system design & management

A Smart City Pilot in Boston: Collecting human-centric urban data

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Introduction

Education

+ MS, Engineering and Management (SDM), MIT
+ MS, Nuclear and Radiological Engineering, University of Florida
+ MS, Physics, Grenoble Institute of Technology (France)

Experience

7-years work experience in the energy sector as a
+ Risk analyst, creating data models to forecast complex systems’ failures
+ Product Manager

Led product portfolio management for large and medium size companies in the clean energy and radiation protection fields
Today’s Agenda

Part 1 - Pilot Description

Part 2 - System Architecture

Part 3 - Pilot Data insights
Part 1 - Pilot Description

BOSTON DOWNTOWN CROSSING (DTX)
Most experiments with sensor data have taken place in silos, where one technology was evaluated by itself, or in proprietary settings where data and methods are not shared publicly....

We want to know how sensors designed by multiple researchers/companies that are dispersed throughout an urban environment can better inform urban planning.

- Steve Walter
  Director, Boston Mayor’s Office of New Urban Mechanics

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What?
A Smart City Pilot to inform urban interventions

Who benefits?
Tech companies, cities and urban planners

Why?
Blueprint for future IoT pilots and other cities
**Goal:**
Launch a proof of concept pilot around the value of implementing a variety of sensors in a hyper-local setting.

**Problem:**
Understand how people move in Downtown Crossing and how environmental conditions change over time.
Part 1
Summary

1
Context

2
Challenge

3
Approach

4
Scope

- Define Use-case
- Concept to Architecture
- Site Selection
- Technology Selection
- Integration & Deployment
- Data Processing
Combining factors to gain knowledge on urban conditions

Environment

- Noise
- Light
- Air

Human Activity

- Activity

TIMELINE

- May: 2 weeks (Project Scope)
- June: 4 weeks (Defining requirements)
- June: 4 weeks (System design)
- July: 3 weeks (System lab testing)
- August: 4 weeks (System deployment)

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Part 2 - System Architecture

BOSTON DOWNTOWN CROSSING (DTX)
DTX Environment

- High pedestrian traffic
- Outdoor commercial area
- 1 intersection & 4 street segments
Spatial - Social - Technological Layers

1. Stakeholders
2. Technology
3. Urban Landscape

Analysis Layers
- Decision makers
- Beneficiaries
- Payers
- Service providers
- Sensors
- Communication
- Data Integration
- Application
- Assets
- Constraints
1 Stakeholders

2 Requirements

3 Concept

4 Design

5 Test

6 Deployment

7 Operation

Stakeholders

- Decision makers

- Beneficiaries

- Payers

- Service providers

- Local Government

- Urban Planner/Manager

- Community Advocacy

- Federal Government

- Education Institution

- Technology Sponsor

- Expertise and Hardware
Concept Options

- **Modular sensor nodes**
  - Single location
  - Cost
  - Utility
  - Network
- **Single sensors**
  - Many locations
  - Cost
  - Utility
  - Network

The diagram illustrates the trade space between cost and utility for different concept options.
Architectural layers

Layering

- Application Layer
  - Form
  - Data Layer
    - Form
      - Communication Layer
        - Form
          - Sensor Layer

Modularity

- Comparison
- Trends
- Application
- Correlations
- Processing
- DB Storage
- Data
- Cloud
  - To Cloud
  - Local network
  - Communication
    - Climate sensors
    - Pedestrian sensors
    - Sensor
    - Gas sensors

Environment
sensor platform
DTX sensing Infrastructure
Testing and Validation

Hardware

Lab test
- Power
- Sensor readings
- Power
- Local communication
- N/A

Site test
- Battery life
- Remote communication

Software

Lab validation
- Time and ID
- Sensor data
- Time and ID
- Local database
- Latency
- Local/external DB Sync**

Site validation
- Frames dropped*
- Local/External DB Sync**
Highlights from operations

External Factors

- Liability (harm to people walking by)
- Hardware theft / Physical damage
- Hide human sensor in florist
- Poor sun exposure of the solar panels
- RF interferences and dropped frames

Internal Factors

- Battery charging
- Ethernet connection
Part 3 - Pilot Data Insights

BOSTON DOWNTOWN CROSSING (DTX)
Data Insights

Data universe

Environment

- Downtown Crossing
  - residential
    - Noise
    - Light
    - Temperature
    - Air
    - August
    - September
    - Week
    - Weekday
    - Weekend
    - Hour

Human activity

- Downtown Crossing
  - residential
    - Hour of arrival
    - Duration of stay
    - pedestrian
    - August
    - September
    - Week
    - Weekday
    - Weekend
    - Hour

Selected path for today’s presentation
Data Insights

What days are the streets the loudest?

Winter Street
- Lower noise level baseline day and night

Summer Street
- Higher noise level baseline day and night

Hourly maximum noise profiles for the measurement period in August 2016.

In both street segments, Friday and Saturday nights are the loudest and Sunday and Monday are the most quiet. In general, Winter street is much noisier than Summer street.
Data Insights

At what times are the streets the loudest?

Winter Street

<table>
<thead>
<tr>
<th>Hour of the day</th>
<th>Moderate</th>
<th>Loud</th>
<th>Very Loud</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 am</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 am</td>
<td>95</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>10 am</td>
<td>90</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>3 pm</td>
<td>85</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>8 pm</td>
<td>80</td>
<td>20</td>
<td>0</td>
</tr>
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Noise ordinance

92% louder than a lawn mower.
7.5% louder than a passing train.
0.5% louder than a jet flying over.

Summer Street

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Noise ordinance

33.3% louder than a lawn mower.
66% louder than a passing train.
0.7% louder than a jet flying over.

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Data Insights

How much light is received?

Winter Street

Summer Street

Luminosity

Overall, Winter street receives less light during the day. Particularly, during the month of August.
Data Insights

How much light is received?

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Dim 20%
bright 36%
very bright 44%

Dim 50%
bright 28%
very bright 22%
Data Insights

CO levels in a typical day in Washington

CO levels in a typical day in Summer Street

Air

Noise
Light
Activity

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Data Insights

1. Noise
2. Light
3. Air
4. Activity

CO2 levels in a typical day in Washington

CO2 levels in a typical day in Summer Street
Data Insights

Is there a pattern in the days?

80% Never stop at the location
20% Stop or return

Hourly activity in Winter and Summer Streets

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5pm is the most active hour in the afternoon. Activity in the morning spikes at 8am and then reduces until lunch time.
Do people stay longer on weekends?

Activity in Downtown Crossing

Despite more people coming during weekdays, citizens tend to stay for longer periods of time during weekends.
Summary
The team behind Bitsence

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Arianna Salazar
Architect and Urban Planner

Ammar El Seed
Software Engineer