

# Εφαρμογές του Διαδικτύου των Πραγμάτων σε Έξυπνες Πόλεις του Σήμερα

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Καναδάς

# Ερευνητικές περιοχές

## □ Δίκτυα Υπολογιστών

- Επεξεργασία δεδομένων και εφαρμογές έξυπνων πόλεων
- Διαδίκτυο των πραγμάτων και δίκτυα νέας γενιάς
- Ασύρματα δίκτυα αισθητήρων



## □ Εργαστήριο έξυπνων τηλεφώνων - GryPhone Lab

- Έρευνα και δημιουργία εφαρμογών
- Ανάλυση ενεργειακής κατανάλωση
- Εφαρμογές e-health



# Τι είναι οι έξυπνες πόλεις?

- Πόλεις που με τη χρήση τεχνολογίας προσπαθούν να:
  - βελτιώσουν το επίπεδο ζωής,
  - προάγουν τη βιώσιμη ανάπτυξη,
  - ενισχύσουν την επικοινωνία
- Βασικό κομμάτι είναι η συλλογή και ανταλλαγή πληροφοριών
- Τα ασύρματα δίκτυα αισθητήρων και το διαδίκτυο των πραγμάτων είναι απαραίτητα

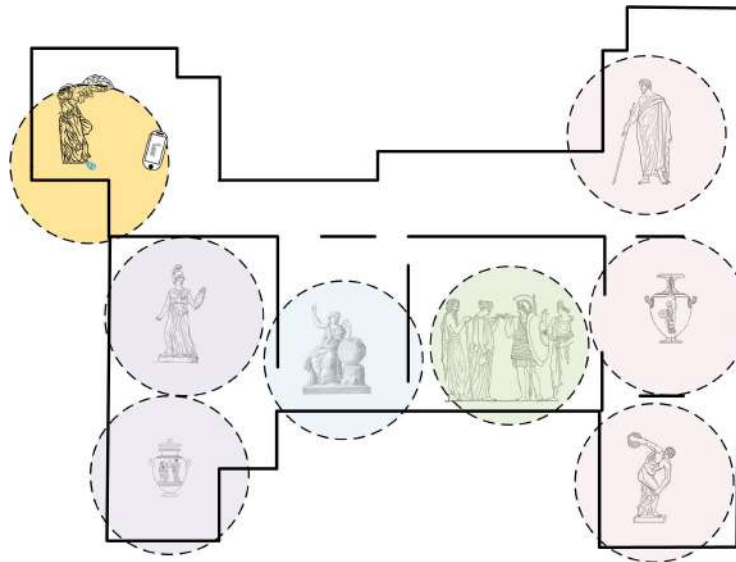
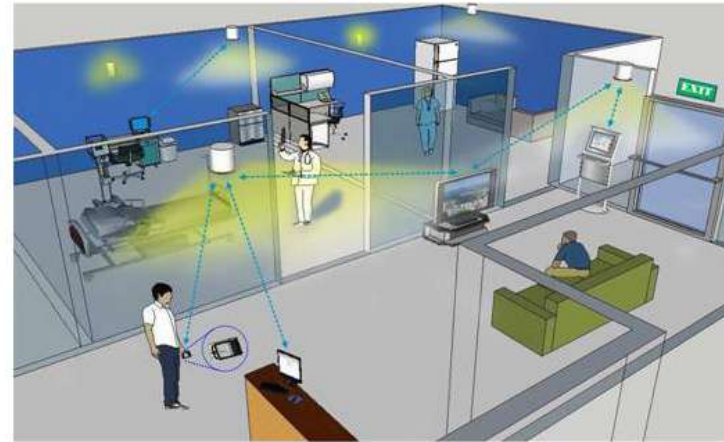


# Εφαρμογές

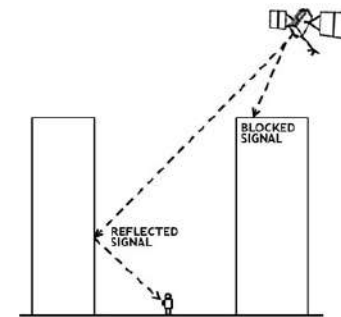
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- Υλοποιημένες εφαρμογές έξυπνων πόλεων
  - *Εντοπισμός θέσης χρήστη σε εσωτερικό και εξωτερικό χώρο*
  - Ιχνηλάτηση επαφών covid-19
  - E-health monitoring

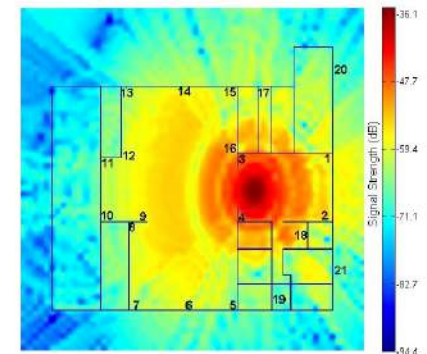
# Εντοπισμός θέσης χρήστη σε εσωτερικό χώρο



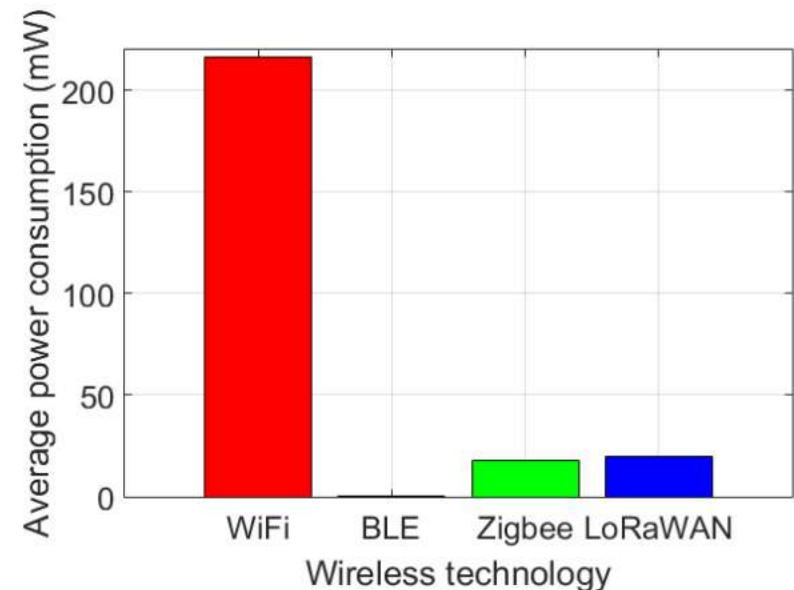
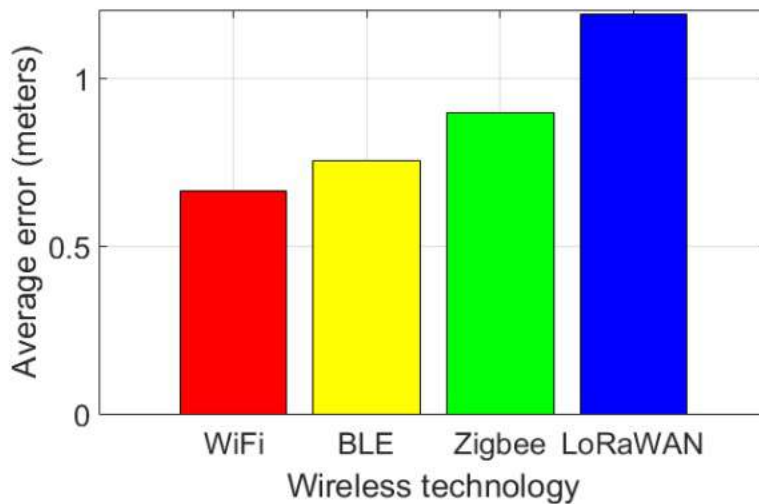
# Μικρο εντοπισμός υψηλής ακρίβειας



- Διαδικασία εντοπισμού μιας οντότητας με υψηλή ακρίβεια
- Οι παραδοσιακές μέθοδοι που εκμεταλλεύονται δορυφόρους (GPS) δεν λειτουργούν σε εσωτερικούς χώρους
- Είναι απαραίτητη η χρήση νέων τεχνολογιών



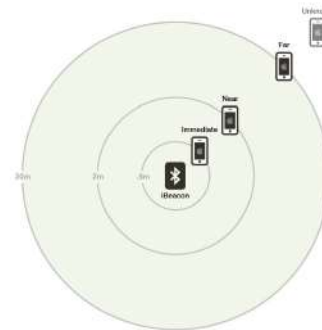
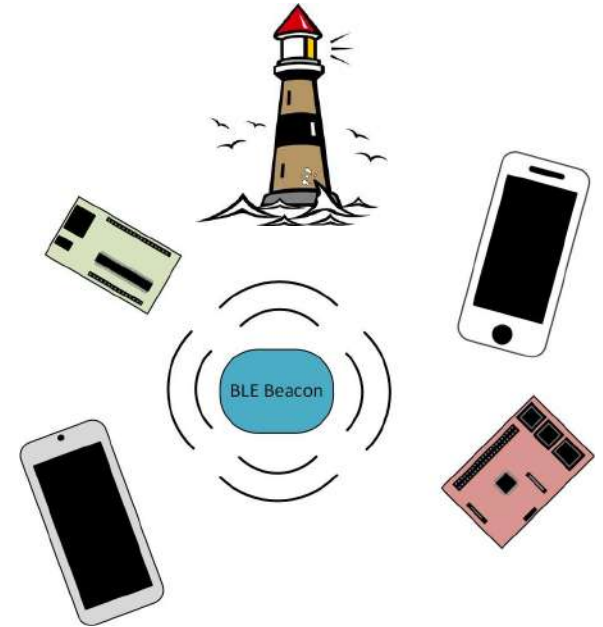
# Σύγκριση ασύρματων τεχνολογιών εντοπισμού





