Toward a Quality-of-Service Framework for Peer-to-Peer Applications

Ankur Gupta, Model Institute of Engineering and Technology, India
Lalit K. Awasthi, National Institute of Technology, India

ABSTRACT

P2P networks have caught the imagination of the research community and application developers with their sheer scalability and fault-tolerance characteristics. However, only content-sharing applications based on the P2P concept have reached the desired level of maturity. The potential of the P2P concept for designing the next-generation of real-world distributed applications can be realized only if a comprehensive framework quantifying the performance related aspects of all classes of P2P applications is available. Researchers have proposed some QoS (Quality-of-Service) parameters for content-sharing P2P applications based on response time and delay, but these do not cover the gamut of application domains that the P2P concept is applicable to. Hence, this research paper proposes an early QoS framework covering various classes of P2P applications; content distribution, distributed computing and communication and collaboration. Early results from the prototype implementation of the Peer Enterprises framework (a cross-organizational P2P collaborative application) are used as a basis for formulation of the QoS parameters. The individual performance measures which comprise the QoS framework are also discussed in detail along with some thoughts on how these can be complied with. The proposed framework would hopefully lead to quantifiable Service-Level Agreements for a variety of peer-to-peer services and applications.

Keywords: Content-Sharing, P2P Networks, Peer Enterprises, QoS Framework for P2P Applications, Quality-of-Service

INTRODUCTION

P2P networks have traditionally been considered too transient in nature to perform useful computations for real-world applications, leave aside the formulation of a viable QoS framework. The only mature application that P2P networks successfully cater to, are those related to content sharing, where the sheer scale of P2P networks along with strategies for content-caching and replication enable content to be located and downloaded in a time-bound manner. Gummadi et al. (2003), made an early attempt at analyzing the P2P content sharing workloads, quantifying the impact of content locality on query performance and bandwidth savings. Since, then some QoS parameters for P2P applications have been proposed, but they

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have been limited to content-sharing applications. Specifically, QoS parameters have been proposed for:

1. Guaranteed content location and retrieval (if it exists) – Query Success
2. Time-bound content location and retrieval – Query Performance
3. Correct content retrieval – Content Quality
4. Video Streaming and Multicasting – Delay, Bandwidth and Jitter

As can be seen from the table, most of the real-world applications based on the P2P concept are freeware for content sharing or communication or those operating within a federated domain. Hence, QoS is not a major requirement for such applications. Hence, research on QoS for P2P networks remains in a nascent stage barring establishment of a few parameters related to content search. A new class of P2P applications integrating content, computation and communication and specialized services – the Peer Enterprises (PE) framework has been proposed by Gupta and Awasthi (2007). The PE framework has the potential to enable new cross-organizational service and business models. Hence, a detailed QoS model if available for such applications would facilitate their deployment and ensure viability. To ensure that P2P applications in general become more pervasive and can progress beyond file-sharing applications, a minimal QoS framework based on specific quantifiable and non-quantifiable parameters must be established. Such a framework shall provide the much needed guidelines for P2P application designers and developers to cater to the QoS parameters and help meet application performance requirements effectively. Research on QoS pertaining to P2P systems has focused on the following areas:

a. Content Search;
b. QoS-aware Routing;
c. Content Delivery/Video Streaming; and
d. Use of P2P concepts in Grid Computing/Service-Oriented Architectures

BACKGROUND

P2P applications can broadly be classified (Milojicic et al., 2002) into the following categories based on their functionality:

a. Content Distribution
b. Distributed Computation
c. Communication and Collaboration

d. Table 1 summarizes the application categories, application characteristics and examples of some well-known P2P applications.

RELATED WORK

A good discussion on QoS pertaining to content management for P2P file-sharing applications is provided by Meo and Milan (2008), wherein a QoS policy at individual peers works out the best content management strategy for ensuring high-availability of content and its assured retrieval. Using a Markovian model it works out which content should be retained by a peer and which should be discarded to improve the
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