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Interaction Approaches for Internet and ATM Quality of Service Architectures, ICATM98

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Internet and ATM possess Quality of Service (QoS) architectures which shall allow them to integrate services of data and telecommunications formerly performed by separate infrastructures. We believe that none of them will be able to oust the other. That means both will exist for at least the middle-term future. Therefore, an interaction between both is necessary, especially in the field of distributed multimedia applications where both worlds 'meet' first. These applications require a certain QoS to perform gracefully. Hence, in particular the interaction between Internet and ATM QoS architectures is important. In this paper, interaction approaches for the QoS architectures developed for the Internet and for ATM are discussed. We do not restrict on common approaches but derive also more unconventional models by regarding the possible communication patterns based on different topological variants for heterogeneous IP-ATM networks.

Keywords: Signalling in Heterogeneous Networks, IP/ATM Networks, Integrated Services, QoS

1 Introduction

ATM and Internet are the two major players in communications at the moment. At first glance they are counterplayers, at least in some respects, with different strengths and weaknesses, and need to compete with each other – the Internet defending its position as a global internetwork and ATM trying to become one. That ATM will really ever become a global internetwork is often doubted (by data communications people). However, ATM will play a certain role, even if it does not become the successor of the Internet. We believe that both will exist for at least the middle-term future, thus, they must be able to interact with each other.

The interaction of these two worlds is particularly desired in the relatively new field of distributed multimedia applications where both worlds meet first. These applications depend on the provisioning of QoS mechanisms by the communication system. This need has been observed in both worlds, and both have developed independently of each other QoS architectures that shall be able to provide integrated services. So one of the most important aspects of the interaction between both worlds is the seamless interworking between the QoS architecture of ATM and the Internet integrated services architecture (IntServ). That means to enable the provision of QoS end-to-end regardless of what is inside the network and whether both ends are located in the same world or not, i.e. providing a homogeneous service over a heterogeneous network.

In this paper, we discuss interaction approaches for Internet and ATM QoS architectures. In the next section we give a brief overview of existing ATM / Internet interaction models and compare their QoS architectures. Then we examine the communication patterns in heterogeneous IP-ATM networks in Section 4. Based on that, several interaction models for the QoS architectures of the Internet and ATM are derived in Section 5. Finally we conclude the paper.

2 Existing Interaction Approaches

Over the last few years, several approaches have been developed for the interworking of ATM and legacy networks *without* QoS support, e.g., IETF's Classical IP over ATM [11] with its extensions for multicasting, MARS (Multicast Address Resolution Server) [6], and short-cuts, NHRP (Next Hop Resolution Protocol) [12], and ATM Forum's LAN Emulation (LANE)[3] and Multi-Protocol over ATM (MPOA)[4]. IP switching [13] can be seen as a more revolutionary approach, which tries to identify data flows and build up VCs (Virtual Circuits) for them if they seem to be long-lived. The signalling protocols that build up the VCs are especially tuned for this kind of purpose and are no longer the original ATM signalling protocols. So IP Switching might be viewed not as an interaction approach with ATM, but as a competing approach to ATM since essentially only the switching hardware of ATM is being used.

All these approaches do not support data flows requiring a predictable QoS since they were designed for asynchronous data communication only. Further approaches try to integrate IntServ and ATM's QoS architecture by extending these existing approaches for asynchronous data communication. In this paper we reconsider whether this is sufficient.

A different approach has been taken by AREQUIPA [1] where ATM endsystems try to detect whether ATM connectivity is existing up to the communication peer and in that case, an ATM connection is set up for further communication. This approach is only viable if end-to-end ATM connectivity exists.

3 Comparison of ATM's and IntServ's QoS Architectures

The QoS architectures of ATM and the Internet have very different capabilities and characteristics with regard to the signalling and the QoS models. These discrepancies must be overcome for the interworking between ATM's QoS architecture and the Internet's IntServ QoS architecture. The most salient differences between the QoS models are:

- packet-based vs. cell-based traffic parameters and performance specifications,
- the handling of excess traffic: tagging or dropping vs. degradation to best-effort,
- different service classes and corresponding traffic and service parameters.

