



WELCOME WEEK

DEIM

Dipartimento di Energia,
Ingegneria dell'Informazione e Modelli Matematici

Corso di Laurea Magistrale in
Ingegneria delle Telecomunicazioni

Metodi di localizzazione che usano il Wi-Fi

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Localizzazione e pervasività

- Outdoor
 - GPS (US)
 - GLONASS (RU)
 - Compass (CN)
 - Galileo (EU)

- LORAN (LOngRAnge Navigation)
 - CHAYKA (RU)
 - reti cellulari

- Indoor
 - WiFi
 - iBeacon
 - BLE
 - UW
 - visione artificiale
 - laser

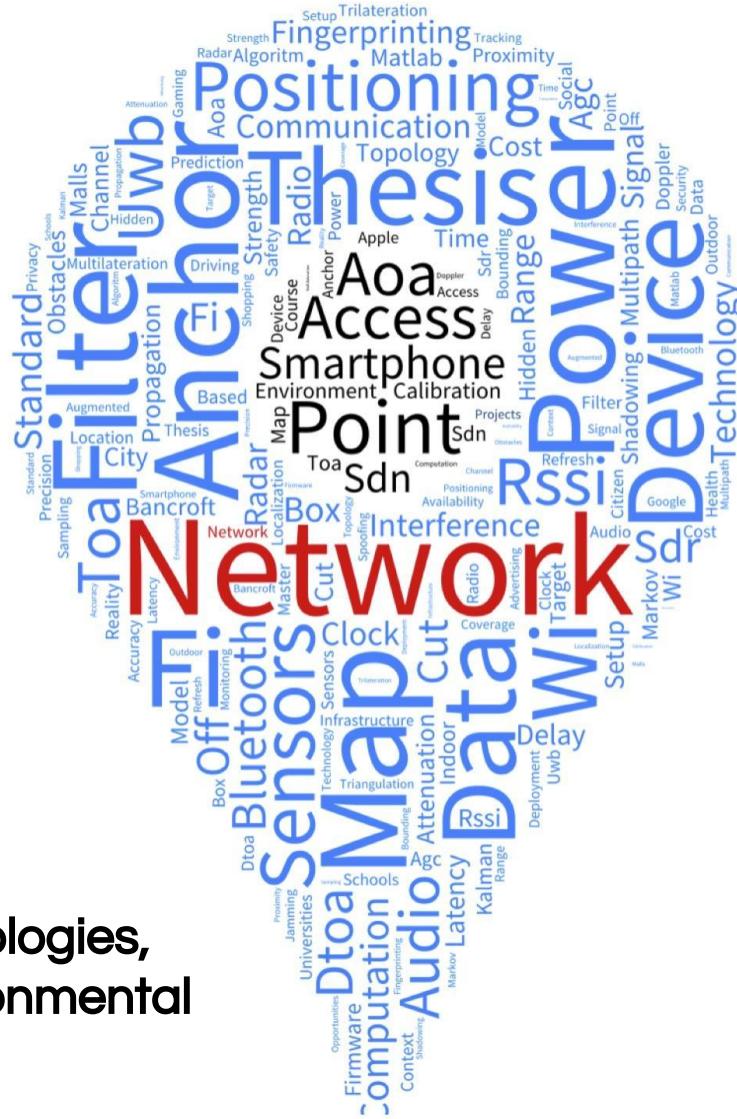
- Omega (US 1971-1977)
 - Alpha (detto anche RSDN—20
Радиотехническая Система
Дальней Навигации)

sistemi di lungo raggio, dedicati ad applicazioni militari o di navigazione aerea e marittima

Eterogeneità per parole chiave

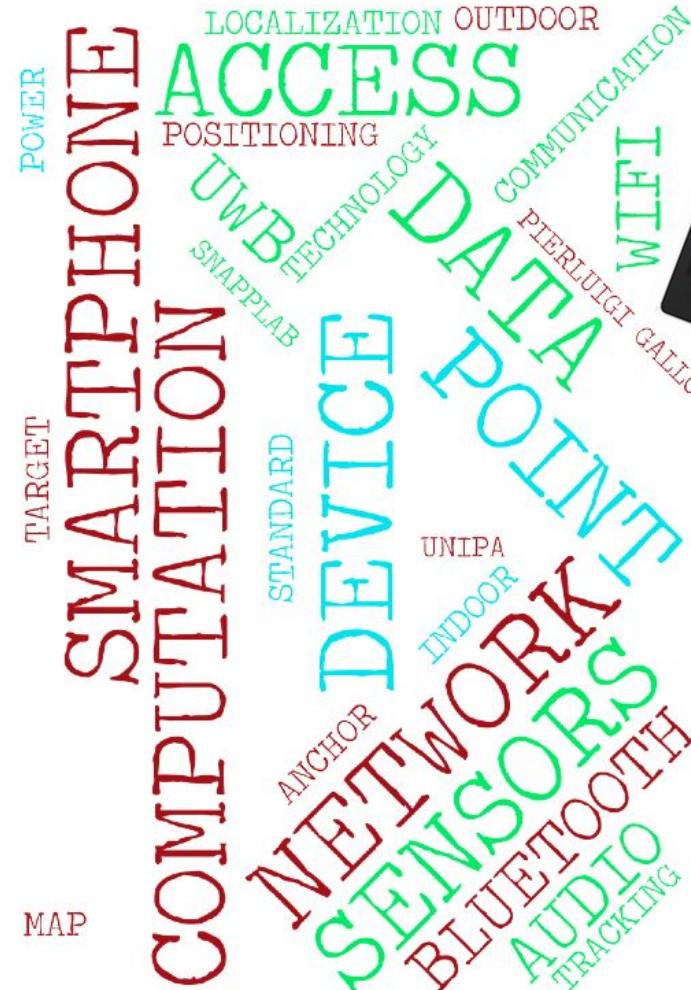
- Device
 - Propagation
 - Context
 - Algorithm
 - Performance
 - Applications
 - Opportunities

Heterogeneity of technologies, operating contexts, environmental dynamics



I dispositivi

- smartphone
- network
- sensors
- access-point
- computation
- interfacce radio
 - Bluetooth
 - WiFi
 - UWB
 - standard
- map
- power
- target
- anchor
- AGC
- firmware
- clock



Smartphones e sensori

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Anche quando si sfruttano le tecnologie radio, è
conveniente utilizzare anche altri sensori

Attenzione all'accuratezza

Accelerometro

Magnetometro

Giroscopio

Barometro

Prossimità

Luminosità

Schermo touch



fotocamera frontale

fotocamera retro

GPS

NFC

Wi-Fi

Bluetooth

GSM/CDMA/4G

La propagazione dei segnali

- propagation
- attenuation
- multipath
- shadowing
- interference
- effetto Doppler
- strength
- LoS
- NLoS
- latency
- delay
- power
- cut-off
- RSSI
- ToA
- AoA
- DToA
- fingerprinting
- range
- anchor
- SDR
- SDN
- radar
- data

Free Space Path Loss

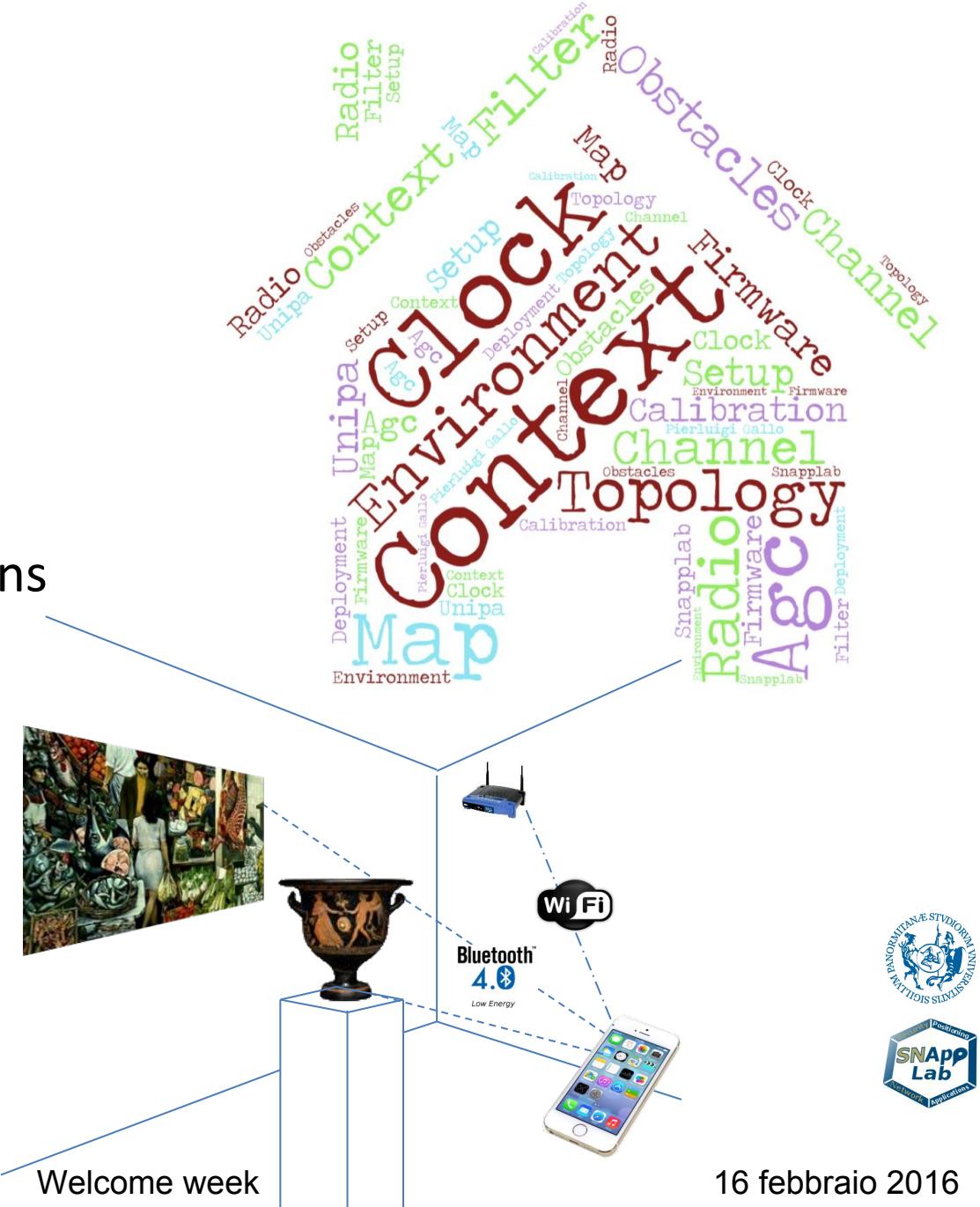
$$FSPL = \left(\frac{4\pi d}{\lambda} \right)^2 = \left(\frac{4\pi df}{c} \right)^2$$

