object of the PATH message. If not, it has to send a ResvErr message to the receiver.

   c) If the "DTM Cloud" has more than one physical segment, the PATH message will be propagated through many EDBMs. The Resv message will be propagated hop-by-hop in a reverse direction and will reach the "channel creator" (the edge transmitter of the "DTM Cloud") if the admission control at all EDBMs succeeds.

**The Control Slots in the Transmission of the RSVP Messages.** In DTM the signalling capacity of a node is determined by the number of control slots it has. It's possible to change the signalling capacity of a node during the operation of the network by changing the number of control slots, which is called dynamic signalling.

In the DTM specification each node has at least one control slot per cycle and there's a problem if the segment has many nodes. To prevent a signalling overhead, [12] advises the use of a Basic Signalling Channel (BSC). Each node has at least one control slot in the base frame. The first 'n' nodes share one control slot and so on. This means that a node can get access to a control slot in every nth cycle. This kind of signalling is not useful to Path messages because of the dynamism of the route changes in the IP environment. The Resv messages could decrease the dynamism of the resource allocation of the DTM technology.

As the channels in the DTM environment are unidirectional, we have to specify how the RSVP Resv and Path messages have to be signalled. They can use the virtual network signalling concept [12]. A node creates a virtual network by signalling to the nodes with which it wants to communicate using the BSC signalling, described before. It specifies which data slots that will be used for signalling within the virtual network. This signalling can be used not only by RSVP Resv messages, but by any kind of control messages to be sent in a multicast group. This concept has similarities with the metasignalling virtual channel (MSVC) of the ATM technology.

## 6 Conclusion and Future Works

Compared to ATM and SONET/SDH, DTM offers a higher network utilization rate and provides the support of advanced integrated services at a much lower cost. The IntServ/RSVP approach has been seen as the solution for applications with quantitative strict QoS needs. The DTM provides a interface with IP layer and the DTM admission control concerns about bandwidth allocation. So the integration of these technologies in the signalling, reservation and management for guaranteed services is perfect. To analyze how strongly the admission control function effects call setup times is necessary. Here, the focus was the analysis of the additional delay imposed by the use of the RSVP protocol as the QoS signalling mechanism. A fair central control slot allocation algorithm using dynamic priorities and based on the traffic characteristics has to be defined. Today the algorithms proposed (KTH-S, KTH-CF, KTH-LR and KTH-RA) are based only on the number of slots available, the closest neighbor or per broadcast.

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