

Always Best Positioned Lösungen im FB IUI

Tim Schwartz

DFKI Saarbrücken, Intelligente Benutzerschnittstellen

Background

- DFG Transfer Unit RENA (Resource Adaptive Navigation)
- (Self-) Localization of people indoors
 - Minimal instrumentation of user
 - PDA or mobile phone with added sensors/senders
 - NO instrumentation of feet, hands ...
 - Instrumentation of environment is OK
 - Infrared
 - Passive/active RFID
 - Bluetooth
 - Ultrasound
 - Wifi
 - Mobile phone cells
 - Radio/TV Stations
 - Lighting conditions
 - Changing magnet field
 - ...



Always Best Positioned

"The good thing about standards is that there are so many to choose from" (Andrew Tanenbaum)

- No standards in indoor positioning so far, but many approaches differing in cost and precision
 - Situation reminds of connectivity (WiFi, GSM, UTMS ...)
 - Always Best Connected
 - Always Best Positioned
 - A positioning system that can use different positioning technologies, either alone or combined (to get a higher precision)
-

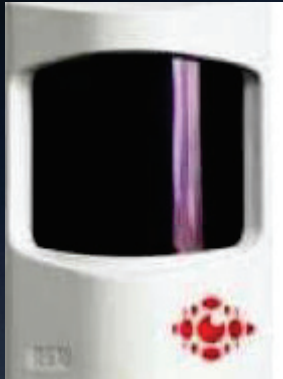
LORIOT

Localization and Orientation in Indoor and Outdoor EnvironmenTs



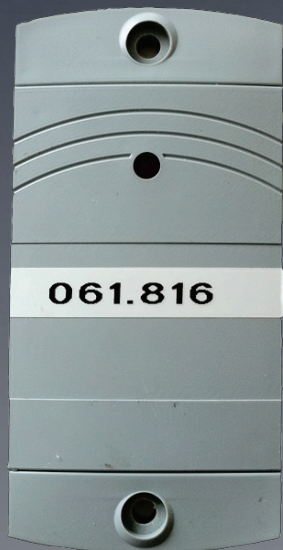
- Uses infrared beacons and active RFID tags
- Built-in infrared sensor
- Active-RFID-Readercard (PCMCIA oder CF)

Sender



Infrared-Beacons:

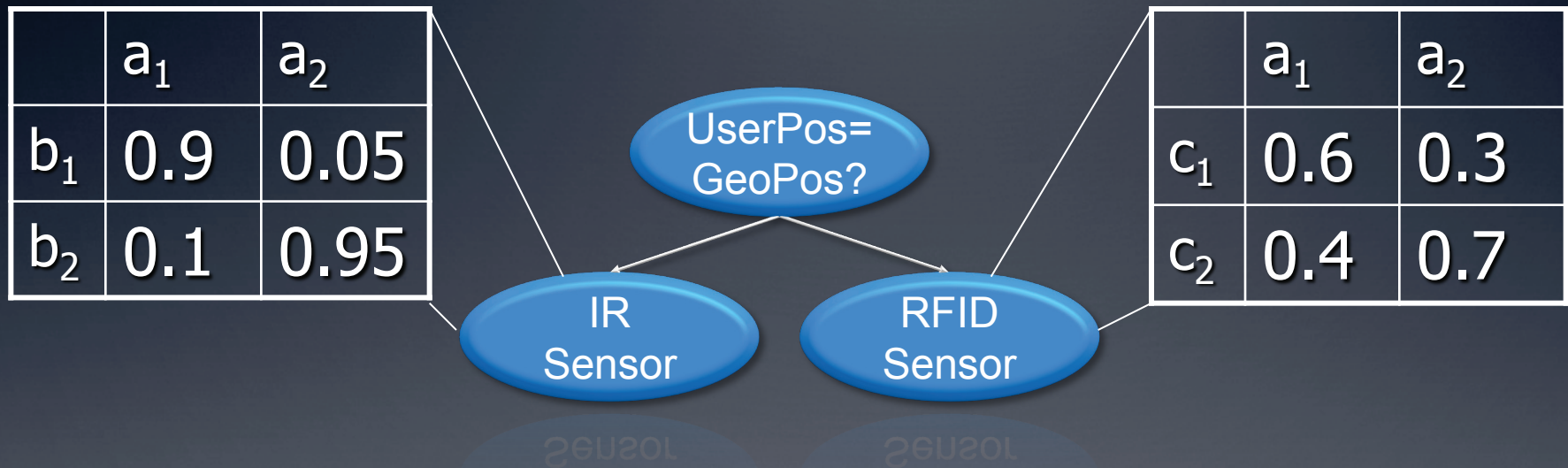
- ▶ Sending characteristics: Light cone
- ▶ Received signal → User in cone
- ▶ Accuracy: High
- ▶ Sending 16 bit ID-code
- ▶ Is directed
- ▶ Needs line of sight