In spazio libero
In indoor le cose
vanno
diversamente



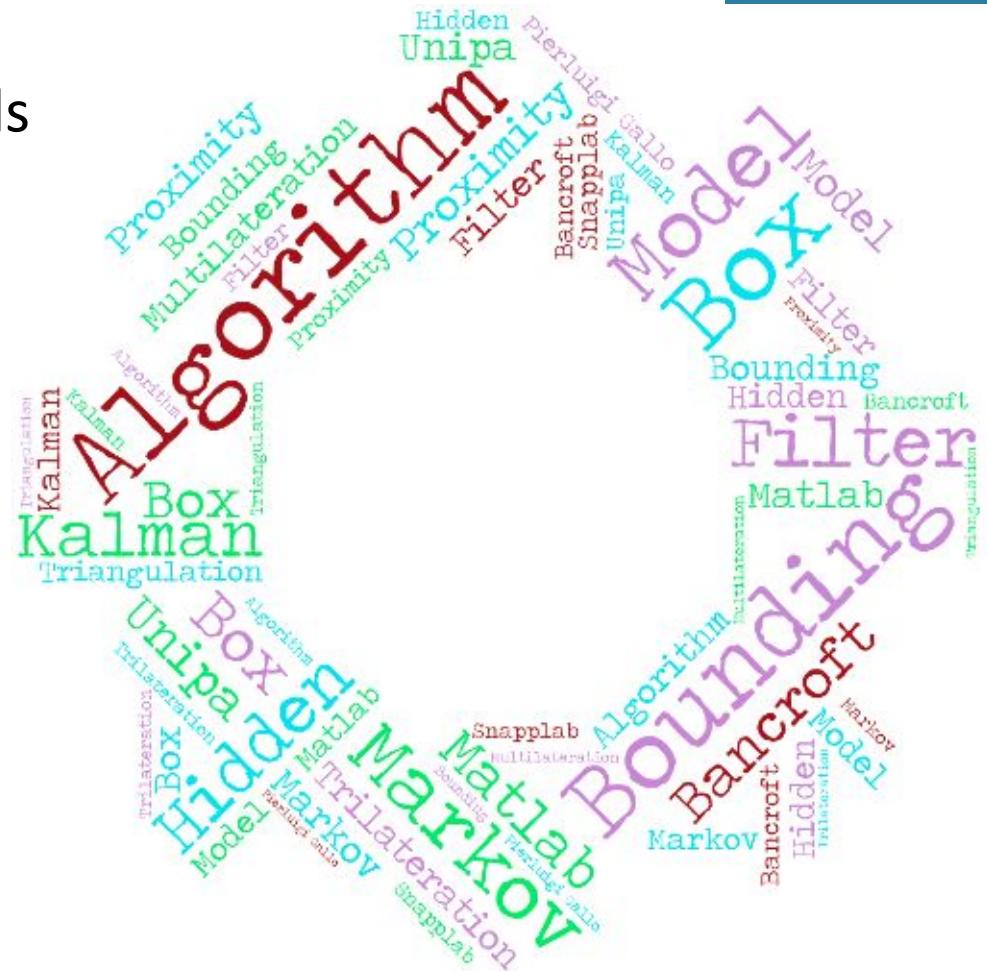
Il contesto

- context
 - topology
 - obstacles
 - environment
 - number of people
 - # of contending stations
 - channel
 - radio-map
 - calibration
 - setup
 - deployment



Algoritmi

- bounding box *
- Bancroft
- proximity
- hidden-Markov-models
- Kalman-filter
- triangulation
- trilateration
- multilateration
- Bayesian analysis



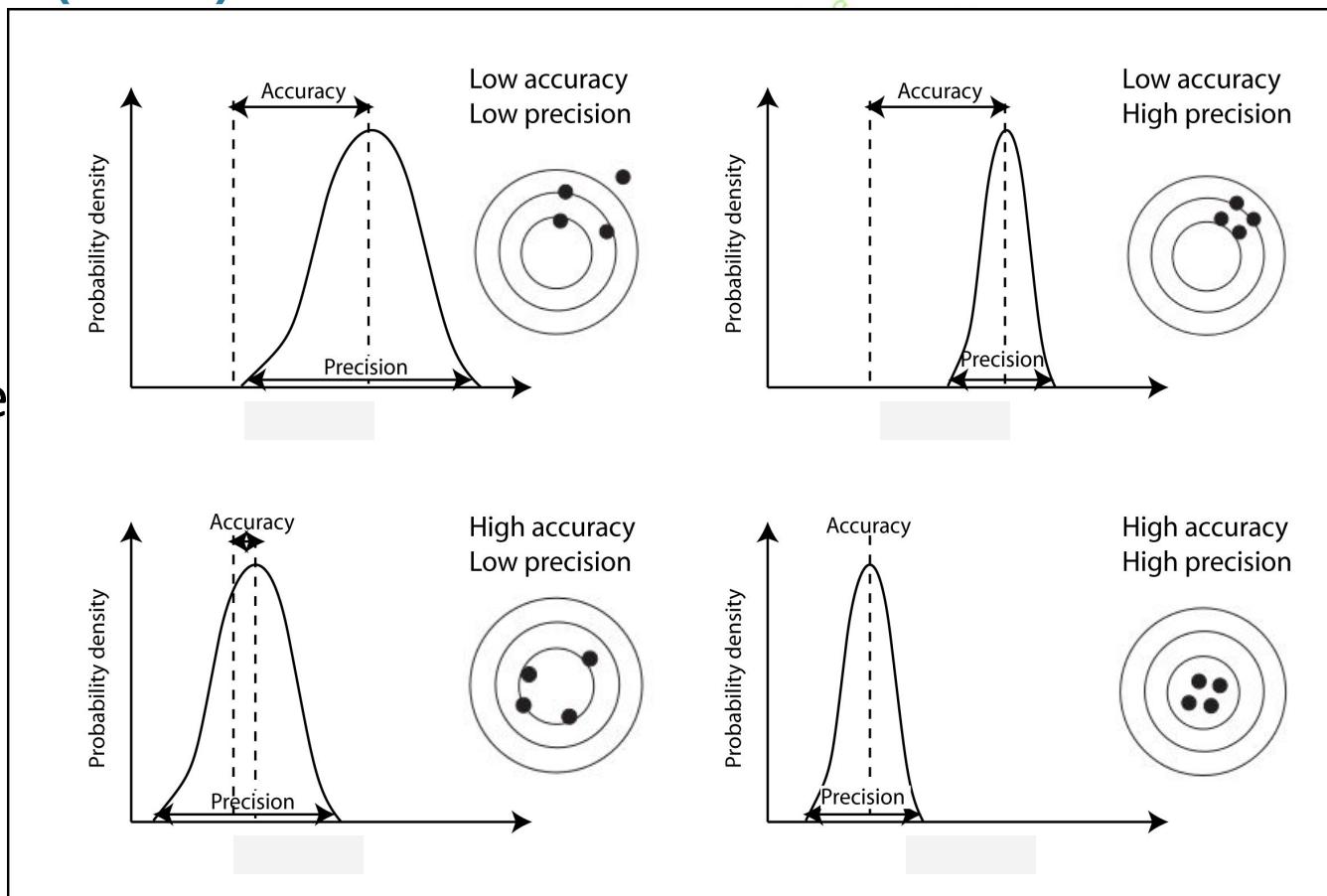
Prestazioni (KPI)

9

- performance
 - precision
 - accuracy
 - cost
 - infrastructure
 - time
 - refresh
 - availability
 - coverage
 - sampling



- performance
- precision
- accuracy
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- time
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- coverage
- sampling



Precisione ≠ Accuratezza

Opportunità

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- Rapporto con le imprese
 - conto terzi
 - progetto PON sulla fruizione dei beni culturali (Neptis)
 - telemetria in ambito marino (U-Track)
 - applicazioni per l'e-commerce (7pixel)
 - Tesina nel corso di Servizi e sicurezza su internet (12 CFU)
 - Tesi di laurea
 - Privacy
 - Safety
 - Security

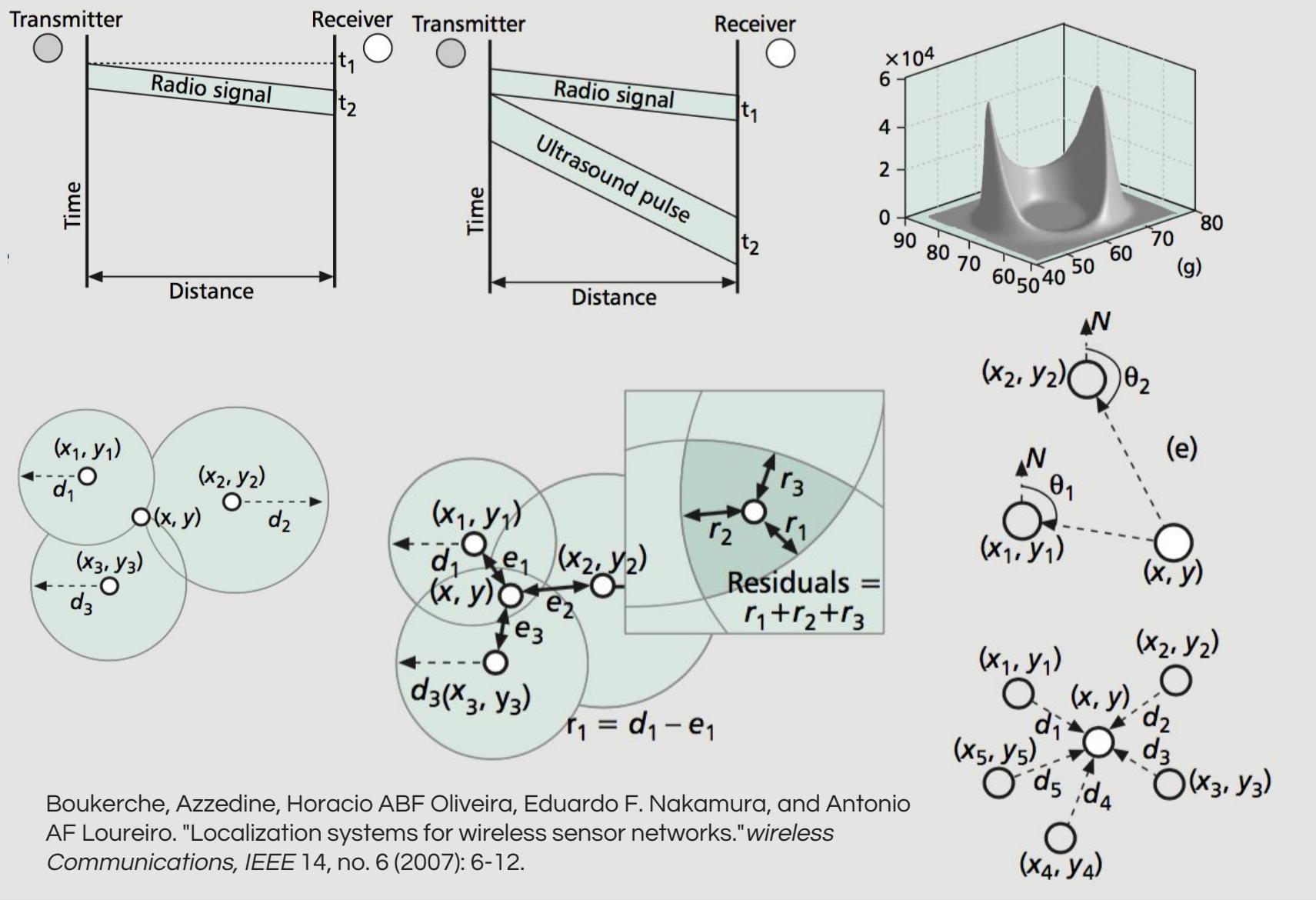


Tecnologie e metodi

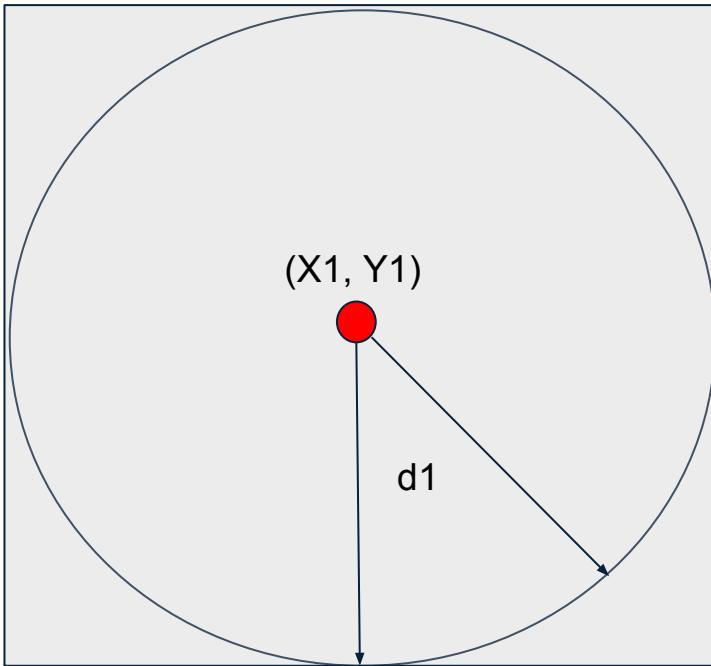
- Network based
 - handset based
- Anchor based
 - anchor free
- Range based
 - range free
- Active
 - passive
- Signal strength (RSSI, fingerprinting)
- Proximity (reticellulari, RFID, ...)
- Angle of Arrival (AoA)
- Time of Arrival (ToA)
- Time Difference of Arrival (TDoA)
- Hybrid techniques