# BLE beacons

- Δουλεύουν όπως οι φάροι
- Χαμηλό κόστος
- Συσκευές με BLE μπορούν να συλλέξουν το σήμα
- Μπορεί να γίνει εκτίμηση της απόστασης από το Received Signal Strength Indicator (RSSI)



Zone	Distance
Immediate	<1 meter
Near	1-3
Far	>3 meters
Unknown	Not in range



# Geofencing



- Νοητός, κυκλικό φράχτης με επίκεντρο ένα αντικείμενο ενδιαφέροντος
- Χρήση: Ειδοποιήσεις σχετικά με είσοδο και έξοδο στην περιοχή ενδιαφέροντος



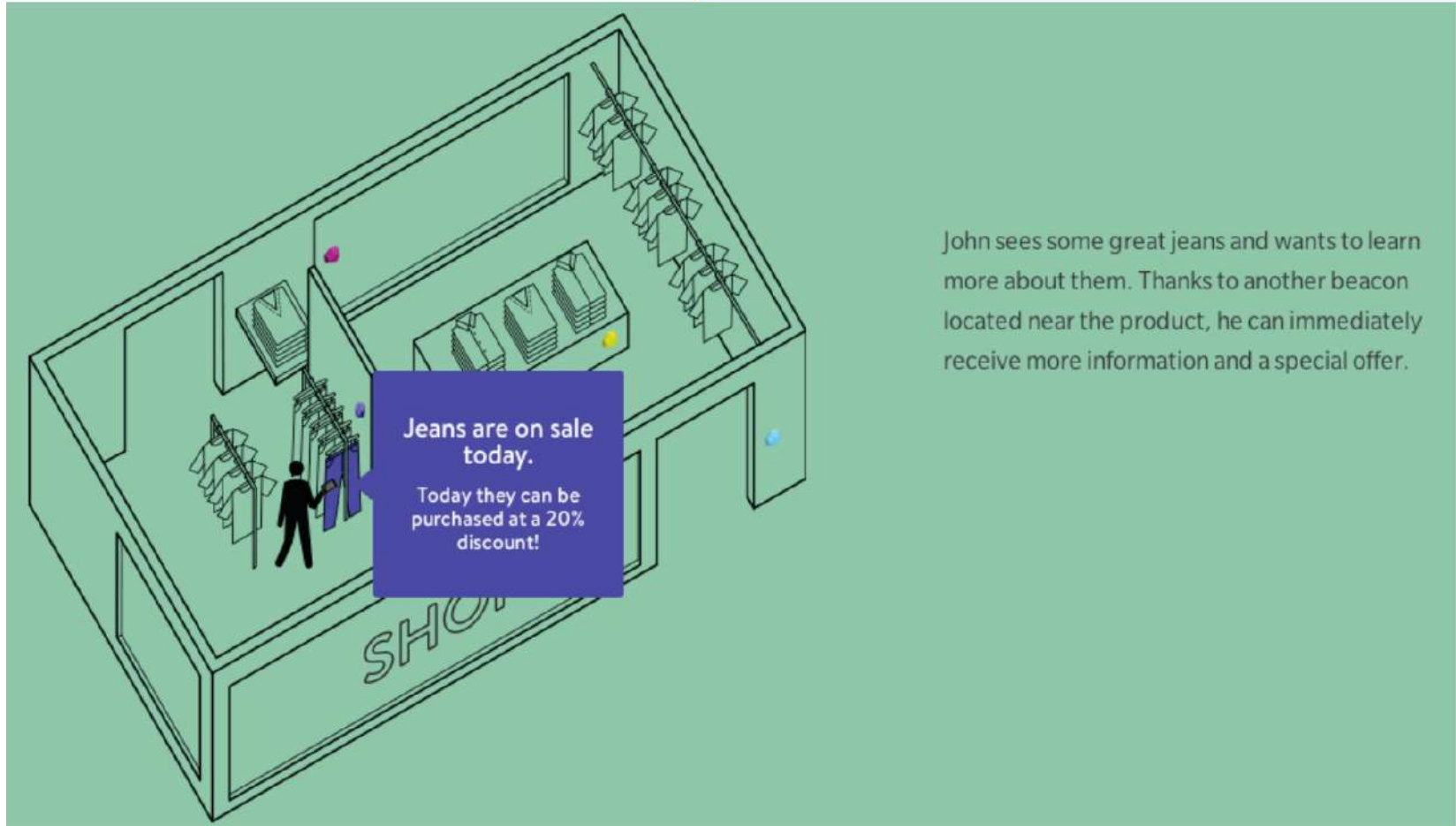
# Scenario

## John's Experience



# Scenario

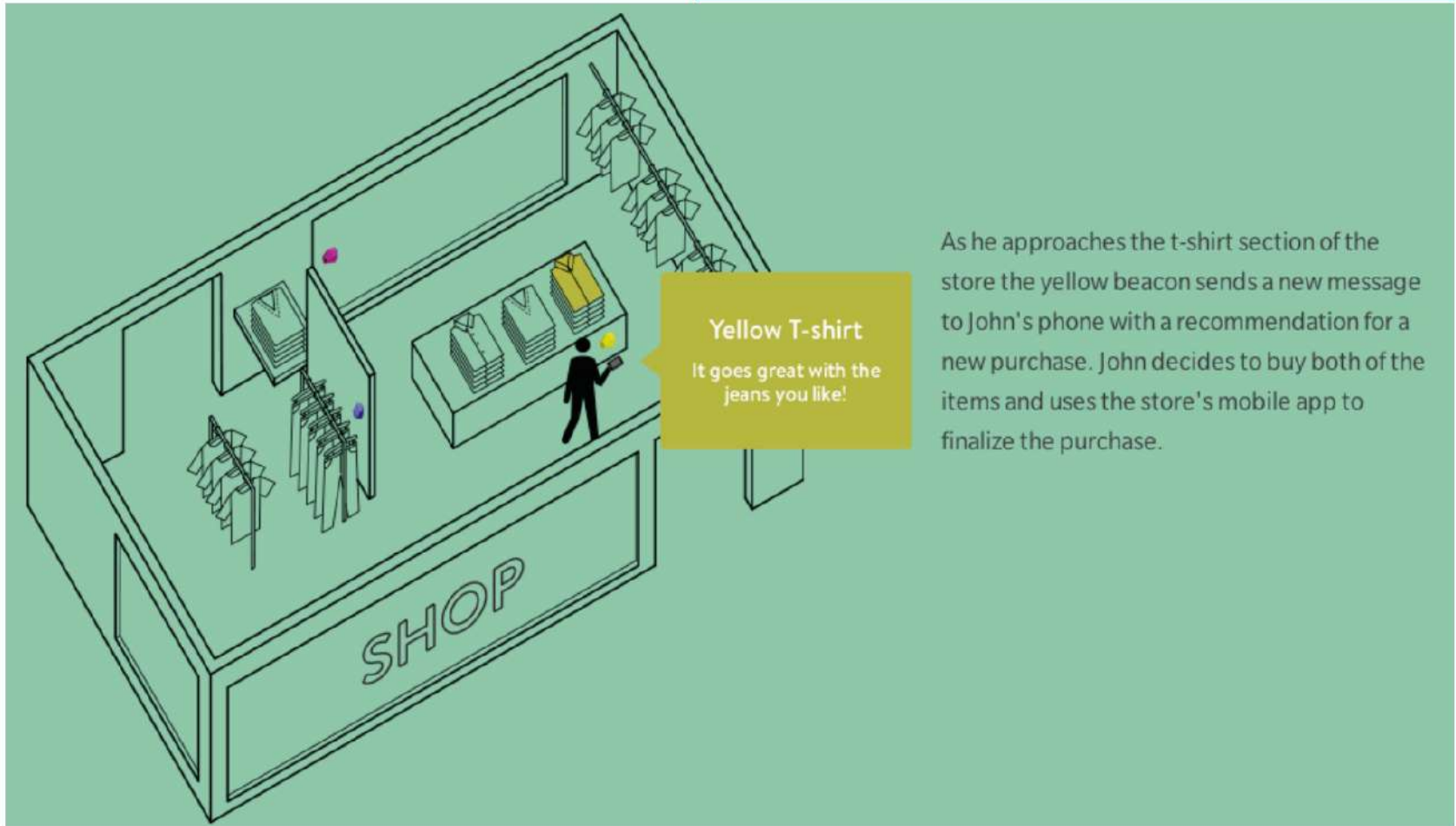
## John's Experience



John sees some great jeans and wants to learn more about them. Thanks to another beacon located near the product, he can immediately receive more information and a special offer.

