CROWDSOURCED & MOBILE PLATFORMS

CIVIC APPLICATIONS & DISASTER RESPONSE

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Background

- Directing a new mobility research center at Carnegie Mellon University since 2009
  - Bicoastal mobility research center
- Focus on various aspects of mobility
- Particular focus on civic platforms and applications and disaster-response technologies
- Three specific projects
  - iBurgh
  - How's My Street?
  - Sensor Andrew

311 Systems

- **Cities have 311 systems**
  - To allow residents to report problems to the city for fixing
  - Problems: Grafitti, potholes, trash, fallen trees, ….
- **Nature of current 311 systems**
  - Operator from 9-5 on weekdays, voicemail after-hours
    - Residents can call the city hotline, leave a complaint
- Problem with the system
  - Manual, error-prone for the 311 operator
  - Complaint-tracking is difficult (trouble-ticket issuing)
  - Insufficient information about the gravity of the problem
  - Aggravated users provide incomplete information
    - "Why the heck don't you fix that damn large pothole on my street?" [Real complaint]

What is iBurgh?

- **First iPhone e-government mobile 311 app**
  - Developed for Pittsburgh City, launched August 2009
  - 8000+ downloads from the iTunes Store within 3 months of launch
  - 1500+ downloads from the Android Marketplace within 2 months of launch
  - Expanding to more cities (Anaheim, CA; Alexandria, VA; …..)
- **Allows residents to interface with the City's 311 system**
  - To report complaints in real-time: Potholes, graffiti, traffic, …..
  - To have the complaints automatically geotagged
    - No need for manual entry of location of complaint
    - Just point-and-shoot, and go!

Why iBurgh?

- **Allows City officials to be more efficient**
- **Visualize the nature and severity of the complaint**
  - Example: Just how severe is the pothole and how urgent the repair
- **Aggregate related/common complaints**
  - Example: Number of people complaining about the same pothole
- **Avoid manual data entry of information**
  - Current manual entry with voicemail-based complaint system
- **Schedule repairs and investigations of complaints efficiently**


iTunes
YinzCam, Inc.
iBurgh
Category: Utilities
Released Aug 04, 2009
Seller: Daniel Burrows
© 2009 YinzCam, Inc.
Version: 1.0.0 (iPhone OS 3.0 Tested)
0.2 MB
Free GET APP
Rated 4+
AT&T 3G 11:52 PM 97 %
iBURGH
powered by YinzCam
1 Take a picture.
2 Add a description.
APPLICATION DESCRIPTION
iBurgh allows the residents of Pittsburgh to stay in touch with their City government by reporting incidents conveniently and quickly even while residents are on the go.
Using their iPhones, Pittsburghers can take photographs of incidents (such as potholes, traffic gridlock, etc.), and have these automatically geotagged and submitted instantly to the City for resolution and handling.
Using iBurgh, the City can also visualize the locations of various incidents and plan efficiently for maintenance/repairs.
LANGUAGES:
English
REQUIREMENTS:
Compatible with iPhone
Requires iPhone OS 3.0 or later
YinzCam, Inc. Web Site
iBurgh Support
ALL APPLICATIONS BY YINZCAM, INC.
TELL A FRIEND
APP STORE FAQS

iBurgh

Photo (if camera used) is auto-geotagged by iBurgh with incident's street address

