

Monitoring Wide Area: Object Detection Case Studies in LA

Seon Ho Kim, Ph.D.

Integrated Media Systems Center
University of Southern California
Los Angeles, CA, USA

Visual Analysis of Urban Streets at Scale

- Lots of useful applications

Traffic
Management



Monitoring
air quality



Public Safety
Solutions



Street
Cleanliness



Graffiti
Detection



Road Damage
Detection



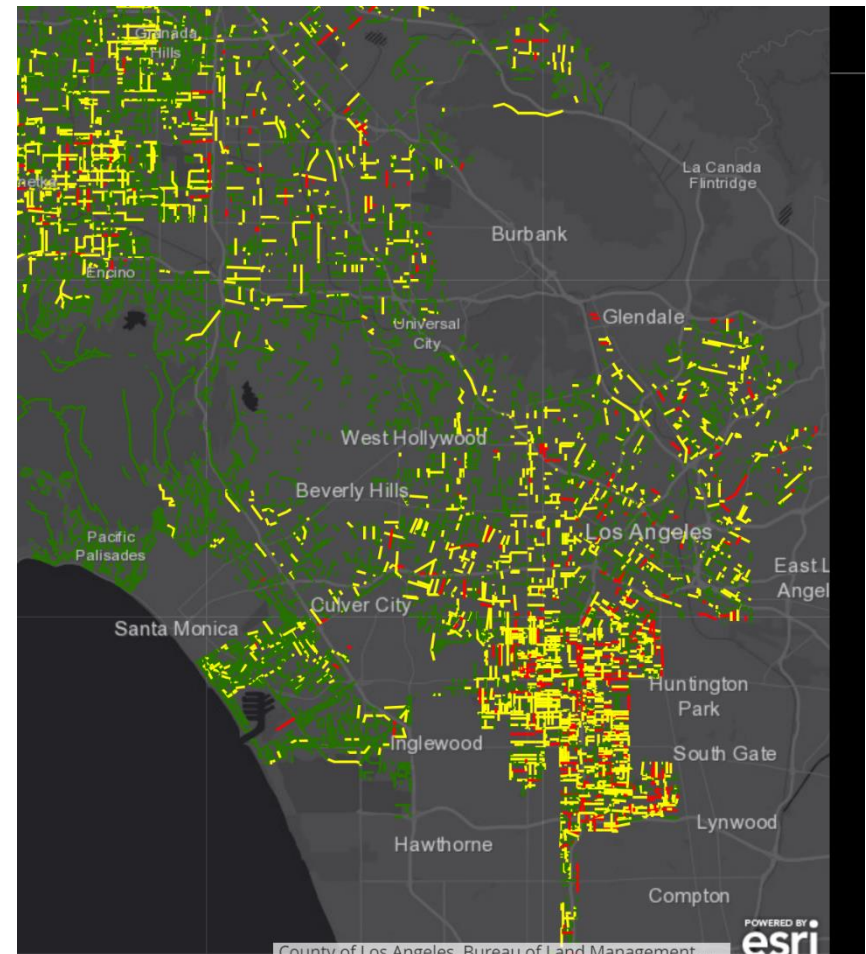
- Lots of challenges

- City of Los Angeles: ~22,000 miles of road
- Frequency of analysis
- Data collection and analysis infrastructure

Highly expensive! → Any affordable solutions?

Los Angeles Street Cleanliness Index

- Beginning...
 - LA's Clean Streets initiative: monitor street cleanliness
- Currently, data are manually collected and evaluated: inefficient, costly → automate!
- In collaboration with the Sanitation Department of LA, ***automatically detect the cleanliness of streets as well as any special objects in need of removal.***