# Scenario

## John's Experience



# Scenario

## John's Experience





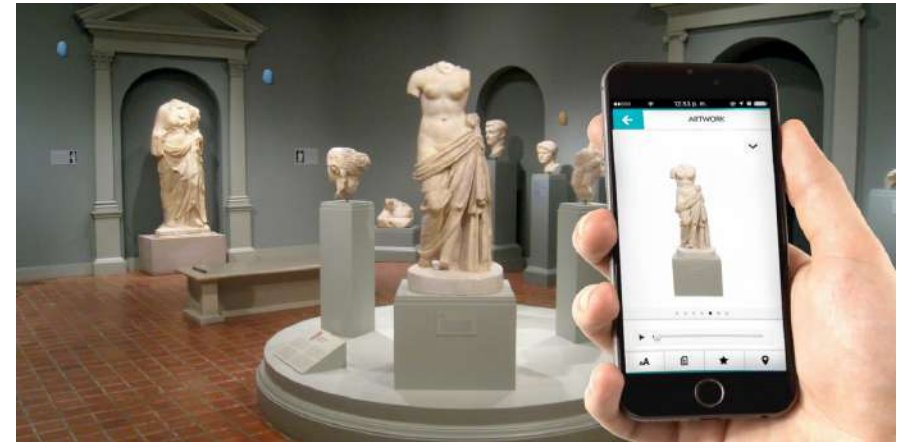
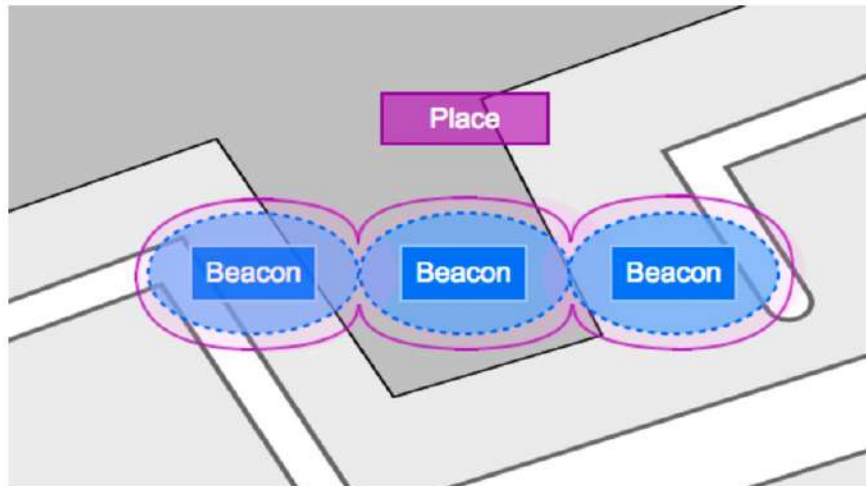
# 1. Single Geofence

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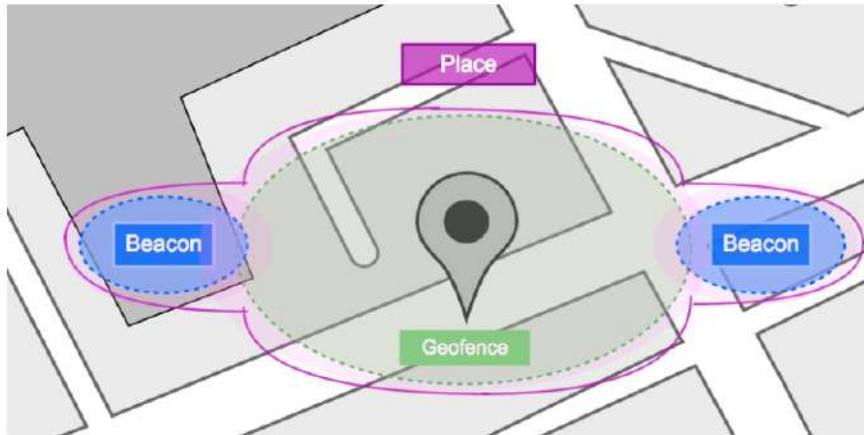
# 2. One or More Beacons

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# 3. One or more beacons and a Geofence

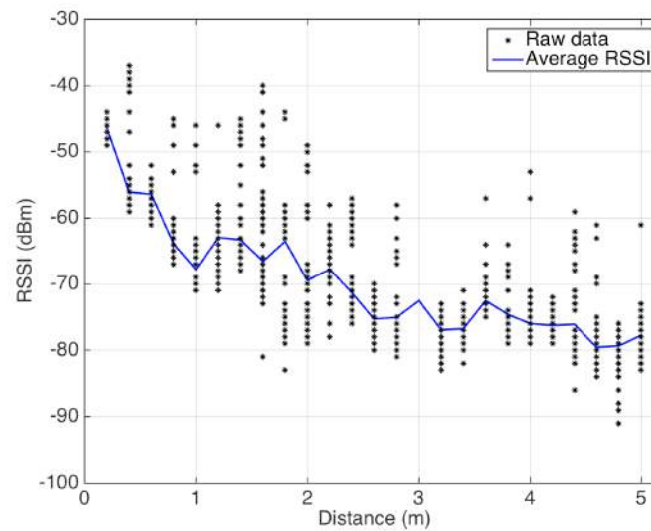


# Trilateration

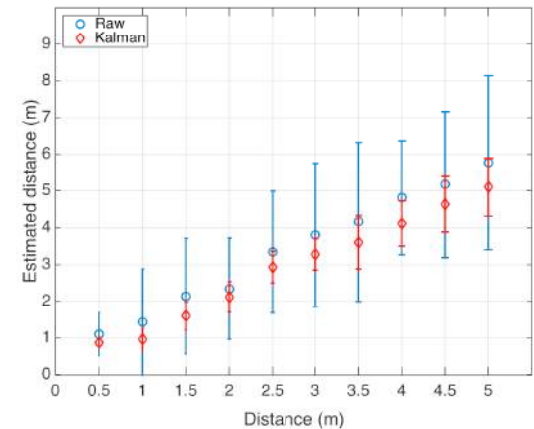
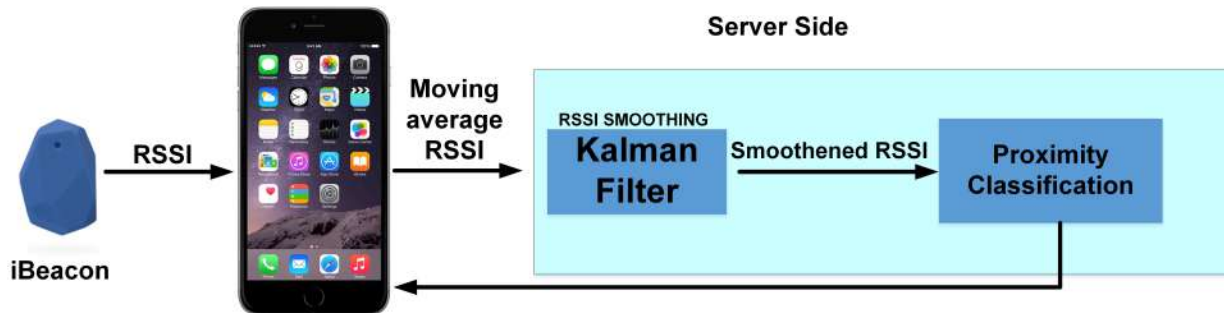
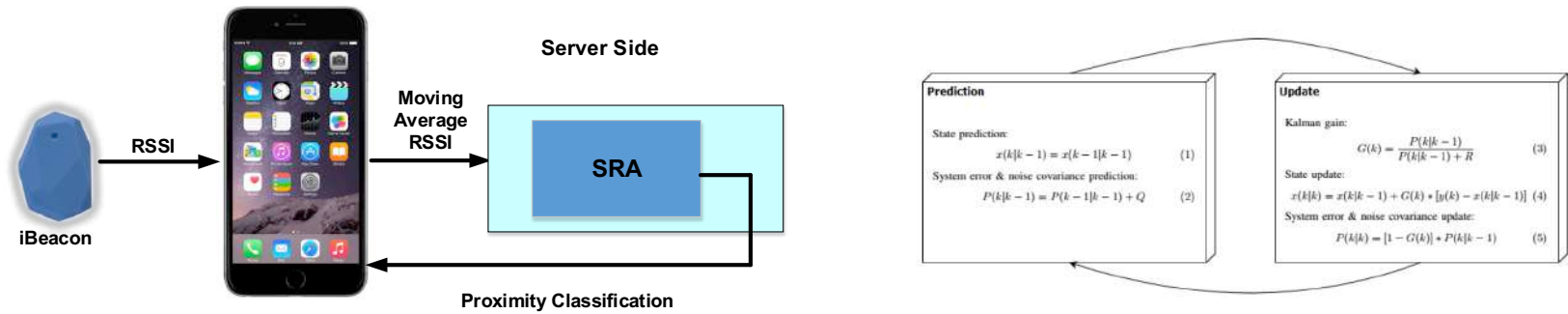