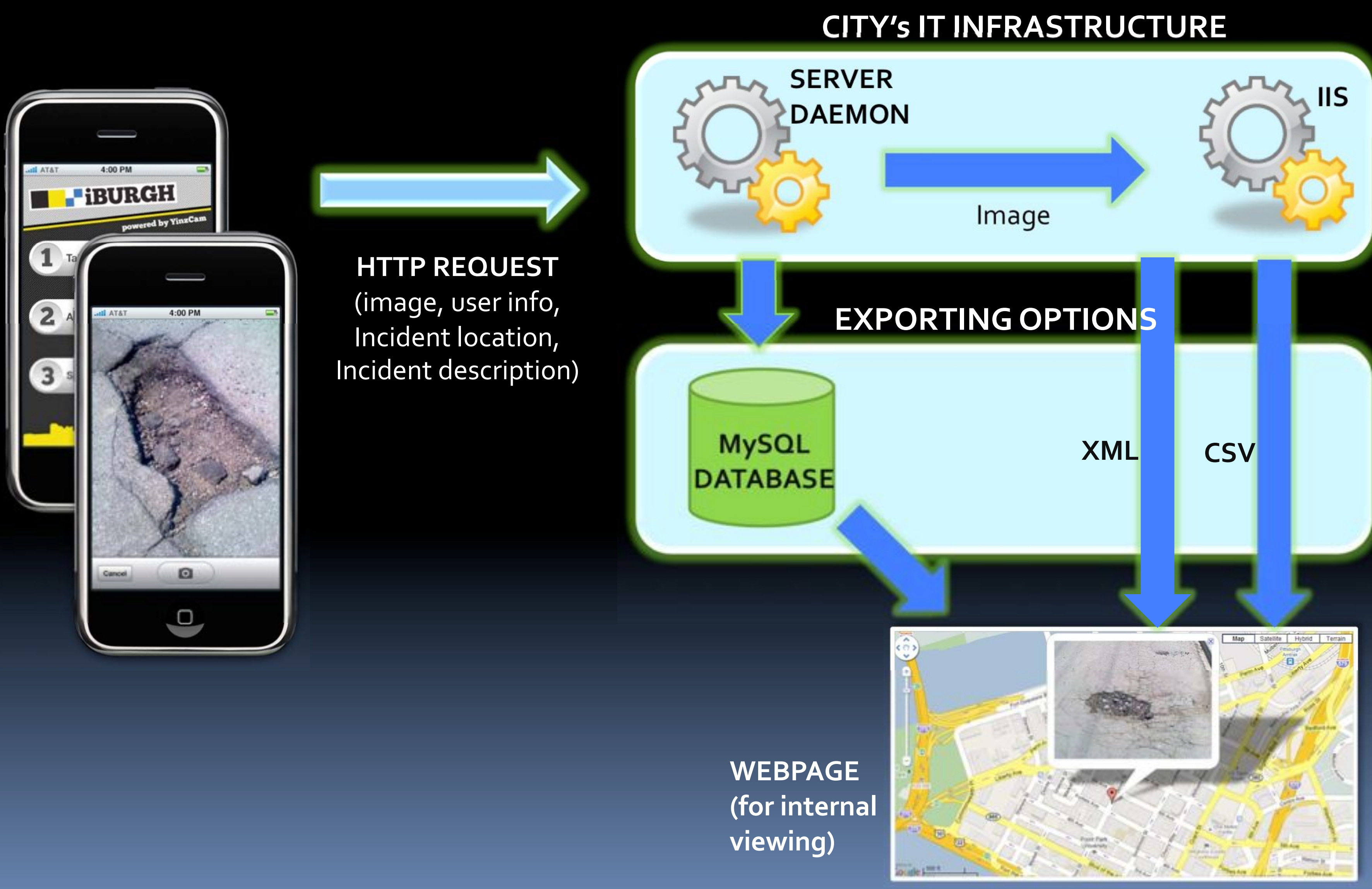
User takes a picture with phone's camera or uses a previously taken picture from an album

User enters a text description (optional) to report more detailed information

User enters information on first use. iBurgh fills this in automatically for future iBurgh reports

iBurgh: For the City

Current Workflow



iBurgh++: What's Next? (1)

