GeoSmart Cities:
Event-driven geoprocessing as enabler of smart cities.

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OUTLINE

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- The Approach
- Event-Driven Geoprocessing
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- Conclusions
INTRODUCTION: THE CONCEPT OF A SMART CITY

SOME CITY PROBLEMS

- Vehicle allocation
- Air pollution
- Health issues

G4 Beijing-Hong Kong-Macau Expressway on Oct 6, 2015. PHOTO: REUTERS

Smart City

City development: efficiency, economic growth, innovation

Management & Planning  Business & Productivity  Quality of Life

ICT Technology
INTRODUCTION: RESEARCH PROBLEM

- Smart city’s applications face limitations on processing and analyzing big amounts of data in a time-wise manner (Batty, M, 2012).

- Geoprocessing of data streams inherits challenges from big data analysis: volume, velocity, variety, value, and veracity.

http://maps.smartsantander.eu
INTRODUCTION: RESEARCH PROBLEM

Pollution (Event)

Sensor networks

City Administrator
Businessman
Citizen

ACTIONS
- Management & Planning
- Business & Productivity
- Quality of Life
THE APPROACH

TWO ASPECTS

- Core functionalities of a geo-smart system aiming to facilitate processing and analysis of sensor data.
  - AWARENESS
  - ANALYTICS
  - ACTIONS

- Integrate EDA to provide an action mechanism for Smart City applications.
  - Users define events and actions of interest.
GEO-SMART SYSTEM: EVENT-DRIVEN GEOFPROCESSING

HIGH LEVEL ARCHITECTURE

FUNCTIONALITY: dynamic urban environment

USERS: city administrator, businessman, citizen.

APPLICATIONS
(5)
Assistant Service
Recommending Service
Reporting Service

INFORMATION SERVICE LEVELS

EVENT DRIVEN GEOFPROCESSING
(MIDDLEWARE)

Event Driven Architecture
Complex Event Processing
Geo Processing

PaaS

SOURCEs: SENSOR DATA
Fixed sensors
Human sensors
Mobile sensors
Contextual Geo-data

Sensor deployment
data streams
Event specification
feedback
API
(1)
(2)
(3)
(4)
(6)

feedback
API
notifications

feedback

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G-EVETS: DEFINITIONS

**G-event**: An occurrence of a change of state associated to a phenomenon of interest, and which is related to a geographic location and a specific time.

**Properties:**
- Relevance
- Discrete
- Atomic
- Finite
- Relative

![Diagram of a factory emitting a pollution cloud, with sensor nodes around a residential area.](image)
G-events (e), are specified by five fundamental characteristics: phenomenon of interest, geographic space, time, recurrence, and causality.

Characteristic represents domains:

- **What?** Phenomenon
- **Where?** Space
- **When?** Time
- **How?** Recurrence
- **Why?** Causality
**G-EVENTS: APPLICATION CASES**

**SPECIFICATION: Low Level G-event**

Low Level g-events (e) are formalized by a set of properties that characterize phenomenon domain $D_p$, space domain $D_s$, and time domain $D_t$.

- **$D_p(e)$**: \{name: car arrival, change : True\}
- **$D_s(e)$**: \{location : sensor (s) | location $\in$ s, observation : car detected\}
- **$D_t(e)$**: \{Time : [05 : 00, 23 : 00]\}

$e = \{\text{car arrival, True, } f(l), \text{ car detected, } [05 : 00, 23 : 00]\}$
High Level g-events (ê) represent aggregations of LLg’s. HLg are specified by describing the properties of recurrence $D_r$ and causality $D_c$ domains.

How can an alert for high concentration of air pollutants be issued to residents in a neighborhood?

- Raise g-event when a ‘cloud’ of pollution is detected, at any time.
- Sensor monitoring PM.
- High PM > 15.0 $\mu$g/m$^3$
- At least 5 spatially related sensors.

High pollution (low level):

Following previous intuition

$$e = \{\text{high pollution, } 15.0, f(l), \text{PM, null}\}$$

Pollution cloud (high level):

$$D_c(E) : \rightarrow \hat{e} = \{E, T', L\}$$

Set of $e$, $E = \{e_1, e_2, \ldots e_5\}$
Locations of $s$, $L = \{l_1, l_2, \ldots l_5\}$
Time constrains, $T' = \text{none}$

$D_c$ for case of spatial relation, $g(L)$ a topological relation:

$$\hat{e} = \{E, \text{null, } g(L)\}$$
Rainfall in sensor
$D_p(e) : \{\text{name: rain fall, threshold : 2:00}\}$
$D_s(e) : \{\text{location : sensor, observation: intensity}\}$
$D_t(e) : \{\text{time : [training time]}\}$

Rain (≥ 3 e):
$E = \{e_1, e_2, e_3\}$
$L = \{l_1; l_2; l_3\}$

Rain on planned route
$\hat{e}' = \{\hat{e}, g'(A_r, R_l), T\}$

$\hat{e} = \{E, g(L), [\text{training time}]\}$

$A_r$, area with rain
$R_l$, Location of planned route
CONCLUSIONS

- Spatial and temporal components of sensor data build understanding on the dynamics of the city.

- Smart: awareness, analytics, and action.

- G-events for the specification of arbitrary events in the context of geo-smart cities.

- As future work, experimental platform will deploy middleware’s main components. SOS’s, complex event engine, and geoprocessing libraries.
Questions

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