EMMON Middleware: Additional Components
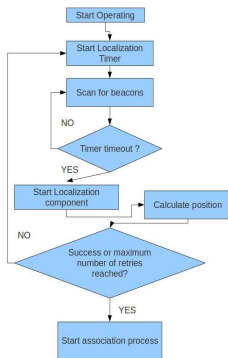
ARTEMIS
Project title: EMMON
EMbedded MONitoring

Positioning

Overview:
- Based on Weighted Centroid Localization (WCL).
- Uses fuzzy logic for RSSI calibration vs. distance.
- Distributed algorithm, independently executed in each patch.


WCL implementation design

$B = \{1 \ldots N\}$, N=number of beacon nodes

R_B : denotes the signal strength of beacon B recorded from the sensor node

x_B, y_B : denotes x, y coordinates of beacon node B

1. for each B{
   $$\overline{R_B} = average\,(R_B)$$
   }
2. for each B{
3. match $\overline{R_B}$ to a distance d_B
   $$w_B = 1/\left(d_B\right)^d$$
   }
5. $$X_u = \left(\sum_{i=1}^{N} w_i . X_i\right) / \sum_{i=1}^{N} w_i \qquad Y_u = \left(\sum_{i=1}^{N} w_i . Y_i\right) / \sum_{i=1}^{N} w_i$$
6. $estimatedPosition = (X_u, Y_u)$

WCL localization algorithm (Pseudocode)

Evaluation and Results:
- Brings significant improvements from DEMMON1 implementation of bounding box and heuristic distance estimation.
- Takes realistic network conditions into account.
- Average positioning error: 2.3m.
- 70% positioning errors are below 2.5m.
- Constant processing time for positioning, irrespective of the number of patches.
- First fully-distributed scalable positioning algorithm - No additional:
  - Overhead
  - Hardware
 - Message exchanges
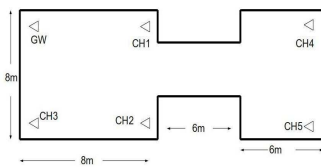
Network area map
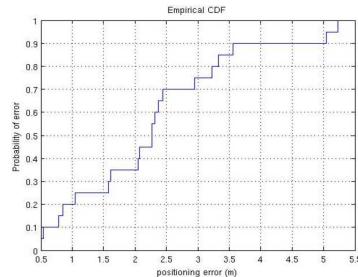
Cummulative density function of positioning error

Webservices

Overview:
- Alternative communication layer between C&C and GWs.
- Uses widely-accepted RESTlet framework.
- Transparent integration with the EMMON architecture.
- Provides out-of-the-box secure communication.
- Allows access through firewalls, hence bridging independent networks.
- Provides bespoke scalability by configuring maximum concurrent incoming and outgoing connections.
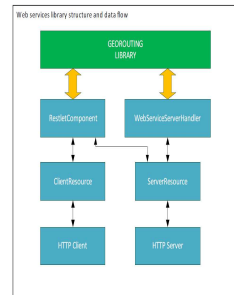
Design and data flow

Evaluation and Results:
- Simulated traffic from 100 to 1000 concurrent calls.
- Zero message loss.
- Scalability is demonstrated by minimum delay even at maximum network load.
- Seamless integration with the rest of the EMMON components.
- Proved accessibility through firewalls.

Over The Air Programming

Overview:
- Extends "Deluge" to transfer images in multi-hop networks.
- Uses pre-defined image allocation to enable the modified version of Deluge and store multiple versions of the EMW in the external flash.
- Provides geographical OTAP commands at C&C.
- Adapts dynamically to reduced functionality with option to only program CHs.

Distribution of images. Modules in green can be re-programmed.

Evaluation and Results:
- Fully automated process for dissemination to each level including fail-safe mechanism.
- Scales as only parent devices disseminate the image to all the children simultaneously, without increasing the dissemination time.
- Disseminates image to targeted area without affecting the rest of the network, hence having manageable impact on the network.
- Extends state-of-the-art Deluge by providing multi-hop, greater-flexibility image programming.