Mobile XSiena: Towards Mobile Publish/Subscribe

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ABSTRACT
Mobile XSiena is a novel publish/subscribe platform which seeks to extend the XSiena content-based publish/subscribe system in order to support user mobility and create an experimental framework to study the relationship between such mobility and pervasive information dissemination flows.

Categories and Subject Descriptors
H.3.4 [Systems and Software]: Distributed Systems

General Terms
Design, Performance, Experimentation

Keywords
Event-Based Systems, Publish/Subscribe, Mobility Support

1. INTRODUCTION
Publish/subscribe systems [2] are distributed event-based systems which provide applications with means to carry out anonymous, asynchronous and multicast-like communication. In publish/subscribe systems, event publishers and event subscribers are not required to identify the sources or destinations of the events they exchange and rely on the publish/subscribe infrastructure to transport, route and deliver events in a reliable, scalable and transparent way. When a given event is published, the infrastructure takes care of delivering that event to all interested parties without any explicit intervention from the publisher, provided that subscribers have already expressed their interest in that particular type of content. This loosely coupled approach to communication enables publish/subscribe systems to adapt to changing environments where publishers and subscribers join and leave the system without disrupting its operation and the general flow of events. Due to those characteristic features, publish/subscribe systems are particularly interesting in mobile information dissemination scenarios and are in fact the subject of the research effort described in this paper.

2. MOBILE XSiena
XSiena [6] is a generic content-based publish/subscribe system developed at the University of Dresden which is focused on performance and scalability. XSiena was inspired by earlier work on publish/subscribe systems [1] and provides an open source Java implementation which leverages the Apache MINA network application framework to provide non-blocking input/output operations at the application level. Mobile XSiena seeks to extend the generic XSiena system to address the specific requirements of mobile information dissemination scenarios. The following five subsections enumerate several key aspects of such scenarios and link those aspects with specific features of Mobile XSiena.

Mobile device integration
In order to support mobility, mobile devices must be completely integrated into the publish/subscribe system. Mobile XSiena achieves this by porting XSiena to the Android mobile platform, a representative mobile operating system. A hurdle in the way to run XSiena on an Android system comes from its reliance on the MINA object serialization codec, as the Dalvik virtual machine used by Android produces serialized objects which are incompatible with the Java SE HotSpot virtual machine. Therefore, the object serialization protocol in XSiena has been replaced with a custom serialization codec that ensures the correct delivery of events regardless of the virtual machines that send and receive those events. It must be noted that this custom serialization codec improves average encoding and decoding times compared to the default MINA object serialization codec by up to 10%.

Seamless networking
Mobile information dissemination scenarios should foresee mobile devices roaming across different networks and should not rely on static addresses to handle communication between those mobile devices and the infrastructure. Mobile XSiena supports both cellular and wireless local area networks and provides mechanisms to enable discovery of brokers on those networks. A multicast discovery protocol enables applications to detect brokers which are connected to the same local area network. This protocol has been complemented with a unicast broker discovery mechanism that connects applications with a public broker through a cellular network connection when local area network connectivity is not available. These discovery protocols, combined with an interconnected set of public brokers, ensure pervasive and seamless connections between mobile applications and the deployed wide area publish/subscribe infrastructure.
Reconnection support

Due to the nature of wireless networking, mobile applications can suffer from intermittent disconnections. Furthermore, these mobile applications may reconnect to the publish/subscribe infrastructure at a later time, changing brokers as they roam networks and recover from disconnections. In order to support this phenomena, XSiena requires some major extensions in the form of event queues and a broker handoff protocol [5]. Disconnections require both applications (in the case of publishers) and the infrastructure (in the case of subscribers) to enqueue undelivered events and define summarization and selective discarding policies for them. These policies depend on the nature of events and whether complete event series need to be preserved or only the most recent event is of interest to its subscribers. When a formerly connected application disconnects and then connects to a different broker, normal event delivery may only be resumed after all pending events are transmitted from their respective event queues and a broker handoff protocol is carried out in order to update the routing information.

Location-based matching

Location information is an extremely useful resource in mobile information dissemination scenarios as it enables systems to discriminate relevant information and provide users with valuable notifications. Therefore, the events and filters created with Mobile XSiena contain location information as part of their attributes. For events, this location information determines the relevancy range of such events, whereas location-based filters indicate the interest range of a given subscription. These attributes enable brokers to match events and subscriptions only if their respective relevancy and interest areas overlap. To enable this kind of location-aware behaviour [3], the matching algorithms implemented in XSiena brokers have to be extended to support location-based matching. Many mobile dissemination scenarios may also benefit from having events and filters tied to the current location of their respective publisher or subscriber. Therefore, the publish/subscribe system must also handle the continuous changes in the location of mobile publishers and subscribers, which requires a further extension to the XSiena publish/subscribe communication protocol.

Persistent events

In order to enable complex information services to be deployed on top of Mobile XSiena, persistent events are an additional requirement driven by the need of certain applications to receive events that were published in the past [4]. This way, persistent events complement the default soft real-time events directed at all subscribers listening at a given time, giving applications the ability to query the publish/subscribe infrastructure about past events in order to better serve mobile application users. This proves particularly useful when dealing with sources of geographic information or commercial services which are offered throughout the year and are thus static in nature. Persistent events model their validity in time with a renewable temporal attribute or lease time and may only be enqueued by Mobile XSiena brokers as long as their lease times have not expired. Maintenance of persistent event lease times require an additional extension to XSiena that must be carefully coordinated with the general queueing mechanism needed to support reconnections.

3. DISCUSSION

While some of its features have already been implemented, the Mobile XSiena platform remains work in progress. Some key mobility-related features of Mobile XSiena such as reconnection support, location-based matching and persistent events require major changes to the XSiena codebase and involve several research challenges. However, the current state of Mobile XSiena has proven sufficient to conduct basic performance measurements in an effort to assess the feasibility of the platform in real-world mobile deployment scenarios. Two series of experiments have been carried with an Android mobile phone connected to the Mobile XSiena infrastructure using both cellular and wireless local area networks. Table 1 summarizes the results of the latency experiment averaged over 1,000 measurements for each network type, whereas Table 2 presents average event throughput performance based on five series of 10,000 publications for each of the network types and their two respective links. Despite the volatile nature of cellular network performance, these preliminary tests over TCP/IP show the potential of Mobile XSiena.

<table>
<thead>
<tr>
<th>Network</th>
<th>Average</th>
<th>σ</th>
<th>P₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLAN</td>
<td>12 ms</td>
<td>4 ms</td>
<td>16 ms</td>
</tr>
<tr>
<td>UMTS</td>
<td>76 ms</td>
<td>41 ms</td>
<td>102 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network</th>
<th>Link</th>
<th>Average</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLAN</td>
<td>uplink</td>
<td>257 events/sec</td>
<td>6 events/sec</td>
</tr>
<tr>
<td></td>
<td>downlink</td>
<td>315 events/sec</td>
<td>2 events/sec</td>
</tr>
<tr>
<td>UMTS</td>
<td>uplink</td>
<td>329 events/sec</td>
<td>23 events/sec</td>
</tr>
<tr>
<td></td>
<td>downlink</td>
<td>105 events/sec</td>
<td>3 events/sec</td>
</tr>
</tbody>
</table>

Table 2: Network throughput (TCP/IP)

4. REFERENCES