# Προκλήσεις χρήσης των beacon

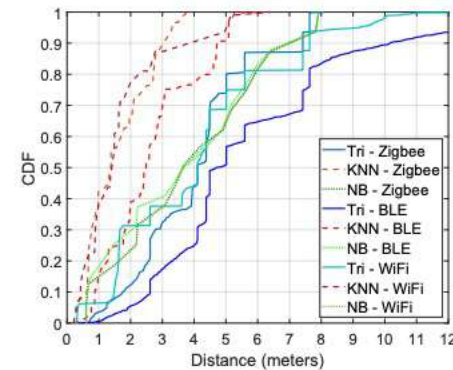
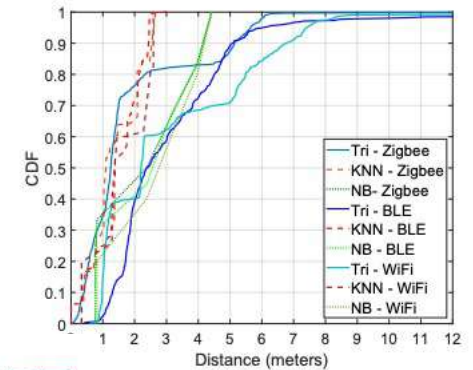
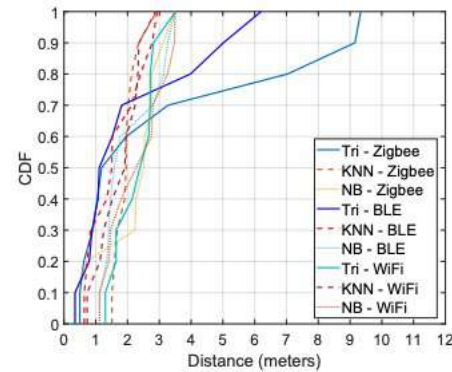
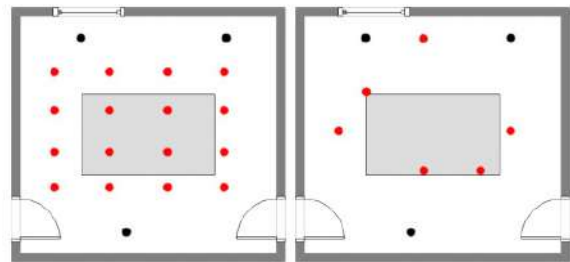
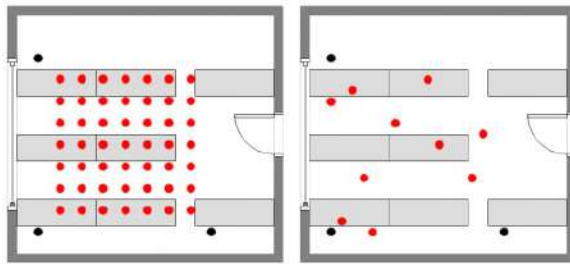
- Δεν έχουν φτιαχτεί για εντοπισμό χρήστη
- Η μέθοδος RSSI δεν προσφέρει μεγάλη ακρίβεια
- Το Bluetooth πρέπει να είναι ενεργό
- Χρειάζεται να «τρέχει» εφαρμογή στο έξυπνο τηλέφωνο



# Βελτιστοποίηση με Cloud Server



# Αποτελέσματα – Microlocation





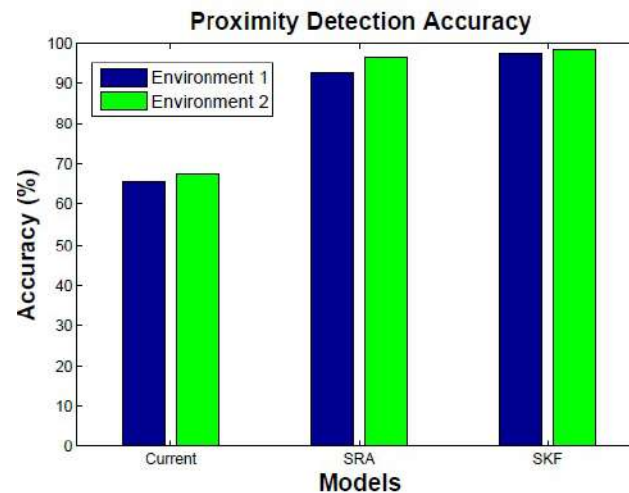
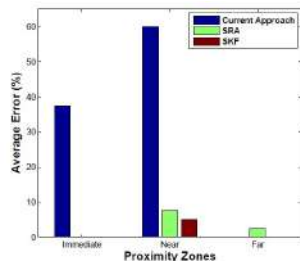
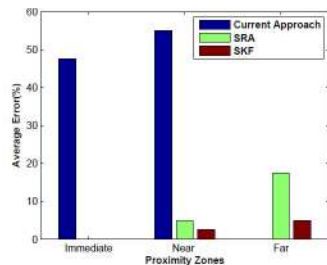
# Αποτελέσματα – Proximity



(a) Environment 1: Large room.



(b) Environment 2: Small room.

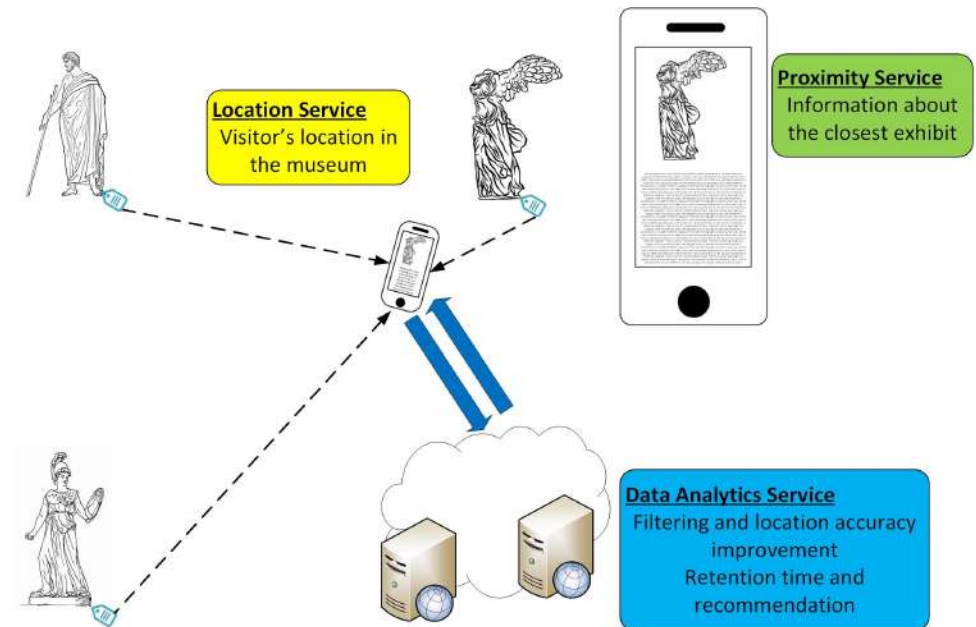


	0.5m			1.0m			1.5m			2.0m			2.5m			3.0m		
<b>SMA</b>	0.38	0.01	0.19	0.40	0.43	0.24	0.32	0.35	0.01	0.24	0.43	1.59	0.15	1.51	0.64	1.69	2.08	1.40
<b>KF-ST</b>	0.69	0.09	0.22	0.39	0.31	0.18	0.41	0.20	0.06	0.51	0.42	0.07	0.47	0.97	0.21	0.39	2.20	0.63
<b>KF-DN</b>	0.72	0.09	0.19	0.38	0.33	0.44	0.41	0.54	0.14	0.49	0.47	0.96	0.45	1.49	1.23	0.38	1.33	0.29
<b>NI</b>	0.57	0.09	0.23	0.34	0.30	0.17	0.34	0.13	0.03	0.59	0.44	0.09	0.38	0.92	0.37	0.16	2.22	1.06
<b>PF</b>	0.20	0.35	0.20	0.37	0.27	0.91	0.78	0.12	0.03	0.52	0.48	0.01	0.42	1.12	0.02	1.06	0.25	0.48
<b>Beacon</b>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>

	0.5m			1.0m			1.5m			2.0m			2.5m			3.0m		
<b>SMA</b>	0.12	0.68	0.17	4.10	0.58	0.49	0.36	0.44	0.79	0.40	0.76	0.32	1.71	1.02	0.31	2.45	1.58	1.90
<b>KF-ST</b>	0.01	0.03	0.01	2.38	0.83	0.37	0.52	0.17	0.39	0.23	0.72	0.42	0.98	0.93	0.23	0.23	0.95	1.67
<b>KF-DN</b>	0.01	0.21	0.02	2.39	0.37	0.36	0.52	0.45	0.41	0.23	0.17	0.46	0.97	0.65	0.29	0.22	1.53	1.69
<b>NIF</b>	0.03	0.02	0.00	1.94	0.94	0.38	0.51	0.10	0.18	0.17	0.78	0.22	0.93	0.34	0.47	0.96	0.96	1.69
<b>PF</b>	0.01	0.10	0.08	2.46	1.85	0.35	0.53	2.36	0.18	1.47	1.86	0.12	1.38	1.36	0.38	0.47	0.15	1.68
<b>Beacon</b>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>	<i>E</i>	<i>K</i>	<i>G</i>

Improving BLE Beacon Proximity Estimation Accuracy through Bayesian Filtering, A. Mackey, P. Spachos, L. Song, K. Platantionis, IEEE Internet of Things Journal