Active RFID Tag:

- ▶ Sending characteristics: Radial
- ▶ Received signal → User somewhere near tag
- ▶ Accuracy: Low
- ▶ Contains own coordinates
- ▶ Is undirected
- ▶ No line of sight needed

Sensor Fusion With Dynamic Bayesian Networks



CPTs represent the sending characteristics:

- ▶ Receiving IR-beacon → high evidence for user near beacon
- ▶ Receiving RFID-tag → less evidence for user near tag
- ▶ Each network is a hypothesis where the user is currently positioned

Clouds of geoDBNs

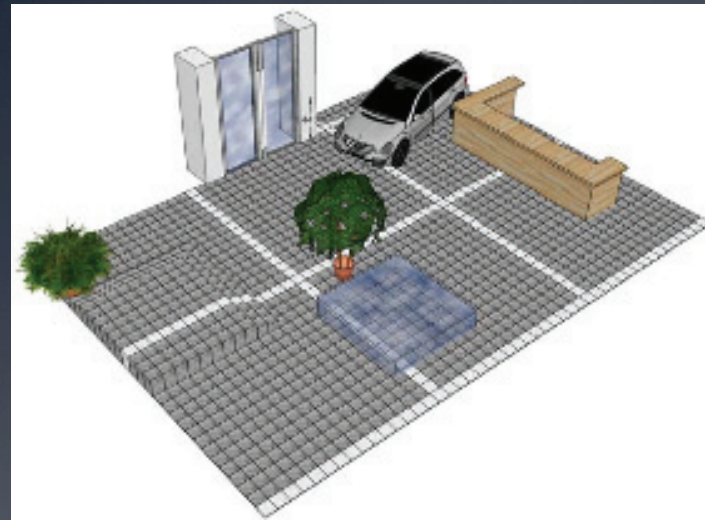


Evaluation

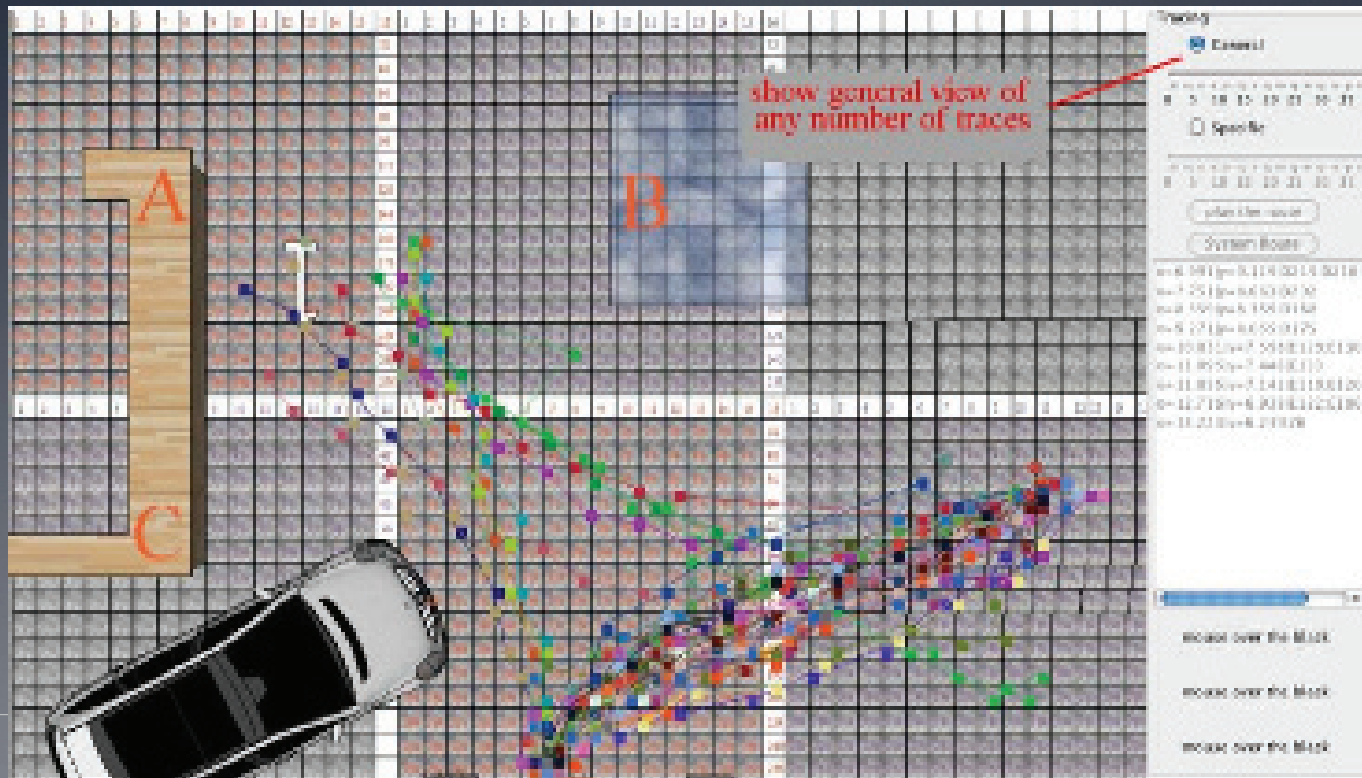
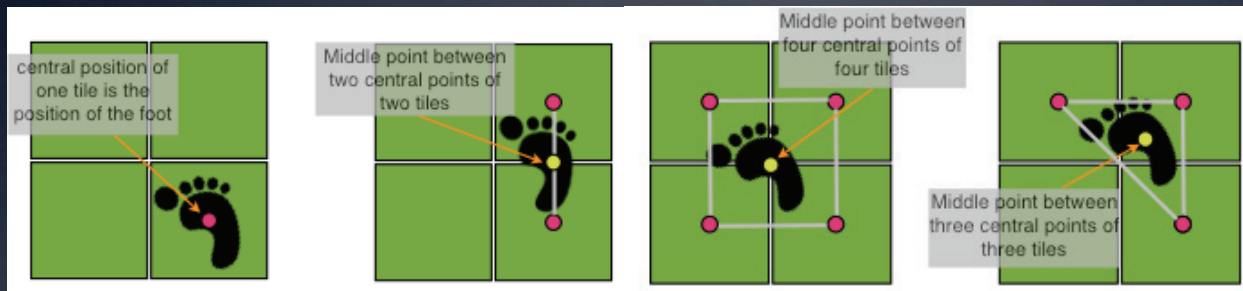
- First evaluation at the Chair of Prof. Wahlster
 - Promising, but restricted environment (small rooms ...)
 - Measured accuracy 1.5 – 2 meters
- More rigorous evaluation at DFKI foyer Saarbrücken (still running)