Principali tecniche ed algoritmi

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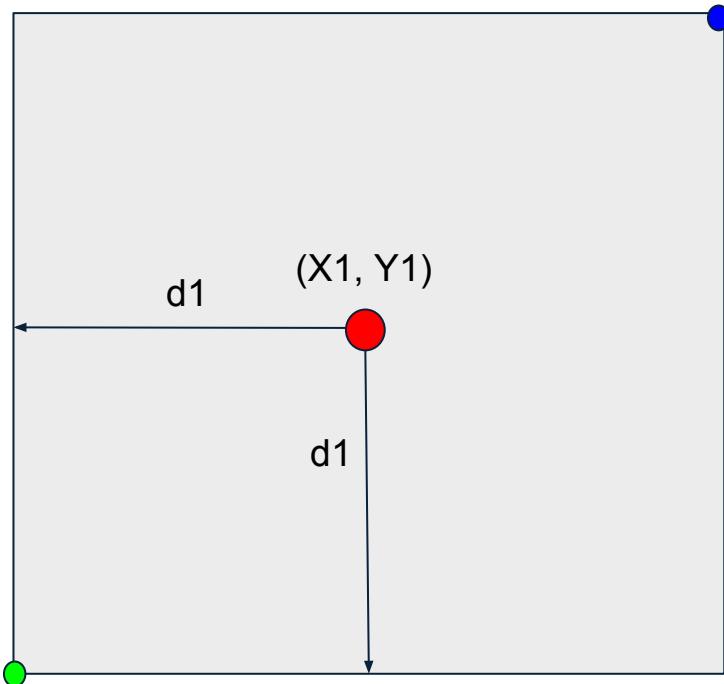


Bounding box



Bounding box

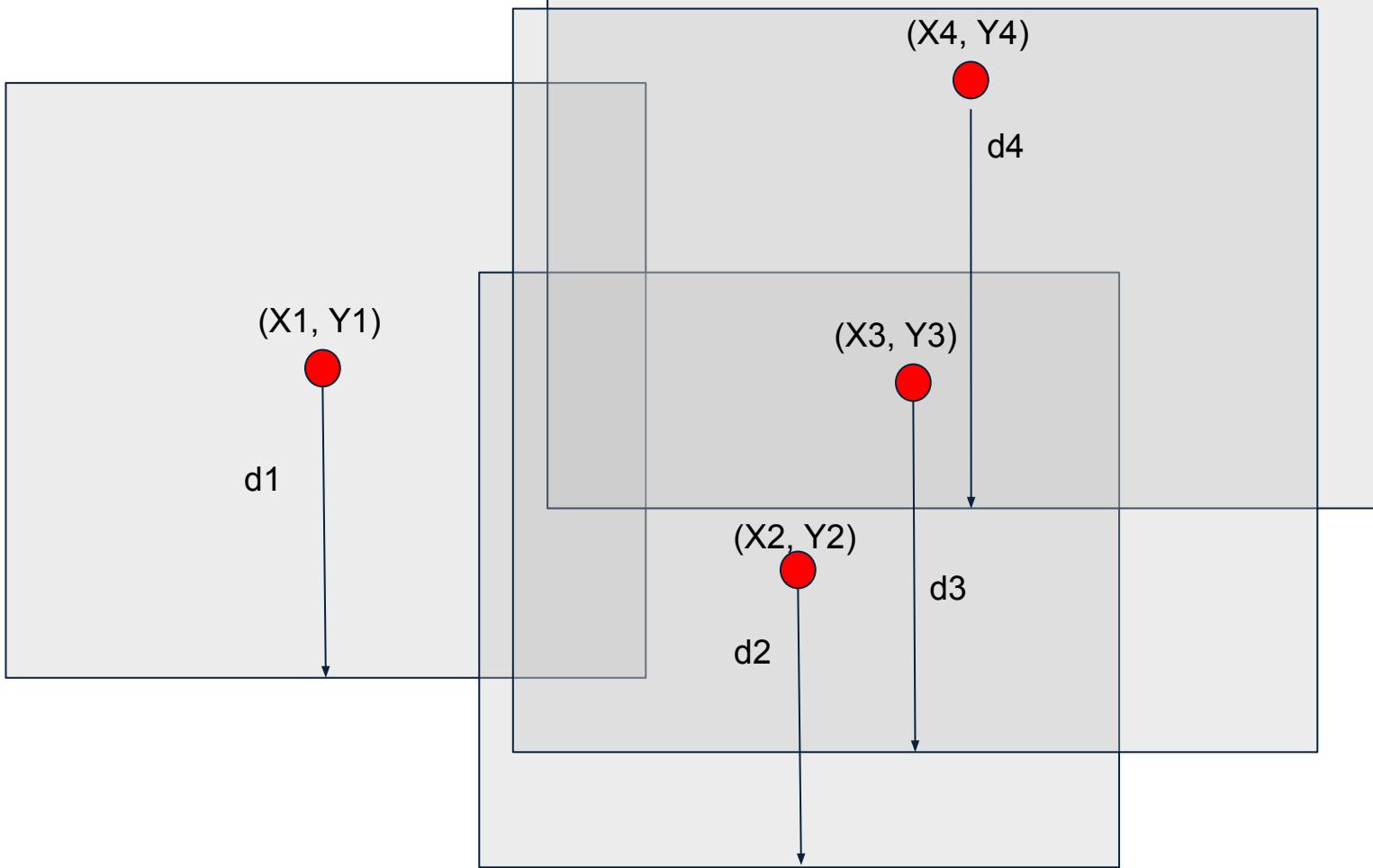
$$(X_{1\max}, Y_{1\max}) = (X_1, Y_1) + (d_1, d_1)$$



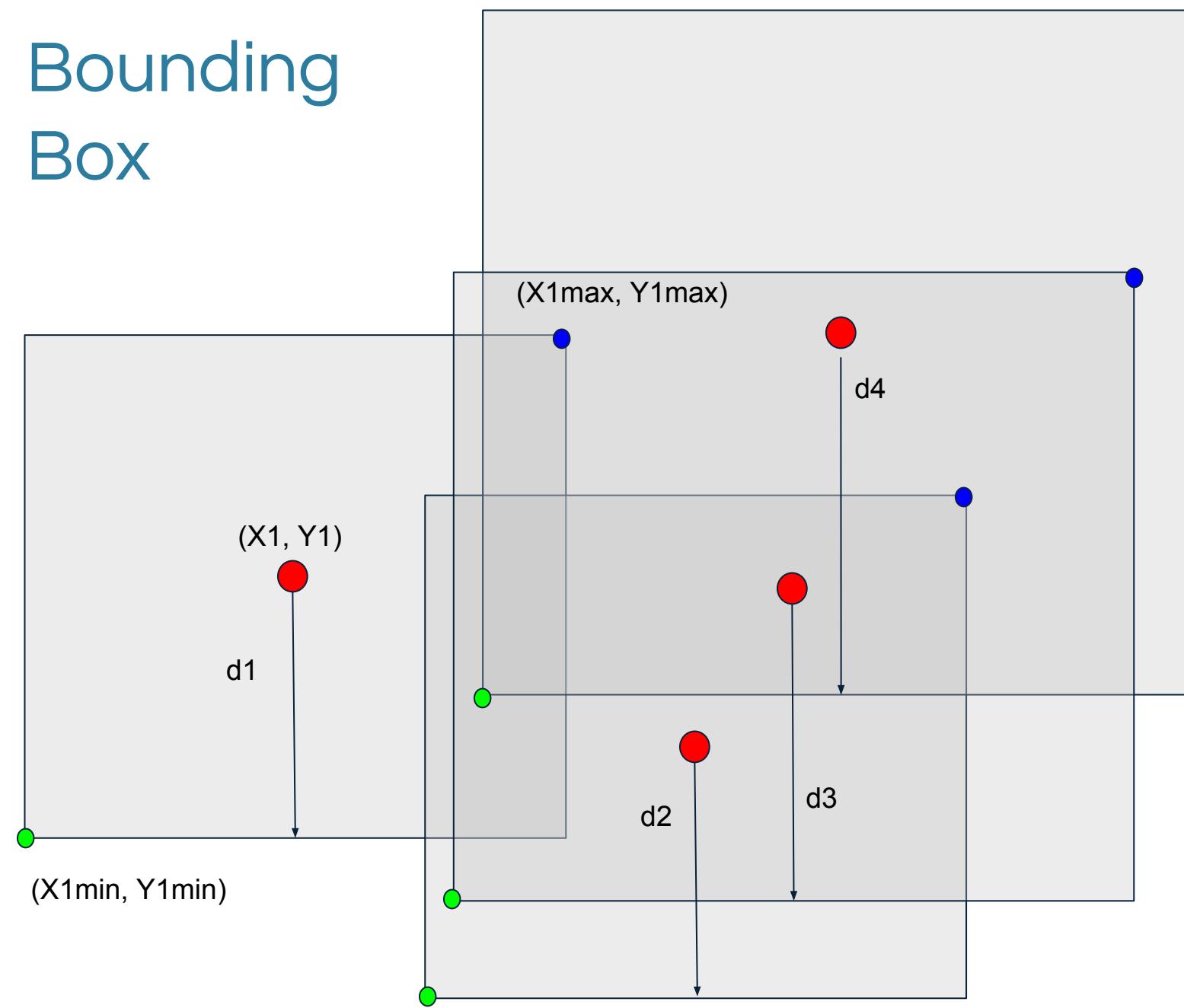
$$(X_{1\min}, Y_{1\min}) = (X_1, Y_1) - (d_1, d_1)$$



