Research
EDA/CPE for Smart Cities

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This document contains a non-exhaustive list of research for smart cities and how they use event-driven architectures and complex event processing.

1 Applications and Stories

Common themes:

- Traffic management
- Parking
- Intelligent buildings (security, lighting, energy efficiency)
- Waste management
- Environmental monitoring

[1, p. 2]:

- Energy consumption profiles
- Concentration and distribution of pollutants
- Urban heat distribution caused by urban structures
- Energy efficient urban design
- Use of public transportation services
- Traffic flow of vehicles
- Movement of goods and freight
- Pedestrian's flow
- Use and load of telecommunication networks

- Presence of citizens in places of interest
- Livability
- Citizens living habits
- Citizen health monitoring

[2, p. 8 ff.]:

- Structural health: monitor cracks in buildings
- Smart parking: monitor free/taken parking spots
- Waste management: monitor trash can status
- Smart roads: guide citizens in traffic and detect traffic patterns
- Smart surveillance and intrusion detection for homes where the local police department is automatically notified
- Pollution monitoring
- Smart lighting
- Smart energy grid
- Smart industry

[3, p. 7 f.]

- Transport: dynamic route calculation informed of accidents and congestion
- Energy: reporting of faults
- Emergency services: detection of accidents and crimes
- Waste management: detection of full bins
- Air and water: reporting of air and water pollution
- Recreation: produce data on large events like concerts to inform public transport

[4, p. 8 ff.]:

- Price calculation for EV parking lots based on energy market
- Status monitoring of hospital patients
- Monitoring and intelligent routing of ambulances
- Congestion control, smart parking and traffic management
- Smart streetlights for intelligent and weather-adaptive lighting
- Noise pollution monitoring

[5, p. 209 ff.]:

- Traffic flow management: reduce emissions, noise and travel times by monitoring and actively controlling traffic
- Smart grid: distributed generation and distribution (voltage stability, loss reduction), real-time energy pricing (demand response, electricity markets)
- Intelligent buildings: increase security and energy efficiency, automate HVAC
- Healthcare in residential environments: monitor environment (temperature, humidity, luminosity...) and movements to analyze health and well-being

[6, p. 16]:

- Parking availability
- Environmental monitoring: visualize temperature, luminosity, noise, CO2 emissions on map
- Participatory sensing: user app collects data, users can enter events (e.g., defects, accidents) manually
- Precision irrigation: irrigate plants based on soil humidity, wind, and weather forecast
- Smart energy metering

[7, p. 30]:

- Public parking space availability prediction
- Real-time 3D maps of power consumption, public transport,... (real-live version of SimCity)
- Neighbor vote for turning on/off nearby street lamps
- Redirect cars or suggest public transport in case of high air pollution
- 101 other scenarios which have been considered are listed in [8]

[9]:

- Prioritization of trucks in freight corridors
- Real-time parking availability
- Decrease congestion through smart traffic signal timing

[10, p. 1]:

- Precision irrigation for agriculture and city parks based on soil measurements and weather

[11]:

- Anomaly detection in real-time for 100,000+ connected cars, full solution is available on GitHub

2 Event Definitions

"Geo-event: An occurrence of a change of state associated to a phenomenon of interest ($\mathbb{D}_p$), and which is related to a geographic location ($\mathbb{D}_s$) and a specific time ($\mathbb{D}_t$)." [1, p. 3]

$$\mathbb{D}_p = \{name : value, phenomena : [value_1, value_2, ..., value_n], condition : value\}$$
$$\mathbb{D}_s = \{extent : value, granularity : value\}$$
$$\mathbb{D}_t = \{time - window : value, granularity : value\}$$

3 Available Data

CityPulse [12] (historic):

- Road Traffic
- Pollution
- Weather
- Cultural/Social/Library Events
- Parking

Helsinki Regional Transport Authority [13] (real-time):

- Public transport vehicle position
- Arrivals and departures
- Driver changes

Singapore OpenData [14], [15] (real-time):

- Air quality
- Carpark availability
- Taxi availability
- Weather measurements (temperature, humidity, precipitation, wind, UV radiation)
- Weather forecast

- Traffic images

List of Real-Time Public Transportation APIs with evaluation [16]