While the traffic characterization of both QoS models is quite similar, the service definitions differ substantially such that a simple one-to-one mapping is too 'semantic-lossy'. Thus we think a mapping might have a dynamic or even adaptive n:m character, i.e. the mapping is not fixed, it might adapt itself and one service class of IntServ might, depending on the actual values of the specified parameters, be mapped on different service classes in ATM and vice versa. The QoS parameters must be mapped as well. While the two parameter sets certainly have an intersection, they are neither a subset nor a superset of each other, thus making an easy mapping impossible.

Another problem is the treatment of non-conforming traffic, which in IntServ becomes best-effort traffic while it is at best being tagged with the CLP bit in ATM and therefore is treated worse than ATM's best-effort traffic (UBR or ABR). This means that traffic that is non-conforming in front of the ATM cloud would be treated better than traffic which does not conform inside the ATM cloud – an obvious mismatch.

There are many differences between IntServ's signalling protocol RSVP [9] and ITU-T's Q.2931 which can be viewed as the basis for all ATM signalling protocols. Prominent examples for the differences are the ability to provide heterogeneous QoS for multiple receivers, dynamic vs. static QoS, receiver vs. sender-orientated reservations, soft- vs. hard-state, reservations independent of vs. integrated with flow setup, n:m vs. 1:n multicast model, and the transmission of control messages as best-effort vs. separate signalling traffic.

Many of the differences in signalling can be traced back to the roots of the two signalling mechanisms: RSVP is based on the observations made during the experimental Mbone multicasts of the IETF meetings and therefore multicast is seen as very closely related to QoS in the IETF [8]. Q.2931 on the other hand is based on the traditional PSTN signalling and its successor N-ISDN with its signalling protocol Q.931.

Among the capabilities of RSVP which are not (yet?) supported by ATM are the most important: dynamic and heterogeneous QoS, and sharing and aggregation mechanisms for scalability within a session. These are characteristics which are especially useful in the multicast case. Capabilities of ATM which are not being (well) supported by IntServ: the accurateness of QoS over the whole lifetime of a connection, the bidirectionality of unicast connections, and the scalability with regard to the number of sessions.

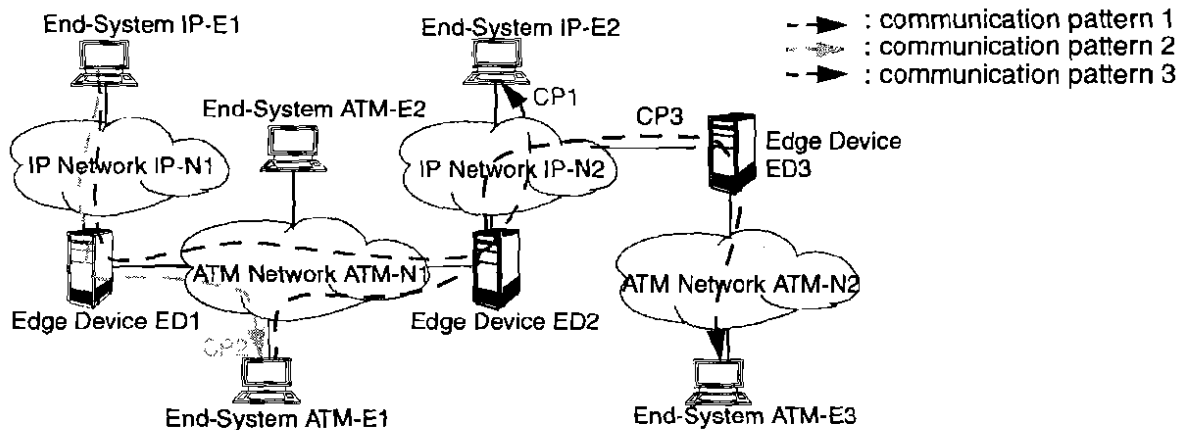


Figure 1: Possible Interactions between Internet and ATM.

