UMOBILE ACM ICN 2017 Tutorial

Session: Contextualization Aspects Integration Into the Network Operation

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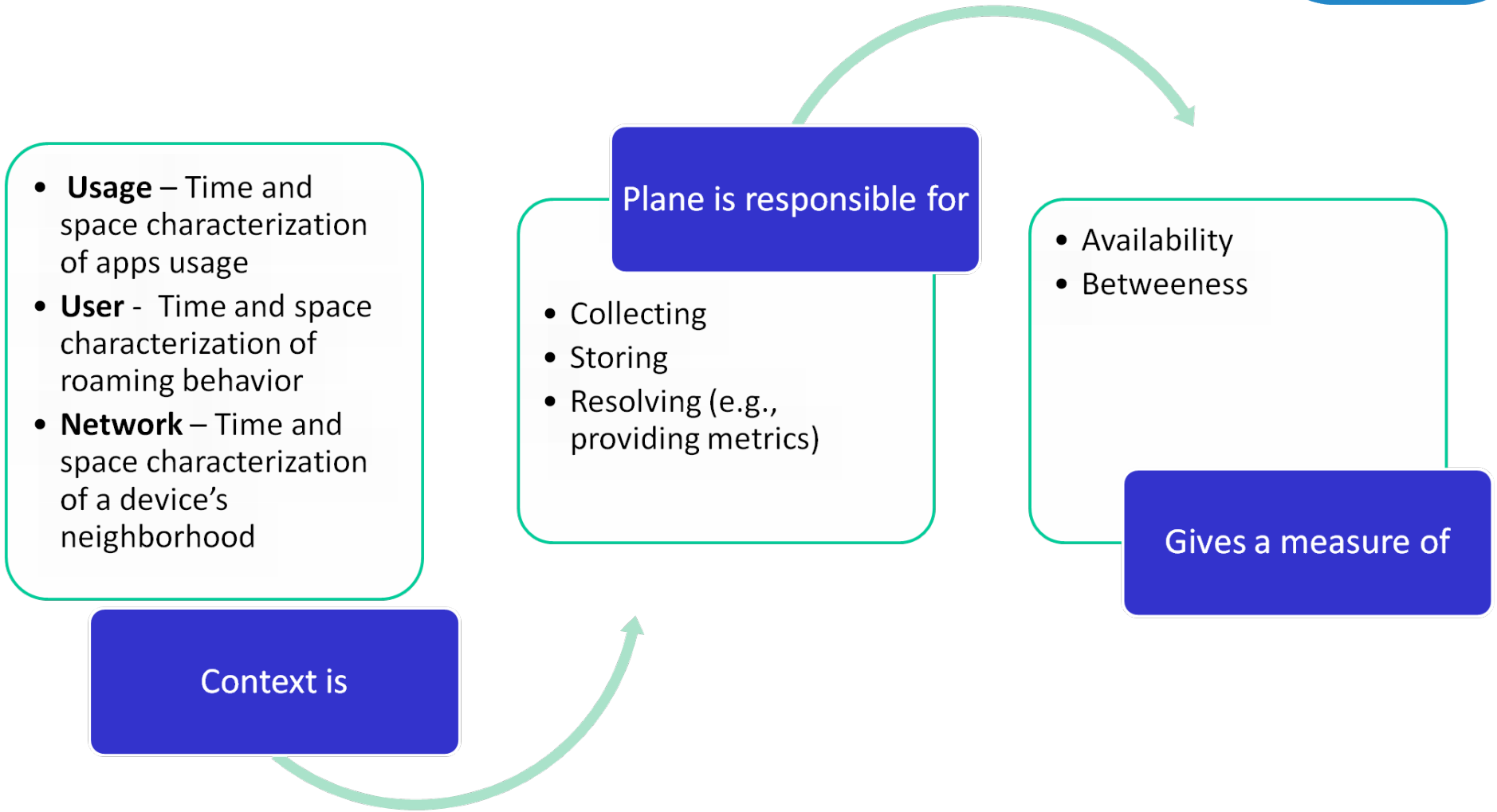
Session Overview

1. **Contextualization in UMOBILE**
   - The Context Plane
2. **The Contextual Manager agent**
   - Software architecture
   - Modules: capture, storage, inference
   - The A (affinity network), U (availability derived from usage), and I (similarity in preferences) weights

3. **PerSense Mobile Light, a tool for network contextualization**
   - Introduction to the tool (how to use it, results it provides)
   - Demo