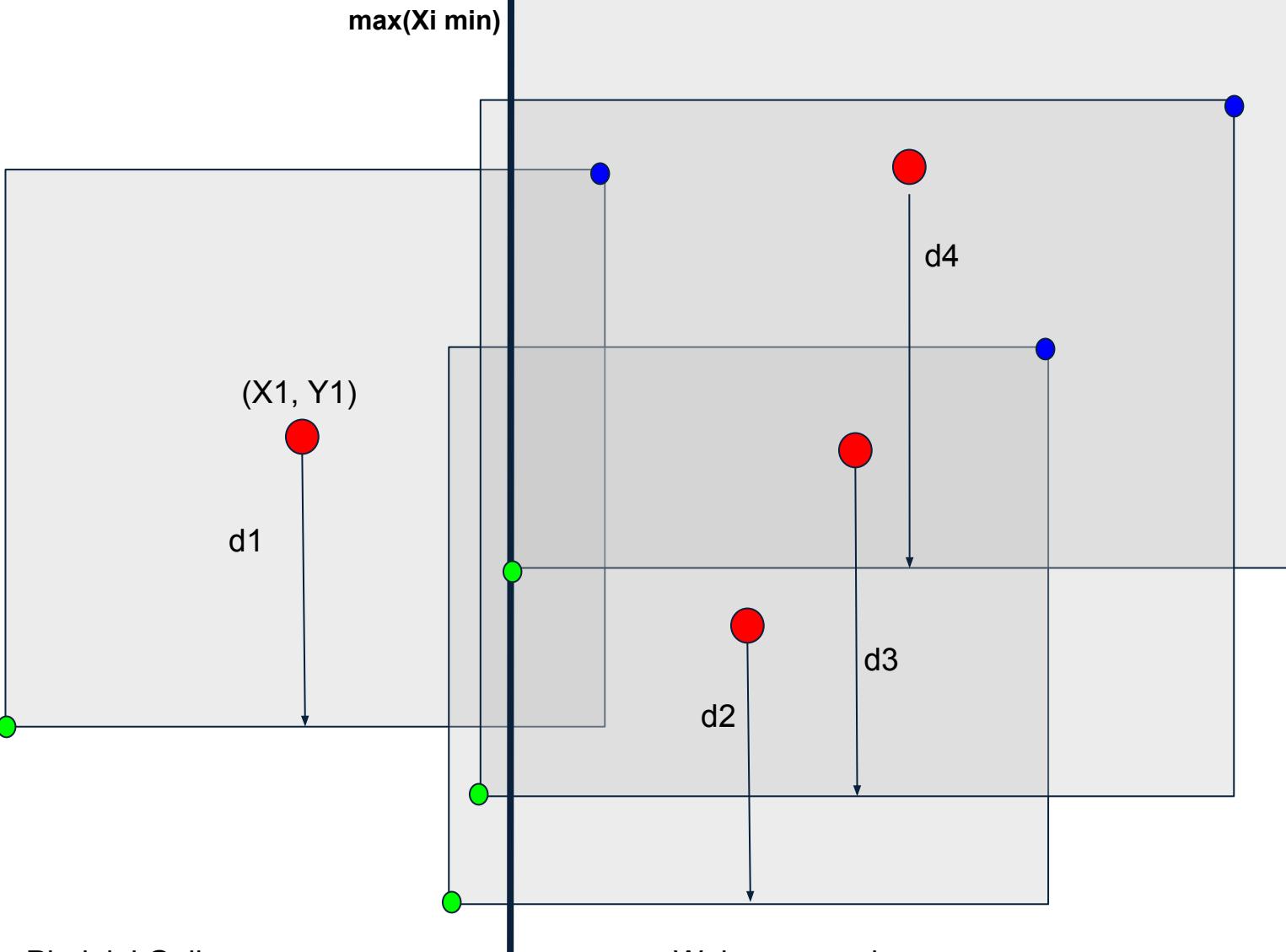
Bounding Box



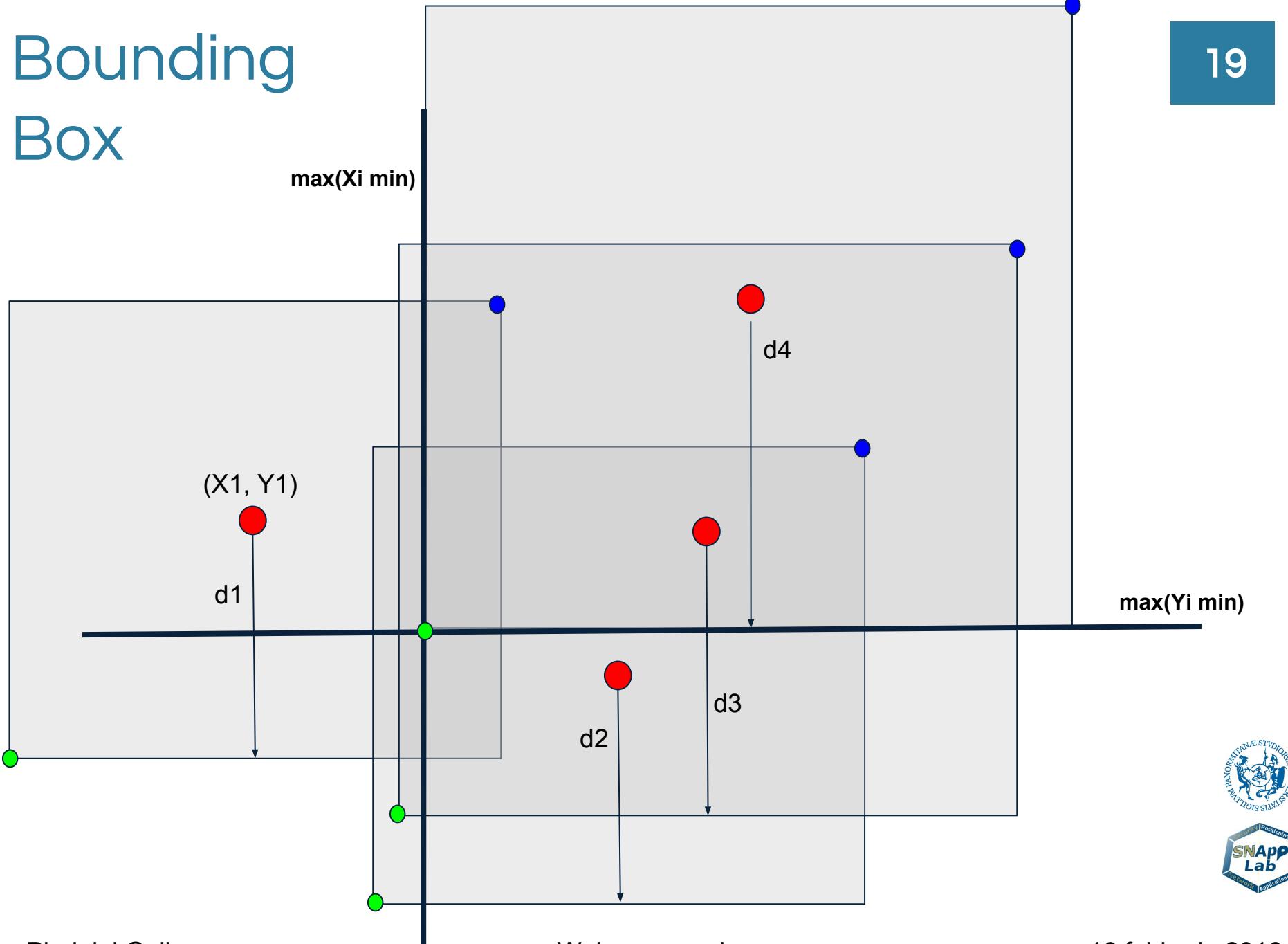
Bounding Box



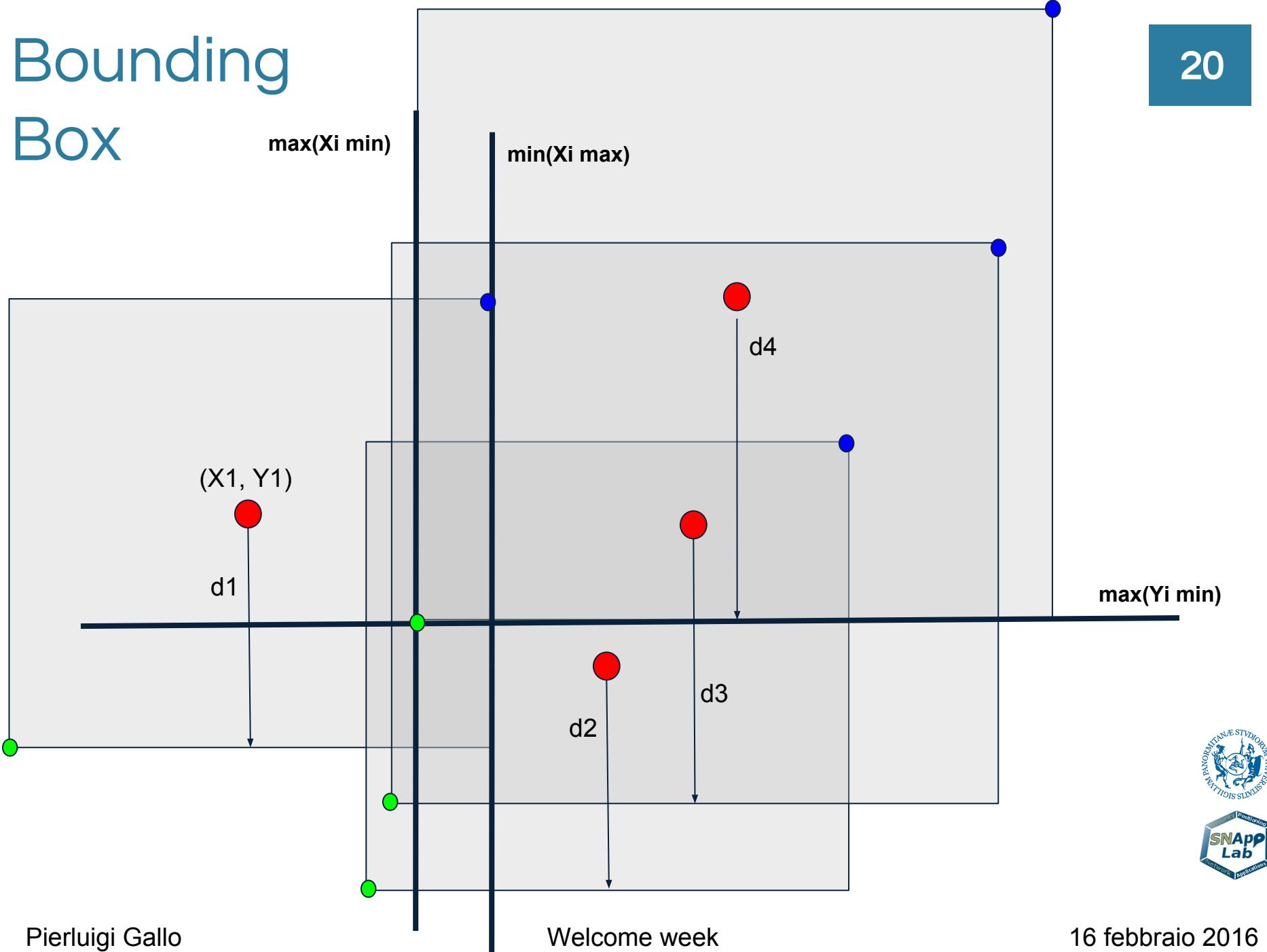
Bounding Box



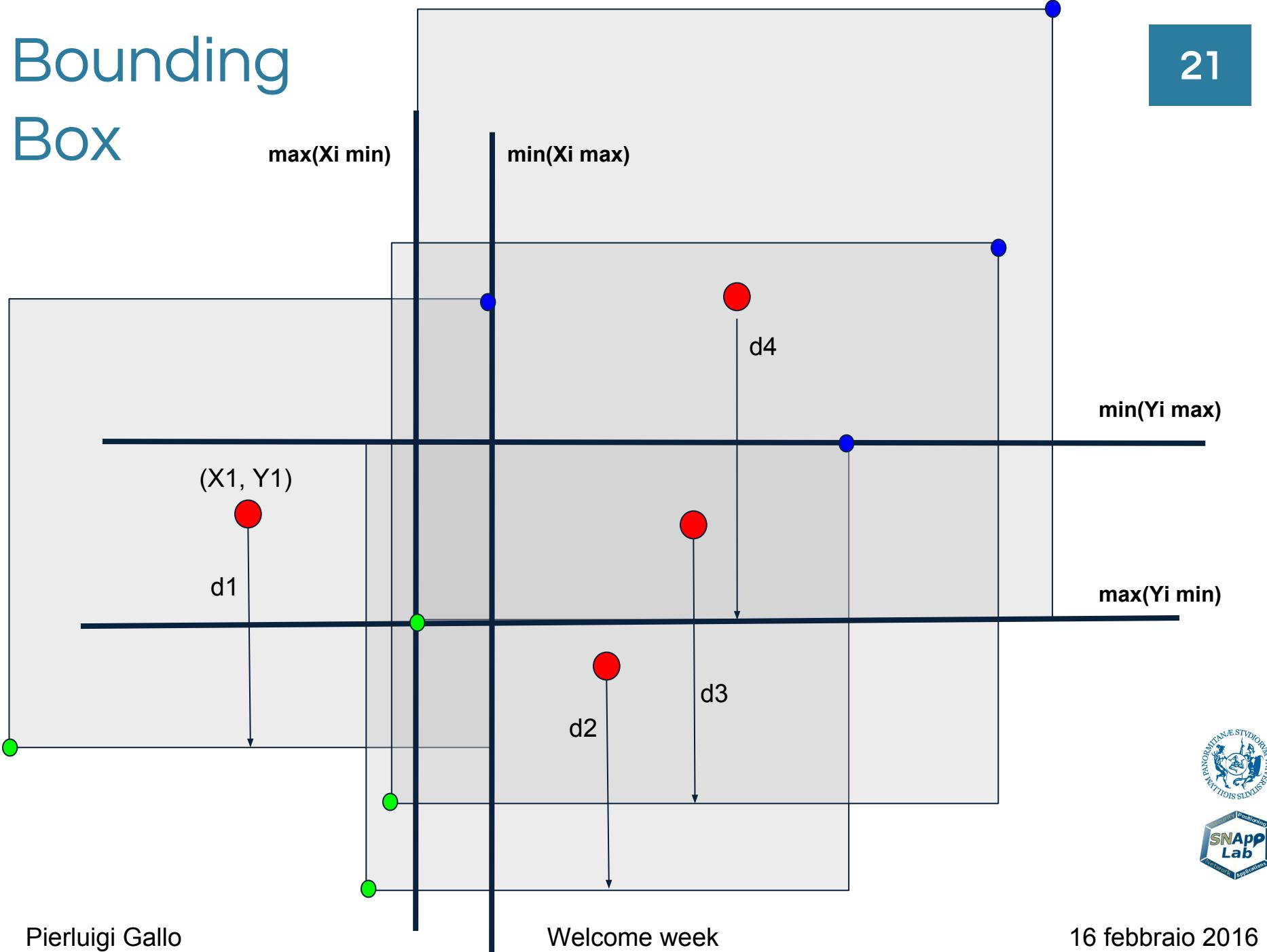
Bounding Box



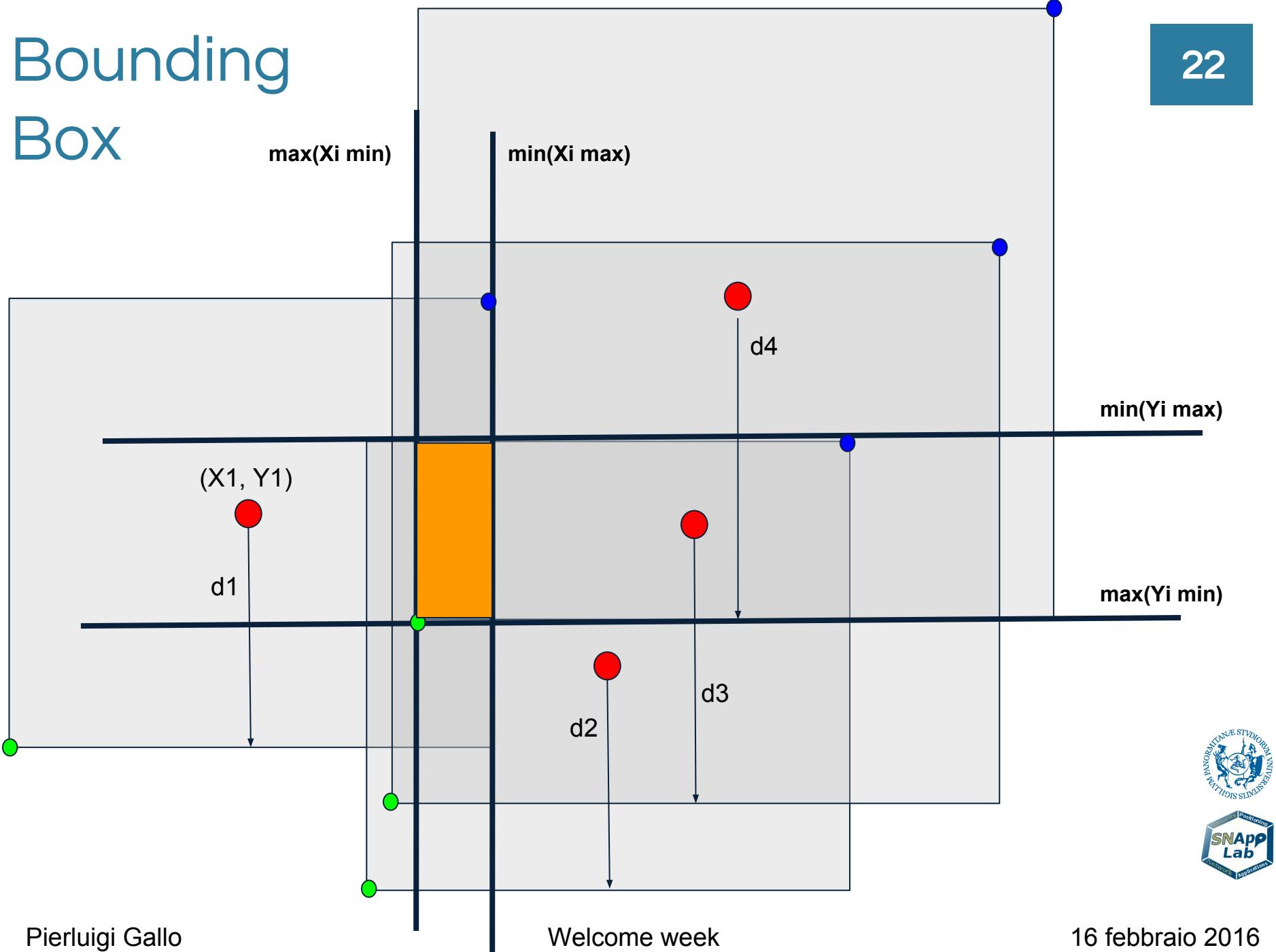
Bounding Box



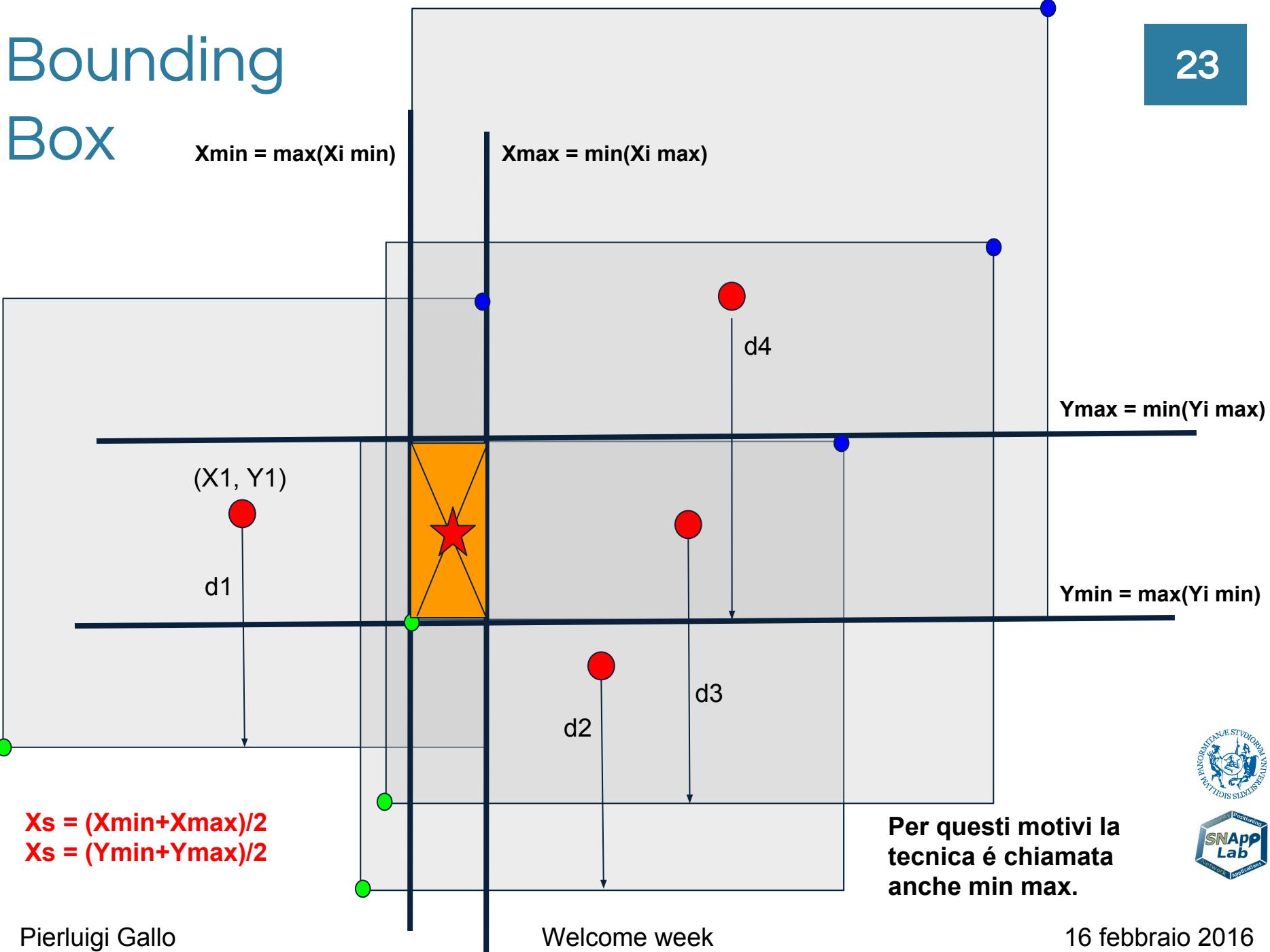
Bounding Box



Bounding Box

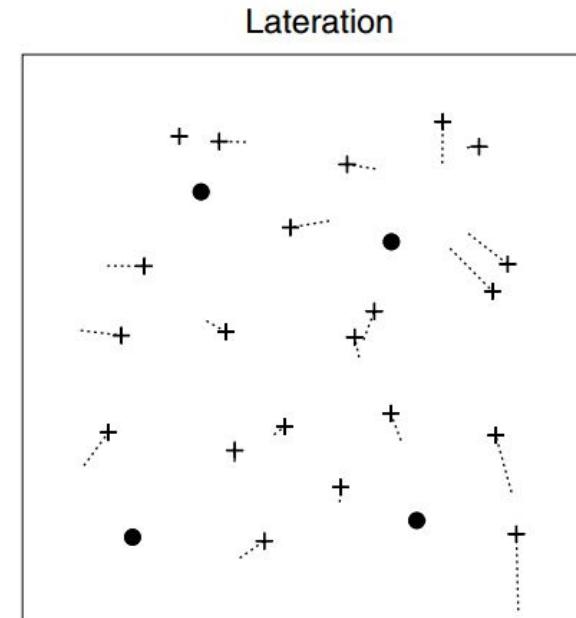
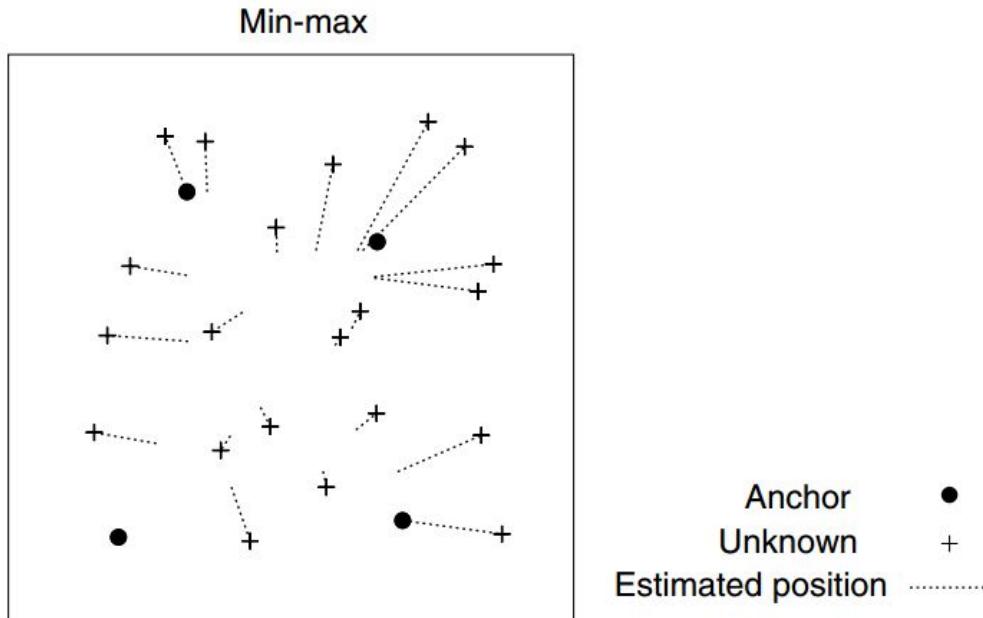


Bounding Box



Bounding Box

bassa complessità computazionale
minore accuratezza
maggiore robustezza
errori maggiori per target fuori dal poligono



Koen Langendoen, Niels Reijers, Distributed localization in wireless sensor networks: a quantitative comparison, Computer Networks, Volume 43, Issue 4, 15 November 2003, Pages 499-518, ISSN 1389-1286, [http://dx.doi.org/10.1016/S1389-1286\(03\)00356-6](http://dx.doi.org/10.1016/S1389-1286(03)00356-6).



