SCALE: Safe Community Awareness and Alerting Network

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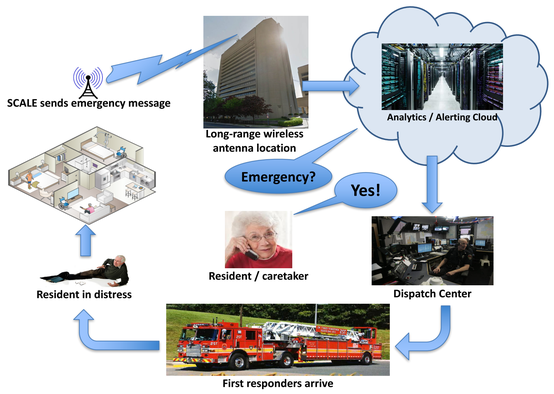
"Democratizing safety by bringing the Internet of Things (IoT) to everyone"

Goals and Overview

- Extend a connected safe home to everyone at a low incremental cost
- Automatically detect emergency events, alert residents, confirm emergency via phone or app, and initiate contacting first responders
- Jump-start a live testbed for identifying and researching Internet of Things (IoT) challenges
- Connect disparate systems via an open multi-protocol data exchange
- Bring together key industry, academic, and government organizations to brainstorm, share ideas, and collaborate on prototype systems
- Expand community awareness and involvement in safety and IoT

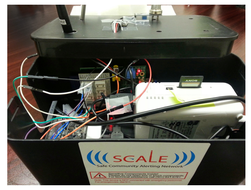
SCALE
Safe Community Alerting Network



SCALE Applications

Home Safety – In Rockville, MD

SCALE has been deployed in Victory Court Senior Apartments in Montgomery County, MD.
Multiple types of sensors (temperature, light, motion, seismic, and explosive gas) are installed on these boxes to help monitor home safety.
How do we make these cheap sensors work together for better sense making?
How to make the entire system more resilient?



FlexSCALE multi-sensor box supports multiple wireless technologies & Ethernet

Air Quality – In Dhaka, Bangladesh

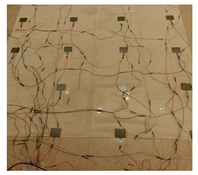
EnviroSCALE is an extension of SCALE for air quality monitoring.
- Cheap commodity gas sensors
- Support of multiple networks (3G and Wi-Fi)
- Battery for outdoor deployments

How to conduct data compression and schedule communication to fit in the limited 3G data plan?
How to improve resilience to network failures?

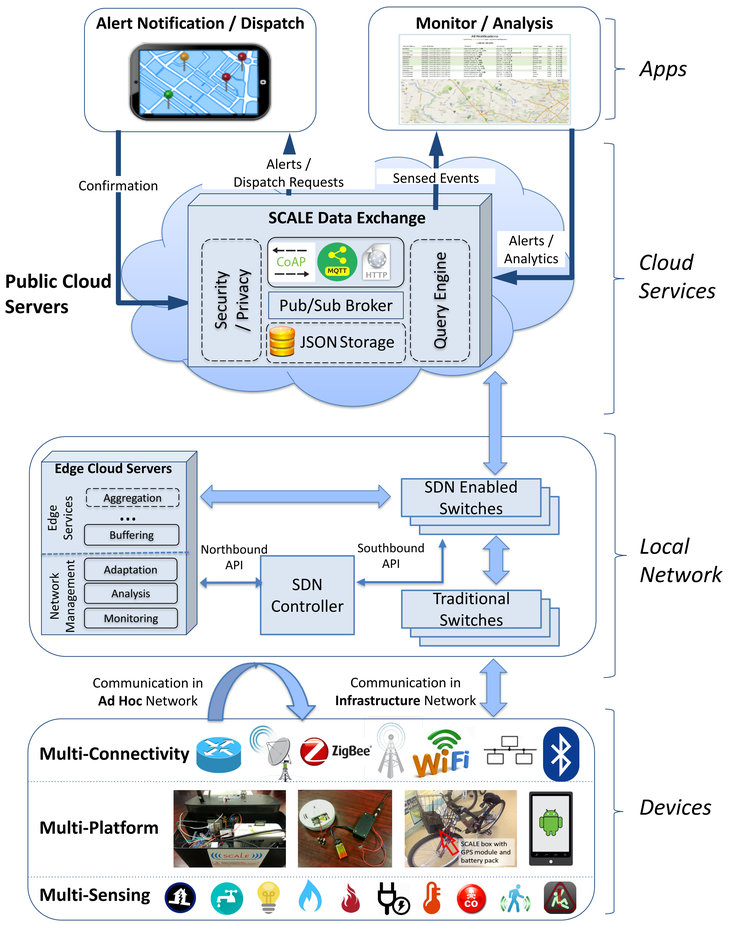

EnviroSCALE box deployed in Bangladesh with 3G modem and multiple types of gas sensors to monitor air quality

Personal Fall Detection – In Irvine, CA

Combined in-situ pressure sensors and wearable sensor tags for indoor personal fall detection.
How to optimize the personal sensing effectiveness in terms of energy consumption and reliability by leveraging the knowledge of the heterogeneous IoT objects and the real-time environmental conditions?