1. Contextualization in UMOBILE

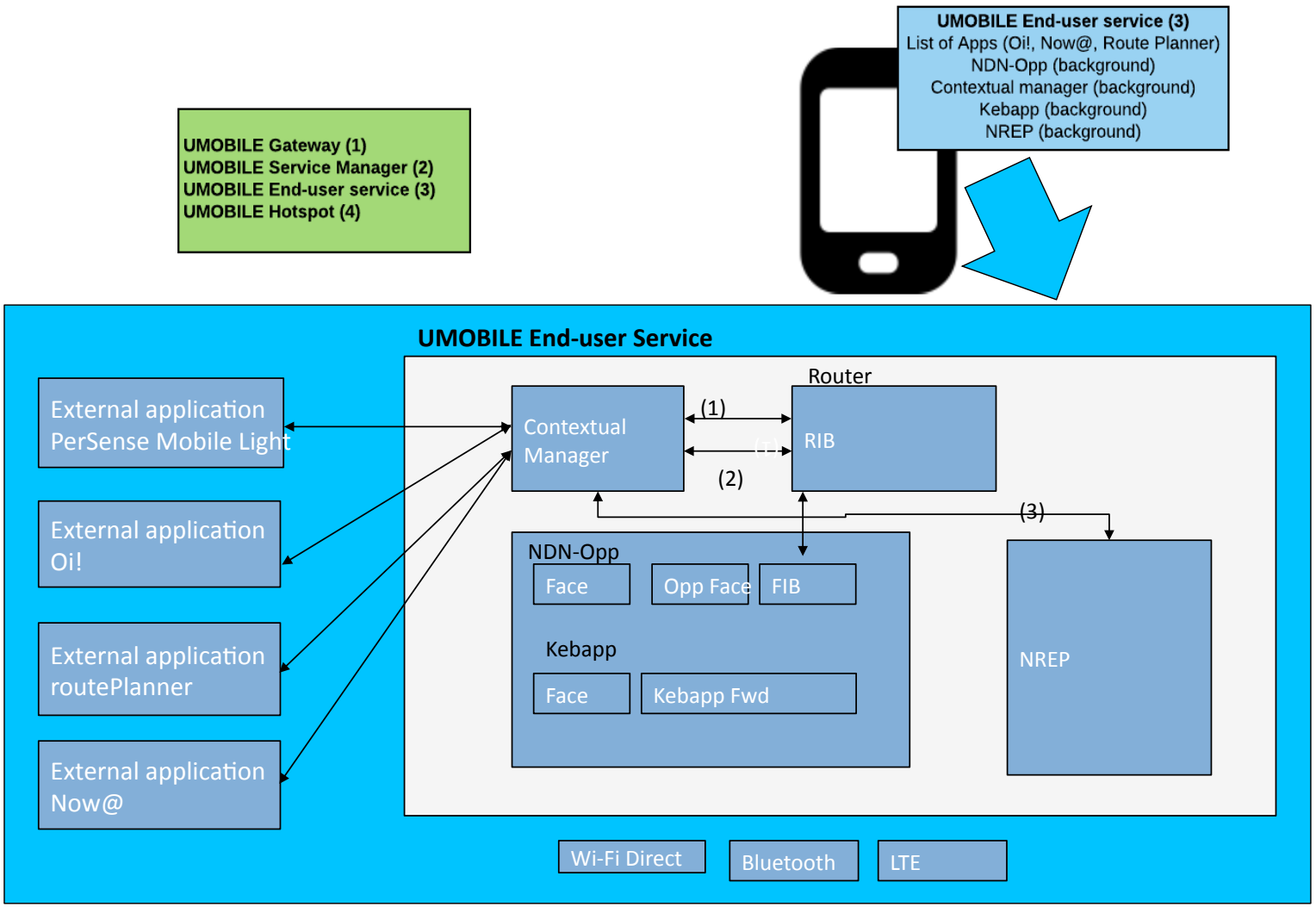
The Context Plane



2. The UMOBILE Contextual Manager

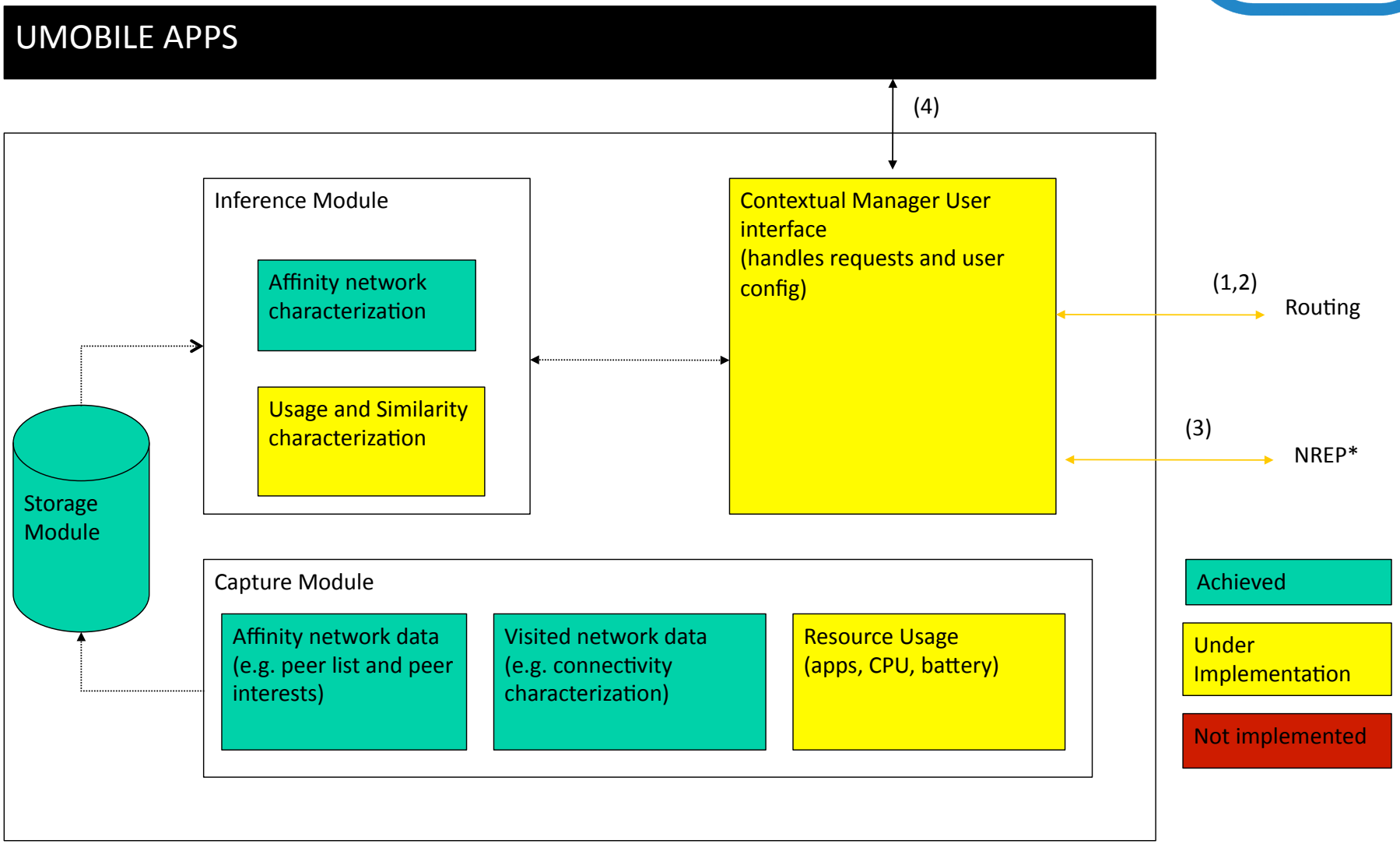
The Context Plane

UMOBILE Contextual Manager



Contextual Manager

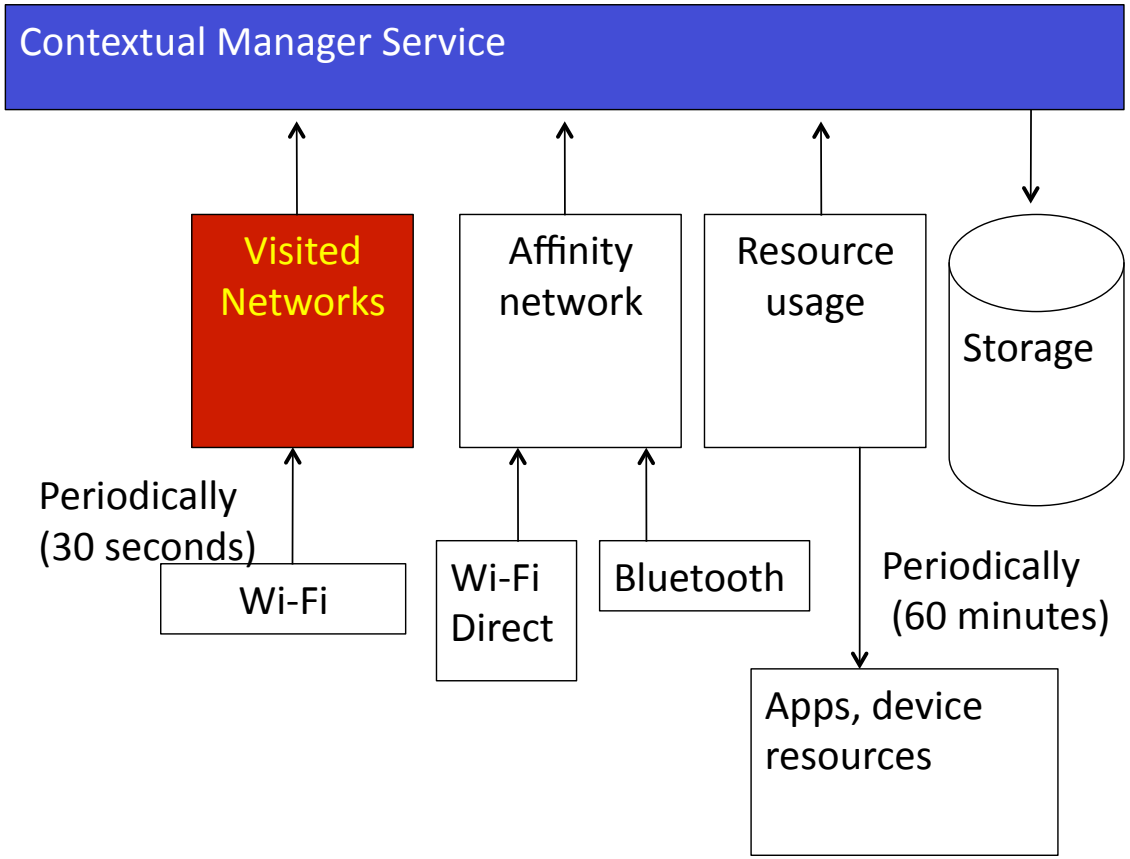
High-Level Architecture



Contextual Manager

Capture Module: **Visited Networks**

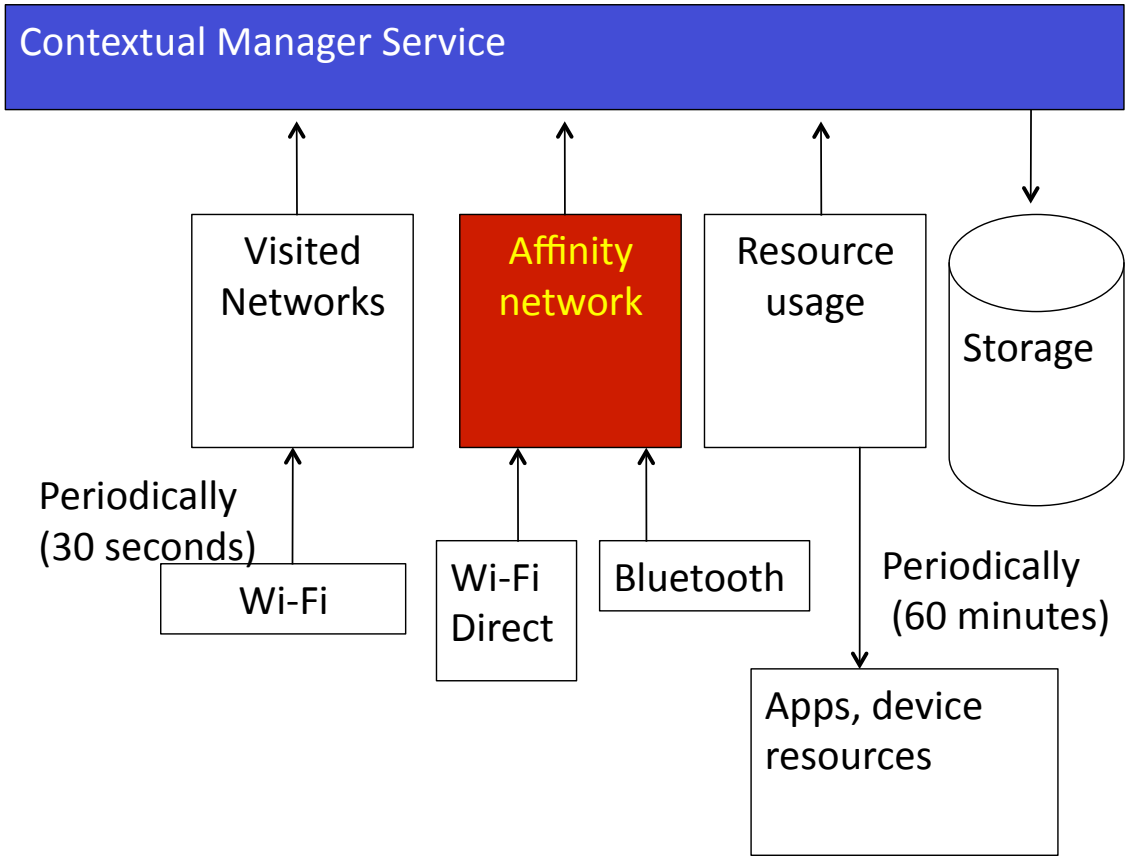
- **Visited networks**
  - Individual roaming behavior