Applicazioni location-aware



Applicazioni location aware

- Big potentials of location-aware applications in indoors
 - Target advertising
 - Driving and navigation (especially for impaired individuals)
 - Vehicular traffic analysis and prediction (urban canyons)
 - E-health and monitoring
 - Locality based social networks (LBSNs)
 - Augmented indoor reality
 - Other location based services (LBSs)
- Outdoor solutions are not available indoors but ...
 - A plethora of mid-range and low-range radio technologies;
 - Availability of indoor maps (Google and Apple are collecting 2D/3D indoor maps for large and public buildings);



Creare mappe in ogni situazione



Interazioni tra localizzazione e mappe



Mappe in ambienti esterni: diffuse ed ampiamente utilizzate (in molti casi senza offuscamento anche per punti strategici);

Mappe in interni: centri commerciali, aeroporti, università, ospedali, musei, centri conferenze, etc.

Tratto dalle regole d'uso delle mappe di Google:

- (l) promote or provide instructional information about illegal activities;
- (m) promote physical harm or injury against any group or individual; or
- (n) transmit any viruses, worms, defects, Trojan horses, or any items of a destructive nature.



Location-based cyber-security

- I cellulari usano A-GPS (Assisted GPS), attacchi agli smartphones possono essere effettuati durante la fase di trasferimento dati con la rete cellulare
- Il GPS puo' subire jamming e spoofing [1]
- Man in the middle (segue la posizione per poter avere accesso alla stessa rete locale)

Un attacker puo' effettuare piú facilmente transazioni bancarie a scapito di un utente quando questi e' in viaggio



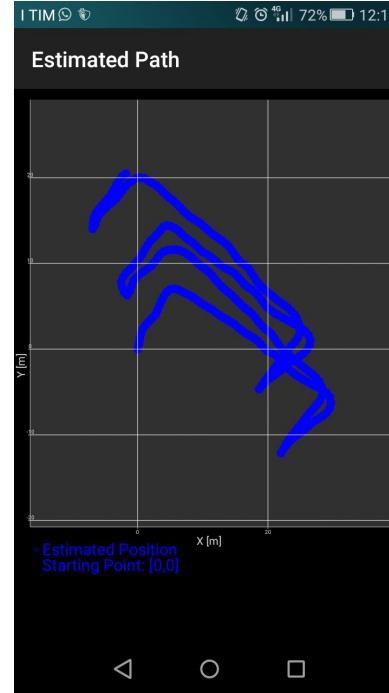
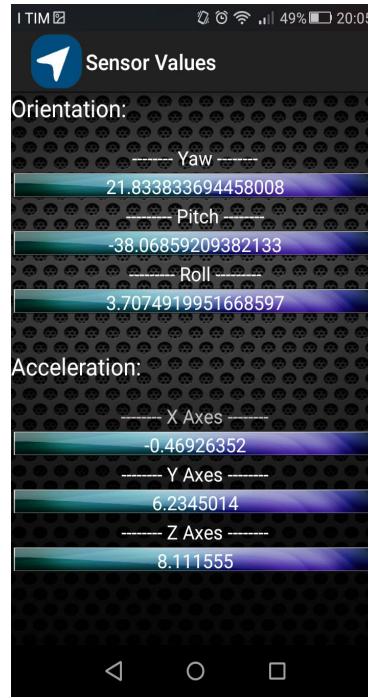
[1] Nighswander, T., Ledvina, B., Diamond, J., Brumley, R., & Brumley, D. (2012, October). GPS software attacks. In Proceedings of the 2012 ACM conference on Computer and communications security (pp. 450-461). ACM.

Risorse umane ed opportunità

Dottorato, Tesi, stages, progetti, tesine



Pedestrian DR + proximity



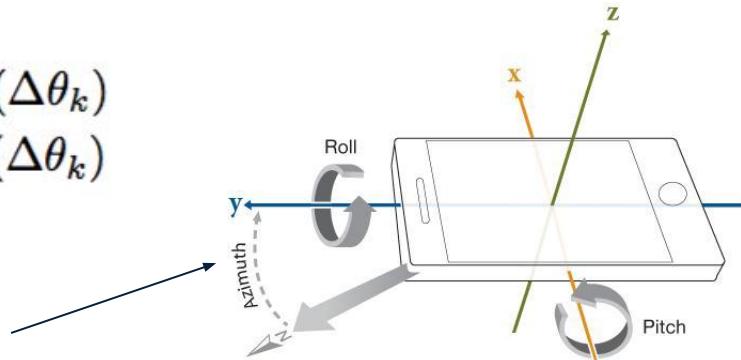
Giulio De Nicola

Telecommunication
Engineering student
University of Palermo

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Tesina e tesi di laurea
sulla localizzazione

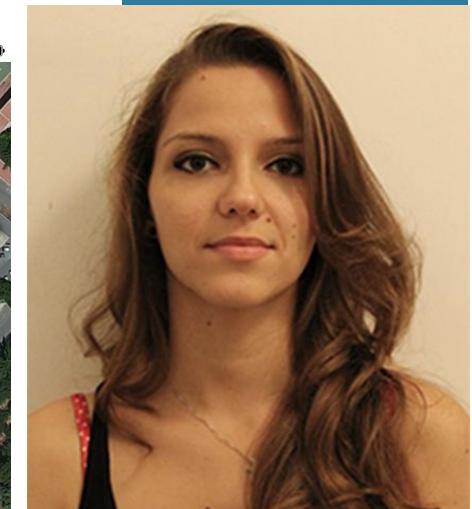
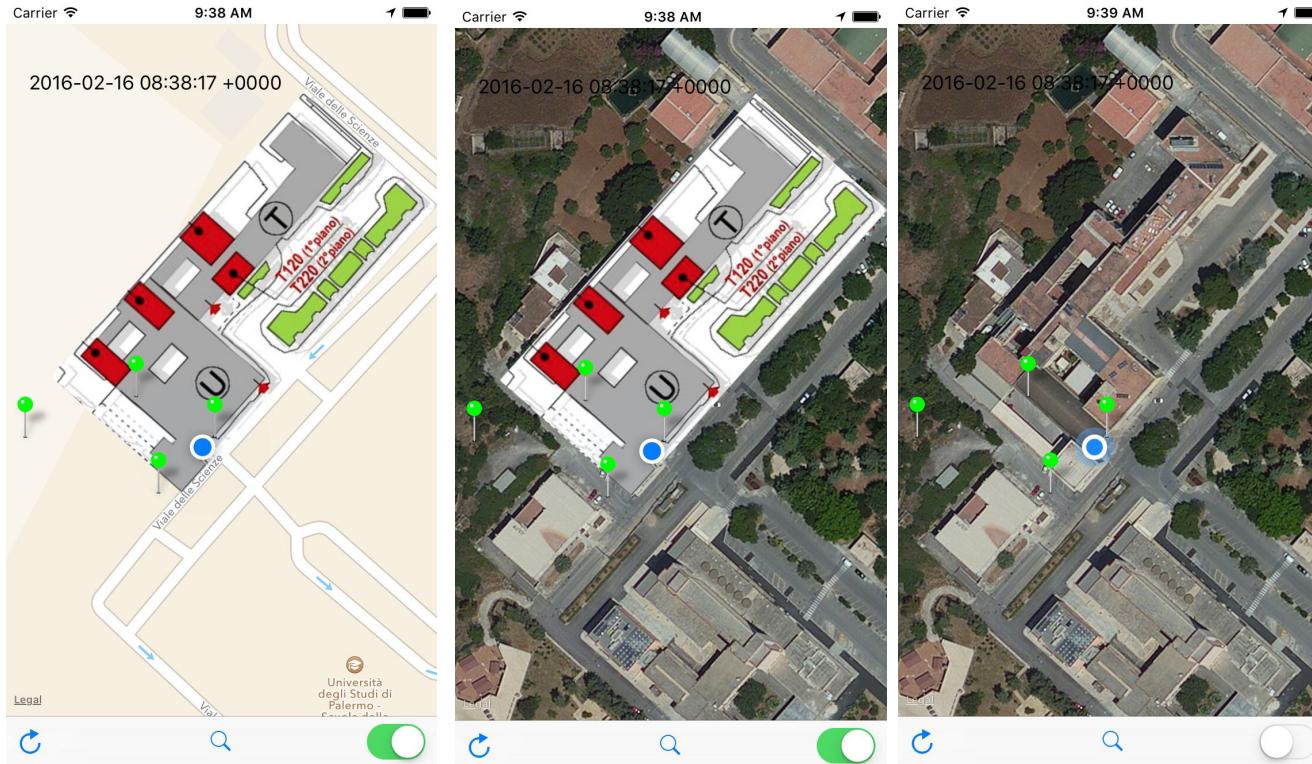
$$\begin{cases} x_{k+1} = x_k + SL_k \cdot \sin(\Delta\theta_k) \\ y_{k+1} = y_k + SL_k \cdot \cos(\Delta\theta_k) \end{cases}$$

$$R = \begin{bmatrix} E_x & E_y & E_z \\ N_x & N_y & N_z \\ G_x & G_y & G_z \end{bmatrix}$$



Source: <http://www.mathworks.com/matlabcentral/fileexchange/40876-android-sensor-support-from-matlab/content/sensorgroup/Examples/html/CapturingAzimuthRollPitchExample.html>

Giochi di squadra position-aware



Claudia Amato

Telecommunication
Engineering Student
University of Palermo

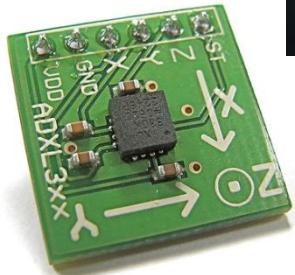
Obiettivo: raggruppare i giocatori della stessa squadra (non si conoscono a priori), nel più breve tempo possibile. Vince la squadra che raggruppa tutti i propri giocatori per prima o che ha il maggior numero di giocatori raggruppati allo scadere di un determinato tempo.

Descrizione: I giocatori si muovono liberamente all'interno di un'area predefinita, quando la distanza tra due giocatori amici (o tra un giocatore ed un gruppo di giocatori della stessa squadra) scende sotto una certa soglia, essi vengono considerati come un unico gruppo e vengono mostrati sulla mappa come un unico punto con accanto il numero di giocatori corrispondenti.