4 Enumeration of Interaction Patterns

Based on topological observations we can derive three potentially possible interaction approaches (see Figure 1):

1. Communication between IP end-systems with an ATM subnet on the transmission path, e.g. IP-E1 wants to send data to IP-E2 ($IP-E1 \rightarrow ED1 \rightarrow ATM-N1 \rightarrow ED2 \rightarrow IP-N2 \rightarrow IP-E2$), symbolised by communication pattern 1 (CP1) in Figure 1. An example for this is an Internet video-conference, which would certainly be happy to utilize ATM's QoS abilities when transmitting over an ATM subnet.
2. Communication between an ATM end-system and an IP end-system, e.g. IP-E1 would like to send data to ATM-E1 ($IP-E1 \rightarrow ED1 \rightarrow ATM-N1 \rightarrow ATM-E1$), symbolized by CP2 in Figure 1. An example application for this communication pattern could again be a videoconference, which however this time consists of some participants with IP-connectivity and some with ATM-connectivity.
3. Communication between ATM end-systems with an IP subnet on the transmission path, e.g. if ATM-E1 wants to send data to ATM-E3 ($ATM-E1 \rightarrow ATM-N1 \rightarrow ED2 \rightarrow IP-N2 \rightarrow ED3 \rightarrow ATM-N2 \rightarrow ATM-E3$), symbolised by CP3 in Figure 1. An example application for this could be the connection of two ATM LANs via the Internet for the purpose of building up a virtual private network. In order not to lose too much of the guarantees given by ATM, it would be favorable to be able to utilize IntServ/RSVP flows for the linking of the two ATM LANs.

Although in RFC 1821 [7] similar topological observations are made, it considers only CP1 in more detail. In the same vein are all IETF models for the interaction between IntServ and ATM's

QoS architecture based on the support of that pattern. We do not think that it is necessarily sufficient to constrain on one of the possible communication patterns. However which of the communication patterns are really worthwhile being investigated is in our opinion an open issue which depends on the topology of the future networking infrastructure. We perceive two possible topological scenarios with two variants each for a future IP/ATM network:

1. ATM in the core of the network surrounded by other network technologies to which users might be connected. This might not be realistic in the Internet, yet it is at least possible for corporate networks. With this scenario, we can restrict the view on patterns CP1 and CP2. The two variants depend on whether ATM will be able to come to the desktop or not. If ATM will really play a significant role in the LAN environment or for residential users, then both patterns, CP1 and CP2, have to be taken into account. If ATM will only be a WAN solution then a possible interaction model only needs to care about CP1.
2. The alternative scenario is that ATM is just one of many link layer technologies. In that case all communication patterns might have some importance, even CP3. Again the variants of this scenario depend on the question whether ATM will make it to the desktop or not. If ATM will not be solely a WAN solution then all three communication patterns will have to be taken into consideration. Otherwise, i.e. if ATM will be one of many WAN technologies, mainly CP1 (and sometimes also CP3) will have to be supported by the interaction model.

Whether ATM will play an important role on the desktop depends on various factors, e.g., costs, technical suitability, manageability, and the availability of native ATM applications. The latter depends on the fast introduction of a standardized ATM API (Application Programming Interface) and how it is accepted by application programmers which are used to TCP/IP applications and APIs, but have mostly no experience with native ATM-mode applications. Also, TCP+UDP-based applications have the advantage of providing support for heterogeneity. Besides the slow deployment of an ATM API, another argument often raised against the vision of ATM on the desktop is that there is a large gap between the services demanded by applications and the services provided by ATM. Here a mapping of cell-level guarantees and services to something more meaningful for applications like packets or frames would be needed. There seems to be at least one layer of abstraction missing - may be a perfect gap for IntServ to fill out and continue IP's dominance on the desktop.