  - Data collected via regular Wi-Fi scans
  - Stores computed data for 1 week (1 table per day of the week)
  - Table entry is tupple: *<int AP Id, String HASHED SSID, String HASHED BSSID, int dayoftheweek, int number_visits, double average_visitduration, int firstConnectedTimeStamp, int LastConnectedTimeStamp, boolean Connected, double lat, double long>*
  - *Related Libraries: PerSense Mobile Light*



Contextual Manager

Capture Module: **Affinity Network**

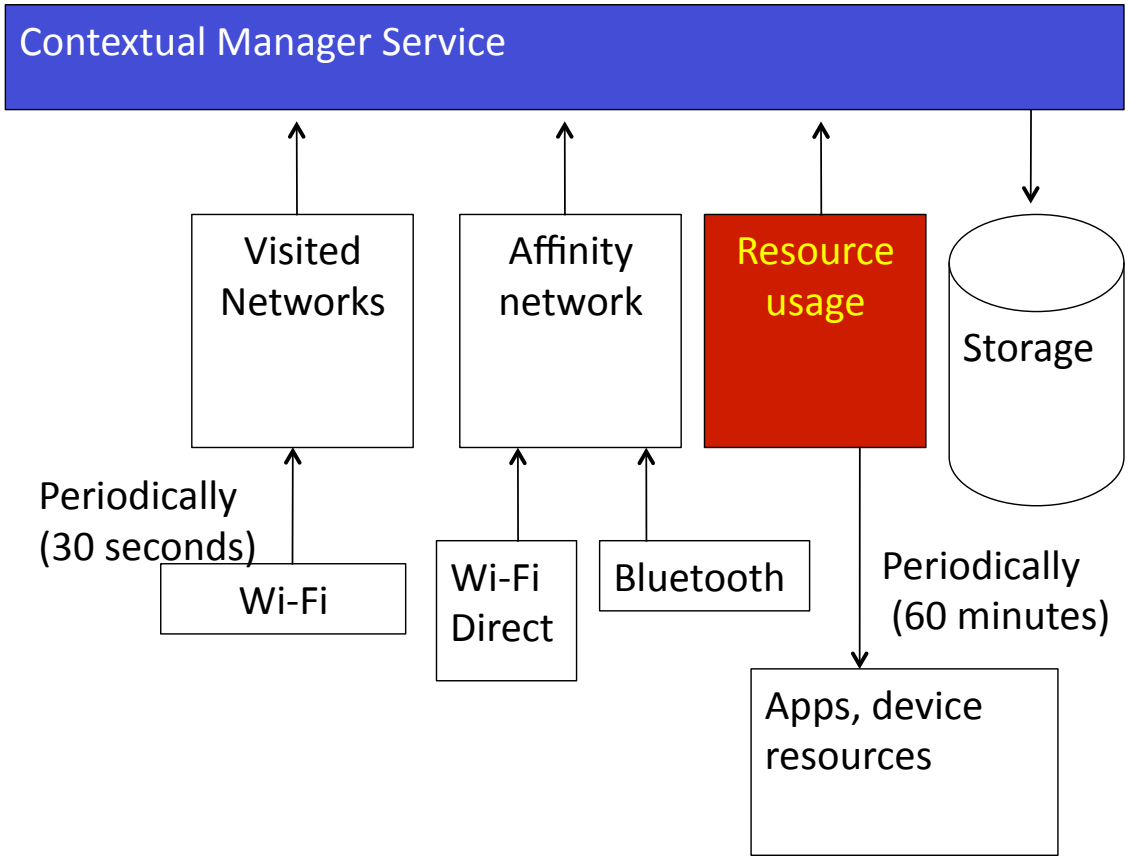
- **Affinity Network**
- Snapshot of the neighborhood availability over time and space
  - Stores raw data for 1 week (1 table per day of the week)
    - Each entry in one day corresponds to one Peer, identified by HASHED BSSID
    - Table entry is tupple: *<int HASHED MAC, String UUID, int dayoftheweek, int array HourArray, double average_encounterduration, double lat, double long>*
- *Related Libraries: PerSense Mobile Light*