- Crowd-sourced analytics <u>within</u> a city and <u>across</u> cities
- Analyze the data to allow for improved scheduling/efficiency of public-works repairs and projects
  - Seek similarities in complaints, locations and severity
  - Example: Derive routes for pothole repairs, based on severity and number of complaints
- Analyze the data for reduced manual effort in 311 response
  - Seek similarities in the data for compression and faster handling
  - Example: Image-processing on submitted images to replace 30 different reports of the same pothole with a single image and a severity rating of 30
- Analyze the data for improved city/urban planning
  - Seek similarities in the trends of reports in cities undertaking new projects
  - Example: Look for trends in a city with a new high-speed rail and proactively handle issues for a different city that is planning a similar project

iBurgh++: What's Next? (2)

- **Increased support and coverage**
  - More platforms: Blackberry, Windows Mobile, Palm Pre
  - More cities: Anaheim, Alexandria, ….
- **Personalized for every resident**
  - Be notified of related government meetings and discussions
  - Those that affect *my* life, *my* district of residence, *my* neighborhood, *my* street, *my* place of work
- **Watch government at work live**
  - Be able to post questions into live Council meetings, integrated with streaming Council meeting video
  - Post live video and twitter questions, and see responses
- **Integrate a video-based complaint system**
- **Integrate with twitter (already done for one city)**
- **Meet with government representatives on the road**
  - Know their schedule and when they hold meetings

Mobile 311 Cloud

- Plan
  - Release a generic version of the mobile 311 app for iPhone, Android, Blackberry
  - Integrated with a back-end cloud
- Multiple exporting options for data
  - Email (daily, weekly), XML feed, RSS, text file, CSV, manual export, visual display
- Each city
  - Subscribes to the service
  - Configures its data-export options
  - Can take advantage of the analytics we provide
- Unique opportunity for observing/analyzing/improving intra-city and cross-city operations

Where's the Research?

- **Image-processing on the back-end**
  - Using the images for automated repair assessment
  - Example: Detect the size of potholes so that repair crews know how much asphalt to take with them
- **Trustworthiness of the data**
  - Using additional data to vet a single user's data
  - Example: Vetting a complaint if more complaints of a similar nature have been received within a specific time-span
- **Correlation and data analysis**
  - Leveraging patterns of usage within one city/neighborhood to make other cities more efficient
  - Showing the actual $$ value, in terms of efficiency from cross-correlating this data

Snowpocalypse 2010

- Massive snowstorm in the East Coast of the United States in early 2010
- Cities and businesses severely affected for weeks
- Cities unprepared for the sheer amount of snow that kept piling up
- Even Carnegie Mellon closed down! ☺

Crowdsourced Engagement

- Disasters bring out the best in people
- Natural pattern of people helping each other
  - Neighbors would call each other asking for the best routes
- Witnessed this behavior online as well
  - On Twitter, people helped each other out
  - Sample conversation
    - Q: “Anybody know if the Fort Pitt tunnel is passable?”
    - A: “No, it isn’t, you might want to take the Liberty Tunnel”
    - Q: “Oh, okay, thanks, any idea how long to the airport?”
    - A: “A good two hours. Good luck!”
  - These were all people who didn’t know each other, but were following the #snowpocalypse hashtag
- Opportunity to provide this information for all

How's My Street?

- Worked with the Pittsburgh City Council to deploy a crowdsourced platform for people to enter and display the data
- Keep it simple and usable
  - People could drop one of three markers to report a location's condition
  - Red: Not passable
  - Yellow: Passable
  - Green: Clear
- Within hours, the site was swamped with reports
- Value of the site
  - People shared information easily with each other
  - Visually possible to see trails of green markers for passable routes
  - Intuitive because people understand red-yellow-green for tagging


Map
Satellite
Terrain
Road Not Passable
Road Passable
Road Clear
Click and drag to scroll the map.
Use the bar on the left or the scroll wheel on your mouse to zoom in and out.
Millvale
Spring Garden
Herrs Island
East Allegheny
Homestead
Glenwood
Arlington
Arlington Heights
Google

