QoS Monitoring and Analysis approach for publish/subscribe systems deployed on MANET

Elaborated by:

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**Publish/subscribe systems**

- A communication paradigm that allows producers to send messages to consumers in an asynchronous way via an event service.
- The event service is composed of brokers acting as intermediate entities between producers and consumers.

**Mobile Ad hoc Networks**

- MANETs is a collection of mobile nodes like (PDAs, Mobile phones, Personal computers) which are free to move in a random and unpredictable way.
Publish/Subscribe systems on MANET introduce several problems related to quality of service like Logical link degradation between brokers.
Objectives

- Maintain an acceptable quality of service of Publish/Subscribe systems deployed on MANETs
- Monitor logical link quality between neighboring brokers at middleware layer
- Detect logical link degradation between brokers at middleware layer
- Ensure the system survivability
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<th>Failure type</th>
<th>Failure source</th>
<th>F-D architecture</th>
<th>Message</th>
<th>Used technique</th>
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<td>Active</td>
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<td>DHT</td>
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<td>Content based</td>
<td>All types</td>
<td>Architecture</td>
<td>Passive</td>
<td>Fixed threshold</td>
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</tr>
<tr>
<td>Harmony [KKY+10] [YKK+09]</td>
<td>Dynamic</td>
<td>Subject based</td>
<td>Hybrid</td>
<td>Node and link</td>
<td>mobility</td>
<td>Hybrid</td>
<td>Active</td>
<td>PING and monitoring and analysis</td>
</tr>
</tbody>
</table>

**Proposed approach**

- Unable to detect link failure
- Can cause message loss especially in dynamic contexts
- False alarms due to the fixed interval designed for message reception
- High traffic due to message exchange

**False alarms caused by fixed threshold values**
Proposed approach

Monitoring module

Analysis module

Monitoring approach

Analysis approach

General context

Motivation

Objectives

Related work

Proposed approach

Approach evaluation

Conclusion & future works

Monitoring approach

Analysis approach

Proposed approach

Approach evaluation

Conclusion & future works

Monitoring module

Analysis module

Logical link

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Monitoring approach

- Extracting and collecting QoS values in order to evaluate the system state
- The considered QoS metric: Latency
- Monitoring module consists of two complementary components: an observer and a logger
- The monitoring module is based on **message interception** in order to extract latency values
Analysis approach

- **Reactive** and distributed approach

- Involves on each broker a failure detector responsible for analyzing QoS parameters and detecting failures

- Based on **statistical methods** and **Extreme Value Theory** (EVT) in order to detect logical link degradation between neighboring brokers at middleware layer

- Based on the comparison of QoS metric values to an adaptive threshold value

  - **If** the QoS metric values exceeds for a number of consecutive times (e.g. 2) the threshold value, **So** logical link degradation between neighboring brokers is detected

- Analysis is formed by 2 phases: a pretreatment phase and a treatment phase
Phase 1: pretreatment phase

1. **Approximation with empirical distribution**

   - Extraction of both max values and mean values from the period forming the latency serie
   - The max values are approximated to the Gumbel distribution using the *Extreme Value Theory*
   - The mean values are approximated to the Gaussian distribution using the test of *SHAPIRO* and *WILK*

2. **Initial threshold calculation**

   \[
   Th_{QoS_{max}} = x_0 - S \ln \left[ \ln \left( \frac{1}{p} \right) \right]
   \]

   \[
   Th_{QoS_{mean}} = f \left( \phi^{-1}(p), \mu_{QoS_{mean}}, \sigma_{QoS_{mean}} \right)
   \]

3. **Failure detection in the pretreatment phase**

   - Adaptive threshold calculated through confidence levels
Phase 2: Treatment phase

- Initial max threshold value
- Initial mean threshold value

→ Applying the **Exponential Weighted Moving average (EWMA)** technique to generate adaptive threshold values

\[
Threshold_{QoS} = \lambda \times \sum_{j=0}^{i-1} ((1 - \lambda)^j QoS_{i-j}) + (1 - \lambda)^i \times Th_{QoS_{initial}}
\]

- Previous latency values
- Initial thresholds
Simulation parameters

- **Publish/Subscribe system**: SIENA (Scalable Internet Event Notification Architecture)
- **Network simulator**: JiST/SWANS (Java in Simulation Time/Scalable Wireless Ad hoc Network Simulator)

<table>
<thead>
<tr>
<th>Simulation parameters</th>
<th>Values</th>
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</thead>
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<tr>
<td>Field size</td>
<td>2000m x 3000m</td>
</tr>
<tr>
<td>Nodes number</td>
<td>200 nodes</td>
</tr>
<tr>
<td>Mobility model</td>
<td>Continuous Random Walk</td>
</tr>
<tr>
<td>Transmission range</td>
<td>300m</td>
</tr>
<tr>
<td>Routing protocol</td>
<td>AODV</td>
</tr>
<tr>
<td>Transport protocol</td>
<td>UDP</td>
</tr>
<tr>
<td>Message size</td>
<td>120 bytes</td>
</tr>
</tbody>
</table>

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Threshold measured via confidence level

Initial max threshold

Initial mean threshold

Violations → 

Failures
Acceptable latency values

adaptive max threshold

adaptive mean threshold

Latency function of simulation time

Failure
The overhead of the 2 modules

Overhead introduced by monitoring and analysis modules

- Without monitoring nor analysis modules
- With monitoring and analysis modules

Message size (bytes)

Execution time (µs)
• A distributed approach for monitoring and analysis of publish/subscribe system deployed on MANET

• Analysis approach is based on statistical methods as well as Extreme Value Theory to detect logical link degradation at middleware layer

• The overhead of the proposed modules is negligible
Thank You!

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