Contextual Manager

Capture Module: **Resource Usage**

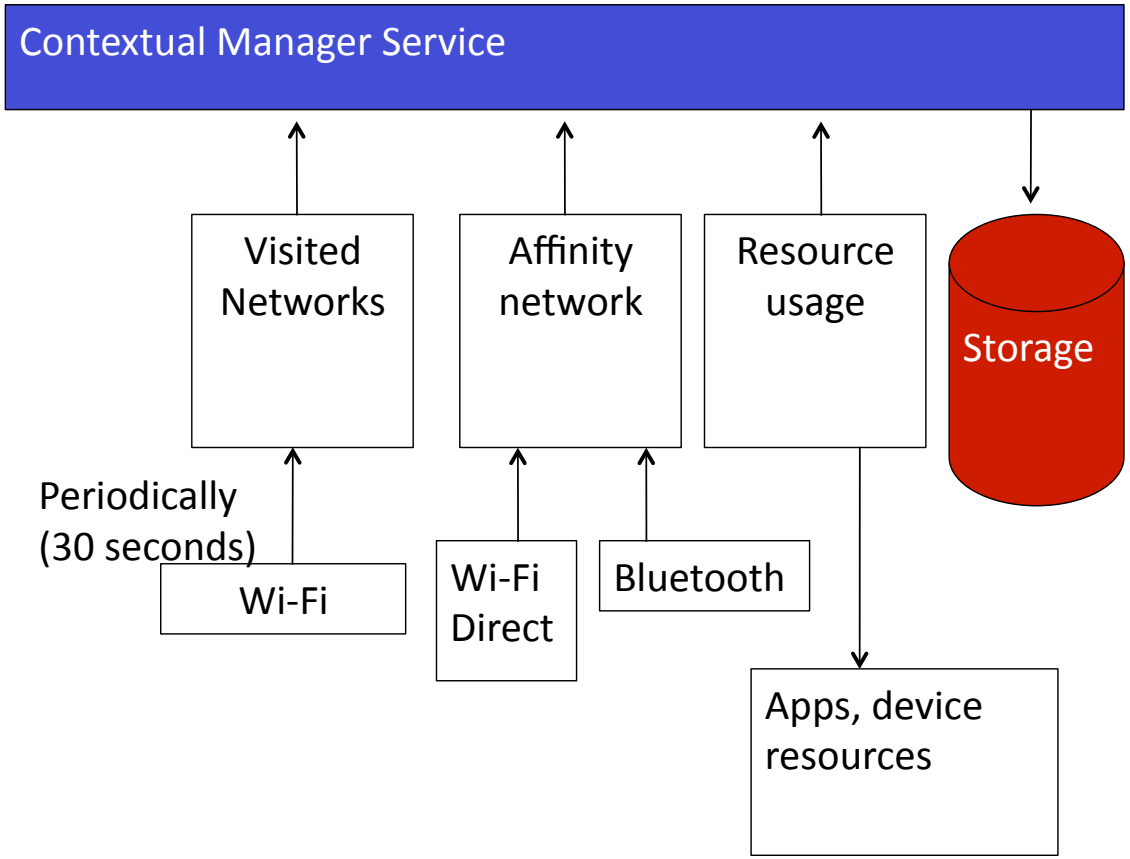
- **Resource Usage**
- Stores resource consumption and app usage (per day and per hour)
- **Physical resource usage**
  - Entry: *<String TypeofResource, int array[24] UsageperHour>*
    - *Energy: TypeofResource=energy*
    - *Storage: TypeofResource = Storage*
    - *CPU: TypeofResource = CPU*
- **Category of application usage**
  - Entry: *<app_id, double TotalUsageDuration, double CPUConsumption, double connectivityConsumption, String CategoryPreferences>*



