Poster: SIP-based QoS Support and Session Management for DDS-based Distributed Real-time and Embedded Systems*

Akram Hakiri, Berthou Pascal, and Gayraud Thierry
Université de Toulouse; UPS, INSA, INP, ISAE; LAAS; F-31077 Toulouse, France
{Hakiri, Berthou, Gayraud}@laas.fr

Aniruddha Gokhale, Joe Hoffert, and Douglas C. Schmidt
ISIS, Dept of EECS, Vanderbilt University
Nashville, TN 37212, USA
{gokhale,jhoffert,schmidt}@dre.vanderbilt.edu

ABSTRACT

End-to-end quality-of-service (QoS) support in middleware is critical to achieve publish/subscribe (pub/sub)-based distributed real-time and embedded (DRE) systems. This poster describes ongoing work on supporting QoS properties over wide area networks within the OMG's Data Distribution Service (DDS) by leveraging the Session Initiation Protocol (SIP) and Session Description Protocol (SDP).

Categories and Subject Descriptors

D:Software [**2:Software Engineering**]: 2:Design Tools and Techniques

General Terms

Design, Performance

Keywords

DDS over WANs, SIP, QoS

1. INTRODUCTION

Many publish/subscribe (pub/sub)-based distributed real-time and embedded (DRE) systems operate in heterogeneous environments that receive data from a large number of sensors and multimedia sources and stream it in real-time to remote entities. A key requirement of these DRE systems is to optimize the performance and scalability of applications and provision/control key network resources [1]. The Object Management Group (OMG)'s Data Distribution Service (DDS) [2] is a data-centric pub/sub middleware that simplifies application development, deployment, and evolution for DRE systems. Contemporary DDS implementations, however, do not currently support key QoS properties of pub/sub DRE systems over wide area networks (WANs) because the DDS middleware inherently resides on end-systems and thus defines only mechanisms that control end-system properties, such as OS-level parameters and tuning network parameters for the connecting link. In particular, DDS provides no mechanisms for provisioning/controlling end-to-end QoS over WANS, which complicates the assurance of QoS for large-scale DRE systems.

A promising approach to address these challenges is to integrate DDS with the Session Initiation Protocol (SIP) [3] and the Session Description Protocol (SDP) [4]. SIP/SDP are powerful mechanisms available over WANs to convey new enhanced services including information about the end-systems, identification of the originator of a session, identification of the multimedia content in the session initiation request which might contain pictures, signals from sensors, and a personalized ring-tone.

Despite the promise of SIP/SDP, the integration with DDS is not straightforward since the level of abstraction of SIP/SDP makes them agnostic to account for the application QoS needs of pub/sub DRE systems. The rest of this paper outlines our solution approach to close the gap between SIP/SDP and DDS so that DDS and its QoS support can be realized over WANs.

2. SUPPORTING OMG DDS OVER WANS

This section briefly outlines our approach to supporting OMG DDS over WANs. The solution requires addressing two primary challenges discussed below.

2.1 End-to-End QoS Provisioning

Context: Recent work [5] describes how applications are increasingly being distributed over multiple machines in WANs to ensure scalability and availability. Not only is the amount of data exchanged becoming large, but the exchanged flows are becoming more diverse. DiffServ flows have different priorities, delays, and bandwidth requirements, which must obtain the required network resources to fulfill application requirements [6].

Problem: An important property for WAN-based pub/sub DRE systems is that the right answer delivered too late becomes the wrong answer, *e.g.*, small delays can incur sub-

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stantial damage or losses. As Next Generation Networks (NGNs) [7] become increasingly reliant on IP, providing end-to-end network QoS assurance becomes hard. To ensure that end-to-end QoS is met, developers of DRE systems must define traffic profiles for each application and ensure this service specification is never exceeded.