The customized prototype sensor mat for fall detection

System Architecture: Managing Heterogeneity



Resilient Multi-Network IoT Communication

- SCALE system is comprised of multiple, heterogeneous networks (e.g. Wi-Fi, Ethernet, Zigbee, Bluetooth).
- The connectivity and availability of these networks are dynamic. The infrastructure and service failures can occur.
- In SCALE project, we explore the solutions for resilient IoT communication on three levels: failure avoidance, failure detection and failure recovery.

Failure Avoidance

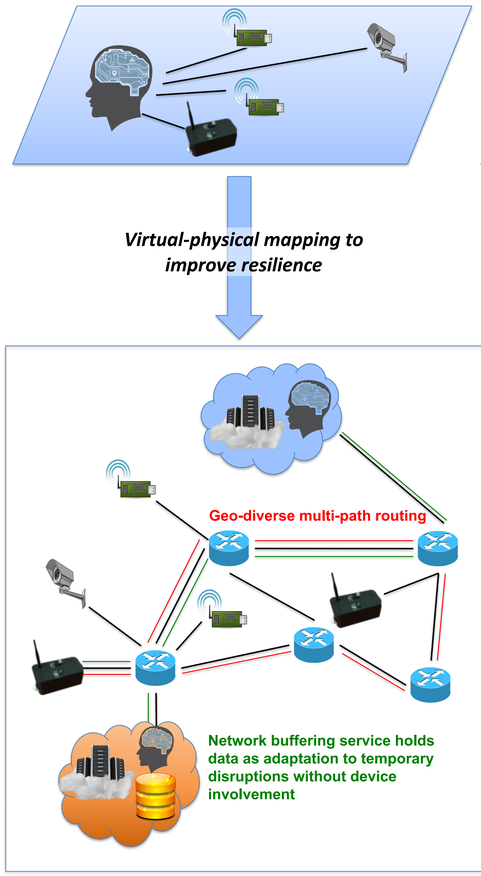
- Geo-diverse multi-path routing increases chances of delivering data during network failures, especially geo-correlated ones (e.g. disasters).
  - Peer-to-peer overlay solution
  - SDN-based solution to build multi-path heuristics.
- Redundant services abstraction enables the network to handle delivering data to backup services and failing over to them when the primary is unavailable.

Failure Detection

- Use heartbeat mechanism to monitor the status of connections to the public cloud service. It reports problems due to congestion, failed links, or an outage of the primary cloud service itself. The heartbeat mechanism is implemented on different levels:
  - At end device
  - At edge server

Failure Recovery

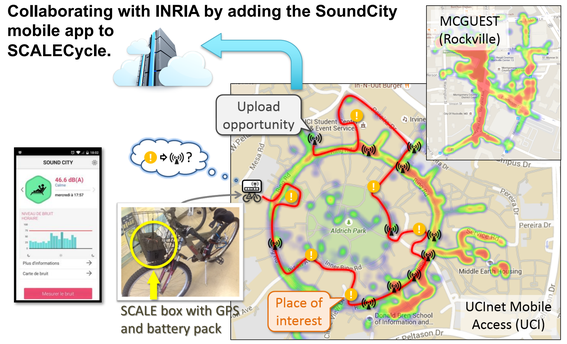
- SDN controller adapts network flows to route around perceived failures or even redirects data to a temporary network buffer to avoid data loss until fault is recovered.
- Application services are deployed in response to faults so as to maintain some degree of (degraded) operation (e.g. localized earthquake detection).

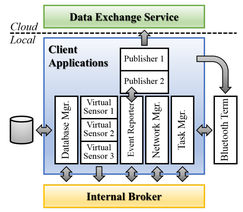


SCALECycle: Mobility Enhancement

SCALECycle platform

- A SCALE multi-sensor box on a bike with GPS receiver, battery, and various sensors (Wi-Fi quality, air pollution, etc.)
- Conducted measurements in two real testbeds: UCI campus and Victory Court Senior Apartments in Montgomery County, MD. Collected Wi-Fi RSSI/quality and air quality.
- Collaborating with INRIA by adding the SoundCity mobile app to SCALECycle.





Upload planning for mobile data collectors (MDCs)

- Utilize knowledge about community IoT deployments and network infrastructure to make data collection more efficient (i.e. maximize data utility and reduce collection overhead).
- Formulated upload planning as a constrained optimization problem.

$$\text{maximize } U(\lambda, l) = \sum_{i=1}^{N} p(\boldsymbol{a}_i) \cdot f\left(\Delta(\boldsymbol{a}_i, \lambda, l)\right) \Big/ \sum_{i=1}^{N} p(\boldsymbol{a}_i),$$
$$\text{s.t. } \boldsymbol{\Lambda}_{i,j} \le \mathbf{C}_{i,j}, \forall i = 1, \ldots, N, \forall j = 1, \ldots, M.$$

- Proposed a two-phase approach using heuristic algorithms for static planning and Lyapunov control for dynamic adaptation.
- Simulation results show 30-60% improvement in data utility and up to 30% reduction in collection delays.