Interesting Uses

- Snowplow operators
  - Used it to figure out where the red/unplowed areas were
  - Used it to make more money
- FedEx and courier drivers
  - Used it to figure out passable and clear routes to travel to locations
  - We added a routing option
    - Provide start and end points, and we would route between them (if possible) through green and yellow roads
- Residents
  - Used it to figure out how to commute, or whether to venture outdoors
  - Used it to report the urgency of their street for plowing
- Caveats (but, of course)
  - Information is not accurate, trustworthy or timely
  - People can report more aggressively in order to get their streets plowed
  - Saw examples of abuse, but they were mostly in the noise

Vetting the Data

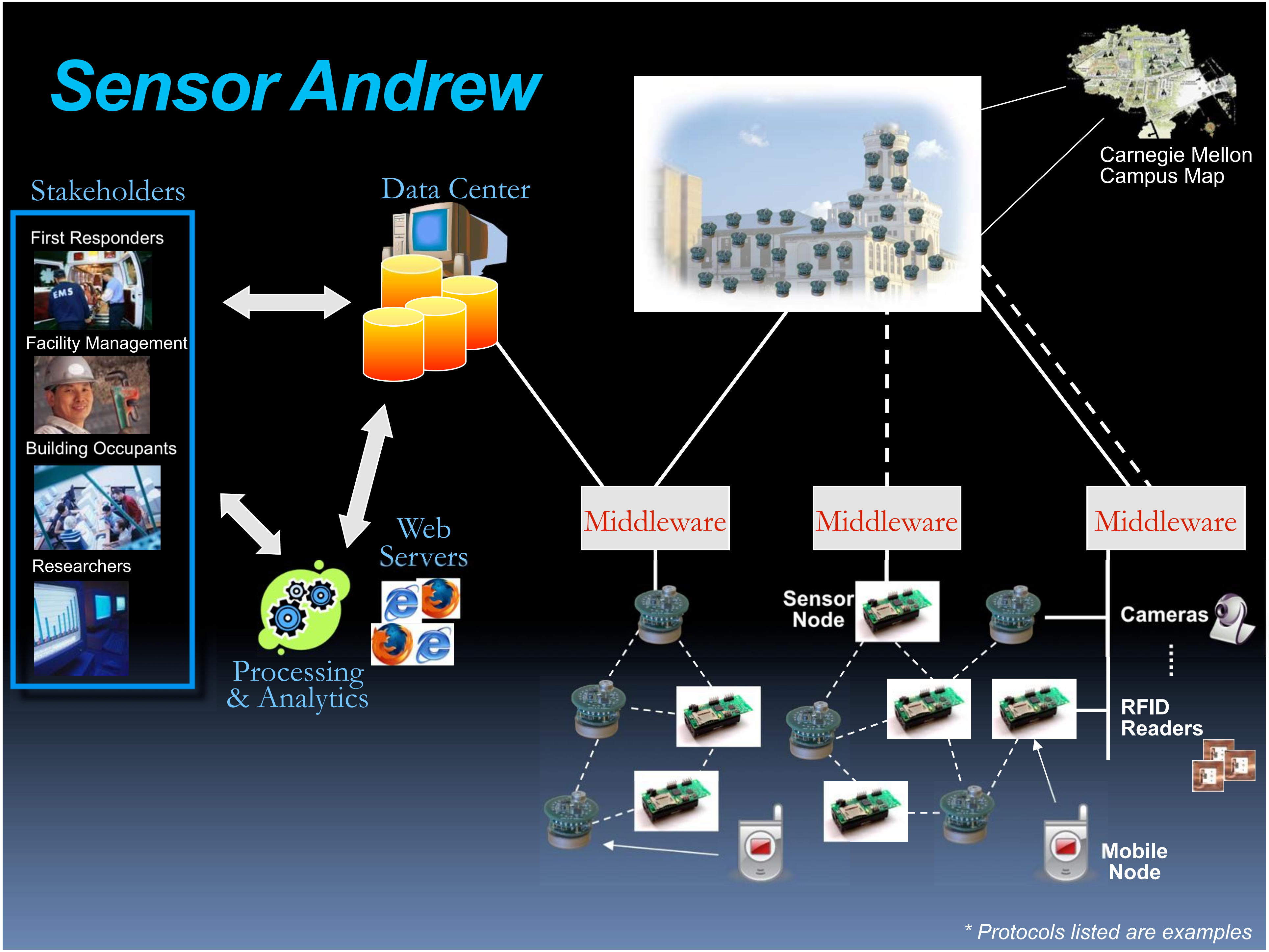
- No way to determine if the data has integrity
- Some options
  - My students and I drive around the city to figure out whether streets are passable or not
  - We rely on inputs from people we trust in each neighborhood
- A new option
  - We equipped taxicabs with smartphones with a simple user interface having red, green and yellow markers
  - As they drove around, they pressed one of three buttons (red, green, yellow) on their smartphones
  - Each time, the input was auto-geotagged and sent to our servers
- Caveats (but, of course)
  - Information is not complete
  - Data entry is error-prone (driver could press the wrong button, could mistakenly tag the street later, etc.)