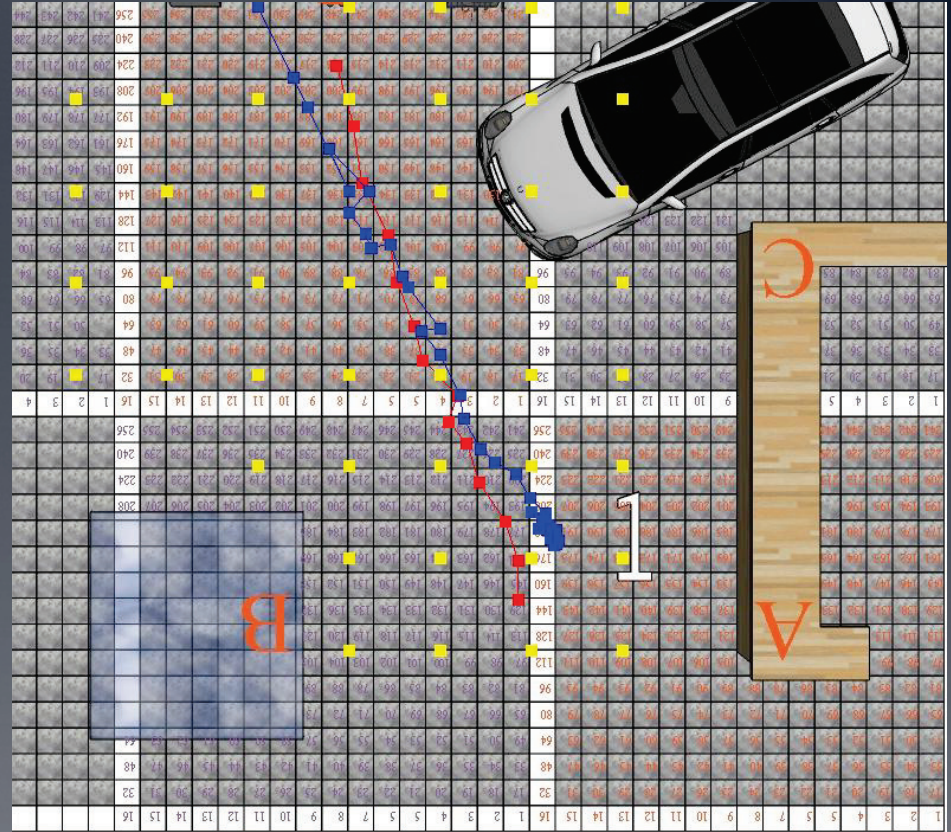
Collecting Natural Traces



Collecting Natural Traces



Experiment



UbiSpot

An “opportunistic” positioning system running on SymbianOS phones using cell info, WiFi APs, Bluetooth info and GPS (outdoors)



Approach

Positioning Engine (Fingerprinting, geoDBNs ...)

Coordinates (unintelligible for humans)

Map (perfect for navigation)

Semantic Annotation

Semantic Description (e.g. Kitchen or Lecture Room 6)



Frequency of Appearance Fingerprinting

- We do not use RSS, but count how often a device (cell tower, WiFi AP, Bluetooth device) can be received during a time period

Snapshot 0:

Cell IDs: {4778784, 4778791}
WiFi APs: {00:0b:0e:1b:37:40,
00:0b:0e:1b:3f:c0, 00:0b:0e:1b:3f:c2}
Bluetooth IDs: {00:22:fd:34:d3:32}

Snapshot 1:

Cell IDs: {4778784, 4778791}
WiFi APs: {00:0b:0e:1b:37:40,
00:0b:0e:1b:37:42, 00:0b:0e:1b:3f:c0}
Bluetooth IDs: {00:22:fd:91:53:23}

Snapshot 2:

Cell IDs: {4778784}
WiFi APs: {00:0b:0e:1b:37:40,
00:0b:0e:1b:37:44}
Bluetooth IDs: {00:22:fd:91:53:23}



Fingerprint for Office-118:

Cell IDs:

4778784; FOA: 3/3 = 100%
4778791; FOA: 2/3 = 67%

WiFi APs:

00:0b:0e:1b:37:40; FOA: 3/3 = 100%
00:0b:0e:1b:37:42; FOA: 1/3 = 33%
00:0b:0e:1b:37:44; FOA: 1/3 = 33%
00:0b:0e:1b:3f:c0; FOA: 2/3 = 67%
00:0b:0e:1b:3f:c2; FOA: 2/3 = 67%

Bluetooth IDs:

00:22:fd:91:53:23; FOA: 2/3 = 67%
00:22:fd:34:d3:32; FOA: 1/3 = 33%

Ranking

- UbiSpot calculates a correlation coefficient between the current measured fingerprint and the stored fingerprints
- A ranking algorithm is used to refine the result
- A crucial parameter in the algorithm is how many successive measurements are taken into account (TimeWindowSize)

UbiSpot indoor 19:05:13
singin seutu > Kirkkonummi > Malasa > Hotel M
1st Floor
Lecture Room 6 : 56 Sc