Sul display di ciascun giocatore viene mostrata la propria posizione e quella dei gruppi già costituiti (se ce ne sono).

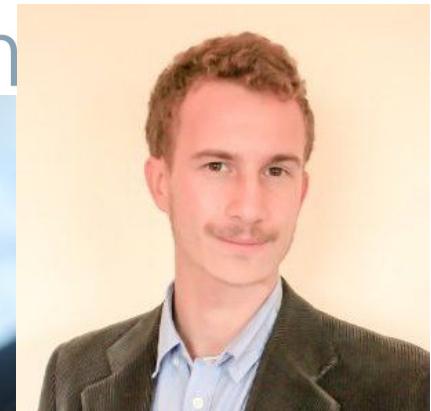


Pedestrian Heading Detection on unconstrained smartphones



Accelerometer measures a_x , a_y , a_z , dynamic and static accelerations

Pierluigi Gallo



Samuele D'Alcantari
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Engineering
University of Palermo

Dead Reckoning, also known as Step and Heading System estimate user's position by knowing the initial position.

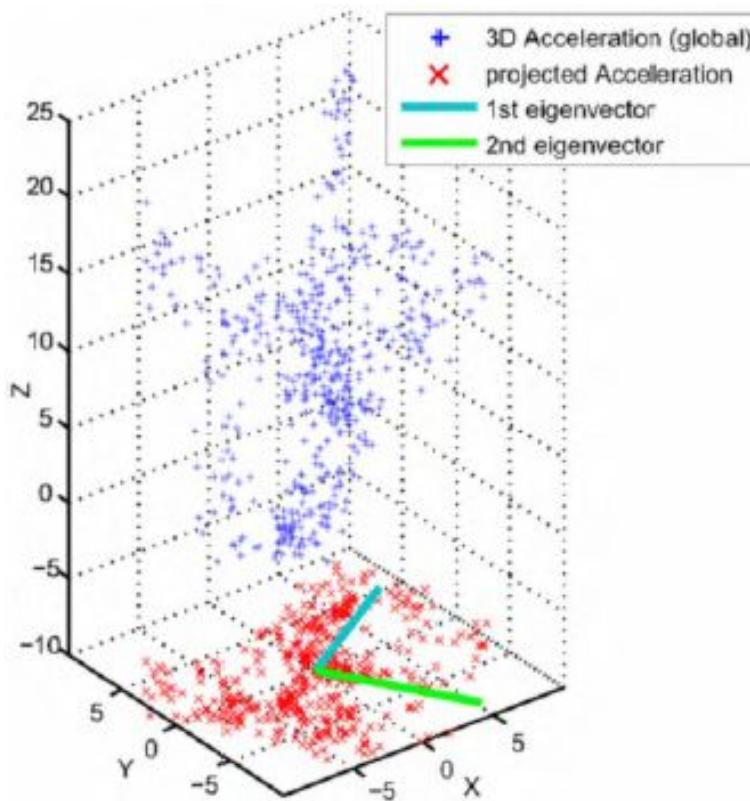
- Step Detection (SD) → Very reliable algorithms.
Step Length estimation using the accelerometer;
- Heading Detection → Not very reliable: trustful algorithms only in few and specific situations.

Welcome week



16 febbraio 2016

Determinare l'heading



Source: [6]

- Forward or backward?
 - Calibration of the smartphone.
- All the measurements are noisy!
 - (As the example in the figure)
 - Appropriate choice of standard deviations and filters (for example to smooth the curve of the SC acceleration).
- How much fixed is the phone?
 - Correct evaluation of the Sliding Window
- Use of a Particle Filter [5].



Uso di iBeacon



Giampiero Tarantino
Telecommunication
Engineer
University of Palermo

-
Tesi di laurea sulla
localizzazione (WIDAR)
collaborazioni con
UNIPA/CNR sulla
localizzazione

Local Poi

UNIVERSITÀ DEGLI STUDI DI PALERMO - DIPARTIMENTO DEIM 3° PIANO

OPZIONI DI LOCALIZZAZIONE
LOCALIZATION: false
ACCURACY: ACCURACY_LOW
LOCALIZATION MODE: ONLY_IBEACON
CAMERA: false
CAMERA TARGET: true
BOUNDARY: true 19.27.36
IBEACON LOCALIZATION MODE:IBEACON_MODE_CENTROIDE_HISTORY_FOLLOWER_V1

Ottimizzazione delle spedizioni

36



Francesco Randazzo

Telecommunication
Engineer

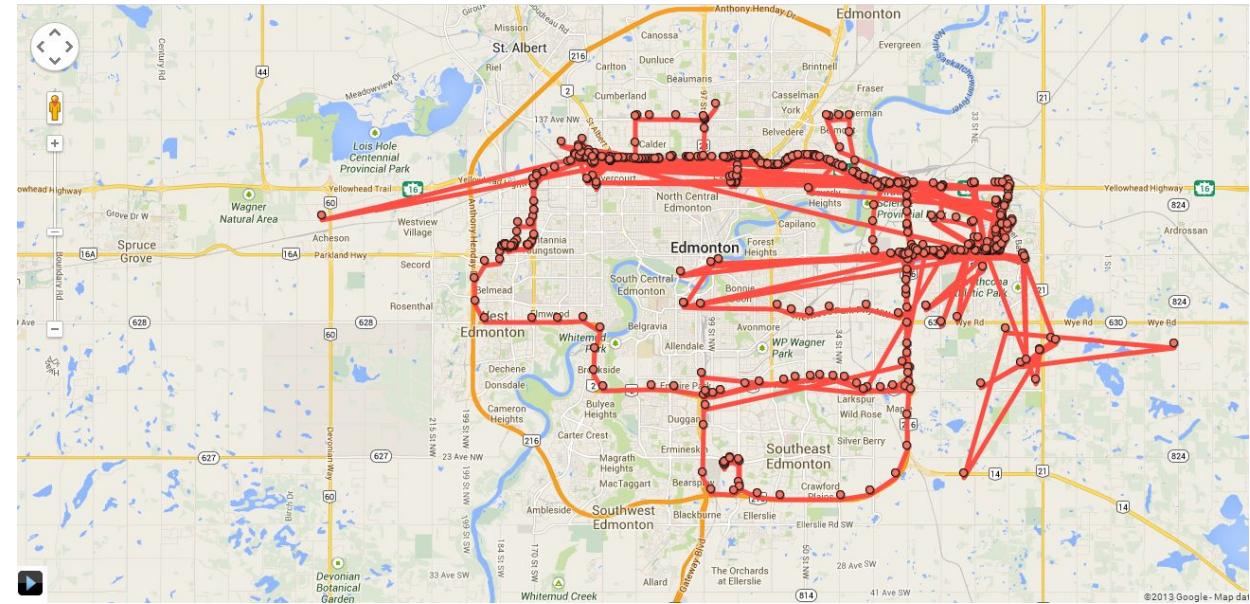
-
7pixel collaborator

-
PhD student
University of Palermo

impatto della localizzazione e del
tracking in ambito e-commerce

location-based clustering

target advertising
utilizzo di Google location history



CORSO DI LAUREA MAGISTRALE IN INGEGNERIA DELLE TELECOMUNICAZIONI

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Prerequisiti di accesso

Una qualunque Laurea
dell'Informazione (L8)

- Cibernetica
- Elettronica
- Gestionale e
Informatica
- Informatica e delle
Telecomunicazioni

Tecnologie trasmissive



Cosa si studia nella LM in **Ing. delle Telecomunicazioni**

- Internet ed applicazioni mobili
- telefonia cellulare
- antenne e sistemi satellitari
- reti di sensori e monitoraggio
- teoria dell'informazione e criptografia
- analisi di "big data"
- circuiti e sistemi per le telecomunicazioni
- comunicazioni in fibra ottica

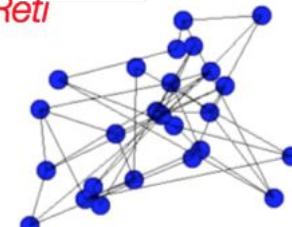
VoIP



Reti cellulari



Reti



- Internet
- la sicurezza nelle
comunicazioni,
- le comunicazioni mobili cellulari
- i sistemi elettronici di
ricetrasmissione
- comunicazioni ottiche

CLOUD



Video Streaming



Social Networking



Opportunità e sbocchi occupazionali



TESI ALL'ESTERO E PROGETTI EUROPEI

Svolgimento di tesi di laurea in contesti di progettazione europea, in collaborazione con altre Università (Germania, Belgio, USA, ...)

SBOCCI OCCUPAZIONALI

- Impiego e/o consulting presso aziende, amministrazioni ed enti pubblici e privati, settori della produzione e dei servizi;
- Trasporti, energia, big data, Internet delle Cose (IoT) e servizi correlati
- Progettazione e realizzazione di sistemi di telecomunicazioni
- Pubblica amministrazione
- Gestione delle smart grids e delle smart cities
- Healthcare
- Libera professione (Albo degli ingegneri sez. A – Informazione)

Gestione di reti e servizi radio-televisivi



Progettazione e realizzazione di sistemi e reti di telecomunicazioni



Produttori di dispositivi, società di consulenza e servizi



Navigazione, rilevamento radar, missioni spaziali



Aspetti tecnici

Attività svolte presso il laboratorio SNAPP lab del
DEIM



WMPS: Wireless MAC Processor Positioning System

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Input data:

$\{(x_{APi}, y_{APi}), i=1,2,\dots,N\}$

Localization algorithm

Bancroft's algorithm + Mean square

Output data:

(x_T, y_T)

Ranging function

clock cycle count

Time to distance conversion

ToA

Sensing platform

Broadcom B43 + WMP

implementation

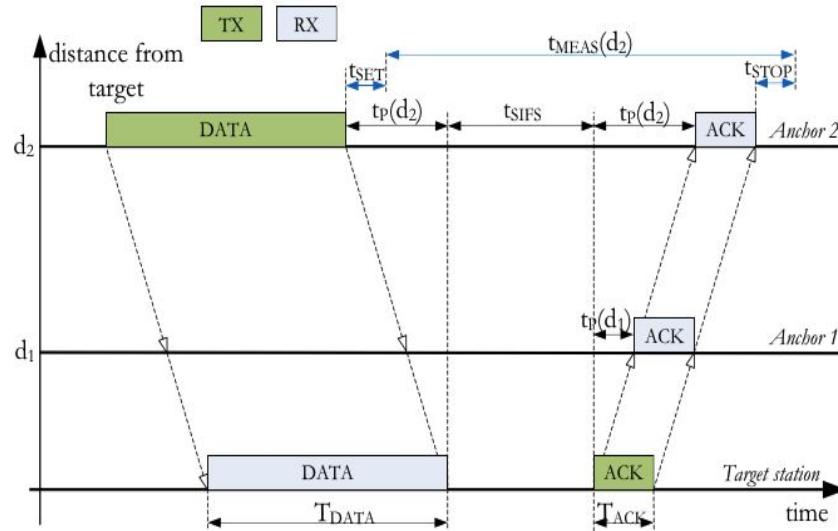
Programmable API defined in
firmware. WMP implementation

nanosecond time resolution
(88MHz clock freq)