4 Challenges

“Geoprocessing of data streams inherits challenges from big data analysis: volume, velocity, variety, value, and veracity.” [1, p. 1]

[2, p. 2 ff.]:

- High cost and long development tmie →private–public collaboration and common platform
- Choice of communication paradigm (continuous, random, incremental) →hierarchical structure
- Sustainability of network and compatibility of devices
- No best practices for IT platforms

[3, p. 9 f.]:

- Big data: efficient query and storage and extraction of meaning
- Privacy
- Security: threats from cyber-terrorism/-vandalism

5 Architectures

The architecture in figures 2 and 3 is an instantiation of the reference architecture in figure 1 and was used with data from SmartSantander project to detect geospatial events, e.g. temperature above 0 °C in the city center. [17] mentions that Flink has good throughput but no geospatial matching capabilities.

The CityPulse project described in [7], [18]–[21] uses AMQP for message transport. The overall architecture is shown in figure 4 while the stream processing is shown in figure 5.

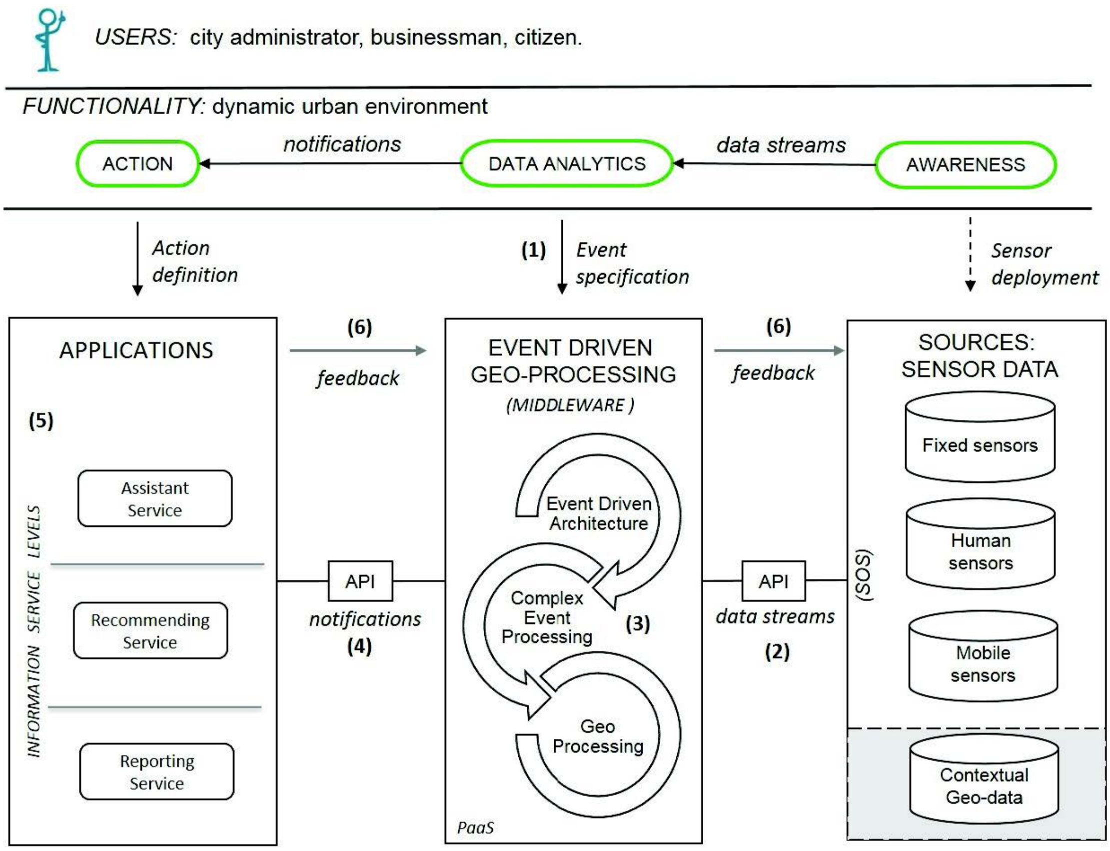

Figure 1: Event-driven geoprocessing system architecture [1, p. 3]