Where's the Research?

- Trustworthiness of the data
  - Using additional data to vet crowdsourced input
  - Example: Taxicab operators are but one source of data, how about traffic sensors
- Correlation and data analysis
  - Providing dynamic routing capabilities on top of the data
  - Leveraging plowing histories to preemptively schedule snowplows for the next snowstorm
  - Incorporating topology information as another data feed to provide better routing of snowplows
- Develop behavioral models of users

Sensor Andrew

- Assisting first-responders in determining their vital signs and stress levels
- Assisting first-responders in locating hazardous materials in buildings being evacuated
- Allowing buildings to be managed better in terms of their energy, maintenance, etc.
- Large-scale campus-wide sensor testbed to explore
  - Middleware issues
  - Quality of service: Security, fault-tolerance
  - Infrastructural value to other disciplines (e.g., civil engineering)



Sensor Andrew
Stakeholders
First Responders
Facility Management
Building Occupants
Researchers
Data Center
Web Servers
Processing & Analytics
Carnegie Mellon Campus Map
Middleware
Middleware
Middleware
Sensor Node
Cameras
RFID Readers
Mobile Node
* Protocols listed are examples

Sensor Andrew Middleware (1)

- Working with civil and environmental engineers and facility managers
  - Not interested in the protocols, endian-ness, hardware
  - Want their data, want it now, in formats they want
- Middleware for Sensor Andrew
  - Intended to support the development of applications running across different hardware
- Secret Sauce
  - Use the well-known URL mechanism to address all sensors/actuators in the same way
  - Hide the hardware details "behind" the URL

Sensor Andrew Middleware (2)

- Uniform resource access
  - Use the same mechanism to access all devices (sensors and actuators)
- Simplicity
  - Keep the interface as simple and intuitive as possible
- Heterogeneity
  - Support different kinds of devices
    - Firefly, gumstix, EnerSure, Telos motes, webcams, mobile phones, ……
- Thin clients
  - Keep the code on the devices as minimal as possible
  - Use the native protocols to access the devices

Sensor Andrew Middleware (3)

- Cluster
  - Logical grouping of devices
  - Clusters may contain other clusters
  - Analogous to a directory in file system
  - Example: PHB34 could be a logical cluster for devices for Porter Hall room B34
- Universal Resource Locator (URL)
  - Describes the location of a device within the logical cluster hierarchy
  - Example
    - cmu.edu/ph/b34/temp/temp1
    - cmu.edu/cic/2202/humidity/humidity1

Sensor Andrew Middleware (4)

- Device queries allow a user to query one or more devices in a cluster or cluster hierarchy
- Wildcard extensions to support multi-device query
  - …/cluster1/* - matches any device within cluster1
  - …/cluster1/** - matches any device within cluster1 and any of cluster1's subclusters
  - Example:
    - cmu.edu/ph/b34/temp/* ⇨ all temperature devices within a specific room (PHB34, in this case)
    - cmu.edu/cic/**/humidity/* ⇨ all humidity devices within an entire building (CIC, in this case)

