Adaptable Communication Software for Differentiated QoS

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Introduction and Research Directions

The performance of network and communication software is a major concern for success of the emerging application such as **E-commerce**. One drawback of current Internet is the lack of **QoS** support which is essential for business and electronic commerce applications. The efforts based on Integrated Services (IntServ) and RSVP are not deployable in large scale Internet Networks. They are also not appropriate for short flows such as retrievals and updates in e-commerce transactions and short-lived TCP connections. Differentiated Services (**DiffServ**) is a new approach for QoS support in the Internet. DiffServe is the proper technique to deal with various quality of service needs.

This project aims to provide solutions to one major problem in DiffServ:
DiffServ based bandwidth reservation is assumed static in the Internet. If the user wants to change the service level agreement, the change must be communicated to the ISP using fax or WWW forms. The network nodes have to be reconfigured manually by a network operator within one or more ISP domains and it takes time. Our goal is to support dynamic service level negotiations in order to allow applications to request bandwidth on demand. This can be achieved using an appropriate signaling protocol between the user and the affected ISPs. Through adaptability mechanisms, we plan to limit the burden on users in reconfiguring the system to provide the highest quality of service in the current environment

An adaptable communication software can allocate the bandwidth for different application needs. We propose to conduct a series of experiments that will lead in the development of policies for adaptability at the application, system, and network layer to meet the quality of service (QoS) requirements. We plan to conduct experiments that study the impact of e-commerce applications on the network resources. Next we study the impact of network and system constraints in determining the QoS that can be guaranteed to the user. Based on these experiments, we plan to identify guidelines and expertise that will allow the application and network to meet the quality of service requirements at all layers. We focus on three fundamental research problems: mechanisms and infrastructure for implementing adaptability; quality of service provision and control; expert rules/guidelines for adaptability control. This will allow the research mechanism/protocols that will provide differential QoS and their impact on various emerging applications such as multimedia and electronic commerce. This research will provide advanced system services, protocols, techniques and their evaluation through scientific experimental study. This will enable researchers in building integrated-service subsystem that satisfactorily implement applications requiring different levels of quality of service.

1. Adaptable Communication

The objective of meeting the quality of service requirements of applications and communication software requires that both are adaptable. Convenience, privacy/security, response time, throughput, reliability, timeliness, accuracy and precision are adaptable features for QoS in the e-commerce application. Reliability and bandwidth guarantee are some of the adaptable features in the communication level.

Differentiated Services (DiffServ)
The application should be able to negotiate resource requirements from the service provider. DiffServ [5] is a mechanism to provide QoS in Internet. The main idea of DiffServ [5] is the aggregation of flows. Reservations of bandwidth have to be done for a set of related flows (e.g. for all flows between two subnets). These reservations are static since no dynamic reservations for a single connection are possible. Therefore, one reservation may exist for several, possibly consecutive connections.

The packets in DiffServ model are tagged with different priorities by the user (either in an end system or at a router) or by the service provider. According to the priority class of the flow, the routers reserve corresponding shares of resources (in particular bandwidth). This concept enables a service provider to offer different classes of QoS at different costs to the customers.

Currently there are several proposals for the realization of DiffServ such as Premium and Assured Services [5], Scalable Resource Reservation Protocol [6] (SRP), and User-Share Differentiation (USD) [7]. These approaches allow customers to set a fixed rate or a relative share of packets which have to be transmitted by the ISP with high priority. The service negotiation between user and ISP is usually a static process. The user and the ISP negotiate the Differentiated Services parameters for a longer term, e.g. for several hours or days. Based on that negotiation, the ISP performs a re-configuration of the network. A more dynamic approach would allow a more fine-grained service negotiation so that renegotiations are possible in the minute or even second time frame.

Based on these ideas, we plan to conduct the following tasks for differentiated QoS mechanisms in Internet:

- Evaluation of appropriate classification, queuing, policing, and shaping mechanisms (traffic conditioning components) for DiffServ based on simulation/emulation and prototype implementations.
- Adaptation and modification of the DiffServ scheduling and queuing components for the Network.
- Implementation of an appropriate QoS routing scheme for DiffServ.
- Integration of QoS-routing-based forwarding and scheduling.