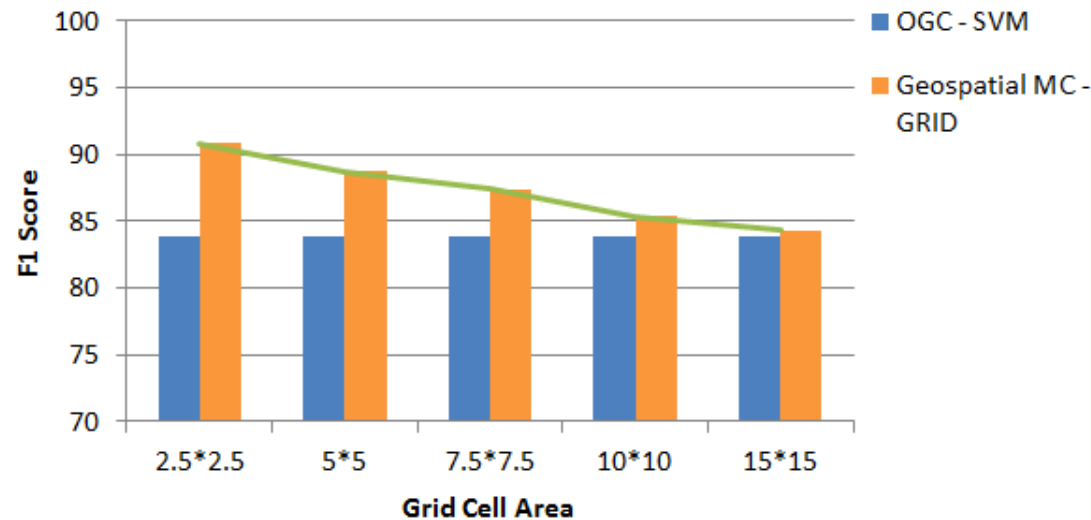
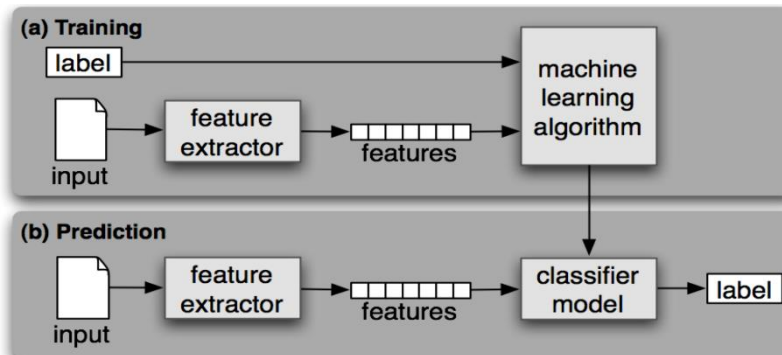
Case 1: Image Classification of Street Cleanliness

Image Label	Description	Examples	Image Label	Description	Examples
Bulky Item – Few	1 to 3 items (e.g., coach, desk, mattress, and tire) are thrown on the street.		Encampment	A tent for people who live in streets.	
Bulky Item – Many	More than 3 items are thrown on the street.		Overgrown Vegetation	There is extra vegetation on the streets.	
Illegal Dumping	There is an area which is full of waste which needs special equipment to remove.		Clean	The street is clean 😊	

Images collected by the Sanitation Department, City of Los Angeles

Image Based Classifier

- Achieved 80 – 90% accuracy (depending on class): stable and practical
- The more images in an area, the higher the accuracy becomes: promising



Published in IEEE Big Multimedia, 2018

Question 1

Automatic classification is good
but Images are manually collected so slow and
expensive

→ any way of ***automatic & affordable data collection?***

Case 2: Video Based Detection and Classification

- Utilize existing infrastructure
- 800+ garbage collection trucks are being operated in LA
- Through the cameras attached on the sides of a truck which is being operated for five hours a day, collect and analyze videos.
- Extract one keyframe (i.e., an image) per second from videos.



Video Frame Examples and Classification

- For videos, higher performance is needed to be practical
- Achieved comparable accuracy using the model learned from images



