Performance Management for Efficient QoS provision and Resource Utilisation in Broadband Internet Infrastructures

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Abstract. An important problem of broadband Internet infrastructures is efficient resource utilisation at access points, while keeping the Quality of Service (QoS) demands of applications stable and optimal. Considering the resource bottleneck of broadband access networks, there is a need for integrated performance management of such networks providing "feedback" from monitoring and analysis of traffic, QoS parameters, topology and anomaly effects for the purpose of short and long term bandwidth resource planning.
This paper is aimed to discus design challenges of advanced performance management architecture for efficient bandwidth resource planning of broadband access networks with monitoring "feedback". Based on resource planning and performance data base, the proposed architecture is designed to include techniques and algorithms for modelling and simulation of optimal resource allocation strategies in advance considering impact of traffic, topology selection, and anomaly analysis as well as feedback from QoS analysis.
Application specific QoS monitoring and analysis is used for validation of resource allocation planning considering QoS based applications, such as VoIP, multimedia and Grid. The architecture is derived from the experiences of INTERMON project for inter-domain QoS analysis studying the impact of topology and traffic (see [1], [2], [4]). A scenario for the integration of QoS and topology analysis of INTERMON toolkit in the proposed performance management architecture is described.

1 Introduction

Currently, there is a challenge for flexible broadband Internet infrastructures based on more efficient and economical usage of resources in order to provide stable QoS provision of applications [3].
Resource planning for QoS based applications in Internet is a promising area for more efficient resource utilisation and enhanced QoS support. Especially, for the broadband Internet access networks, with their constraints of bandwidth resources and possibility for flexible Internet connectivity, there is a need of performance manage-

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ment toolkits, which provide monitoring and modelling "feedback" for more efficient resource allocation planning according to the QoS demands of applications.

Today, there are two research directions, which need to be merged together for more efficient QoS provision and resource usage in broadband Internet:

- advanced performance management systems and tools able to study different factors, such as topology and traffic, on the QoS of applications
- techniques and technologies for optimal resource allocation which, could be used for efficient resource planning.

Performance management of application QoS in the area of inter-domain networking was the focus of INTERMON project [1], [4]. Other works studied traffic and congestion impact on the QoS of applications [5], QoS parameter behaviour dependent on the link failures [6], effect of inter-domain routing on QoS parameters (see [7], [8]).

The importance of resource allocation in advance for efficient QoS provision in Internet was considered in [10], [14], [15], [25]. Resource reservation planning affects the complexity of the routing and path selection process (see [11], [12]), and requires extensions of protocol, admission control and resource management, as for instance RSVP extensions for reservation in advance [13]. Efficient techniques and algorithms for optimal resource allocation were developed using different methods, for instance operation research algorithms adapted for flexible resource reservation requests [16] and neuro-dynamic programming using reinforcement learning [17].

Examples for integration of resource optimisation techniques and algorithms in practical tools are the automated bandwidth allocation planning tool called IconoNET [18] and Globus Architecture for Reservation and Allocation (GARA) [19], [26]. Algorithms and tools were designed to model and simulate optimal resource allocation strategies for QoS based applications, for instance real-time [20], and Grid applications [21].

Although there is a wide research on efficient resource allocation techniques considering demands of QoS based applications, integration of real performance monitoring data in the modelling and simulation strategies for optimal resource allocation is still a challenge [9]. This is a technology gap in today bandwidth resource planning for QoS based applications. It is mainly based on resource modelling by using of powerful mathematical methods (operation research, artificial intelligence, etc), without to consider different kinds of performance management "feedback" [10].

For bridging the gap and achieve a performance-oriented resource planning, which could support more efficient QoS of applications based on Internet broadband infrastructures, we propose a new performance management architecture for operational and long term resource allocation planning of broadband access networks, aimed to combine techniques for optimal resource allocation in advance with "feedback" from performance analysis considering QoS, traffic, topology and anomaly effects.

In section 2, we discuss the design of the advanced performance management architecture for efficient resource usage and QoS provision in broadband Internet access networks, aimed at integration of performance monitoring and analysis data into techniques and algorithms optimising bandwidth allocation for QoS based applications.

