Improving QoE via context prediction: A case study of using WiFi radiomaps to predict network disconnection

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ACROSS
Autonomous Control for a Reliable Internet of Services

International Workshop on Autonomous Control for Performance and Reliability Trade-offs in Internet of Services

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Outline

- Scope
- WiFi radiomap-based Indoor Positioning Systems
- Platform Design and Implementation
- Case study-based evaluation
- Conclusions & Future Work

Scope

- Work in Progress
- Main goal: Develop an open platform for studying, analyzing and utilizing context for improving QoE
- This paper: focus on prediction of position using WiFi radiomaps
- Prototype implemented (on Android) and evaluated with simulated data (with Python script)

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Fingerprinting Positioning (1)

- Based on the real-time comparison of received radio parameters (traditionally RSS) with pre-measured position-stamped signal signatures (called fingerprints) which are stored in a database.
- It consists of two phases:
  - *Offline phase (or training phase)*: The collection of the fingerprints to be stored in a database
  - *Online phase (or positioning phase)*: the instantaneous measurement is correlated with the database to estimate the most likely position.

Fingerprinting Positioning (2)

Offline phase / Training

"lat": 35.0083**7**00,
"lng": 33.696**5**000,
"measurements": [
{"macAddress": "0", "ssid": -65 },
{"macAddress": "1", "ssid": -66 },
{"macAddress": "2", "ssid": -80 },
{"macAddress": "3", "ssid": -85 }
]

"lat": 35.0083**8**00,
"lng": 33.696**7**000,
"measurements": [
{"macAddress": "0", "ssid": -75 },
{"macAddress": "1", "ssid": -76 },
{"macAddress": "2", "ssid": -60 },
{"macAddress": "3", "ssid": -58 }
]

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Fingerprinting Positioning (3)

Online phase / Positioning

"lat": 35.008**3**700,
"lng": 33.696**5**000,
"measurements": [
  {"macAddress": "0", "ssid": -65 },
  {"macAddress": "1", "ssid": -66 },
  {"macAddress": "2", "ssid": -80 },
  {"macAddress": "3", "ssid": -85 }
]

"lat": 35.0083**8**00,
"lng": 33.696**7**000,
"measurements": [
  {"macAddress": "0", "ssid": -75 },
  {"macAddress": "1", "ssid": -76 },
  {"macAddress": "2", "ssid": -60 },
  {"macAddress": "3", "ssid": -58 }
]

"lat": ?,
"lng": ?,
"measurements": [
  {"macAddress": "0", "ssid": -62 },
  {"macAddress": "1", "ssid": -67 },
  {"macAddress": "2", "ssid": -81 },
  {"macAddress": "3", "ssid": -87 }
]

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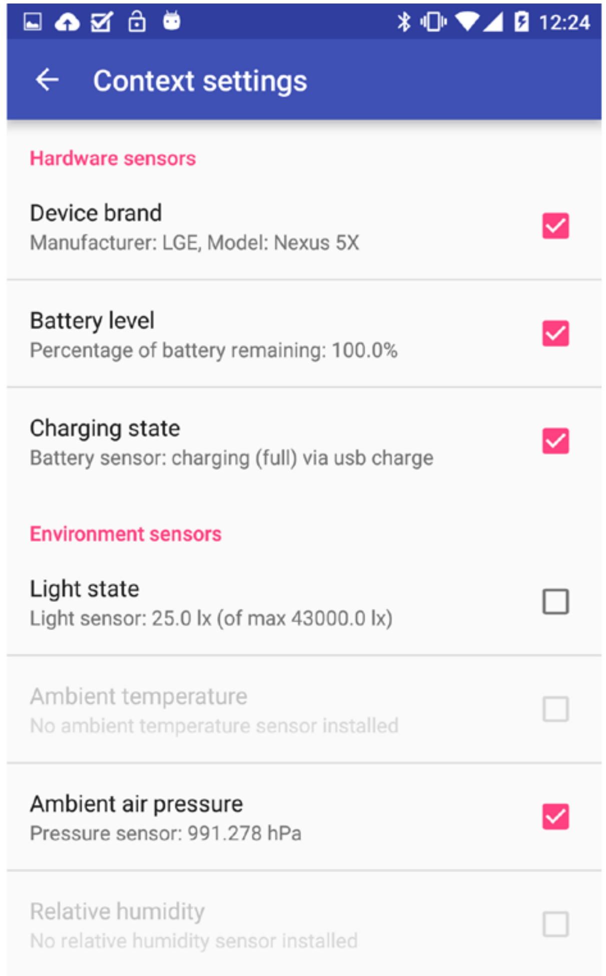
Platform Design and Implementation



https://github.com/nearchos/CAIPS

Case study-based evaluation

- Aims
  - Assess the potential of WiFi-based indoor positioning as a means of predicting network disconnection
- Method
  - Identify and map Points of Interest (POIs)
  - Measure network connectivity at POIs
  - Create simulated motion paths (recurring, on a weekly basis)
  - Run pattern-matching algorithm to *predict* the next POI, and thus the predicted network quality