Solution Approach: To provision WAN-level resources to support end-to-end QoS, we define a new SIP Signaling Class of Service (S-CoS) for transferring signaling messages. To provision this new S-CoS, we leverage DDS latency, transport priority, and bandwidth QoS settings. Using appropriate S-CoS dimensioning enables control of transfer packet setup latency in the access and core network for resource provisioning. Moreover, to support the DDS QoS policies, SDP is used to describe the session characteristics, such as which media streams are included in the session, and the codec used for data streaming. We define a new QoS support for SIP-based network architecture to integrate DDS application (SIP Client), QoS-enabled SIP (Q-SIP) Server, and policy based network management. We also define new SDP extensions to integrate DDS QoS policies in SIP/SDP packet headers. Our approach requires no modifications to applications, which can continue to use standard DDS QoS policy and programming interfaces.

2.2 Autonomic Adaptation and Robustness in Dynamic Environment

Context: A multimedia application for, say, a UAV video distribution using multi-layer resource management mechanisms, is often coordinated via middleware to ensure video flows can meet their mission QoS requirements by adapting both the computer and the network resources. The architecture adaptively controls the video transmission captured from cameras (publishers) subsequently sending them to middleware based distributed processing units. The information is then distributed over QoS-aware networks to one or more remote receivers (subscribers) including displayers and image processing software. UAVs should provide high data rate and ultra-low latency and involve data dissemination to multiple operators that cooperate in the operation in ground station.

Problem: There are many challenges associated with providing reliable and low latency communication with ground stations, including consistency, configurable reliability, and reliable delivery atop any type of reliable or unreliable transport. With the advent of wireless sensors networks, minimizing the amount of data transmission across is crucial [8]. Moreover, various QoS properties are essential to provide to each operator with only the necessary data at the right time. The network infrastructure should therefore be flexible enough to support varying workloads at different times during operations, while also maintaining highly predictable and dependable behavior. Meeting these challenges requires a high level of structural and temporal decoupling for the control, adaptation of resources, and to maintain real-time performance. Such a capability should seamlessly interoperate at both the end-systems and the network.

Solution Approach: SIP/SDP allows the usage of static and dynamic media payload description (which exists as a well-known id associated to it) that can be used by the transport protocol. The dynamic media payload description should, however, include more information that characterizes the format to ensure the robustness and the automatic adaptation in dynamic environment. The dynamic mechanism is that the DDS QoS policies mapped into SIP messages are used by the SIP proxy (Q-SIP). Thus, when the host changes its QoS requirements, the SIP message is intercepted by the proxy SIP to be redirected to the destination for notification (offer/response contract).

Subsequently, the receiver node adapts its DDS QoS policies with those notification (here just changeable QoS setting are applied) and sends a response to its Q-SIP which notifies an underlying Bandwidth broker with the new QoS requirements to adapt its class of Service (to change from, say, real-time CoS to non real-time CoS, and vice versa). For interoperability, this mean that the SIP messages including DDS QoS settings are used for non DDS application, because they are just text messages (like HTTP). Any SIP compliant terminal should interpret SIP messages and ignore SIP DDS attributes in the messages. Thus, it is possible to distribute thousands of messages per second, while maintaining the scalability, an ultra-low predictable latency, controlling a tradeoff between latency and throughput, and stability under low resource conditions.

3. CONCLUDING REMARKS

This paper describes our approach to supporting OMG DDS and its QoS policies over WANs. Our solution comprises two artifacts: (1) At the service plane, DDS applications use SIP signaling messages that allow senders to contact receivers to obtain their IP addresses and to agree the media description and "qos-dds" attributes; (2) At the control plane, the network QoS provisioning mechanism encodes application QoS requirements within SDP messages supplied to the network elements to (a) negotiate QoS, (b) coordinate the data path and signaling path management, and (c) enforce the end-to-end network resource reservation. Our ongoing work is focused on conducting experiments to validate the end-to-end QoS expected by DDS-based DRE systems operating over WANs.

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