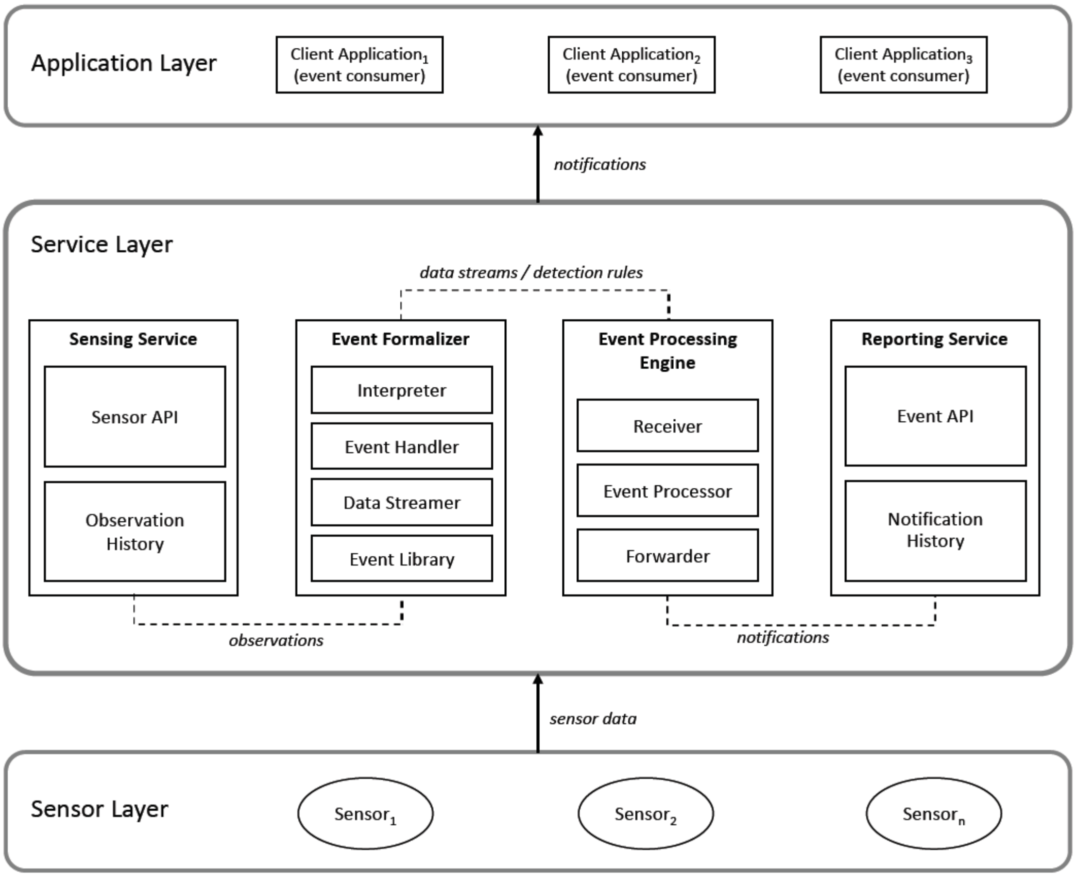

Figure 2: Reference Architecture for Smart City Applications (RASCA) [17, p. 12]