Another point, only seldom considered, is that the interaction approaches should also be made dependent on what the purpose of the internetwork is: global internetwork, private internetwork with centralized administration and control (of network engineering and protocol usage), or private internetwork with distributed management by independent organizations but on a scale that is still moderate. The global case will probably be dominated by Internet technology due to its support of heterogeneity. The last two cases might be a niche for ATM - homogeneity may be achieved at least in the backbone, especially in the centralized case.

5 Interaction Models

5.1 Traditional Model (Straightforward Solution)

The traditional model serves situations corresponding to pattern CP1, however since it is straightforwardly implemented it does not make clever use of the features provided by ATM. ATM SVCs (Switched Virtual Circuit) or PVCs (Permanent Virtual Circuit) are used as fast bit pipes and the QoS provisioning is done solely by the IntServ architecture. This is essentially Classical IP over ATM 'abused' for IntServ, which is of course principally possible and inexpensive in terms of

invested effort, but ignores all the features provided by ATM and is very expensive in terms of usage of resources. It operates on ATM as if it were a 'dumb' point-to-point network or a leased line and does not make any use of the features provided by ATM like the VC model (which allows for a presorting of flows on the data link layer), bandwidth management, or traffic management (traffic control and scheduling in hardware). Instead it duplicates these functions in the IntServ architecture (in software, which is usually less efficient).

This represents the most hostile approach to ATM and neglects the capabilities of ATM signalling as far as possible and therefore neglects many of the good features of ATM, but on the other hand avoids its complexities as well.

There is much less implementation complexity in the traditional model compared to other approaches. Despite of its obvious deficiencies it must be seriously analyzed with regard to the performance loss and resource wastage it incurs in comparison to the more sophisticated models. In the traditional model, ATM is viewed as a black box while the other approaches show a tendency to more and more regard the internals of ATM.

5.2 ATM Subordination Model

The ATM subordination model is an extension of the traditional model but tries to make use of the ATM features as far as possible. ATM is still viewed as a subnet providing services for the IntServ architecture.

There are two different forms how the interaction can be designed. ATM could be aware of the interaction (and be adapted) *or* ATM remains unaltered and is passively used by IntServ with all its constraints. In the latter case, the IP over ATM signalling would have to be adapted, since the ATM QoS architecture would be regarded as fixed. For the former, there are radical approaches which want to do away with the ATM signalling and install a completely new signalling for ATM especially in support of overlaying an IP network over ATM. IP Switching approaches might be regarded as examples of this approach if they are extended to use RSVP as an explicit mechanism to set up VCs. This approach is also called 'ATM under IP' [13], showing literally the active subordination of ATM to the Internet. However most approaches take the more pragmatic passive subordination of ATM which regards ATM signalling as fixed. Furthermore, the extensions to ATM signalling and the changes to the IntServ architecture may be regarded as steps towards each other.

The IETF favours the passive ATM subordination model [10] since they view ATM as an important link layer technology, whose QoS capabilities should be utilized by an Integrated Services Internet. However, the IETF does not consider a more integrated solution of the QoS architectures as we will present one in the next subsection. The reason is that most people active in the IETF expect ATM to be solely a WAN solution, and may be *the* WAN solution presenting the backbone of a future Internet, however ATM will never make it to the desktop in their view. So a good solution could be to regard RSVP/IP and ATM as complementary techniques, where ATM is at the core, a place where its QoS routing feature is very desired, and RSVP/IP is at the edges of the network, where its ease of use is well desired. So they should not be considered as opponents but rather as partners, though still on a provider-user basis.

5.3 Partnership/Competitor Model

The partnership/competitor model serves situations where the pattern CP2 applies, i.e. communication between ATM- and IP-connected end-systems on a peer-to-peer basis. Hence, it may also be called peer model or integrated model since it requires an integrated fashion of interworking between ATM and Internet. However, this model will only become interesting if ATM is success-

ful on end-systems. If that happens the kind of interaction provided by the peer model is probably necessary to be supported, hence the peer model is important, as it accepts ATM as a full-blown protocol stack that is able to operate end-to-end, and not solely as a data link technology as in the ATM subordination models.