Available Data:

Country: 262	IAP's: 2	Bt's: 0
--	--	--
Cell: 44498	LA: 518	Net: 03

Options Landmark

UbiSpot indoor 07:25:33
aa > Helsingin seutu > Kirkkonummi > Malasa >
3rd Floor
Room : 75 Sc

Available Data:

Country: 244	IAP's: 2	Bt's: 1
--	--	--
Cell: 32025	LA: 1117	Net: 91

Options Landmark

UbiSpot indoor 09:30:55
Finland > Uusimaa > Helsingin seutu > Kirkko
1st Floor
Lecture room 5 : 81 Sc

Available Data:

Country: 244	IAP's: 1	Bt's: 4
--	--	--
Cell: 32025	LA: 1117	Net: 91

Options Landmark

UbiSpot indoor 12:09:51
> Uusimaa > Helsingin seutu > Kirkkonummi > M
1st Floor
Lecture Room 6 : 82 Sc
Lecture room 5 : 69 Sc

Available Data:

Country: 244	IAP's: 0	Bt's: 4
--	--	--
Cell: 32025	LA: 1117	Net: 91

Options Landmark

Evaluation

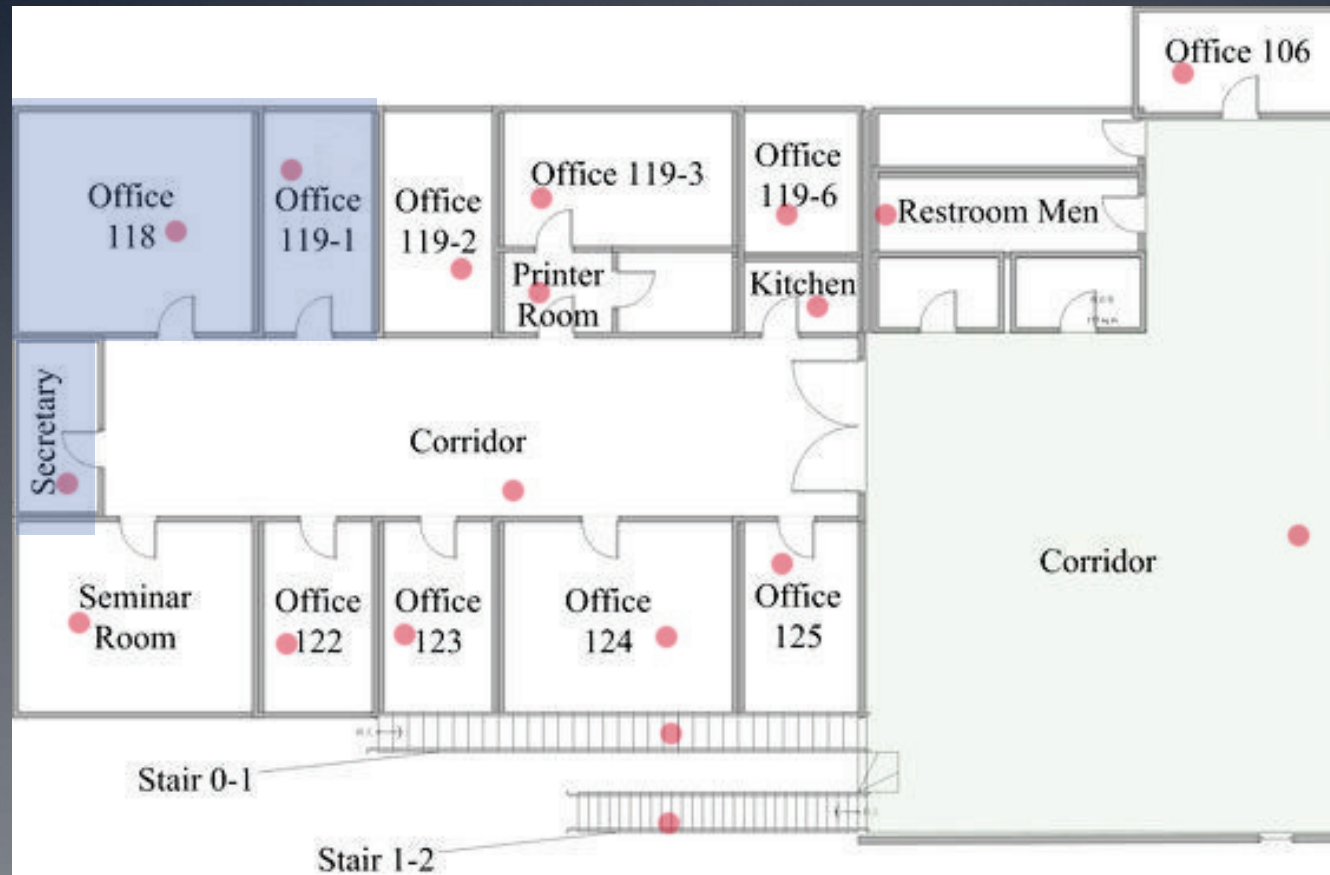
- Best case evaluation:
 - How accurate can we get, given a “high density” of different signals?
 - Since we’re measuring frequency of appearance: what is the impact of Time Windows Sizes (TWS) on the accuracy?
 - Does unfiltered Bluetooth increase or decrease the accuracy?
 - Test Environment:
 - Our lab at Saarland University
 - Lots of WiFi APs, lots of Bluetooth devices (stationary & mobile)
-