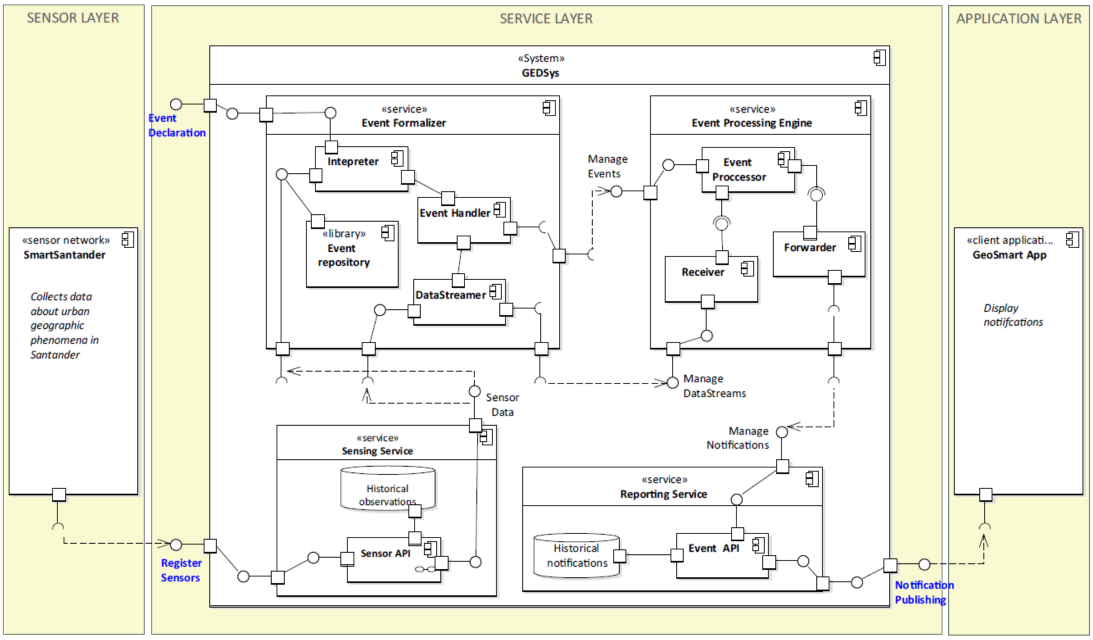

Figure 3: Implementation of RASCA [17, p. 13]

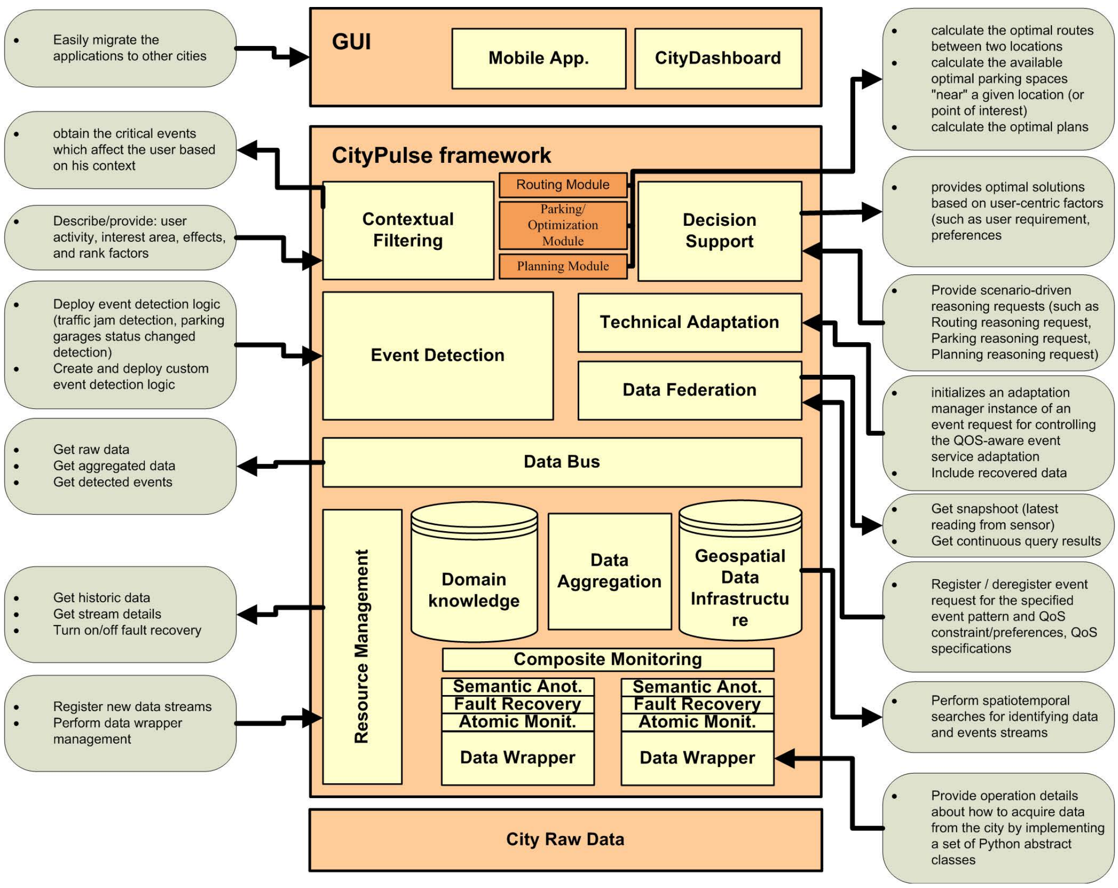

Figure 4: Smart City Framework for CityPulse [18, p. 39]