2. Adaptable Quality of service

We plan to develop both quantitative and qualitative parameters for quality of service at different layers of the application, systems, and network. We plan to identify requirements and mechanisms that can provide appropriate quality of service for a variety of applications. One such effort will be in resource management. Resource reservation, while being able to guarantee QoS, often results in under-utilization. Adaptability allows the resource to be shared. Therefore the utilization of resource can be increased while at the same time provide acceptable QoS to applications. We will investigate how to maintain certain QoS parameters for transmission of objects in electronic commerce in case of network bandwidth changes. What are the equivalent tradeoffs in terms of presentation quality? What are the guidelines for maintaining timeliness, accuracy, and precision when an anomaly occurs or there is a constraint on system resources?

We have extensive facility to conduct experiments in our Raid laboratory where we support a reliable, adaptable, interoperable distributed system and an adaptable communication software [4]. We conduct measurements to develop the benchmarks and values for input parameters for our experiments. For example, we have studied the impact of various requirements of e-commerce applications on the wide area network resources [1] using the WANCE tools [2]. WANCE tool has been used extensively to study the effect of applications such as distributed transaction processing in electronic trading [3], on the communication behaviors of the network.

We will develop mechanisms that will allow adaptation among a choice of protocols to increase performance and robustness. We will formalize the classes of conditions that must be satisfied for correct adaptation and reconfiguration. Our research will focus on e-commerce application and provide insights and guidelines for realizing adaptable communication software for differentiated QoS.

Electronic commerce
Electronic commerce is financially appealing application that involve distributed transaction processing. It involves communication among several servers (at user, broker, and stock exchange sites). Various components of transaction processing system rely on the communication software for high performance and acceptable QoS. The network latency, server scheduling mechanisms, failures either functional or operational can cause a severe loss in the quality of service. QoS parameters in this application are accuracy of order execution, response time for real-time quotes or confirmations, throughput, meeting the deadline. The data objects can be business forms, multimedia documents and images. This requires further study as follows:

Digital markets need to transmit multimedia objects across the network. Digital market place and information retrieval systems require efficient and reliable end-to-end support for processing queries from the global networks. The system must meet the criterion of timeliness, high-bandwidth for large data chunks, and scalability for global inquiries. Our research will provide guidelines for software support for efficient access to widely distributed digital market data and reliable, secure and efficient delivery of large data objects in various networks. The changes in parameters such as frame sizes, codec schemes, color depths, and frame resolutions are made by users interactively. The changes are not currently made automatically based on the system measurements of currently available resources.

In the following, we propose tasks that will be researched by us at Purdue.

Contribution Claims and Relevance/value to IBM

Our experimental research in communication software, DiffServe and quality of service directly addresses IBM key technology interests in communication technology (Internet II) and development/deployment for electronic commerce application. The innovative technologies that will be developed in the project include :

1. Experiments and evaluation of DiffServe QoS mechanisms and protocols. It will facilitate development of DiifServe for E-commerce application.
2. A new class of routing, congestion control and QoS provision algorithm that will exploit the user-programmable features of communication networks to provide tailor made QoS and Communication services to applications such as E-Commerce.
3. New Mechanism for adaptability in communication networks will be proposed and evaluated. Those mechanisms will enable both the applications and network software to respond to traffic, congestion, multimedia data delivery, variable bandwidth requirement and reconfigure the network to adapt to the new situation based on some QoS requirements.

List of IBM Contacts of the PIs :

- Anant Jhingran, Senior Manager, Networked Data Systems, IBM TJ Watson Research Center (letter enclosed)
- Krishna Sriram, Business Development Consultant, ALLSTATE Account, IBM Global Services (letter enclosed)
- Shunge Li, a PhD student in our lab worked as an intern at IBM in 1996 under the supervision of Mr. Joe Benas at IBM Poughkeepsie, NY.
- We would like to further develop our relationship with Dr Liba Savadova at IBM Zurich, Switzerland.

Project URLs : `http://www.cs.purdue.edu/faculty/bb.html`

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