Bulky Item



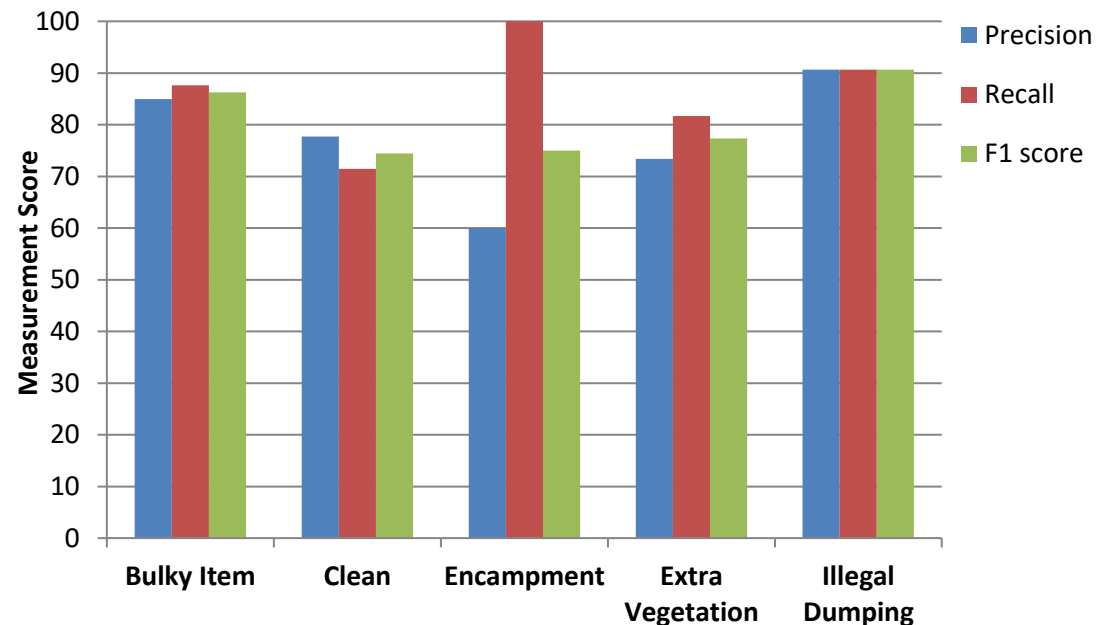
Illegal Dumping



Encampment



Clean



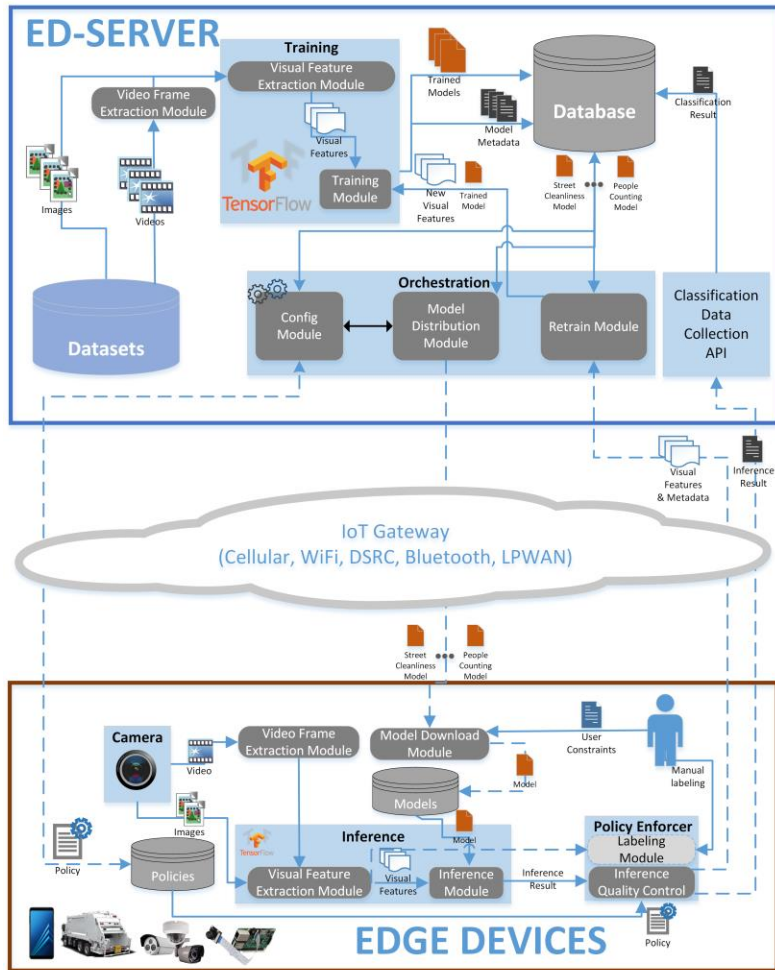
Question 2

Automatic recording is good

But data transfer to server is too expensive

→ any way to be ***affordable***?