Based on the experiences of the European IST project INTERMON [1], [2], [4], [24], which result is an architecture for inter-domain QoS analysis integrating monitoring,

modelling and simulation of topology, traffic and QoS parameter data, we propose a new stage of automated performance management using integrated monitoring tools and data bases in the area of resource planning of broadband Internet infrastructures with focus on access networks.
For enhanced flexibility and interoperability, components and data bases of INTERMON could be integrated in the proposed performance management architecture. Section 3 gives an example scenario for usage of INTERMON topology discovery and QoS analysis in the new context of resource planning.

2 Design of performance management architecture for optimal resource allocation planning in broadband Internet

The proposed performance management architecture for broadband Internet infrastructures is focused on the provision of different kinds of performance monitoring and modelling data as "input" and "feedback" for techniques and algorithms for optimal resource allocation in advance. The goal is optimal resource allocation planning of broadband access networks based on learning of monitoring "feedback" of traffic, topology, QoS and anomaly effects.
Resource allocation planning is directly impacted by the volume and multiplexing of monitored traffic flows, discovered topology changes and detected anomalies. For instance, change in topology and traffic has influence on resource utilisation, which should be considered in the algorithms and techniques for optimal resource allocation. Anomalies, dependent on the source, could lead to increasing traffic load, which impacts the resource usage. Therefore study of anomalies and prediction of their effects ("what if" analysis) is important for the resource allocation planning.
Discovery of alternative topologies and path information (like path quality and stability metrics [4]) between broadband access networks could be considered in techniques for optimal resource allocation. A "feedback" from QoS parameter monitoring and modelling could provide insight on the efficiency of the selected resource allocation strategies and needs for their enhancements.
Algorithms and techniques for resource allocation have to support flexible interfaces to resource reservation requests of different kinds of QoS based applications like Grid [19], VoIP [23], real-time [20].
Improvement and adaptation of basic optimisation technologies is required to consider different kinds of resource requests for flexible QoS provisioning [16] and reservation interfaces for specific application classes like Grid [21].
The general design of the performance management architecture for efficient resource planning in broadband access networks includes:

- performance management components (monitoring and modelling of QoS parameters, traffic, topology and anomalies)
- resource planning techniques and algorithms for modelling and simulation of optimal bandwidth allocation considering resource demands of QoS based applications and performance management "feedback"
- integrated data base for related performance and resource planning data.

The interaction of resource planning and performance management components is provided based on integrated data base including resource allocation planning information related to performance monitoring data describing topology, traffic, QoS and anomalies. Figure 1 describes the general concept of the proposed performance management architecture for broadband access networks:

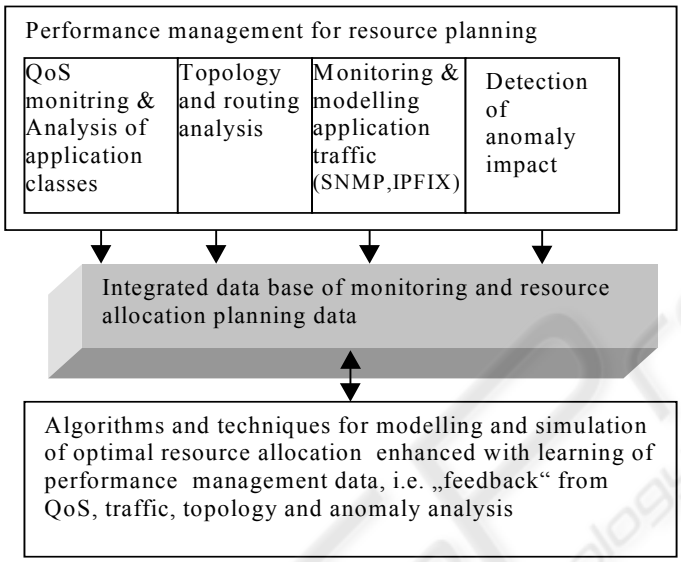

Fig. 1. Integrated performance management architecture for resource planning with monitoring "feedback"

A critical foundation of the proposed performance management architecture is resource allocation planning at access networks with possibility for exchange of performance management and resource planning data between different access networks. For this purpose, distributed performance management data bases of broadband access networks could be linked by usage of controlled access.