Example: Vital Responder

- Joint project with Carnegie Mellon University and the University of Porto and University of Aveiro
- Goals
  - Develop the next-generation wearable garment for vital-sign detection and body-information monitoring
  - Develop indoor and outdoor localization to detect where personnel are
  - Integrate with infrastructural assets (intelligent sensor-enriched buildings) to respond to emergency and critical events
- Target: First-responders in Pittsburgh and Portugal

Wearable Platform

- Commercially manufactured in Portugal
- Currently in use by fire-fighters there
- Sensors embedded in the fabric
  - EKG sensors
  - GPS
  - Accelerometers
  - Pulse oximeters

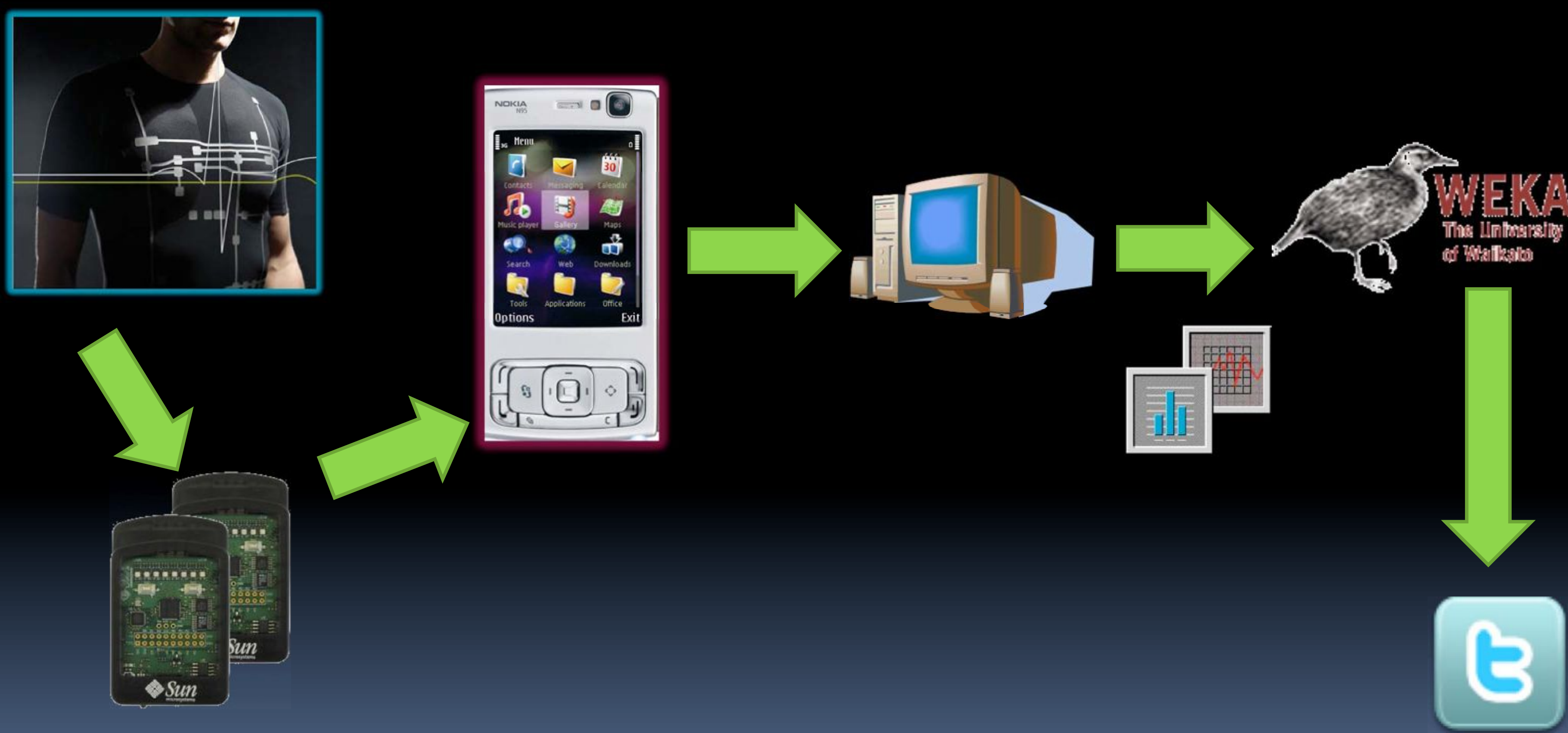
Example Use: Twitter Jacket

