Sensor Network Macroprogramming with Workflows and Events

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Context & Problem Statement

Wireless Sensor and Actuator Networks (WSANs):

- detect events, decide, and act upon the environment
- neat, but challenging, because of:
  - limited processing and memory
  - low power, battery-operated
  - lossy communication
  - decentralized operation

Developing WSAN applications is **too hard** for average users and/or domain experts:

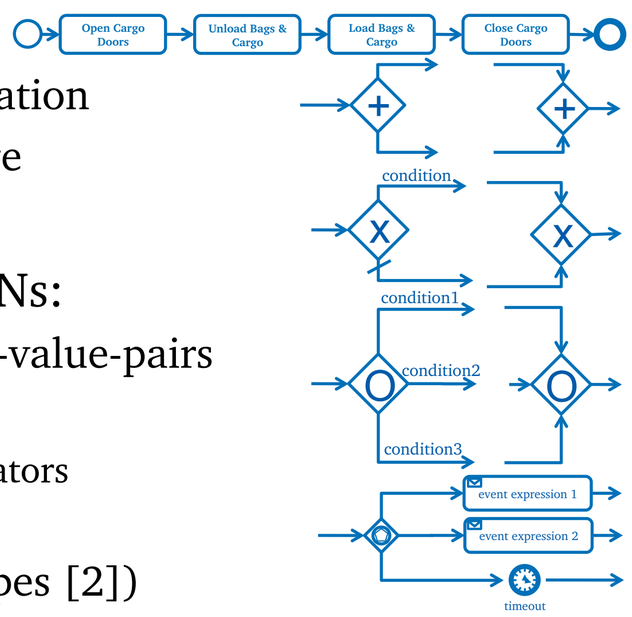
- Java / C / nesC are too **low-level**
- middleware approaches mostly focused on data extraction (no actuation)

Workflow Modeling

Employ BPMN 2.0 modeling notation

Adopt basic control flow patterns:

- sequence
- splitting / synchronization
- (multi) choice / merge
- event-based choice

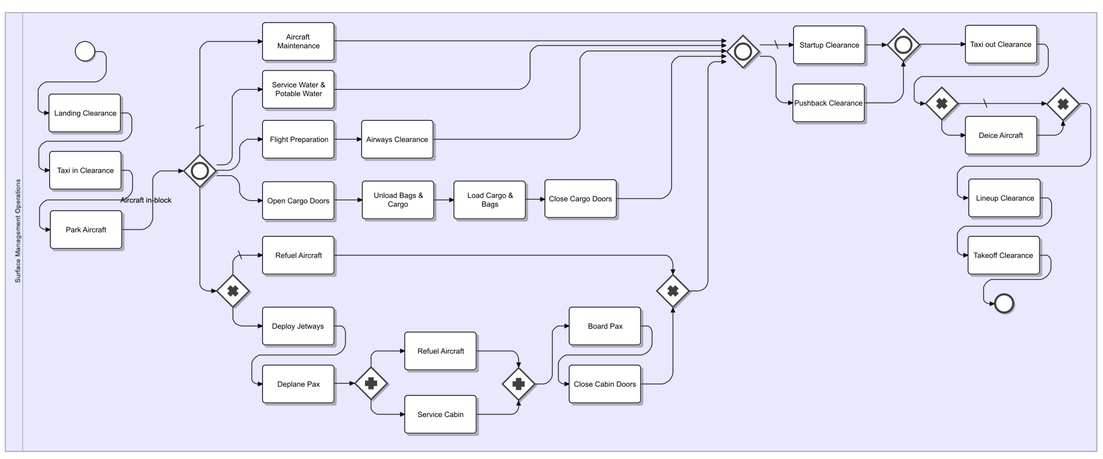


Extensions for WSANs:

- workflow data: name-value-pairs
- node's properties:
  - available sensors/actuators
  - sensor values
- groups of nodes (Scopes [2])

Case Study

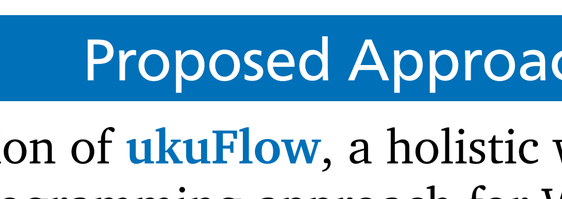
Airport Surface Management Operations:



Proposed Approach

Realization of **ukuFlow**, a holistic workflow macroprogramming approach for WSANs.

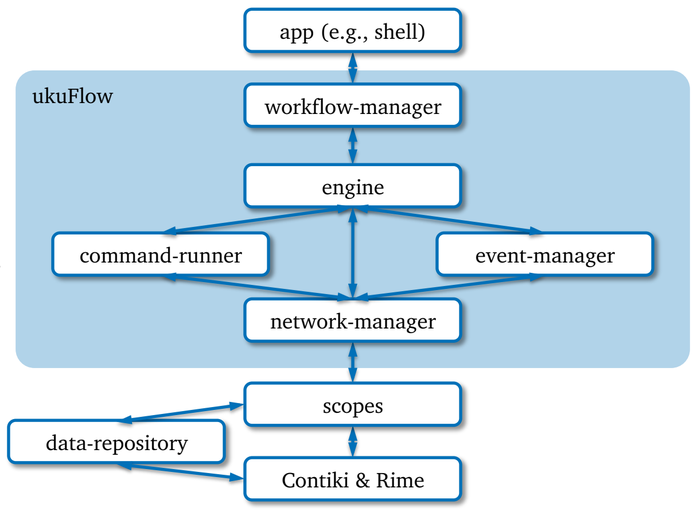
- application logic defined through workflows, enabling domain experts to program WSANs [1]
- generic **workflow model** based on BPMN for defining application logic
  - simple, arrow and boxes combination of **imperative** and **event-driven macroprogramming** style
  - **abstracts away internal complexities** like routing, grouping, data collection, event detection and action execution, etc.
- entirely **in-network workflow engine** for low power, 8/16-bit embedded microcontrollers
  - virtual machine (interpreted)



System Development

Software Design:

- coarse-grain, stacked modules
- compact workflow data representation
- FCFS workflow scheduling
- in-network event-detection



Implemented in C for Contiki, Rime

Evaluation:

- COOJA simulations
- in TUDμNet (WSAN testbed federation [3, 4])

References:

1. **Workflow Support for Wireless Sensor and Actor Networks,** P. E. Guerrero, D. Jacobi, A. Buchmann
   4th International Workshop on Data Management for Sensor Networks, Vienna, Austria, September 2007
2. **Structuring Sensor Networks with Scopes,** D. Jacobi, P. E. Guerrero, I. Petrov, A. Buchmann
   3rd IEEE European Conference on Smart Sensing and Context (EuroSSC), IEEE Communications Society, Zurich, Switzerland, October 2008
3. **TUDuNet, a Metropolitan-Scale Federation of Wireless Sensor Network Testbeds**. P. E. Guerrero, A. Buchmann, A. Khelil, K. Van Laerhoven
   9th European Conference on Wireless Sensor Networks, Trento, February 2012
4. **http://tudunet.dvs.informatik.tu-darmstadt.de**

GRK 1362: Cooperative, Adaptive and Responsive Monitoring in Mixed-Mode Environments

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