Floorplan

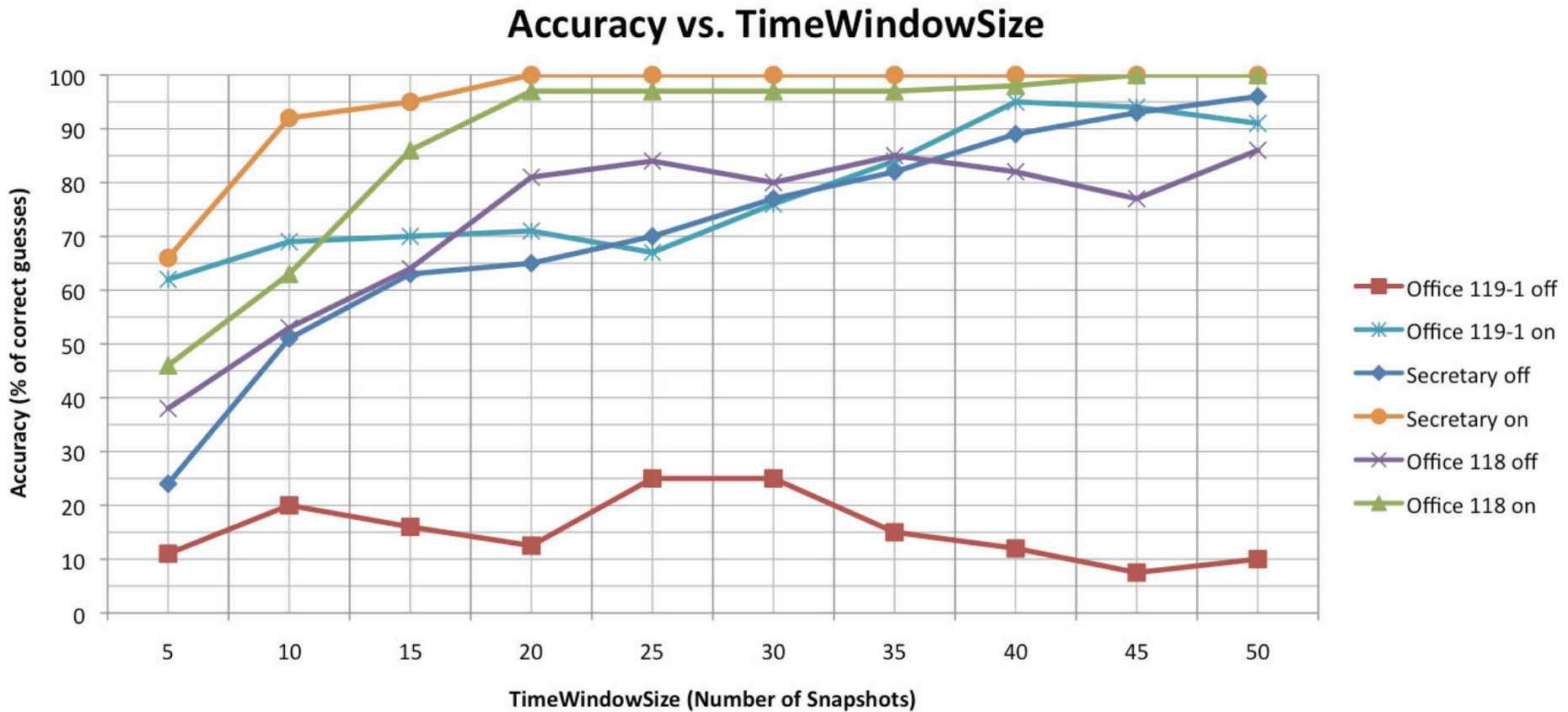
23 learned Landmarks (19 in our lab + 4 others in the building)