Case 3: Edge Computing



- **Train** machine learning models on the server (initial model)
- **Distribute** the models to edge devices (e.g., smartphones, smart edge cameras)
- **Inference** happens on edge devices using CPU on edge
- **Report selected results** to involved agencies
- Improve models **iteratively**

IEEE BigMM, 2019. ICIP 2020. BigData 2021

Current Pilot Camera System

5 Front/Side Cameras
3 Rear Cameras



Implemented and tested
real time trash detection
and classification with
video cameras on
garbage collection truck

Edge computing module at
the truck: GPS, memory,
processing power, wireless
network, SW models

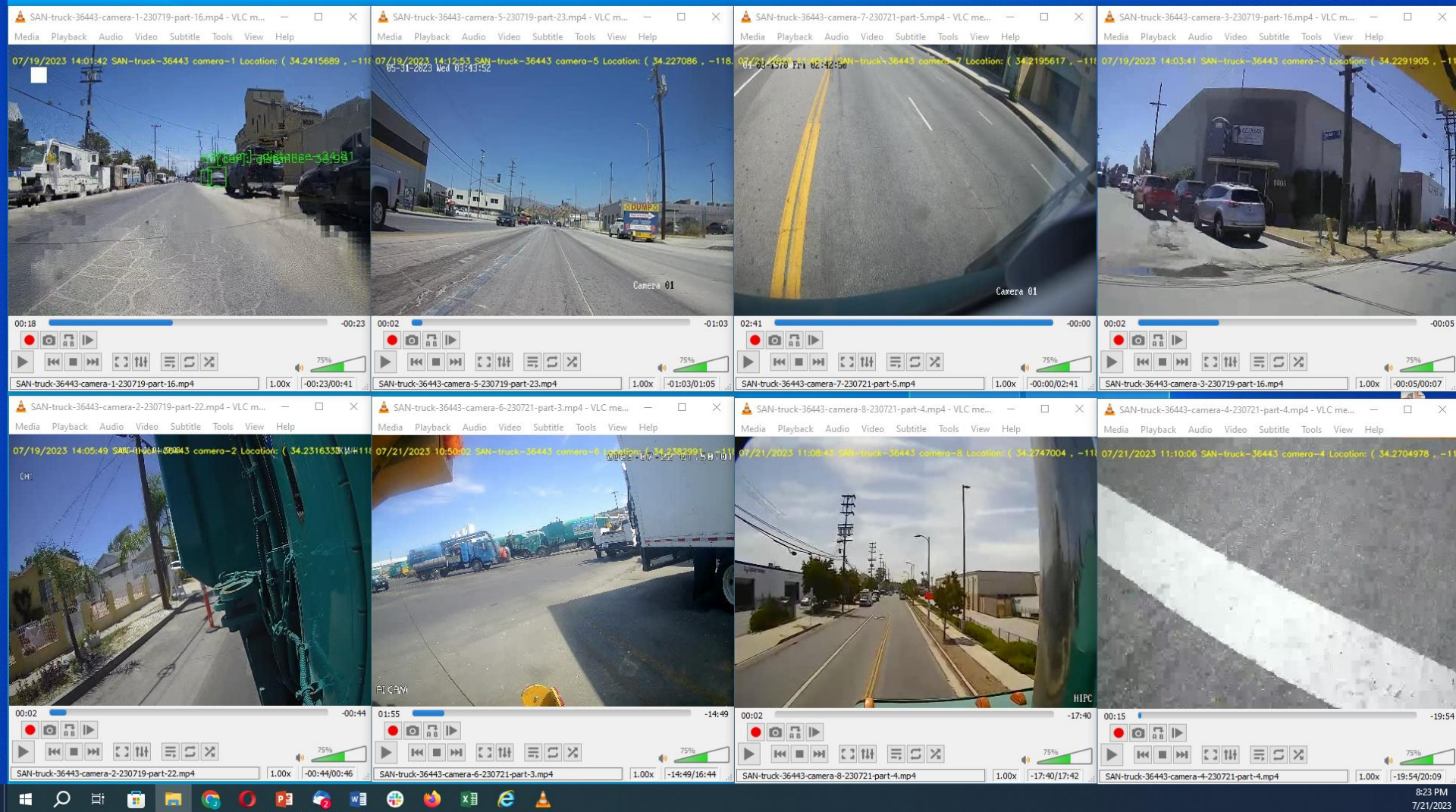


Fanless computer with i3 Systems
edge processing software

AI Vision Analytics from
University of Southern California
(USC)

Cradlepoint 4G/5G/WiFi Router

Example Images from Pilot System



Question 3

Visual data have lots of information

Data collection is expensive. Only trashes?

