Noctua: A Publish/Subscribe Framework For In-Network Processing

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Motivation

Efficient networked applications for the Internet of Things

- Developing high-performance applications for low-power wireless networks requires domain expertise
  - Challenges: Energy consumption, link quality, memory capacity, processing speed, and device mobility

- Goal: A macroprogramming framework that dynamically optimizes an application by leveraging the shared resources of devices on its network

Communication

Publishers

Subscribers

- Publish/subscribe messaging paradigm
  - Data sources (publishers) and sinks (subscribers) are decoupled in both time and space

Privacy

- Through access controls, subscriptions can be limited to aggregated forms of data
  - This protects sensitive information without severely limiting flexibility in application development

System Architecture

- Noctua is built on Mosquitto, an open-source MQTT broker
  - The Dispatcher dynamically schedules requests for computation based on available network resources
  - Compute Engine runs on all devices with shared resources; performs computations when resources are available and a task has been allocated by the Dispatcher

Computation

- Data-centric networking allows data to be identified by names or topics, and for computations to be requested on-the-fly.
  - For example, a subscription to \( \text{avg}(\text{temp1}, \text{temp2}) + 2 \) automatically generates subscriptions to temp1 and temp2, and allocates a resource to compute the result

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literals:</td>
<td>ints, floats, 5, 8, 2.7</td>
</tr>
<tr>
<td>Operators:</td>
<td>(-, +, *, /)</td>
</tr>
<tr>
<td>Parenthesis:</td>
<td>( (47 - 5) + 8 )</td>
</tr>
<tr>
<td>Identifiers:</td>
<td>temp, speed, xl, yl</td>
</tr>
<tr>
<td>Static Routines:</td>
<td>( \text{avg}(), \text{min}(), \text{max}() )</td>
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</tbody>
</table>

Expression Grammar for Subscription Topics

 MQTT Protocol Example

- GPS A
- GPS B
- Distance(A, B)

Privacy Protection