random probability to hit the right room by guessing: $1 / 23 = 4.3\%$

Three mobile phones in three adjacent rooms at the same time trying to determine their position

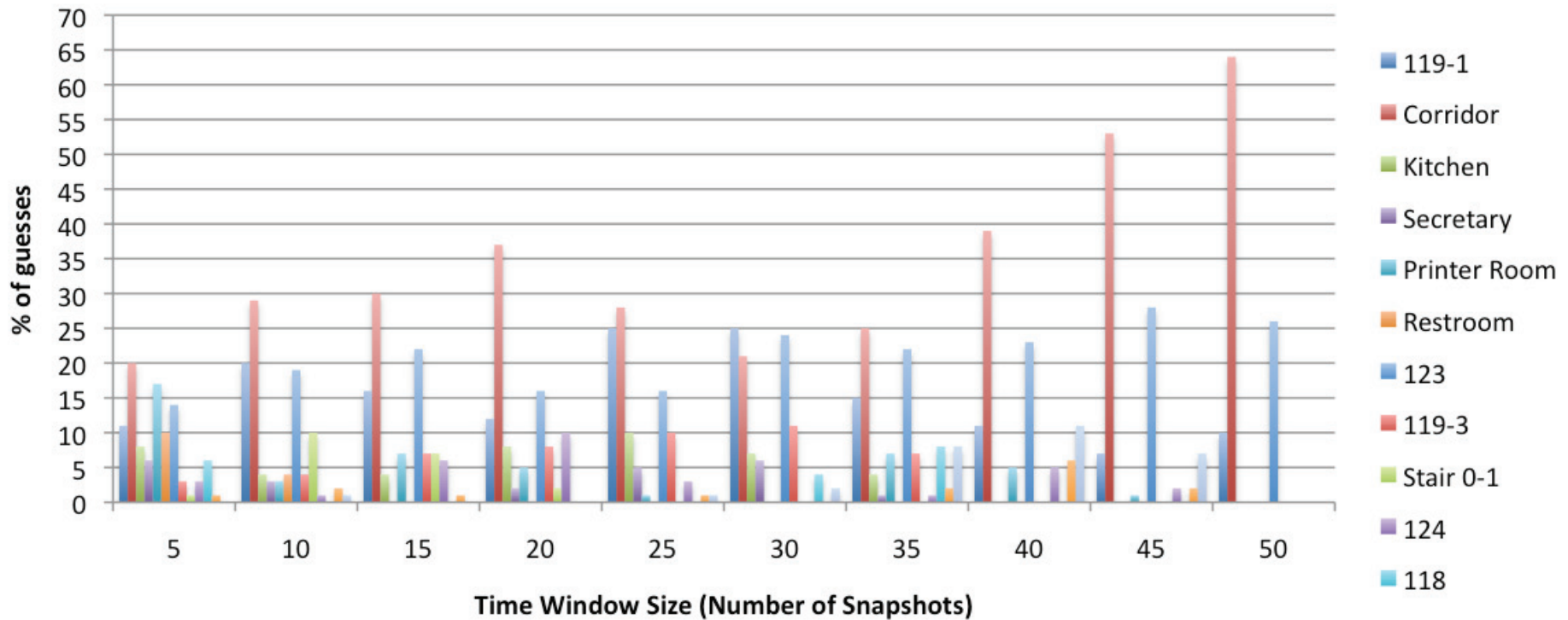


Impact of TWS



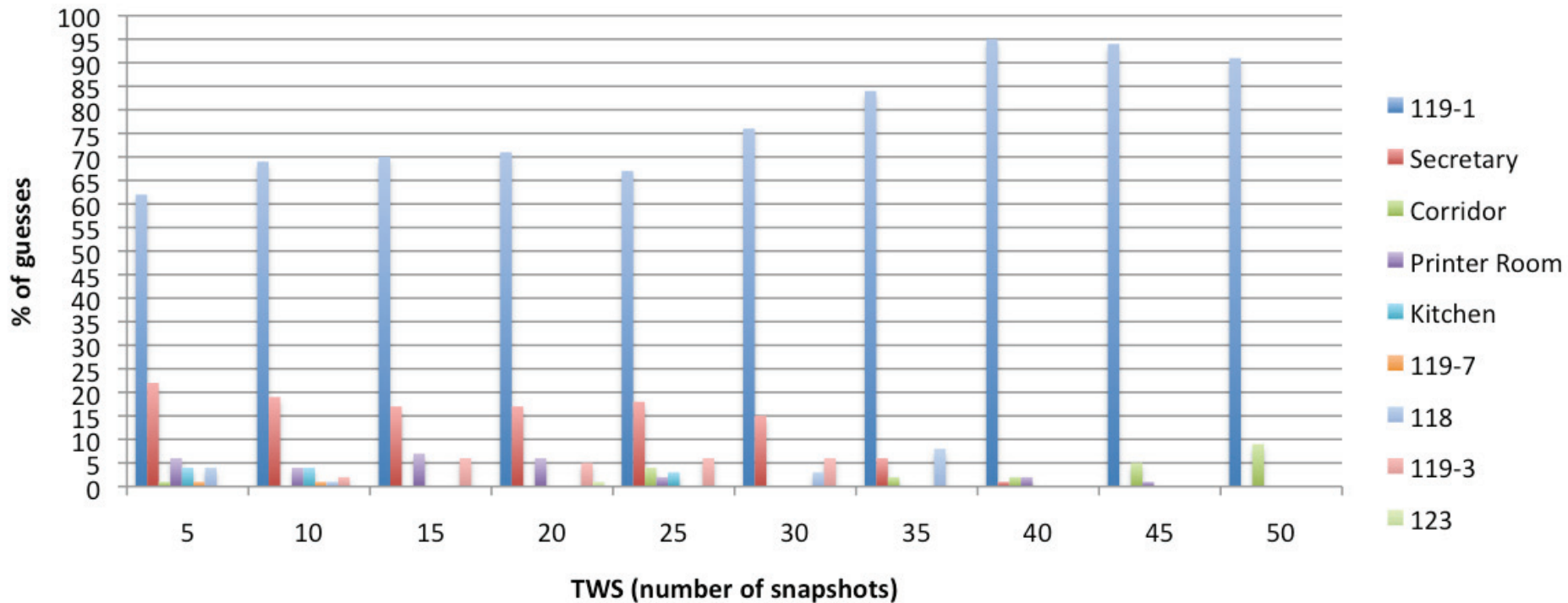
The Outlier

Hits and Misses Room 119-1



Same Room with Bluetooth

Hits and Misses Room 119-1 with Bluetooth



Results

- a TWS of 20 seems to be a good trade-off, since 3 of 6 measurements show no significant gain with $TWS > 20$ (160 sec)
 - Bluetooth seems to increase the accuracy as can be seen in case of room 119-1
 - Maybe due to employees staying in their office most of the time
 - With enabled Bluetooth and a $TWS > 20$ we get a correct guessing range between 65% and 100%
 - Reducing the number of learned Landmarks in a building increases the accuracy to $> 85\%$ (with a $TWS > 5$)
-

Summary

- Two Always Best Positioned systems
 - LORIOT
 - Uses infrared beacons and active RFID tags
 - Estimates coordinates of the current position
 - Evaluation still ongoing
 - UbiSpot
 - An “opportunistic” system using cell information, WiFi APs and Bluetooth information
 - Estimates the current room (semantic expression)
 - Evaluation shows a hit rate between 65% and 100% in a “high density” environment
-