# Διαδραστικό μουσείο με beacons





# Αριθμός και θέση των beacon

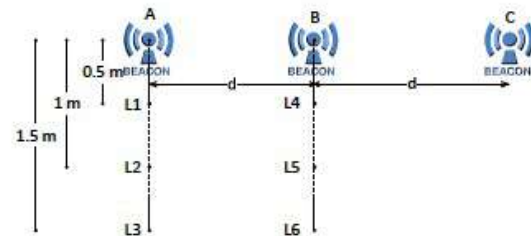
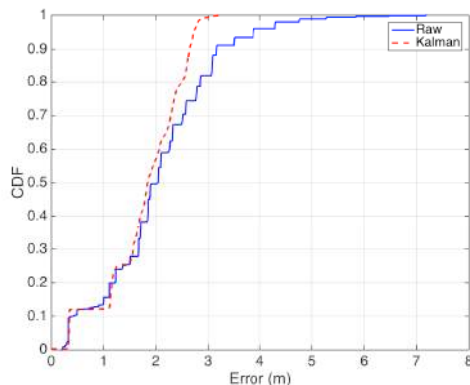
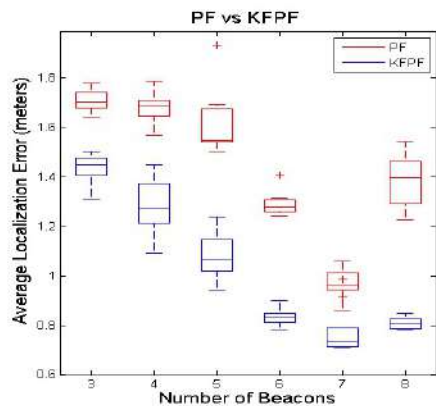
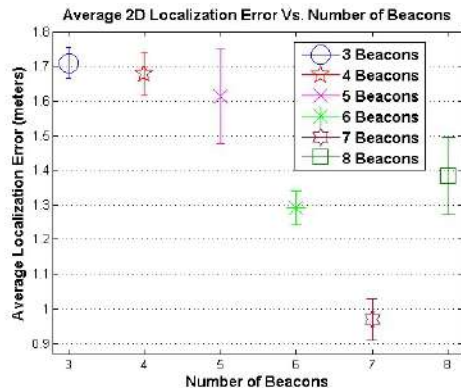


Figure 13: Laboratory topology.



d	Location	Estimation			Accuracy (%)
		A	B	C	
1	L1	109	2	0	98.2
	L2	101	4	1	95.28
	L3	100	7	2	91.74
	L4	6	101	8	87.83
	L5	9	109	11	84.5
	L6	10	85	16	76.58
1.5	L1	104	1	0	99.05
	L2	105	3	1	96.33
	L3	102	1	2	92.73
	L4	4	103	8	89.57
	L5	5	107	10	87.7
	L6	9	85	14	78.7
2	L1	103	0	0	100
	L2	103	2	0	98.10
	L3	102	4	2	94.44
	L4	3	111	6	92.5
	L5	4	103	6	91.15
	L6	9	87	14	79.09

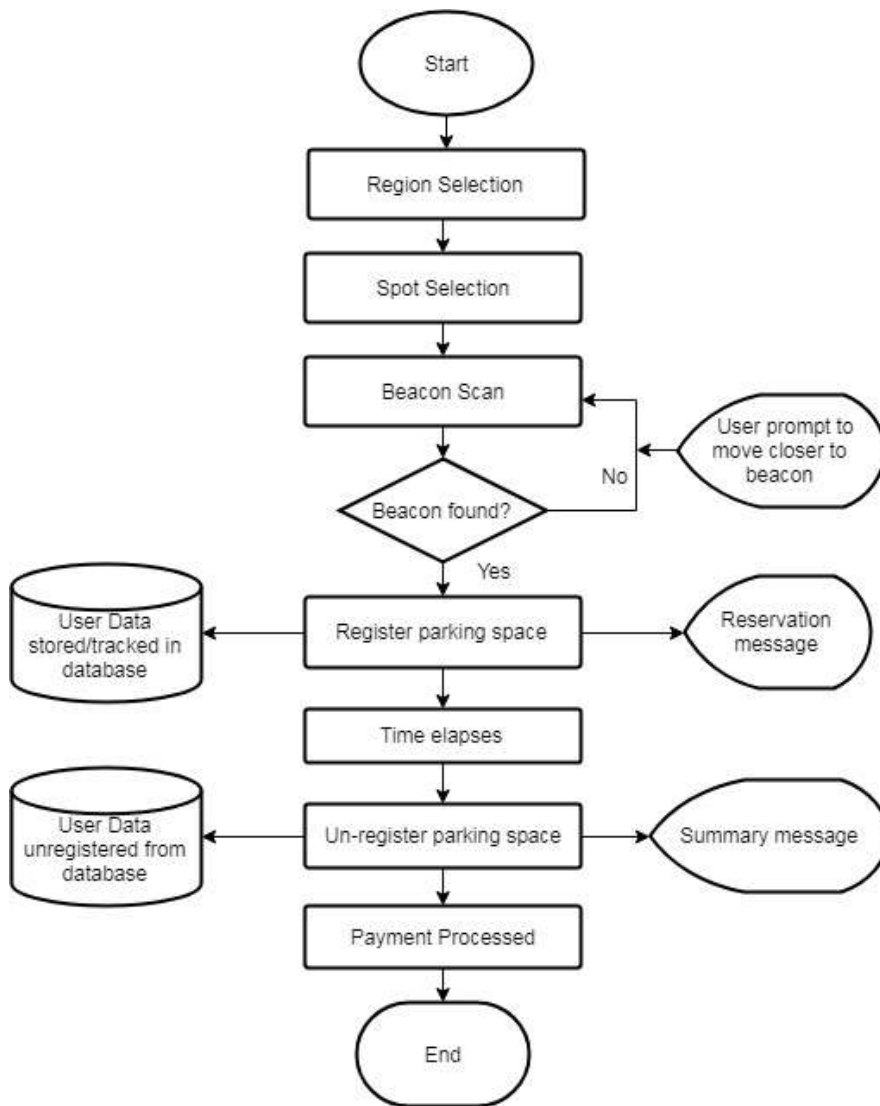
# Εύρεση θέσης στάθμευσης

- **Πρόβλημα:** χρόνος αναμονής, κατανάλωση καυσίμου



- Προϋποθέσεις βέλτιστης απόδοσης
  - Χαμηλό κόστος
  - Εύκολη υλοποίηση
  - Ελάχιστη παρεμβολή με άλλες ασύρματες εφαρμογές

# Μοντέλο συστήματος



(a) Menu screen.

(b) User info screen.

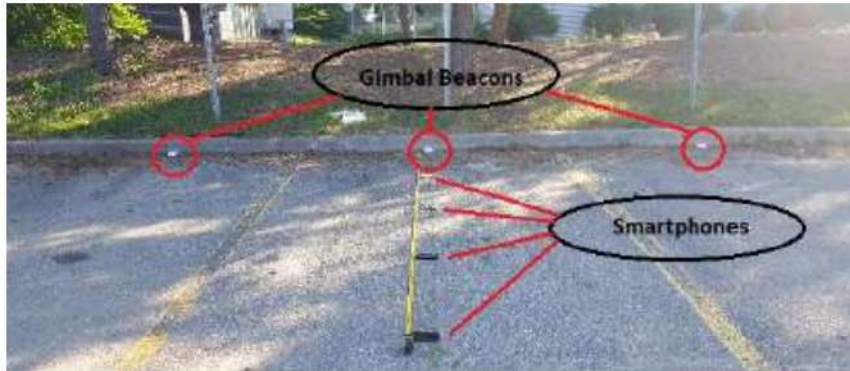
(c) Parking spot scan screen.



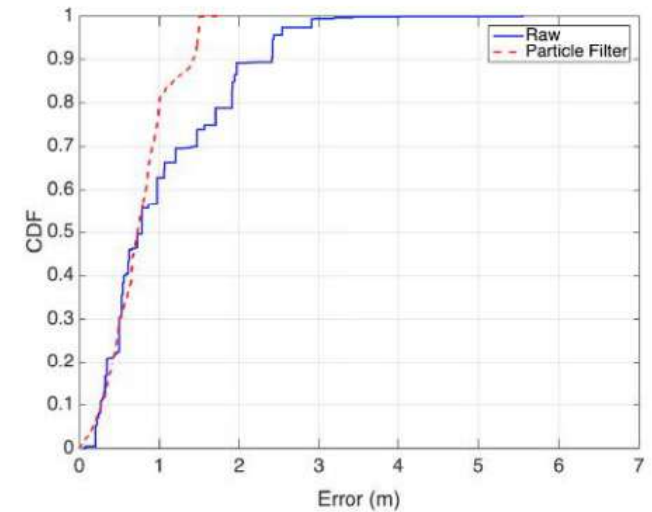
(a) Availability screen.

(b) Parking lot.

