Journal of Network and Computer Applications 34 (2011) 1707–1716

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Application of the Java Message Service in mobile monitoring environments

Martin Kuehnhausen *, Victor S. Frost

Information and Telecommunication Technology Center, The University of Kansas, Lawrence, KS 66045, USA

ARTICLE INFO

Article history:
Received 23 December 2010
Received in revised form
6 May 2011
Accepted 12 June 2011
Available online 24 June 2011

Keywords:
Telemetry
Transport protocols
Intermittently connected wireless networks
Communication system software
Data communication
Software engineering

ABSTRACT

Distributed systems and sensor networks in particular are in need of efficient asynchronous communication, message security and integrity, and scalability. These points are especially important in mobile environments where mobile remote sensors are connected to a control center only via intermittent communication. We present a general approach for dealing with the issues that arise in such scenarios. This approach is applied to provide flexible and efficient cargo monitoring on trains.

The Java Message Service (JMS) presents a flexible transport layer for asynchronous communication that enables transparent *store-and-forward* queuing for entities that need to be connected to each other. Previously JMS was primarily used in always-connected high-bandwidth enterprise communication systems. We present the advantages of using JMS in a mobile, bandwidth-limited, and intermittently connected monitoring environment and provide a working implementation called the Transportation Security SensorNet (TSSN) that makes use of an implementation of JMS called ActiveMQ. This solution is employed here to enable monitoring of cargo in motion along trusted corridors.

Results obtained from experiments and a field trial show that using JMS provides not just a practical alternative to often custom binary communication layers, but a better and more flexible approach, by providing transparency. Applications on both communication ends only need to implement JMS connectors while the remaining functionality is provided by the JMS implementation. Another benefit arises from the exchangeability of JMS implementations. In utilizing JMS we demonstrate a new, flexible and scalable approach to cope with challenges inherent in intermittent and low-bandwidth communication in mobile monitoring environments.

1. Introduction

There exist a plethora of problems that need to be addressed whenever disparate systems are deployed in the field that need to communicate with each other and a control center. Additional challenges arise given that these systems are often heterogeneous where different system elements are not always compatible to each other. Here we used the following scenario as a motivating example to point out the nature of the problems.

Sensors are connected to cargo containers which they monitor. A train is then used to transport these containers. The sensors, in our case electronic seals, have limited capabilities and are managed locally by a more powerful system element which we call the sensor node that has extended functionality including a communication link back to a control center. Hence, one sensor node controls more than one electronic seal. From an architecture perspective a sensor node can control many different sensors. Whenever a seal detects an event it notifies the sensor node immediately. The sensor node then performs an evaluation of the event and decides whether or not to send it to the control center. In this paper, we focus on sending messages to and receiving control messages from the control center.

The link between the sensor node and control center may provide only intermittent communication. The sensor node must deal with establishing the connection as well as transmitting messages. Especially the latter can cause problems; in a synchronous communication model the sensor node would only be able to send one message at a time and block while waiting for its acknowledgement. This is not feasible in this case because of the intermittent connection, low bandwidth and high latency of the communication link. An asynchronous communication model overcomes this blocking problem. Furthermore, since messages cannot be sent out immediately due to the intermittent connectivity they need to be stored. This can be achieved by implementing a queuing mechanism inside the sensor node.

It is also possible to send control messages such as location or receive status inquiries from the control center to the sensor node. Again, since there does not necessarily exist an active connection to the sensor node messages need to be queued. Hence, the applications in the control center are responsible for implementing proper queuing and retry mechanisms.

Security and message integrity are critical aspects of the overall monitoring system. If people, who want to steal cargo from the

* Corresponding author.
E-mail address: mkuehnha@ittc.ku.edu (M. Kuehnhausen).

1084-8045/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jnca.2011.06.003