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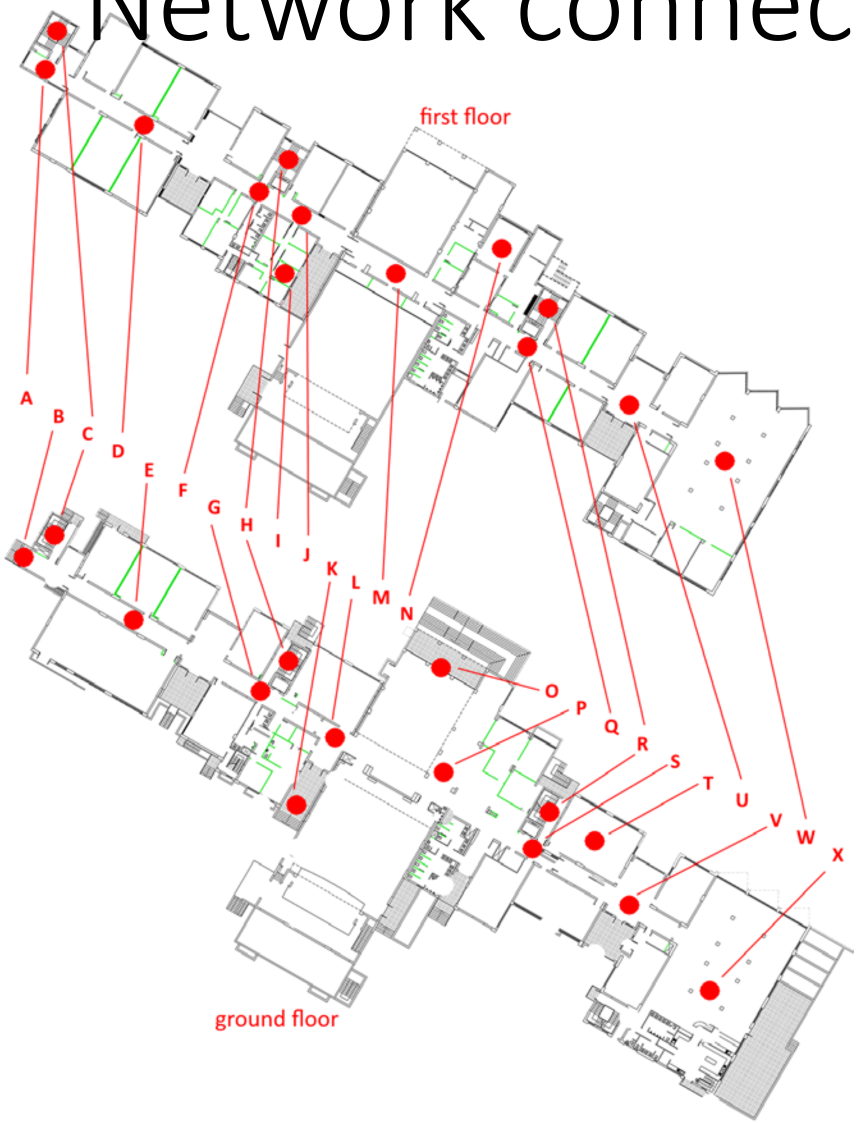
Points of Interest (POIs) and Network connectivity



POI	WiFi strength (dB)	Notes
A	-81	Edge of building
B	-61	Entrance/Exit
C	$-\infty$	Stairwell (weak signal)
D	-62	Transition point
E	-54	Transition point
F	-67	Edge of stairwell
G	-59	Edge of stairwell
H	$-\infty$	Stairwell (weak signal)
I	-43	Office (frequent use)
J	-51	Transition point
K	-74	Entrance/Exit
L	-60	Edge of building
M	-64	Transition area
N	-53	Admin office (frequent use)
O	-59	Entrance/Exit
P	-56	Transition point
Q	-63	Edge of stairwell
R	$-\infty$	Stairwell (weak signal)
S	-66	Edge of stairwell
T	-47	Lab (frequent use)
U	-70	Transition point
V	-62	Transition point
W	-56	Library (frequent use)
X	-52	Cafeteria (frequent use)

Table 1: *Points of Interest* (POIs) with annotations

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Simulated motion paths

Id	Time	Motion path	Notes
i	08:00	B C A D F J I	Arriving to the building
ii	09:00	I J M Q R S T	Going to a timetabled class
iii	12:00	T S R Q M J I	Returning to office
iv	13:00	I J M Q R S V X	Going for lunch
v	13:30	X V S R Q M J I	Returning to office
vi	14:30	I J M Q U W	Going to the library
vii	14:45	W U Q M J I	Returning to office
viii	17:00	I J F D A C B	Leaving the building

Table 2: Fabricated model illustrating user's most common motion patterns in the building

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Pattern matching algorithm

Algorithm 1 Simple pattern matching algorithm

```
procedure PREDICTNEXTPOINT(PATTERNS, PATH, TIME)
    result ← MatchWithAllCharacters
    if result == 1 then
        print 'Found a match'
    else
        if result == 0 then
            PredictNextPoint(path - firstCharacter, time)
        else
            nextPoint ← getClosestMatchInTime()
procedure MATCHALLCHARACTERS(PATTERNS, PATH)
    list result ← ∅
    for do item in patterns
        if item in path then
            result ← result + item
    return result
```

Based on the algorithm by Karp:

R. M. Karp, R. E. Miller, and A. L. Rosenberg. Rapid identification of repeated patterns in strings, trees and arrays. In Proceedings of the Fourth Annual ACM Symposium on Theory of Computing, STOC '72, pages 125{136, New York, NY, USA, 1972. ACM.

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Conclusions

- A work-in-progress paper
  - Assessed the potential of indoor positioning for predicting context (network quality in particular) and its ability to help optimize the QoE

- Future work
  - Collect real-world traces for multiple users over a period of time (automatic POI identification)
  - Test different algorithms and assess their ability to *predict* user motion patterns and user context in general (besides simple string pattern matching)
  - More ambitious: use neural networks to directly infer QoE-sensitive properties (e.g. network quality) from WiFi radiomaps

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Questions?

- Thank you!
- While we are at this…
  …why not submit/attend **ISD2017 @ Larnaca, Cyprus**?
  (track 5 – Mobility and Context-awareness in ISD)

http://isd2017.uclancyprus.ac.cy – Papers due April 29th – Conference on September 6-8th