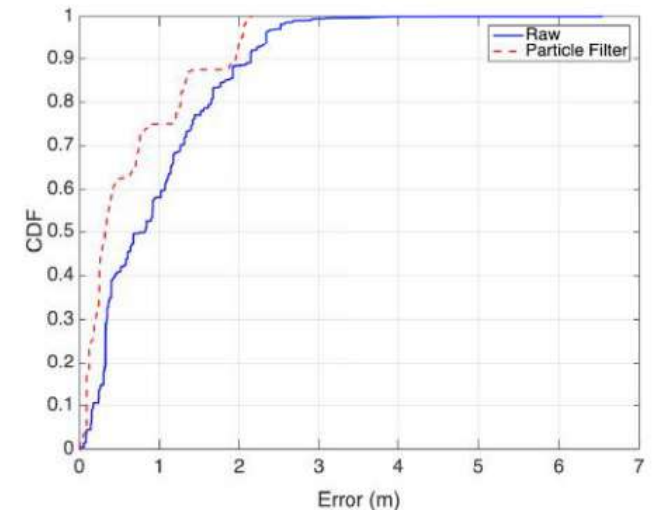
# Προκλήσεις υλοποίησης



X(m)	Y(m)	Raw Data				Particle Filter			
		A	B	C	Accuracy (%)	A	B	C	Accuracy (%)
1	0.5	0	109	31	<b>77.8</b>	0	111	29	79.2
	1	1	72	20	77.4	0	83	10	89.2
	1.5	44	97	0	68.7	9	132	0	<b>93.6</b>
	2	26	18	40	21.4	38	0	46	0
	2.5	20	1	115	0.7	0	0	136	0
1.5	0.5	0	115	2	98.2	0	107	10	91.4
	1	1	53	35	59.5	0	76	13	85.3
	1.5	0	66	1	<b>98.5</b>	0	64	3	95.5
	2	26	41	8	54.6	0	75	0	<b>100</b>
	2.5	65	3	2	42.8	70	0	0	0
2	0.5	0	116	0	<b>100</b>	0	116	0	<b>100</b>
	1	0	79	5	94	0	84	0	<b>100</b>
	1.5	0	48	70	40.6	0	118	0	<b>100</b>
	2	9	91	3	88.3	0	103	0	<b>100</b>
	2.5	1	1	112	0.8	0	0	114	0
2.5	0.5	0	121	1	<b>99.1</b>	0	122	0	<b>100</b>
	1	41	30	24	31.5	1	94	0	98.9
	1.5	2	123	0	98.4	0	125	0	<b>100</b>
	2	1	120	2	97.5	0	123	0	<b>100</b>
	2.5	28	0	93	0	0	0	121	0
3	0.5	0	120	0	<b>100</b>	0	120	0	<b>100</b>
	1	28	77	5	70	28	82	0	74.5
	1.5	0	88	35	71.5	0	123	0	<b>100</b>
	2	17	57	2	75	5	71	0	93.4
	2.5	0	19	101	15.8	0	0	120	0



(a) CDF for indoor distance estimation.



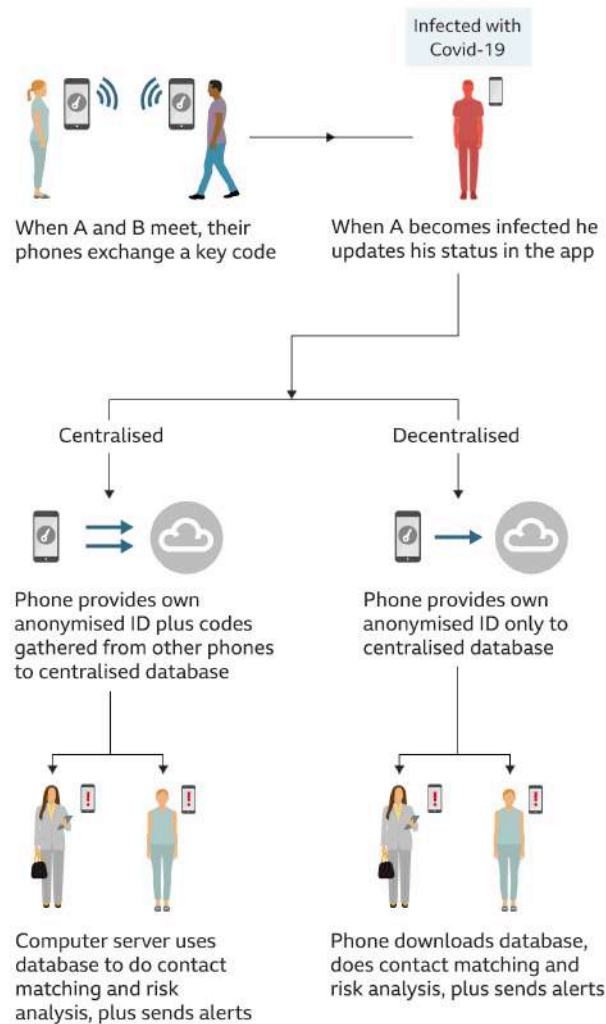
(b) CDF for outdoor distance estimation.

# Εφαρμογές

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- Υλοποιημένες εφαρμογές έξυπνων πόλεων
  - Εντοπισμός θέσης χρήστη σε εσωτερικό και εξωτερικό χώρο
  - **Ιχνηλάτηση επαφών covid-19**
  - E-health monitoring

# Ιχνηλάτηση επαφών



## □ Προϋποθέσεις:

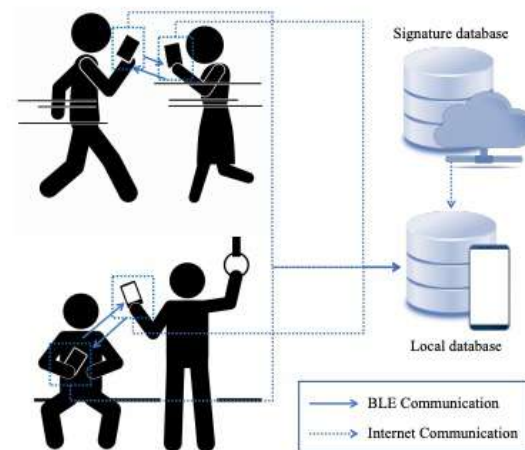
- Διασφάλιση ανωνυμίας
- Απόκρυψη θέσης
- Έγκαιρη ενημέρωση
- **Ακριβής** καταγραφή απόστασης



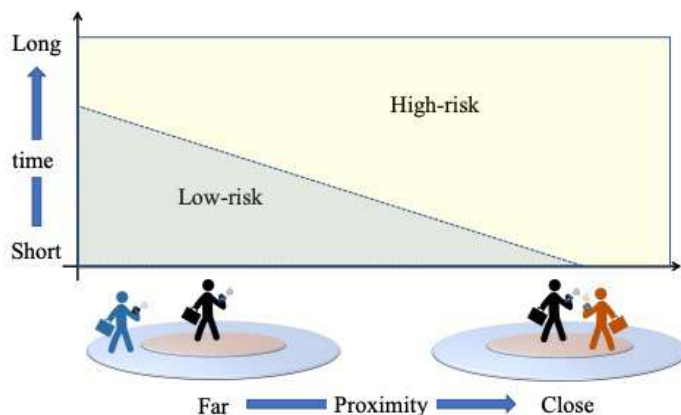
# Έξυπνα τηλέφωνα

- Δύο βάσεις δεδομένων
- Μορφοποίηση πακέτων

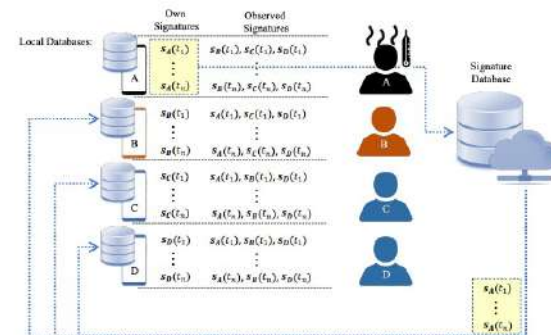
Advertising Packet			
1 byte	4 bytes	8 – 39 bytes	3 bytes
Preamble	Access Address	Protocol Data Unit (PDU)	CRC
2 byte	6 bytes	0 – 31 bytes	
Header	MAC Address	Payload	



- Κατηγοριοποίηση επαφών



(a) Interaction Phase.

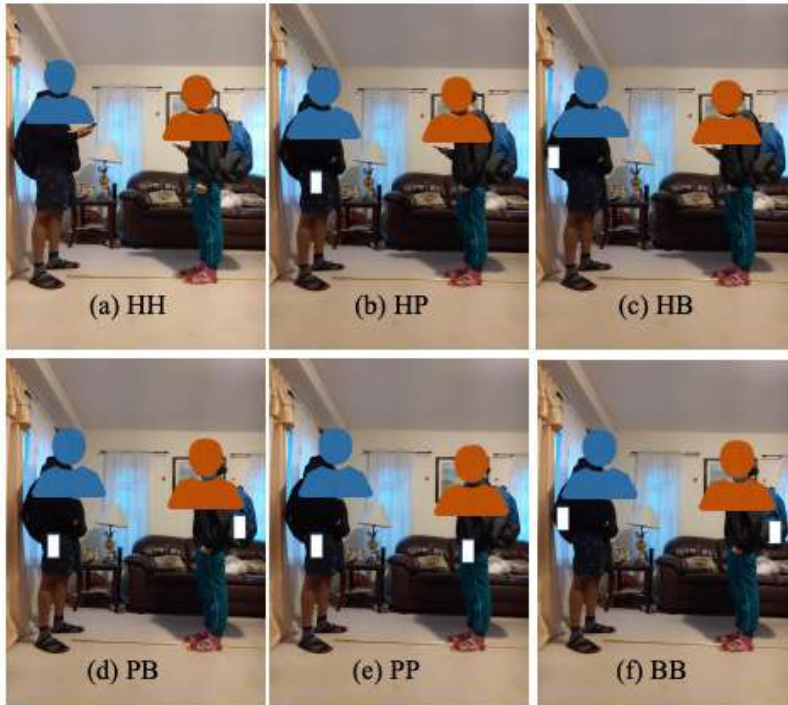


(b) Tracing Phase.