An example scenario of the proposed performance management architecture is aimed to provide efficient QoS provisioning and resource allocation of broadband access networks based on the resource allocation requirements of different kinds of applications with monitoring "feedback". The main steps of this scenario are:

1. Monitoring and modelling of traffic of broadband access networks to obtain forecasting models of resource utilisation considering different traffic classes which will be considered in the resource allocation planning. For this purpose, the architecture includes traffic monitoring and analysis tools, as for instance tools based on IPFIX traffic flow concepts [22].
2. Detection of anomaly effects caused by topology changes, failures and intrusions. This is used to model the resource utilisation based on "normal" traffic in contrast to resource usage due to the anomalies. The topology discovery and

anomaly detection are used to detect "outliers", which has to be considered in the resource modelling framework of the bandwidth optimisation techniques [24].

3. Obtaining of strategies for optimal resource allocation planning (daily and weekly planning) using appropriate algorithms and techniques which consider the resource modelling based on monitoring "feedback" from traffic analysis (step 1) and topology discovery / anomaly detection (step 2).
4. QoS monitoring and analysis for validation of optimal resource allocation strategies for different application classes. The QoS monitoring and analysis could be based on active or passive measurements. When active QoS measurement is used, the application traffic should be emulated to consider application traffic patterns, as for instance in the case of VoIP [23]. This allows efficient application oriented QoS parameter monitoring [5] and resource planning evaluation.
5. Learning of optimal resource allocation strategies. The feedback from QoS monitoring and analysis of applications provides information on how efficiently QoS is being provided based on the actual selected resource allocation strategies (step 3). "Learning" from QoS monitoring "feedback" allows to improve the resource allocation planning considering the actual traffic patterns, which are obtained in operational mode. For this purpose, the concept of neuro-dynamic programming and reinforcement learning could be applied in the framework of QoS-aware resource planning [17].

3 Integration of INTERMON QoS and topology analysis

For enhanced interoperability and more flexibility, the proposed performance management architecture is based particularly on the INTERMON architecture, developed in an European IST project [1] and used in large scale broadband Internet infrastructures in the related area of inter-domain QoS analysis [2]. INTERMON technology for analysis of QoS behaviour in inter-domain environment is based on the automated tool interaction and data base integration ([1], [2], [8], [23],[24]) including:

- Monitoring tools and data bases for inter-domain topology discovery, QoS parameters and traffic, considering SNMP and IPFIX traffic measurements [22]
- Pattern technology to describe QoS behaviour in structures, i.e. "patterns", for more efficient QoS analysis (e.g. "linear approximation" [2] for capacity planning and "outliers" [24] for fault analysis)
- Modelling and simulation environment with automated integration of measurement and topology discovery data to provide "what if" analysis.

INTERMON is aimed at scenarios focussing on end-to-end QoS monitoring and analysis in inter-domain environment considering specific of applications, and impact of topology, traffic, network, and resources on the QoS.

The end-to-end performance management strategy of INTERMON tools allows the integration of selected INTERMON components in the framework of the proposed performance management architecture for broadband access networks and their further enhancements to provide monitoring "feedback" for resource planning. Figure 2 shows an example scenario for usage of INTERMON inter-domain topology discov-

ery to obtain alternative paths and route qualities of end-to-end connection between two access Internet Service Providers (ISP) connecting Madrid and Salzburg [2], [4].