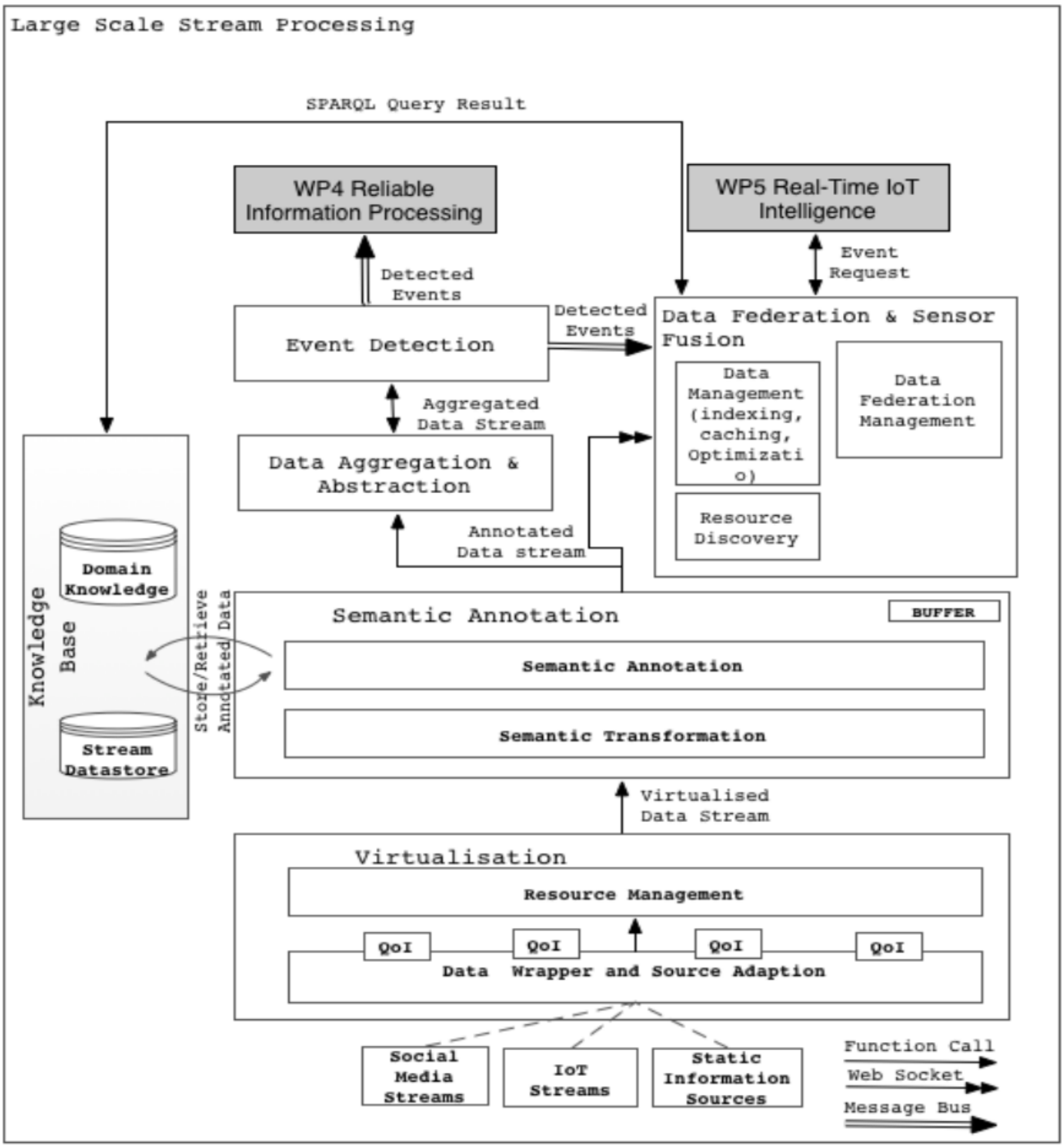

Figure 5: Large Scale Data Analysis Functional Group for CityPulse [18, p. 25]

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