A Generic Platform for Sensor Network Applications

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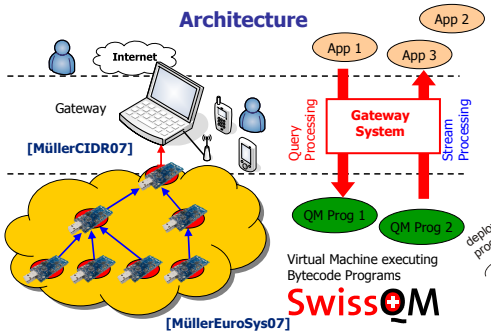
Introduction

Writing application for WSNs difficult:

- Mostly low-level programming
- Ad-hoc implementation (little reuse)
- Lack of infrastructure

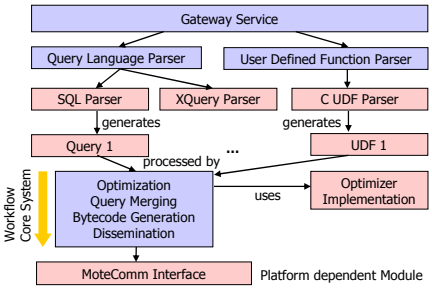
Here, we present SwissQM, a generic platform that simplifies the implementation of custom WSN applications. This is illustrated by **four example applications**.

Architecture



- Applications interact with Gateway
- Applications express acquisition task using
  - Queries (SQL-like, XQuery)
  - User-defined Functions (in C)
- Queries processed and compiled into short bytecode programs
- Programs are disseminated in the network
- Programs are executed by the SwissQM virtual machine on the sensor nodes (tmote sky)
- Results are sent back to Gateway
- Final result processing at Gateway → delivery to user applications

Gateway Service

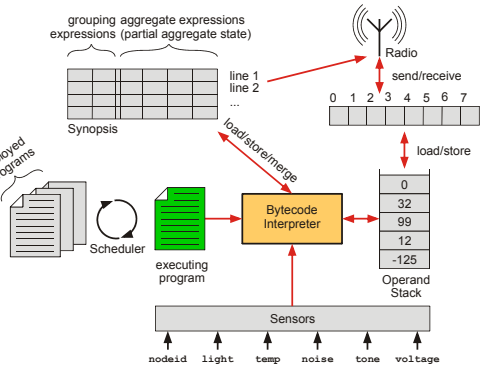


- Query interface for SQL and XQuery
- User-defined Function (UDF) Parser for C
- Modular implementation as OSGi components
  - Extensible: additional languages
  - Flexible: ad-hoc configuration of workflow
- Queries and UDFs are materialised as OSGi bundles (persistent, with OSGi life-cycle management)
- R-OSGi [5] allows remoting of services across JVM boundary. Remote client applications can connect to gateway service.

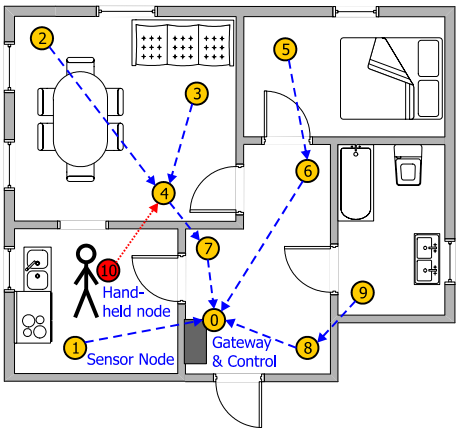
SwissQM Virtual Machine

Small-footprint Virtual Machine for Sensor nodes.

- 45 kB Flash, 4 kB RAM on tmote sky platform
- Instruction Set: 66 bytecode instructions
  - 42 general purpose instructions (like JVM)
  - 23 sensor specific instruction
  - 1 merge instruction (application specific)
- Up to 6 concurrent programs
- Transmission Buffer and Synopsis (Heap)
- Code execution in three program sections
  - **init**, **reception**, **delivery** section
  - Permits implementation of in-network aggregation processing



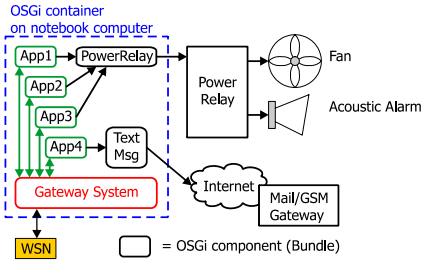
Demo Setup: Sensor Network in a Building



A WSN network deployed in an apartment building.

- 10 sensor nodes
- 1 mobile node carried by user (emergency button)
- Four different customised applications
  - **App1:** Heating Ventilation and Airconditioning (HVAC)
  - **App2:** Fire Detector
  - **App3:** Burglar Alarm
  - **App4:** Emergency Signaling
- Implementation on top of SwissQM gateway service

Demo: Overview



Demo Applications

Requests are expressed in queries/UDFs.

HVAC Application (App1)

"Turn on fan if average temperature measured in living room too high."

Query:

```
SELECT AVG(temp) FROM sensors
WHERE room=1 SAMPLE PERIOD 10s
```

Control:

```
if avg(temp) > T_on → Fan On
if avg(temp) < T_off → Fan Off
```

Fire Detector (App2)

"Turn on alarm and send message (email/text message) when sudden raise in temperature."

Query:

```
SELECT nodeid, temp FROM sensors
WHERE temp>30°C OR raise(temp)>5°C
SAMPLE PERIOD 4s
```

UDF:

```
void raise(int x) {
  static int oldx = 0;
  int delta = x - oldx;
  oldx = x;
  return delta;
}
```

Burglar Alarm (App3)

"Turn on alarm and send message (email/text message) when light readings change."

Emergency Signaling (App4)

"If user presses button >5s send call for help, localisation with nearest building node."

Query:

```
SELECT nodeid, nearest FROM sensors
WHERE oncount(switch)>=5
SAMPLE PERIOD 1s
```

References

[1] R. Müller and G. Alonso. Efficient Sharing of Sensor Networks. In MASS, 2006.

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[3] R. Müller, G. Alonso, and D. Kossmann. SwissQM: Next generation data processing in sensor networks. In CIDR, 2007.

[4] J. S. Rellermeyer and G. Alonso. Concierge: A Service Platform for Resource-Constrained Devices. In EuroSys, 2007.

[5] J. S. Rellermeyer, G. Alonso and T. Roscoe. R-OSGi: Distributed Application through Software Modularization. In Middleware, 2007

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Fonds National Suisse
Schweizerischer Nationalfonds
Fondo Nazionale Svizzero
Swiss National Science Foundation

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UNIL Université de Lausanne
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