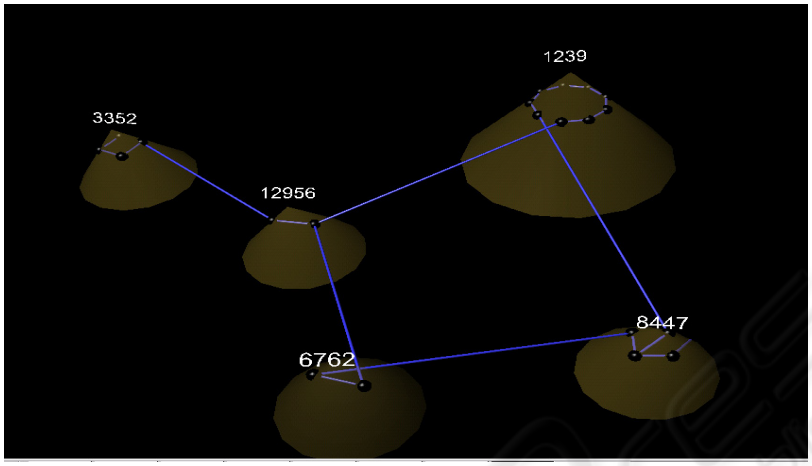

Fig. 2. INTERMON discovery of alternative inter-domain topologies between two access ISPs

Further INTERMON component, which could be used and enhanced for QoS monitoring "feedback" in the proposed broadband performance management architecture, is the analysis of end-to-end QoS parameter patterns.
Figure 3 shows an example of daily QoS parameter patterns obtained for inter-domain connection Madrid – Salzburg, discussed in [2].

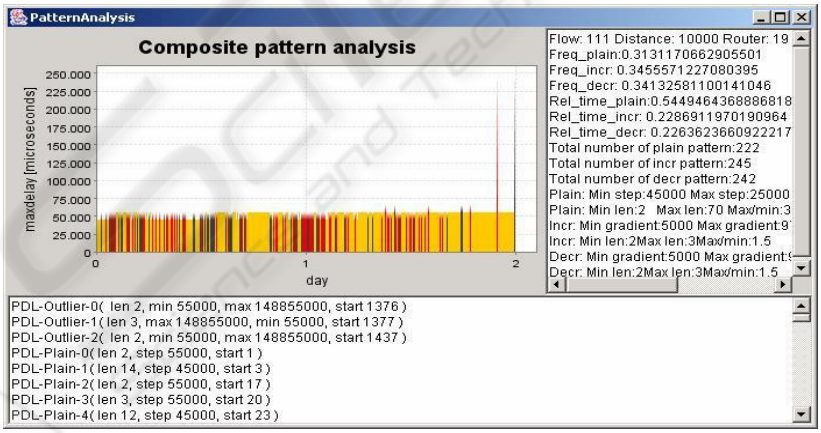

Fig. 3. Daily analysis of QoS parameter patterns

Based on possibilities to abstract QoS parameter values dependent on the requirements for pattern usage, the pattern based QoS parameter analysis could be successfully integrated in optimisation algorithms for resource allocation planning.

4 Conclusions

This paper proposed a performance management architecture for optimal resource allocation in Internet broadband access networks considering "monitoring feedback" of topology, traffic, QoS parameter and anomaly detection data.
It was shown, that enhanced flexibility and interoperability of the proposed architecture could be achieved based on integration and extension of tools and data bases for topology and QoS parameter analysis, developed in the European research project INTERMON. The provision of common interfaces to performance management tools and data bases, developed in different European research activities, will contribute to more efficient QoS and resource analysis of Internet broadband infrastructures based on integrated technologies considering different factors and optimisation goals.

