Embedded Networks Laboratory

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Medusa: A Programming Framework for Crowd-Sensing Applications

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Introduction

Wireless Sensing on Smartphone

- Recent smartphones are equipped with various sensors.
- Sensor data often needs to be processed locally or globally with other phones' data together.
- Processed sensor data will be used in emerging applications such as
  - Activity recognition based on the accelerometer, etc.
  - Location-based apps based on GPS sensor.
  - Participatory sensing apps.
  - Camera-based apps that provide visual context.

The Power of Crowds

- The concept of crowd-sourcing has recently received tremendous attention especially to solve large scale problem composed of small subtasks.
- Useful tools for crowd-sourcing have been developed.
  e.g. Amazon Mechanical Turk

The Notion of Crowd-Sensing

- We leverage the ubiquity of mobile devices with sensors and the power of crowds.

Problem Description

Programming Support for Crowd-Sensing Task

- Crowd-Sensing task inherently requires human mediation.
- It is often logistically difficult to involve human resource between every sensing tasks.

- Support humans-in-the-loop to trigger sensing actions.
- Users should be able to review results.
- The needs for incentives.
- Privacy of the participants
- Security for data communication.

Design Rationale: System Requirements

- Expressivity
  - Worker-mediation.
  - Access stored sensor data.
  - In-network processing.
  - Extensibility.
  - Timeliness.
  - Crowd curation.
  - Incentive / Reverse-incentive.

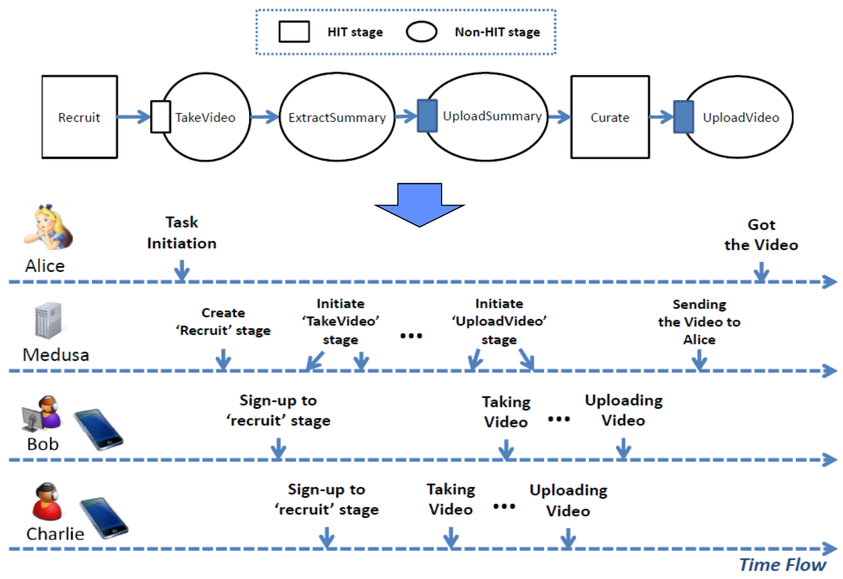
- Runtime
  - Multiple concurrent tasks.
  - Unsynchronized stage execution.
  - Robustness.
  - Anonymity.
  - Secure Communication.
  - Resource usage policy.

Proposed Solution: Medusa - A Programming Framework for Crowd-Sensing Task

MedScript Programming Language

- XML-based high-level language.
- Support all expressivity requirements.
- Provide abstraction to describe a control flow using stages and connectors.