# Προκλήσεις

## □ Αναγνώριση θέσης κινητού



Fitted PL Model			
High-risk Contact	12352 62.1%	725 3.8%	94.5% 5.5%
Low-risk Contact	3330 16.7%	3496 17.6%	51.2% 48.8%
	78.8% 21.2%	82.8% 17.2%	79.8% 20.4%
	High-risk Contact	Low-risk Contact	

Decision Tree			
High-risk Contact	13596 68.3%	1318 6.8%	91.2% 8.8%
Low-risk Contact	2086 10.5%	2903 14.6%	58.2% 41.8%
	86.7% 13.3%	68.8% 31.2%	82.9% 17.1%
	High-risk Contact	Low-risk Contact	

LDA			
High-risk Contact	14454 72.6%	2296 11.5%	86.3% 13.7%
Low-risk Contact	1228 6.2%	1925 9.7%	61.1% 38.9%
	92.2% 7.8%	45.6% 54.4%	82.3% 17.7%
	High-risk Contact	Low-risk Contact	

NB			
High-risk Contact	15662 78.5%	4221 21.2%	76.8% 21.2%
Low-risk Contact	0 0.0%	0 0.0%	NaN% NaN%
	100.0% 0.0%	0.0% 100%	78.8% 21.2%
	High-risk Contact	Low-risk Contact	

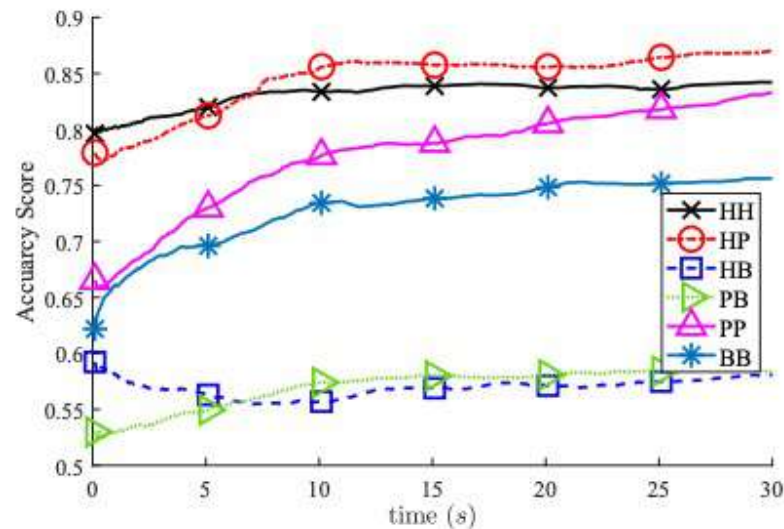
kNN			
High-risk Contact	15680 78.6%	4217 21.2%	78.8% 21.2%
Low-risk Contact	2 0.0%	4 0.0%	66.7% 33.3%
	100.0% 0.0%	0.1% 99.9%	78.8% 21.2%
	High-risk Contact	Low-risk Contact	

SVM			
High-risk Contact	15435 77.6%	4031 20.3%	79.3% 20.7%
Low-risk Contact	247 1.2%	190 1.0%	43.5% 96.5%
	98.4% 1.6%	4.5% 95.5%	78.5% 21.5%
	High-risk Contact	Low-risk Contact	

Ground Truth

# Αποτελέσματα

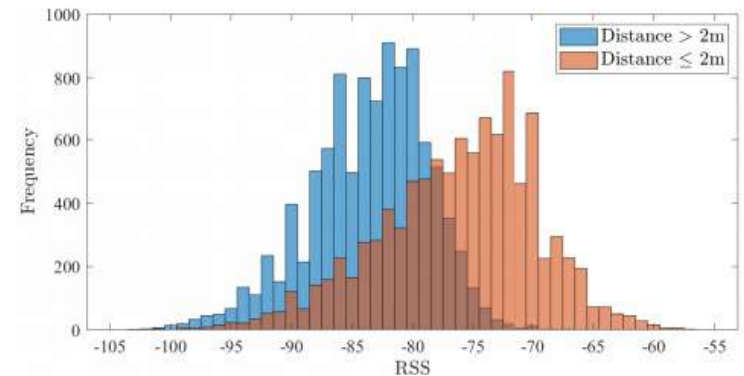
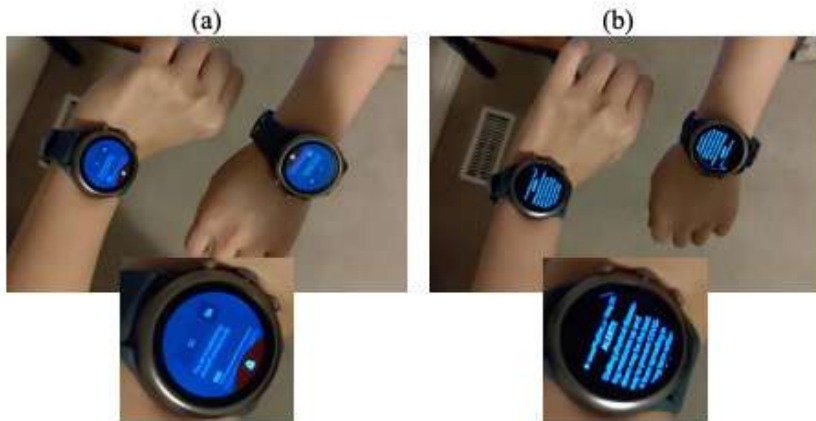
Case	Method	Raw Data		Filtered Data	
		Mean	95% Confidence Interval	Mean	95% Confidence Interval
HH	DT	82.90%	(82.77%, 85.64%)	<b>85.82%</b>	(83.00%, 85.83%)
	LDA	82.12%	(82.02%, 85.01%)	85.13%	(82.23%, 85.21%)
	NB	78.79%	(78.68%, 78.79%)	78.89%	(78.89%, 78.89%)
	kNN	78.81%	(78.66%, 81.35%)	81.53%	(78.96%, 81.63%)
	SVM	78.46%	(78.45%, 78.51%)	78.55%	(78.64%, 78.66%)
	PL	79.62%	(79.63%, 83.38%)	83.79%	(79.63%, 83.38%)
HP	DT	82.80%	(82.69%, 90.67%)	<b>90.75%</b>	(82.90%, 90.84%)
	LDA	82.17%	(82.04%, 90.16%)	90.19%	(82.30%, 90.33%)
	NB	80.27%	(80.14%, 81.71%)	81.81%	(80.40%, 81.98%)
	kNN	81.84%	(81.70%, 86.95%)	87.15%	(81.97%, 87.18%)
	SVM	18.13%	(18.00%, 79.14%)	79.27%	(18.26%, 79.39%)
	PL	77.92%	(77.92%, 85.34%)	85.34%	(77.92%, 85.34%)
HB	DT	77.04%	(76.87%, 81.29%)	<b>81.44%</b>	(77.20%, 81.60%)
	LDA	76.99%	(76.82%, 78.68%)	78.85%	(77.16%, 79.02%)
	NB	76.70%	(76.55%, 76.55%)	76.70%	(76.86%, 76.86%)
	kNN	76.92%	(76.75%, 77.82%)	77.99%	(77.10%, 78.16%)
	SVM	23.22%	(23.06%, 23.06%)	23.22%	(23.38%, 23.38%)
	PL	23.31%	(23.31%, 23.33%)	23.33%	(23.31%, 23.33%)
PB	DT	87.01%	(87.02%, 87.45%)	<b>87.51%</b>	(87.16%, 87.58%)
	LDA	87.01%	(87.02%, 87.02%)	87.01%	(87.18%, 87.18%)
	NB	87.12%	(87.05%, 87.05%)	87.13%	(87.21%, 87.21%)
	kNN	87.03%	(86.96%, 86.96%)	87.03%	(87.10%, 87.10%)
	SVM	86.62%	(86.54%, 83.45%)	83.53%	(86.69%, 83.61%)
	PL	56.38%	(56.38%, 60.37%)	60.37%	(56.38%, 60.37%)
PP	DT	73.35%	(73.12%, 87.18%)	<b>87.26%</b>	(73.47%, 87.34%)
	LDA	72.94%	(72.82%, 87.13%)	87.23%	(73.47%, 87.34%)
	NB	71.34%	(71.22%, 73.77%)	73.90%	(73.07%, 87.33%)
	kNN	71.41%	(71.29%, 73.79%)	73.91%	(71.47%, 74.02%)
	SVM	28.60%	(28.48%, 29.54%)	28.60%	(28.72%, 29.54%)
	PL	66.52%	(66.52%, 77.34%)	77.34%	(66.52%, 77.34%)
BB	DT	77.36%	(77.26%, 90.78%)	<b>90.85%</b>	(77.45%, 90.91%)
	LDA	76.90%	(76.81%, 85.21%)	85.28%	(76.99%, 85.36%)
	NB	76.93%	(76.85%, 85.18%)	85.25%	(77.02%, 85.32%)
	kNN	77.16%	(77.07%, 78.00%)	78.09%	(77.26%, 78.19%)
	SVM	22.94%	(22.85%, 69.34%)	69.44%	(23.02%, 69.54%)
	PL	62.18%	(62.18%, 73.28%)	73.28%	(62.18%, 73.28%)