→ any way to better utilize collected data?

Case 4: Road Damage Recognition and Classification

- Any other useful application of collected data?
- The back-camera attached on truck cab be a visual source for road damage monitoring.
 - *All LA streets can be monitored once a week!*



IEEE Big Data Challenge Cup Competition

Classification of Road Damages

Defined by Japan Road Association [*]

Damage Type			Detail	Class Name
Crack	Linear Crack	Longitudinal	Wheel mark part	D00
			Construction joint part	D01
		Lateral	Equal interval	D10
			Construction joint part	D11
	Alligator Crack		Partial pavement, overall pavement	D20
	Other Corruption		Rutting, bump, pothole, separation	D40
Crosswalk blur			D43	
White/Yellow line blur			D44	

Using images
recorded in Japan
using smartphones



(a) D00



(b) D01



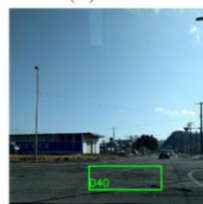
(c) D10



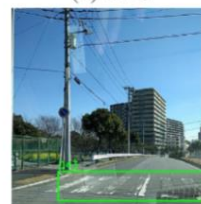
(d) D11



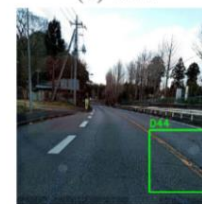
(e) D20



(f) D40



(g) D43



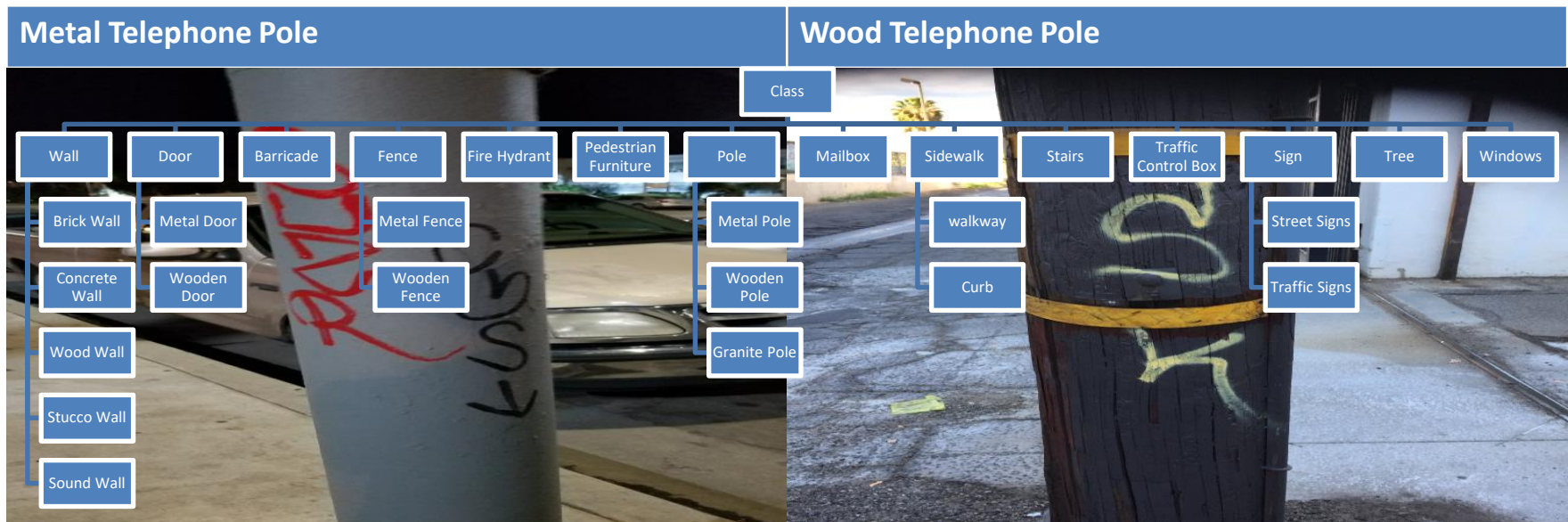
(h) D44

[*] Maintenance and Repair Guide Book of the Pavement 2013, 1st ed. Tokyo, Japan: Japan Road Association, 04 2017.

In 2018, we won Bronze Prize (3rd place) out of 59 teams from 15 countries.
In 2020, we ranked at the 1st place out of 121 participants!