- Automated social networking
- Activity recognition
- Localization using GPS sensors
- Configurable frequency of updates
- Update significant activity/location change
- Infer various related entities/context
  - Company (people a person is with), landmarks

System Architecture

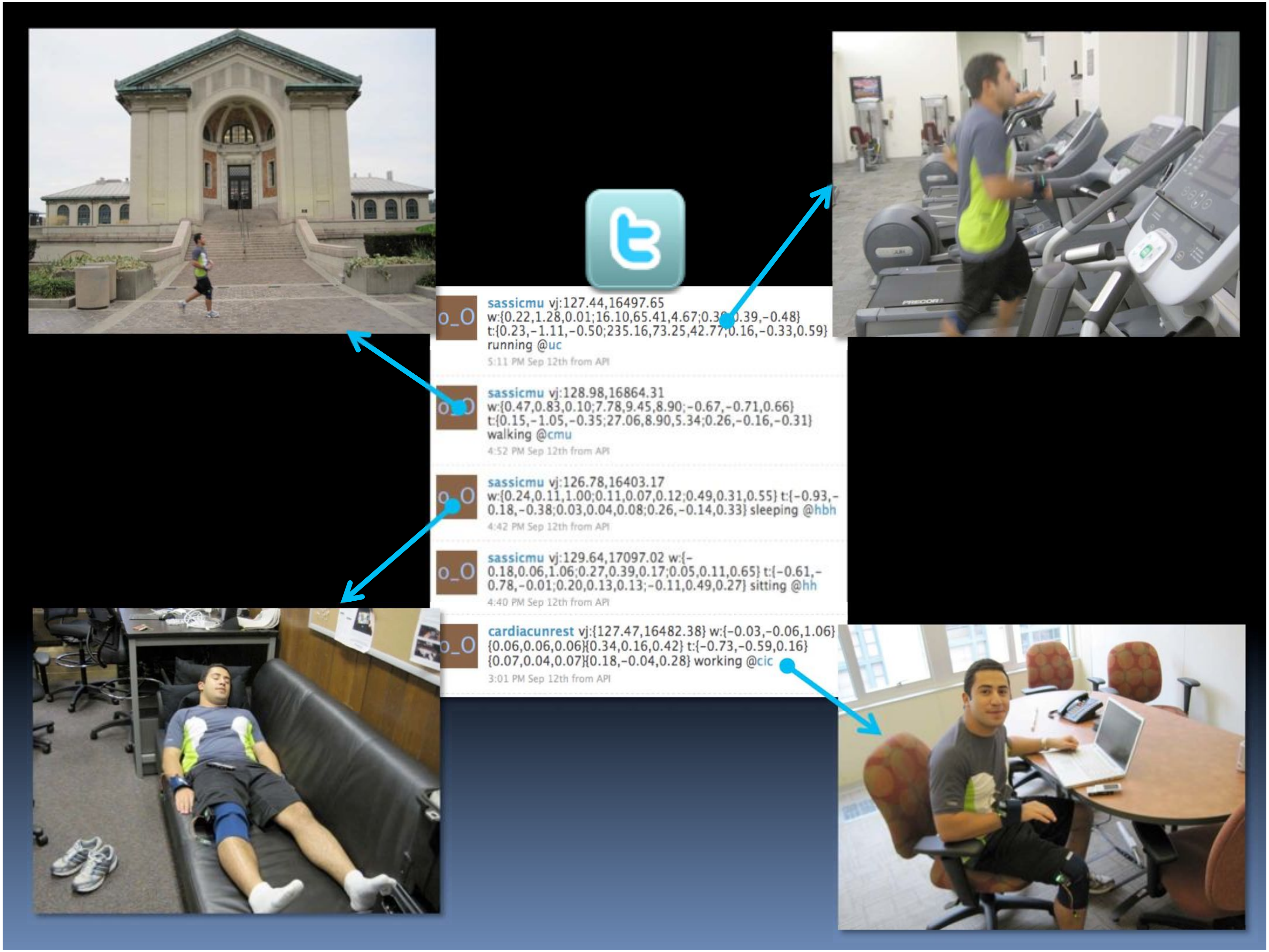
- 3-Axis Accelerometer continuous readings
  - In additional locations, apart from the wearable vest
- Continuous EKG Readings
- Feature extraction on sensor nodes
  - Mean, standard deviation
  - Correlation for each axis-pair / accelerometer
- Features are uploaded to server with initial labels
  - Annotated by the user for now, for initial training
- Server builds activity classifiers
- Classifiers are later used to recognize activities