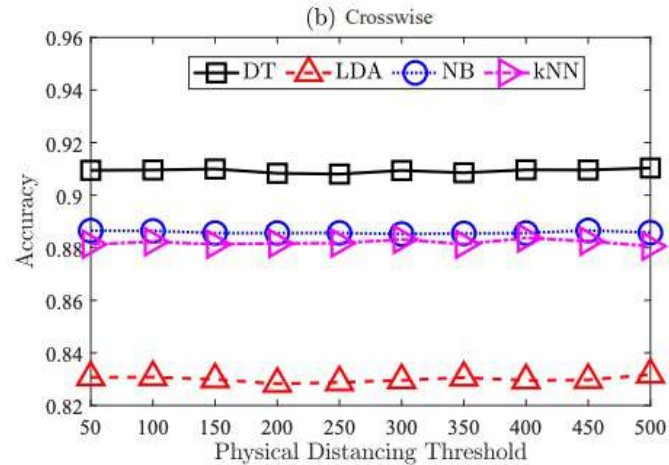
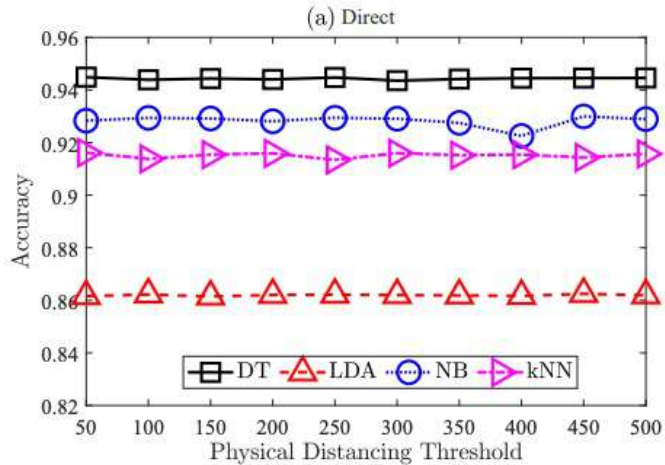
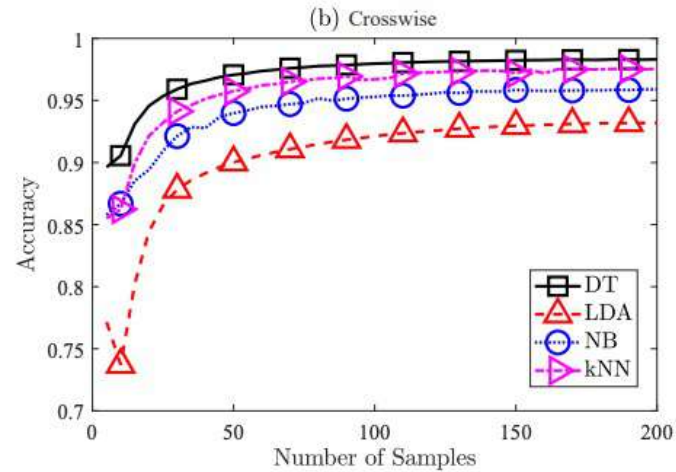
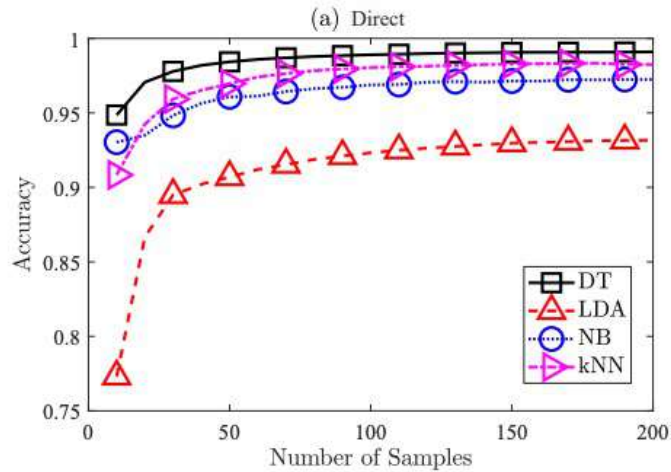
- Εφαρμογή στο Οντάριο και τον Καναδά
- Συμμετοχή στο MIT PACT

# Ιχνηλατηση με wearables

- Βελτιστοποίηση κατηγοριοποίησης
- Χρήση σε εργασιακούς χώρους



# Αποτελέσματα



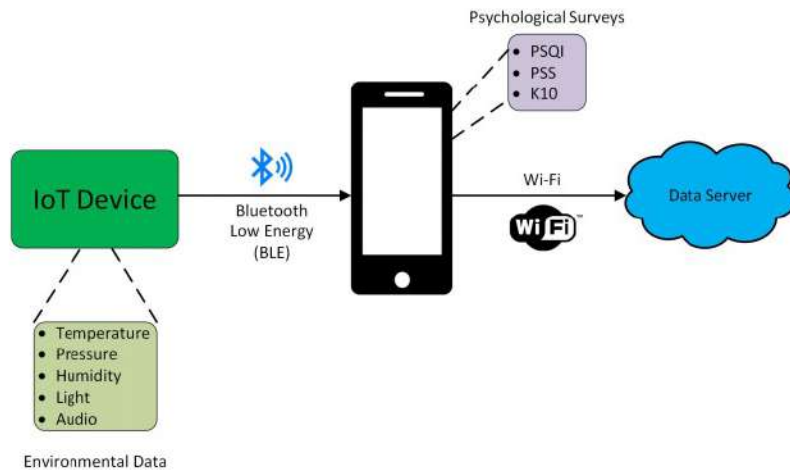
# Εφαρμογές

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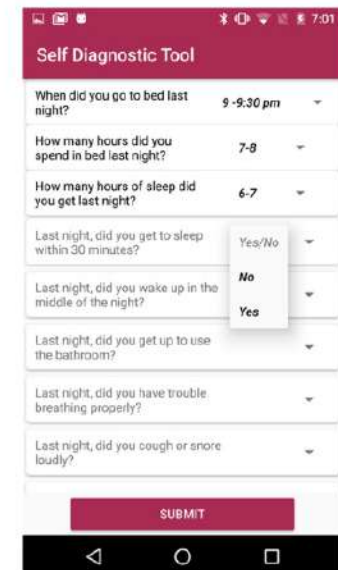
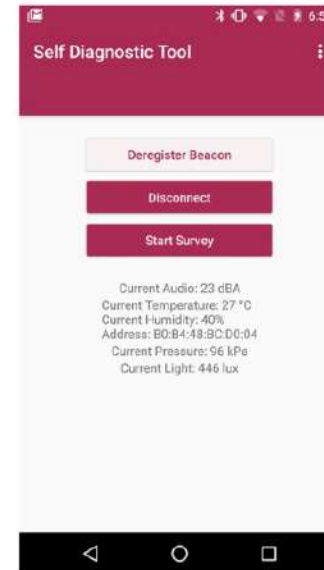
- Υλοποιημένες εφαρμογές έξυπνων πόλεων
  - Εντοπισμός θέσης χρήστη σε εσωτερικό και εξωτερικό χώρο
  - Ιχνηλάτηση επαφών covid-19
  - ***E-health monitoring***



# E-health monitoring



	# of People		PSQI		PSS		K10	
	<i>r</i>	<i>p</i> -value	<i>r</i>	<i>p</i> -value	<i>r</i>	<i>p</i> -value	<i>r</i>	<i>p</i> -value
<b>Pearson Correlation</b>								
Temperature	-0.0816	0.0815	-0.0831	0.0600	-0.0466	0.8073	-0.0637	0.3448
Pressure	-0.0201	0.8441	0.0809	0.3617	0.0892	0.1687	0.0536	0.5484
Humidity	-0.0886	0.0547	-0.018	0.3667	-0.014	0.6137	-0.0215	0.0656
Light	-0.0943	0.056	-0.0576	0.589	0.0675	0.3995	0.057	0.5624
Audio	-0.0744	0.043	<b>0.1938</b>	0.0017	<b>0.1408</b>	0.0007	<b>0.1532</b>	0.004
<b>Spearman Correlation</b>								
Temperature	-0.1029	0.0818	-0.1133	0.0552	-0.0172	0.7714	0.0568	0.3375
Pressure	-0.0129	0.8281	0.0541	0.3607	0.0819	0.1663	0.035	0.5552
Humidity	-0.1141	0.0535	-0.0655	0.2685	-0.028	0.6363	-0.1188	0.0443
Light	-0.0932	0.7251	-0.0294	0.6198	0.0414	0.4852	0.0352	0.5531
Audio	-0.1043	0.6546	<b>0.1829</b>	0.0019	<b>0.194</b>	0.001	<b>0.1682</b>	0.0043
<b>Kendall Correlation</b>								
Temperature	-0.087	0.0832	-0.0851	0.0645	-0.0108	0.7083	-0.0443	0.3348
Pressure	-0.0097	0.8913	0.0451	0.3457	0.0667	0.1567	0.0307	0.6484
Humidity	-0.0994	0.7516	-0.0393	0.3761	-0.0215	0.6453	-0.0829	0.0446
Light	-0.0771	0.8422	-0.0232	0.5756	0.0355	0.3345	0.0258	0.5443
Audio	-0.0983	0.8251	<b>0.1435</b>	0.0016	<b>0.152</b>	0.0005	<b>0.136</b>	0.003



An experimental framework for Wellness Assessment Through the Internet of Things, K. McLeod, P. Spachos, K. Plataniotis, IEEE Internet Computing  
 IoT for Healthcare and Assistive Technologies: Applications, Challenges and Research Opportunities, M. Baucas, P. Spachos, S. Gregori, IEEE Signal Processing Magazine