Case 5: Identify Surface Material Beneath Graffiti

- Cleaning crew need to know what material beneath graffiti is



Detection Example



Case 6: Homeless Encampment Detection

- Automatically detect homeless encampment and its location



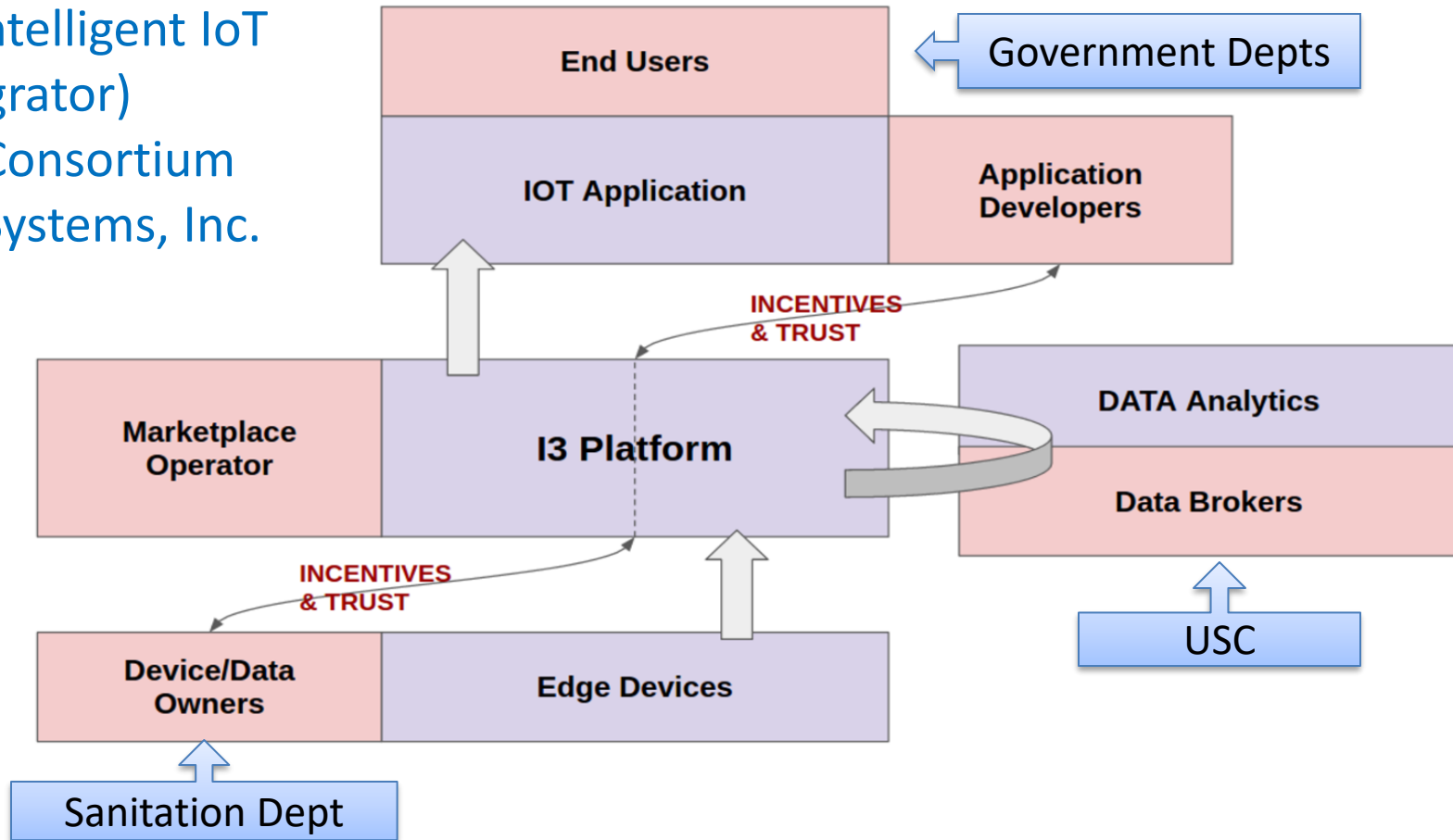
Detection Example



Summary - Integration

I3 (Intelligent IoT Integrator)

- I3 Consortium
- I3 Systems, Inc.



Q & A
