Supporting Multiple Smart-City Applications based on MUSANet, a Common IoMT Middleware
Outline

- Motivation
- MUSANet architecture
- Some applications
- New application deployment
- Next steps
What’s the size of the problem?

Some Cities

- Santander (ES): 35 km²
- Nice (FR): 72 km²
- Barcelona (ES): 101.4 km²
- New York (USA): 783.84 km²
- Rio de Janeiro (BR): 1580 km²
- São Paulo (BR): 1968 km²

Sources:
- Google Maps
- Wikipedia
MUSANet Architecture

MUSANet

• Mobile Urban Sensor and Actuator Network

Three-tier architecture

• Cloud
• Fog
• Edge

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<tr>
<th>InterSCity</th>
<th>Cloud</th>
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<tr>
<td>Storage \ Data Visualization \ Structured Queries \ Resource Catalog</td>
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<th>ContextNet</th>
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<td>Gateway \ Group Definer \ Processing Node \ CEP</td>
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<td>Bluetooth \ WiFi \ 3G/4G \ CEP</td>
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## Lower Layer: Mobile Hub

| Sensor gateway | Bluetooth / BLE  |
|               | Smartphone sensors |
|               | Sensor discovery and data collection |
| CEP           | Complex Event Processing |
|               | Data stream |
| Context-aware | Location |
|               | Timestamp |

Goals:

- Scalable software architecture for mobile communication and low latency processing.
- Processing of mobile data streams.
- Complex Event Processing (CEP) distributed.
- Context-awareness and adaptation.
- Support for mobile-mobile collaboration and coordination.

 Upper Layer: InterSCCity

- Model based storage and retrieval of sensor data
  - Microservices
  - Access over HTTP
  - Structured queries
  - Publisher/Subscriber broker
  - Smart City resource models

InterSCCity Platform

MUSANet

Diagram showing network architecture with nodes such as Gateways, Group Definer Processing Nodes, and control units, connected through the Internet.
Mobile Hub

Resource Discovery
Data Collector
Resource Viewer
Resource Catalog
Actuator Controller
Resource Adaptor

InterSCity

API
ContextNet

Slice
Slice
Slice

Mobile Device
Mobile Device
Mobile Device

HTTP
MR-UDP

MUSANet
Case Studies

Applications

- Bus tracking
- Where is my bus?
- REGIONALert
- Heat Island
- Face Detection
- ALPR
- Face Recognition
Motivation

Existing systems

At 11:28 PM, SCPD reported 2 White males wearing a white shirt, khakis 22-23 y/o involved in a stabbing on 680 Lafayette. Suspects are still on the loose. Call 911

Defesa Civil: chove forte a muito forte em diversos bairros da Cidade RJ. Busque locais seguros - 19h20 - 8/4. Em caso de Emergência, ligue 199

Proposed system

Defesa Civil: você acaba de entrar em uma área que está chovendo muito. Fique em um lugar seguro ou procure abrigo em rua Sobe, 8752 imediatamente. Emergência, ligue 199
Case study: RegionAlert

- 3 actors
  - City Offices (transportation, weather forecast, etc.)
  - Third-party companies
  - Final users
Case study: RegionAlert

- City offices
  - The city offices create a pub/sub topic to publish information about a new alert
  - City offices use the webservice to create and store new alerts in the InterSCity
  - In addition to storing the information in InterSCity, city offices publish the information in the InterSCity broker pub-sub
Case study: RegionAlert

- Third-party company
  - The company subscribes to be notified when an alert is created
  - The company stores user preferences (areas of interest) in its database (not the government’s InterSCity)
  - Can read from, but cannot write to the government’s InterSCity
  - Every time a new alert is created, the company notifies users by area (location & interest)
  - Every time a user enters an area with a valid alert, the company notifies the user
Case study: RegionAlert

- **Final Users**
  - Run third-party application and Mobile-Hub in their smartphones
  - Register their areas of interest
  - Receive alert when a new alert is created and:
    - The alert is related to their interest area
    - OR the alert is about the area where they are located
  - (can be used to collect information from sensors in the city)
1. User enters region “R”
2. GroupDefiner sends user position to Processing Node
3. Processing Node queries database for user’s interest
4. Processing Node queries InterSCity for alerts
1. Government creates a notification
2. The webservice stores the notification in the InterSCity
3. The web service notifies the Processing Node
4. The Processing Node queries InterSCity for new notification
5. The Processing Node queries database for users’ interest
6. The Processing Node sends unicast and groupcast messages to users
1. User re-enters region “R”, sends position and message ID
2. GroupDefiner sends user position to Processing Node
3. Processing Node queries database for user’s interest
4. Processing Node queries InterSCity for alerts
5. Processing Node sends new alerts (new IDs) to user
### Bus Application

**Actors:**

- **Buses**
  - Send information to MUSANet

- **Public transportation affair office**
  - Manage InterSCity
  - Create areas in the city

- **User**
  - Registry into system
  - Query system
  - Receive alerts
Heat Island Application

- **Actors**
  - **Buses**
    - Collect information about temperature
    - Send information to MUSANet
  - **Public transportation affair office**
    - Manage InterSCity
    - Create areas in the city
  - **User**
    - Registry into system
    - Receive alerts
Deploying New Applications

InterScty Platform

Cloud InterScty

Fog ContextNet

Edge M-Hub

- Resource Manager
- Resource Viewer
- Resource Catalog
- Resource Controller
- Resource Adapter

- Bus
- Phone
- Camera
- Train
- Traffic Light
- Laptop
- Street Lamp
Deploying New Applications

Cloud InterSCity

Fog ContextNet

Edge M-Hub
Deploying New Applications

Cloud InterScity

Fog ContextNet

Edge M-Hub
Next steps

- Develop new applications based on data streams
  - Automatic license plate recognition
  - Face detection
  - Face recognition

- Test fault tolerance of each application
  - Drop a slice
  - Drop Internet connection
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