References

1. Advanced architecture for INTER-domain quality of service MONitoring, modelling and visualisation, INTERMON project, http://www.ist-intermon.org.
2. Miloucheva I., Gutierrez P.A.A., Hetzer D., Nassri A., Beoni M.: INTERMON architecture for complex QoS analysis in inter-domain environment based on discovery of topology and traffic impact, IPS Workshop, Budapest, March (2004)
3. Tsuda T.: R&D for a Broadband and Flexible Network Infrastructure, FUJITSU Sci. Tech. J., 39 (2)p.224-233, http://magazine.fujitsu.com/us/vol39-2/paper11.pdf, December (2003)
4. Gutiérrez P.A.A., Miloucheva I.: Integrating Inter-domain Routing Analysis in novel management strategies for large scale IP networks, International IEEE Conference on Next Generation Teletraffic and Wired/Wireless Advanced Networking (NEW2AN'04), St.Petersburg, Russia, February (2004)
5. Papagiannaki, Cruz K.R., Diod C.: Network Performance Monitoring at Small Time Scales, IMC 2003, Oct. (2003)
6. Boutremans C., Iannaccone G., Diot C.: Impact of Link Failures on VoIP performance, NOSSDAV (2002)
7. Markopoulou A., Tobagi F., Karam M. Assessment of VoIP quality over Internet backbones, in Proc. IEEE INFOCOM, New York, NY, pp. 150- 159, June (2002)
8. Gutierrez P.A.A., Miloucheva I.: Analysis of end-to-end QoS behaviour in inter-domain environment, Inter-domain Performance and Simulation Workshop, Salzburg, February (2003)
9. Hetzer D. : Measurement based Resource and QoS Planning in Large Scale Internet, Inter-domain Performance and Simulation Workshop, Budapest, March (2004)
10. Heckmann O., Schmitt J., Steinmetz R.: Robust Bandwidth Allocation Strategies, 10th International Workshop on QoS, IWQoS, Miami Beach, May 15-17 (2002)
11. Gufferin R.A., Orda A.: Networks with advance reservations: The routing perspective. 19th IEEE INFOCOM Conference (2000)
12. Lewin-Eytan L., Naor J., Orda, A.: Routing and admission control in networks with advance reservations. 5th International Workshop on Approximation Algorithms for Combinatorial Optimization, APPROX'02, LNCS (2002)
13. Schill A., Kühn S., Breiter F.: Design and Evaluation of an Advance Reservation Protocol on top of RSVP, Broadband (1998)

14. Wolf L., R. Steinmetz R.: Concepts for reservation in advance, Kluwer Journal on Multimedia Tools and Applications, vol. 4, May (1997)
15. Berson S., Lindell R., Braden R. : An Architecture for Advance Reservations in the Internet. Technical report, USC ISI, Technical report, USC Information Sciences Institute, Marina del Rey, CA , July (1998)
16. Erlebach T.: Call Admission Control for Advance Reservation Requests with Alternatives, Eidgenössische Technische Hochschule Zürich, TIK-Report Nr. 142, July (2002)
17. Brown T.X., Tong, H., Singh S.: Optimizing admission contreol while ensuring quality of service in multimedia networks via reinforcement learning, Advances in Neural Information Processing Systems 11, MIT Press, Cambridge, MA (1999)
18. Frei C., Faltings B. , Melissagris G., Pu P.: IconoNET: a Tool for Automated Bandwidth Allocation Planning, IEEE/IFIP Network Operations and Management Symposium, Hawaii, April (2000)
19. Foster I., Roy A., Sander V.: A Quality of Service Architecture that Combines Resource Reservation and Application Adaptation 8th International Workshop on Quality of Service, IWQOS, pp. 181–188, June (2000)
20. Gupta A: Advance reservation in real-time communication services, in Proc.of the IEEE 22nd Annual Conference on Local Computer Networks (1997)
21. Roy A., Sander V.: Advance Reservation API, Scheduling Working Group, Scheduling Working Document: 9.2, Draft for First Global Grid Forum, 3. March (2001)
22. Raspall F., Tartarelli S., Molina M., Quittek J.: Implementing an IETF IPFIX meter, Inter-domain Performance and Simulation Workshop, Salzburg, February (2003)
23. Miloucheva I., Nassri, A., Anzaloni A.:Automated analysis of network QoS parameters for Voice over IP applications, Inter-domain Performance and Simulation Workshop, Budapest, March (2004)
24. Miloucheva I., Anzaloni A., Müller E.: A practical approach to forecast Quality of Service parameters considering outliers, First international workshop on Inter-domain performance and simulation Workshop , Salzburg 20-21 February (2003)
25. Degermark M., Kohler T., Pink S., Schelen O.: Advance reservations for predictive service in the internet. ACM/ Springer Verlag Journal on Multimedia Systems, 5(3), (1997)
26. Foster I., Kesselman C., Lee C., Lindell B., Nahrstedt K., Roy A. : A distributed resource management architecture that supports advance reservation and co-allocation, International Workshop on Quality of Service (IWQoS) (1999)