### Linking Artificial Inteligence and IoT in Smart Cities IoT Week Bilbao 2018

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## Smart Cities Presents Great opportunities for IoT

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#### What is the problem on this?



### We have a dream

#### a swarm of cooperating ...

### devices!

## The Swarm at the Edge of the Cloud

Edward A. Lee, Jan Rabaey, Björn Hartmann, John Kubiatowicz, Kris Pister, Alberto Sangiovanni-Vincentelli, Sanjit A. Seshia, John Wawrzynek, and David Wessel University of California at Berkeley

Tajana Simunic Rosing University of California at San Diego

David Blaauw, Prabal Dutta, and Kevin Fu University of Michigan

Carlos Guestrin and Ben Taskar University of Washington Roozbeh Jafari

University of Texas at Dallas

**Douglas Jones** University of Illinois at Urbana Champaign

Vijay Kumar, Rahul Mangharam, and George J. Pappas University of Pennsylvania

Richard M. Murray California Institute of Technology

Anthony Rowe Carnegie Mellon University





### **Our Paradigm: Edge Centric**

### a Swarm of smart devices!

Market Share and The State of State of States

767







WORKER.

QUEEN.

DRONE.



### Cities Presents a Swarm Behaviour





### Scientific counselors





Researchers











Interns and trainees

#### **SWARM Networks**

- Autonomous
- Heterogeneous
- Colletive Intelligent
- Spontaneous relationships
- Open networks
- Energy Efficient

#### **Swarm OS Control Plane: An Architecture Proposal for Heterogeneous and Organic Networks**

Laisa C. P. Costa, *Student Member*, IEEE; Jan Rabaey, *Fellow*, IEEE; Adam Wolisz, *Member*, IEEE; Max Rosan; and Marcelo K. Zuffo, *Member*, IEEE



#### Swarm Minimum Broker: an approach to deal with the Internet of Things heterogeneity

Laisa C. C. De Biase<sup>\*</sup>, Pablo C. C. Ccori<sup>§</sup>, Geovane Fedrecheski<sup>\*</sup>, Douglas Navarro<sup>\*</sup>, Renan Y. Lino<sup>\*</sup>, Marcelo K. Zuffo<sup>\*</sup> \*School of Engineering, <sup>§</sup>Institute of Mathematics and Statistics

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## Key challenges



## Communication



### Communication



0 devices in the swarm network

device that starts interaction

0 device candidate for interaction

Ο

device chosen for interaction

physical or logical direct connection between devices

automatic execution of services among devices



exact matching keyword-based

2



semantic matching functionality-based



3

1

automatic service composition

### MicroEconomy

Service Level Agreement Micropayments Reputation Access Control

### Human Interaction



Personal agents Opportunistic user interface gathering Interaction with a complex network

#### Swarm challenges





#### Services wrap device functionality



#### Broker: a communication mediator



#### **Application Services**

#### **Platform Services (Broker)**



#### **Broker architecture**



### Pursuit Swarm Applications in Cities

#### Example:

### **Finding Penny**

### LOST CAT



Unknown to us, Andy got out of the house last Sunday night, May 1, some time after 9pm. We live at \_\_\_\_\_\_SW and Sw \_\_\_\_\_\_\_. It is the strictly an indoor cat and does not know the neighborhood. This is one of the most aftectionate cats that you could imagine. He was rescued from a house fire and we adopted him last Summer. He is initialing his right canine tooth (fang) and the left calline protrudes a bit. Andy has a backing cough that sounds like be's most to bring up a hairball but it is due to upper respiratory problems.

Aney weights some 13 pounds, was wearing a light blue "quick release" color with the bell on it. He is a classical "tabby " gray with black stripes and when weighted weight of the source of the sour

### Many sensors at Environment to help



ar quality sensor



garage door sensor



smart door



security camera



electronic babysitter



smart bulb



cat feeder













### Surveillance Swarm applicability

### Bus stop state on strike

- Where is Penny?
  - Remotely check a line
  - Monitoring an area on strike
  - Look for stolen cars and bikes

## Swarm Flight Traffic Safety

## Renewable Energy Swarm Management

#### **Swarms at The Edge and Smart Cities**

Swarms and Cities have a lot in common:

Complex

Organic

Heterogeneous

# Thank you!

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