Contextual Manager

Storage Module

- **LOCAL SQL database**
- Table 1-7: visited networks (Monday to Sunday)
- Table 8-14: Affinity network (peer status, Monday to Sunday)
- Table 15-21: ResourceUsage (per hour, Monday to Sunday, multiple resources)
- Table 22-29 AppUsage (per hour, Monday to Sunday, multiple apps)
- Interface to external applications
  - Internal database synchronization feasible
- Contextual Manager Service manages requests and storing in database
- Periodic updates and refreshing



Contextual Manager

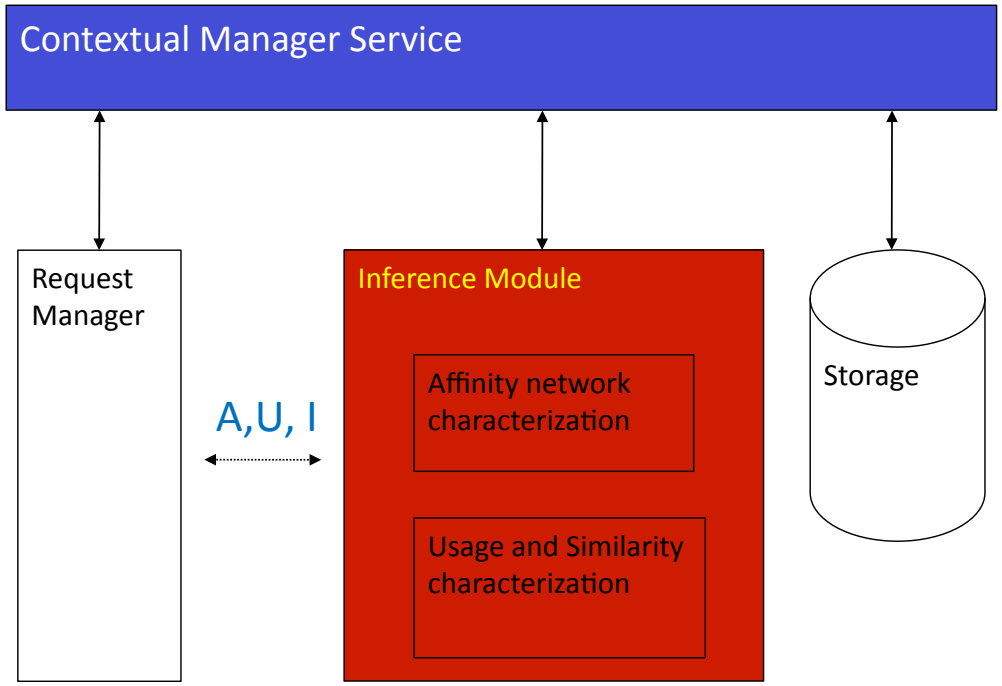
Inference Module, Indicators

Affinity network characterization indicators

- Peer list (bluetooth and Wi-Fi Direct) at instant t or over time window T.
- Interests associated to each peer.
- Battery status of each peer.
- Average, max, min connectivity duration over period T.
- Average. Max, min contact duration.
- Average node degree over time and space.
- Cluster distance.
- Visited networks' characterization/ranking.

Usage and similarity characterization Indicators

- Preferred visited network and/or geo-location.
- Type (category) of preferred application (e.g. most used over time window T).
- Time spent per application category (e.g. per day).
- Similarity level computation towards (registered peers)



Contextual Manager

Inference Module, A and U Costs

- **U(i)**: internal usage weight of node i (**measures availability of the node**)
- **A(i):** affinity network level of node i (**measures node betweeness**)
- **I(i,j)**: similarity for node preferences (measures similarity levels based on preferences)

U(i)

- Battery status: 20%
- Storage status: 80%
- U(i): Low (availability)

A(i)

- Node I degree: 10
- Average encounter duration: 1h
- A(i): high betweeness for node i

I(I,j)

- Node i has as main preferences (out of 10 main preferences) Music, Art [1,1,0,0,0,0,0,0,0,0,0,0]
- Node j has as main preferences Music, Literature: [1,0,1,0,0,0,0,0,0,0]
- Node k has as main preferences Art and Literature: [0,1,1,0,0,0,0,0,0,0]
- I(I,j)=I(I,k) - Node similarity level (computed based on eigenvalue distribution)

3. PerSense Mobile Light, a Tool for Network Contextualization

Non-Intrusive Wireless Technology

PerSense Mobile Light, what For?

- **Android App developed in the context of the H2020 UMOBILE project**
- **What it does:** mines wireless networks **non-intrusively**
  - Wi-Fi and Wi-Fi Direct; Bluetooth
  - Captures wireless foot printing aspects (distances, APs, visits type and duration and geo-location)
  - All data are stored LOCALLY and in accordance with European guidelines
  - Generates csv reports daily – researchers can get them via e-mail.
- **PML <u>does not</u> collect any personal data**
  - **Its Purpose:** industrial investigation - scientific studies and traces concerning roaming and interaction aspects
  - ***Can be extended upon request, to capture parameters relevant to interested parties***
- ***Where it is being (further) applied:***
    - PhD students, smart cities data extraction
    - UMOBILE Lab (soon, to be open to the external community)
- **Questions? Info at senception dot com**

PerSense Mobile Light

How to Run?