Example: Video Documentation

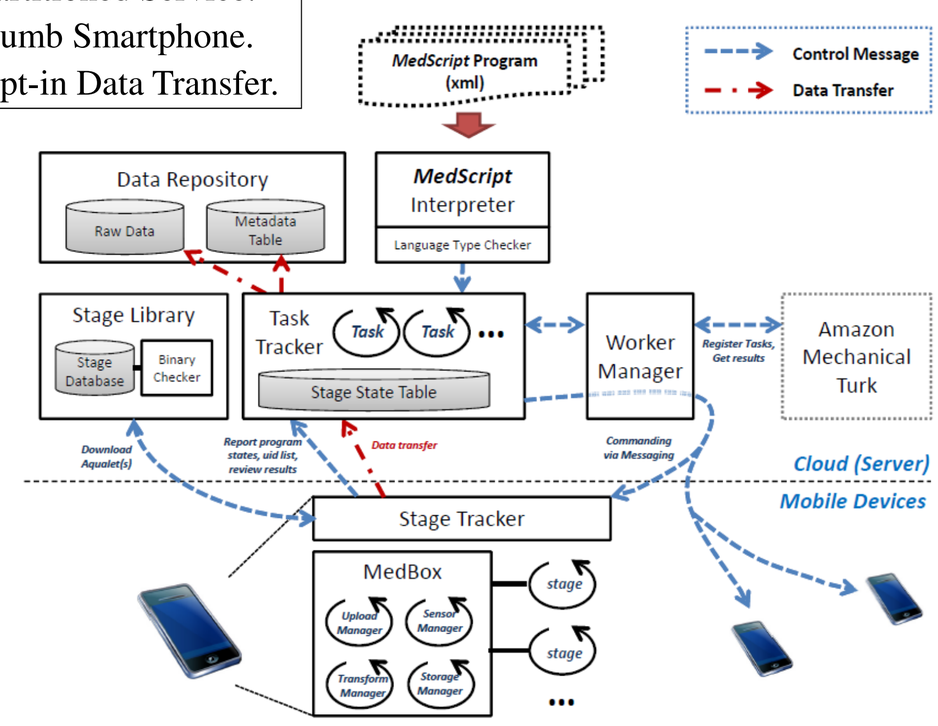


Other Prototyped Crowd-Sensing Apps

Application	Description
Spot Reporter	A journalist is to write an article about a developing forest fire and with its impact on nearby communities. He recruits volunteers with smartphones to send pictures of the extent of fire damage, interview local residents, and report on the efficacy of the first responders.
Auditioning	A television station invites budding actors to submit videos of their acting skills, in order to elect actors for a second stage of in-person auditioning or an upcoming television show.
Collaborative Learning	A software company is developing a lifestyle monitoring mobile app, which lets users self-reflect on their activities. It recruits volunteers to submit labeled samples of accelerometer readings; these are used to build a machine-learning classifier.
Forensic Analysis	Security officials at a stadium are investigating an outbreak of violence and would like to determine people who were at the scene of the outbreak when the violence occurred. They request volunteers, who may have taken pictures during the event, to send snapshots of faces of people in the stadium.

Runtime System Architecture

1. Partitioned Service.
2. Dumb Smartphone.
3. Opt-in Data Transfer.

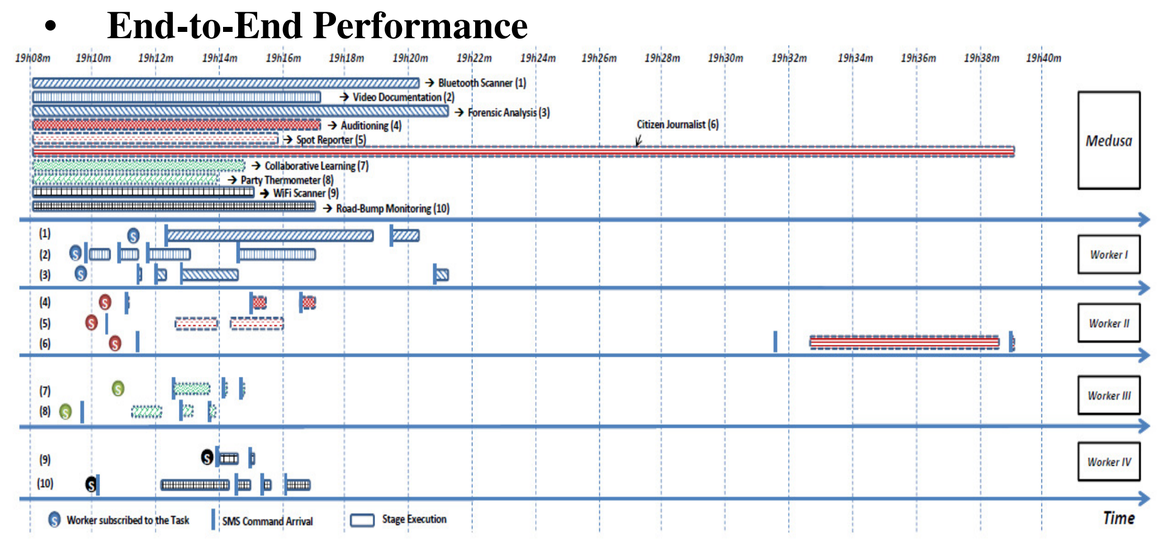


Evaluation

- **Expressivity**

	Medusa	Standalone
Video Documentation	86	8,763
Collaborative Learning	62	7,076
Spot Reporter	45	17,238

- **End-to-End Performance**



*Moo-Ryong Ra, Bin Liu, Tom La Porta, Ramesh Govindan, **"Medusa: A Programming Framework for Crowd-Sensing Applications"**, ACM MobiSys 2012, to appear*