TwitterJacket in Action



Current Activity Database

- Username, Batch, Index, Timestamp
- Mean, Standard deviation, energy, entropy, correlation
- Location
  - Latitude, Longitude
  - Address1, Address2, City, State, Country, Postal
  - Landmarks
- Sitting/Standing/Sleeping
- Walking/Running
- Eating/Watching/Working
- Company, Objects
- At work/play/rest
- User data


sassicmu vj:127.44,16497.65 w:{0.22,1.28,0.01;16.10,65.41,4.67;0.3 .39,-0.48} t:{0.23,-1.11,-0.50;235.16,73.25,42.77;0.16,-0.33,0.59} running @uc
5:11 PM Sep 12th from API
sassicmu vj:128.98,16864.31 w:{0.47,0.83,0.10;7.78,9.45,8.90;-0.67,-0.71,0.66} t:{0.15,-1.05,-0.35;27.06,8.90,5.34;0.26,-0.16,-0.31} walking @cmu
4:52 PM Sep 12th from API
sassicmu vj:126.78,16403.17 w:{0.24,0.11,1.00;0.11,0.07,0.12;0.49,0.31,0.55} t:{-0.93,-0.18,-0.38;0.03,0.04,0.08;0.26,-0.14,0.33} sleeping @hbh
4:42 PM Sep 12th from API
sassicmu vj:129.64,17097.02 w:{-0.18,0.06,1.06;0.27,0.39,0.17;0.05,0.11,0.65} t:{-0.61,-0.78,-0.01;0.20,0.13,0.13;-0.11,0.49,0.27} sitting @hh
4:40 PM Sep 12th from API
cardiacunrest vj:{127.47,16482.38} w:{-0.03,-0.06,1.06}{0.06,0.06,0.06}{0.34,0.16,0.42} t:{-0.73,-0.59,0.16}{0.07,0.04,0.07}{0.18,-0.04,0.28} working @cic
3:01 PM Sep 12th from API

What's Next?

- Improve activity recognition
  - Incorporate additional sensors (humidity, temperature, etc.)
  - Improve classification accuracy
- Indoor localization algorithms
  - Integrate wearable vests with building sensors
- Data collection and validation in pilots
  - Portugal: Ambulance operators, paramedics, fire fighters
  - Pittsburgh: Smart homes for the elderly, facilities-management teams
- Evaluate the usability and performance of the middleware for the developers

Conclusion

- Focus
  - Real-world pilots
  - Real-world data collection through smartphones, sensors, crowdsourced input
- Research
  - Real-time analytics for multiple stakeholders
    - Example: Snowplow operators, residents, city
  - Privacy, trustworthiness of data
  - Algorithms for routing, analysis, recovery on top of the data

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