- **Google App store (Android only)**

- **Start the app**

  Runs in background

  Stores the reports after 1 day in a folder named **PerSense_mobile_light**

- **How to extract results**
  - Open the app and send reports via e-mail OR
  - Go to the internal memory and get the csv files (three different reports per day)

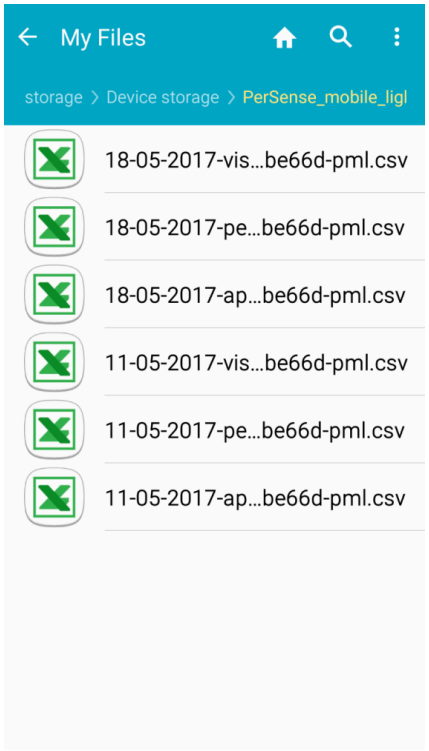
- **How to visualize results?**
  - *Use a mining tool (e.g. Orange, RapidMiner)*
  - *Soon: UMOBILE Portal (February 2018)*

PerSense Mobile Light

Interaction Reports

Three different reports generated daily

- **Roaming Diary (APs crossed)**
  - *Id.* Sequential identifier of the AP waypoint crossed;
  - *Bssid of the AP; Ssid of the AP*
  - *Dayoftheweek.* Integer corresponding to the day of the week, starting by Sunday as 1, and ending with Saturday (7)
  - *Attractiveness. Boolean (0 not connected; 1 connected)*
  - *DateTime.* day and time when the device entered the range of the AP.
  - *Latitude, Longitude.* GPS coordinates for the device.
- **Visited Networks' report, list of access points the device connected to.**
  - *Id.* Sequential identifier of the AP waypoint crossed;
  - *Bssid of the AP; Ssid of the AP*
  - *Timeon. Timestamp for the start of the connection (MAC Layer)*
  - *Timeout. Timestamp for the end of the connection*
  - *Dayoftheweek*. Integer corresponding to the day of the week, starting by Sunday as 1, and ending with Saturday (7). Hour corresponds to the 24-hour timeslot of the day.
- ***Affinity network report* provides a list of neighbors over time (affinity network).**
  - (id); identifier of the device (uuid);
  - MAC address (MAC);
  - DateTime. date and time when the peer was last encountered
  - Lat, Long. GPS coordinates for the device.

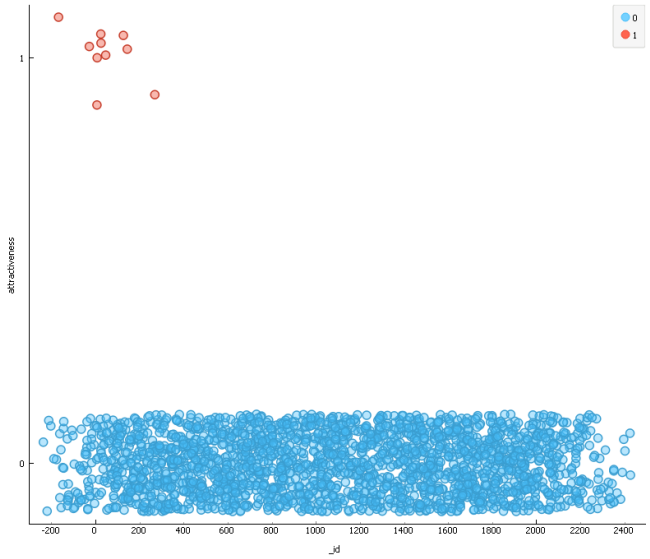


PerSense Mobile Light

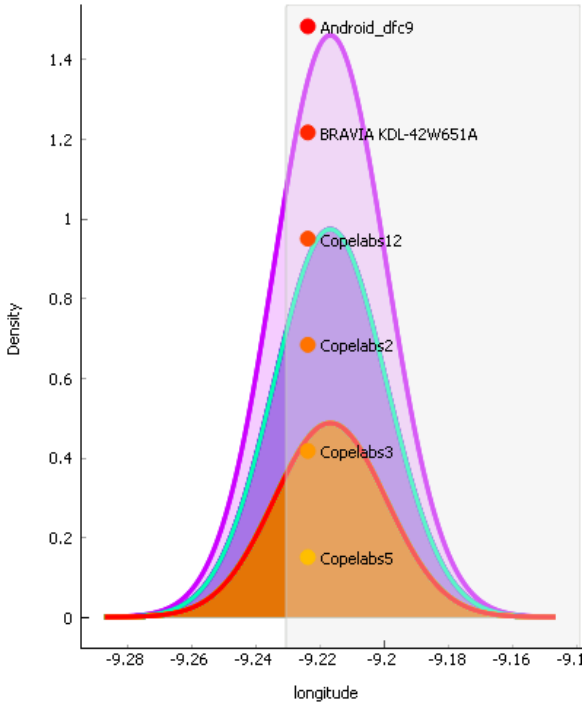
Study I: Social Interaction Analysis in Children*

- 80 students, ages 11-16
- 8 different classes
- 8-10 teachers
- 1 month data collection