The peer model introduces the need of a much tighter integration between ATM and Internet, the Internet is no longer just using ATM but they really need to interwork. This possibly leads to the fact that the QoS of ATM can no longer just be ordered through ATM's QoS interface, but the traffic management of both world's has to be integrated on a lower level. Since ATM's QoS architecture seems more powerful than the IntServ architecture the fundamental problem is the mapping of ATM's QoS on IntServ's QoS, e.g. how to simulate ATM's accurateness and QoS reliability on IntServ's rather crude and unreliable QoS provision.

There are a number of people (many of which are telecommunications' people) who think that 'the time has come to view ATM not solely as a link layer': ATM is about to have a standardized API, it offers routing, addressing and session services. These are all elements which distinguish it from traditional link layer technologies and allow it to compete with IP as an end-to-end solution. However at the moment ATM on the desktop is practically non-existing and therefore, if ever, the peer model will play a role in middle-term future, when there are more ATM end-systems available as for example ATM-connected workstations, video-servers, set-top boxes, or tele/video-phones.

An example on the application level for the peer model taken by the ATM Forum at the moment is the VTOA (Voice and Telephony over ATM) Phase 2 work [5], which tries to approach the interworking between ATM and Internet voice transportation. However, an interworking at the system layer with 'asymmetric' end-systems seems a more fundamental answer to the problem, which however depends on the number of applications the two worlds are really sharing (in a peer-to-peer and not in a provider/user relation).

5.4 Internet Subordination

The Internet subordination model serves situations where pattern CP3 is required. This is the case where an IP network acts as a transit network for communicating ATM-connected end-systems without direct connectivity. At first glance this might look absurd today, but it could have some relevance in case that there will be a scattered set of small islands of ATM networks. For example, organizations that have ATM LANs might connect them via Internet and might be interested in preserving the ATM QoS as good as possible by using IntServ's QoS. Nevertheless the Internet subordination model should have exceptional character since it is not really possible to keep the QoS guarantees given by the ATM network over the Internet section of the transmission path, thereby causing an unpredictable QoS provision.

The accurateness of ATM's QoS can only be approximated by IntServ's QoS but never be guaranteed, since the mapping from ATM QoS service categories and traffic and QoS parameters into IntServ terms seems very problematic. However this is a possible solution if QoS communication between unconnected ATM networks is needed and of course still better than delivering ATM traffic over the best-effort Internet.

From a technical point of view something similar has been developed by the Cornell University and the Connectware Inc.: Cells in Frames, i.e. ATM cells in Ethernet frames, in order to emulate ATM end-to-end. However what would be needed is 'Cells in Packets', i.e. ATM cells in IP packets to be able to cross routers.

6 Summary and Conclusion

We believe that interaction approaches for the QoS architectures of the Internet and ATM are necessary because both worlds will co-exist for a couple of years. Since they tend to serve more and more the same applications due to the pertaining convergence process of data and telecommunications, they have to interwork with each other to fulfill application demands.

New and, also from an economic perspective, interesting applications like videoconferencing and video-on-demand services are run or will be run in both worlds. It is only natural that a seamless interworking between both worlds is demanded. For example, a videoconference should neither be constrained on Internet-connected participants nor on ATM-connected participants but should allow for mixed videoconferences with participants of both worlds. The ATM subordination model is not able to support such communication scenarios. Solutions for the partnership model are not existing yet due to its high complexity. Nevertheless, for real-time data this model has some right to exist, though we are not aware of any approaches in that direction, not even to identify the problems associated with it.

Based on topological considerations and application scenarios we derived the required communication patterns and interaction models for an interworking between ATM and Internet. Which of these will be the prevailing ones, depends on many factors. On the one hand there are technical issues, like the fast introduction of an API to native ATM services and the existence of pure ATM end-systems such as videophones, video-servers, set-top boxes or cameras based on ATM. On the other hand, also economical and political factors, for example the protection of investments, have to be taken into account.

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