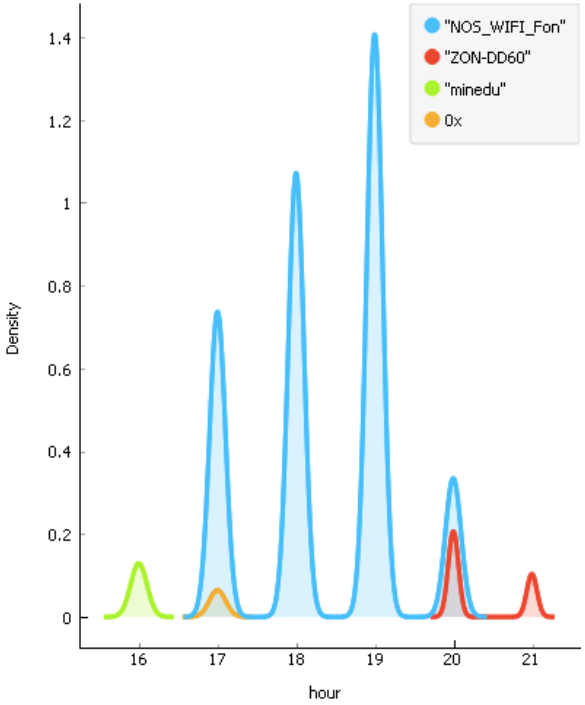
Data collected, 1 day (05.05.2017)
connected (1) vs crossed access points (0 – blue)



Data collected, 1 day (05.05.2017)
Peers around



Data collected, 1 day (05.05.2017)
distribution of visited APs over time



Study on clustering and time correlation of roaming habits/mobility patterns in children
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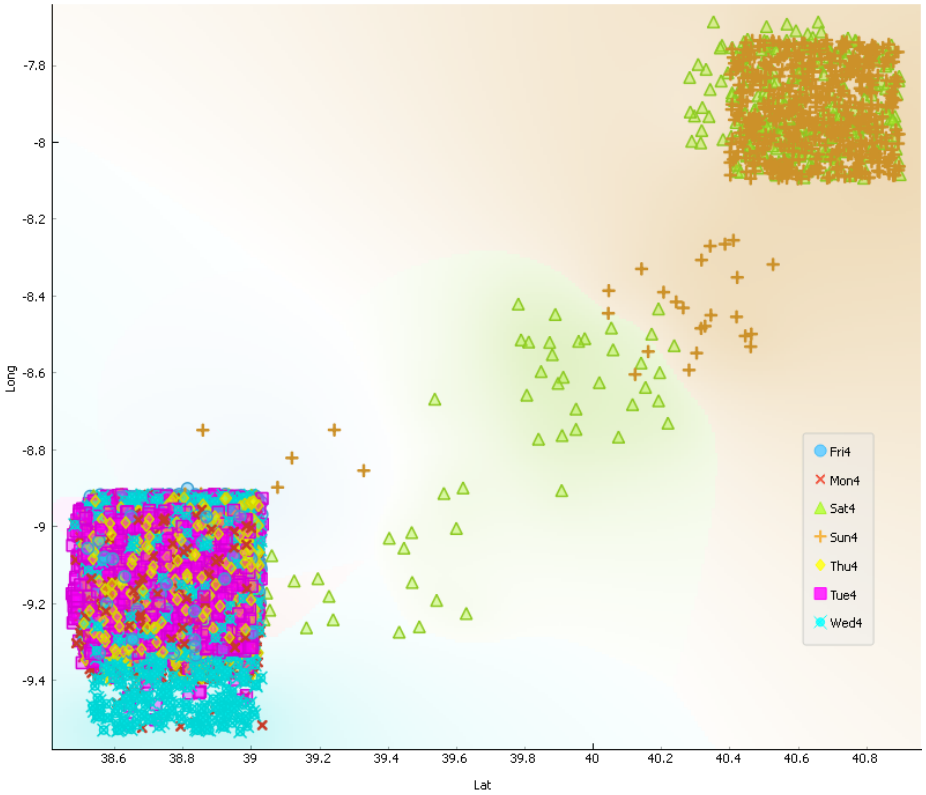
PerSense Mobile Light

Study II: Network Modeling and Measurement*

- 7 users in Lisbon
- 4 shared affiliation
- 2 week data collection (2015)
- Analysis of roaming behavior for network modeling



Main Results

- **Results show that it is feasible to rely on network mining to extract concrete daily routine habits, e.g.,**
  - **Time-based characterization aspects**
    - Duration of a daily routine has in average 15 hours (instead of the common 8 hours routine used in network modeling)
    - There are three different higher connectivity periods during one day, each with a duration of 2-3 hours (usually tending to early morning; lunch time; late afternoon)
    - During a week, there is a one-day period of more intense connectivity, and a one-day period (usually Sunday) of lower connectivity usage
  - **Spatial characterization aspects**
    - In the traces obtained, the paths traversed held thousands of AP per day, at a close distance (0.09m-100m)
    - Maximum traversed distance in 1 day: ~ 10 km
    - Average distance: hundreds of meters

*R . C. Sofia, P. Mendes. A Characterization Study of Human Wireless Footprints based on non-intrusive Pervasive Sensing. Short version Under submission, June 2017.
http://www.umobile-project.eu/publications?download=36:rute-sofia-paulo-mendes-a-characterization-study-of-human-wireless-footprints-with-persense-mobile-light-mobiarch-2016

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