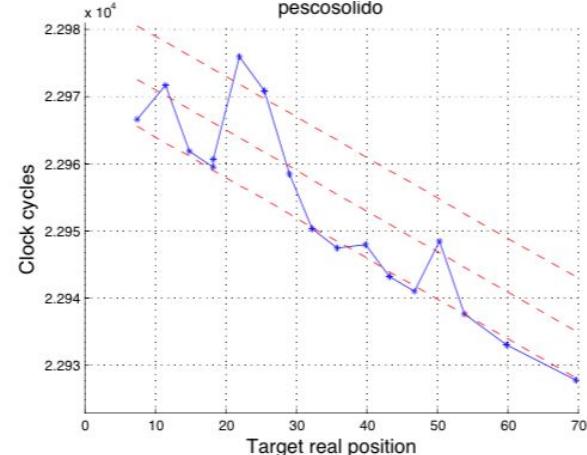
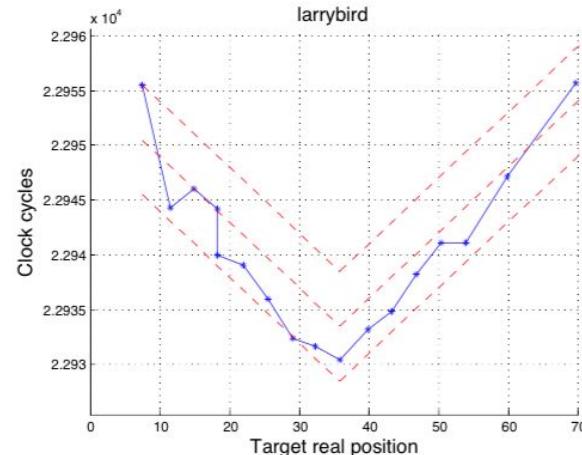
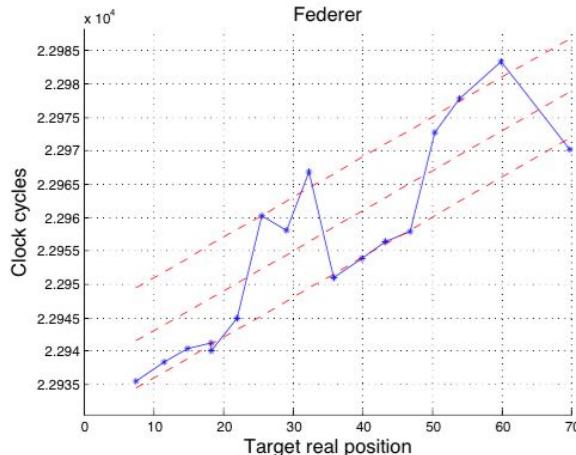
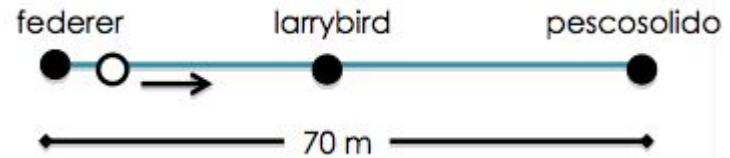
Welcome week

WMPS working principles



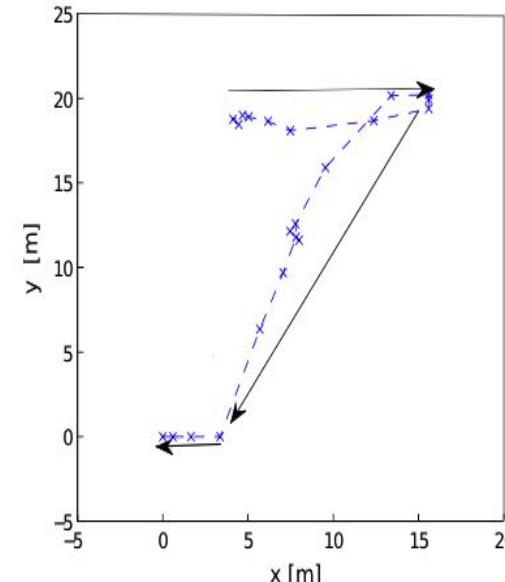
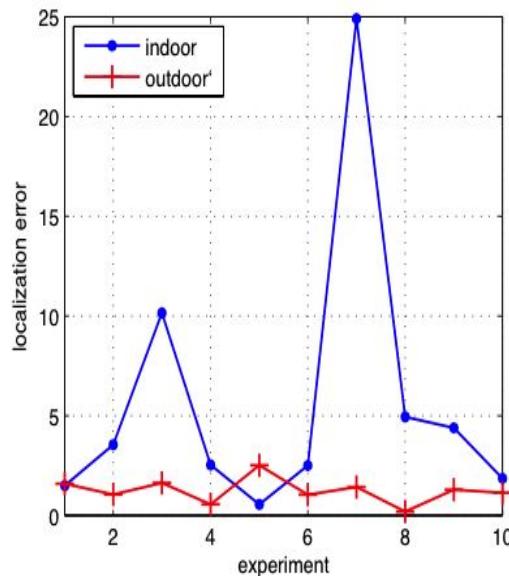
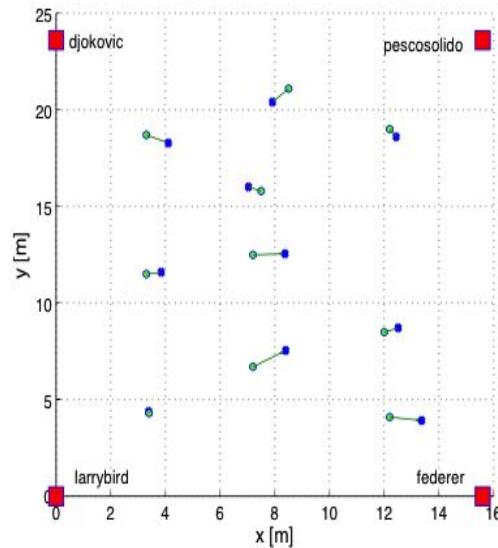
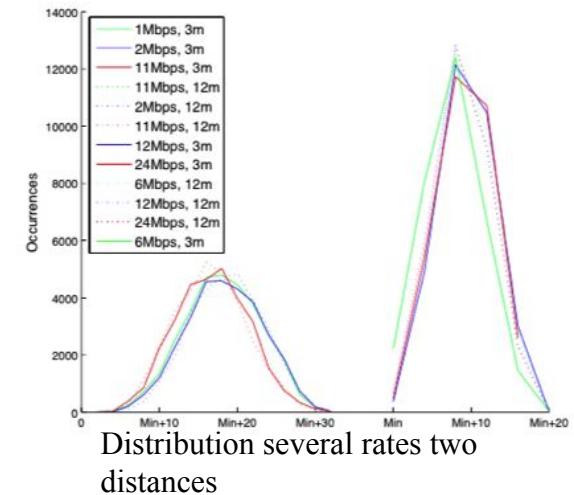
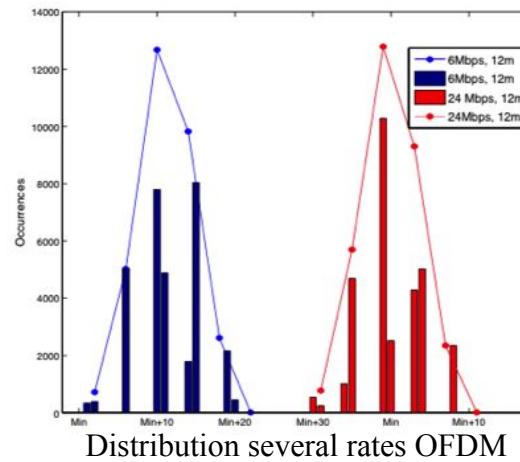
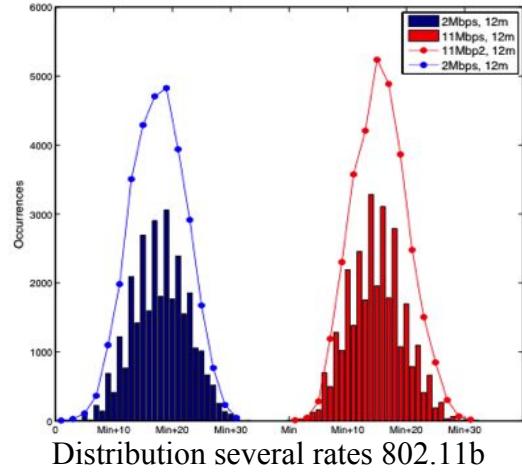
$$t_p(d_2) = [t_{meas}(d_2) - t_{SIFS} - t_{stop} + t_{set}] / 2$$

$$d_2 = t_p(d_2) \times c$$



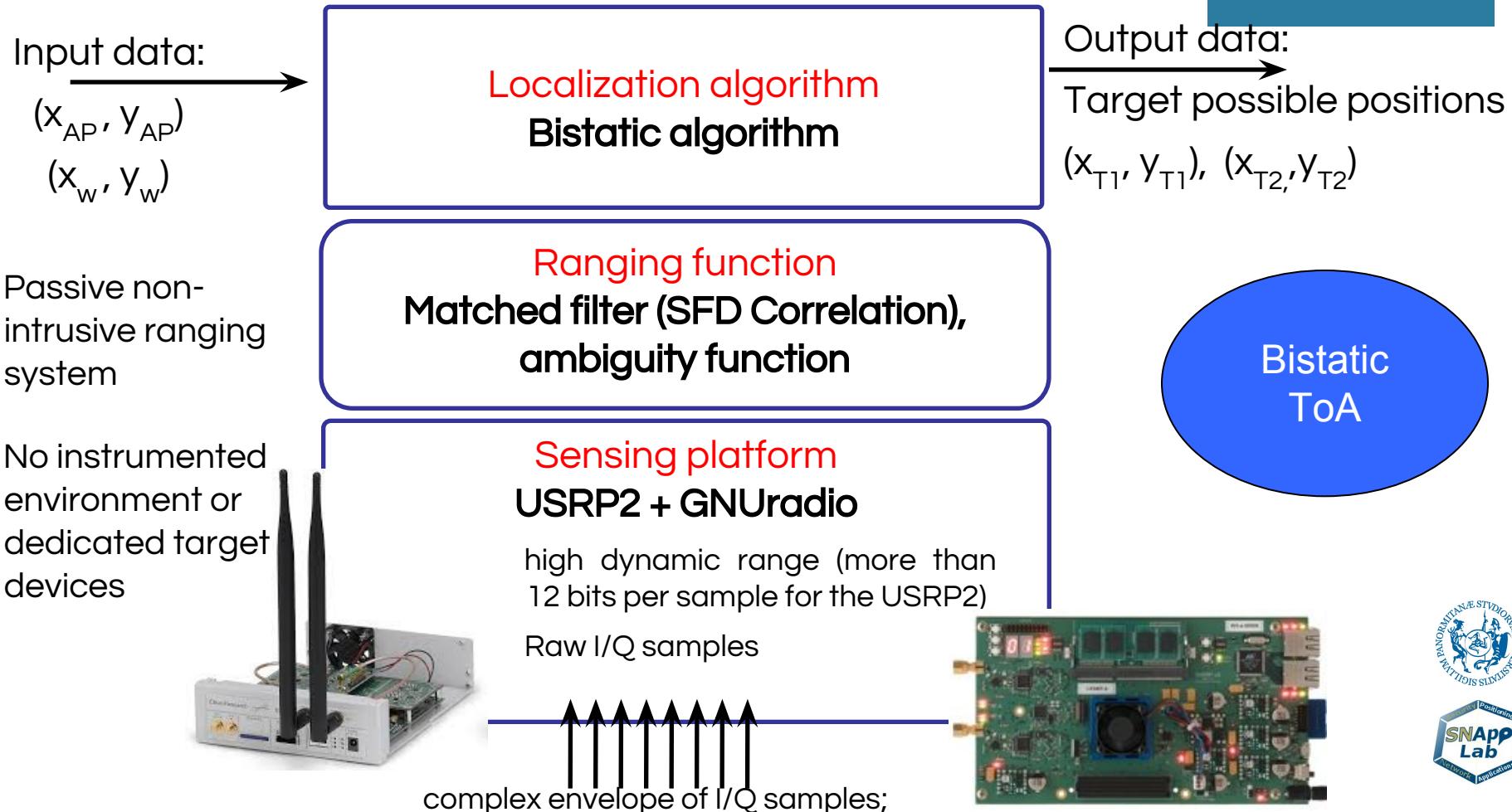
The AGC influence
Welcome week

WMPS - localization and tracking

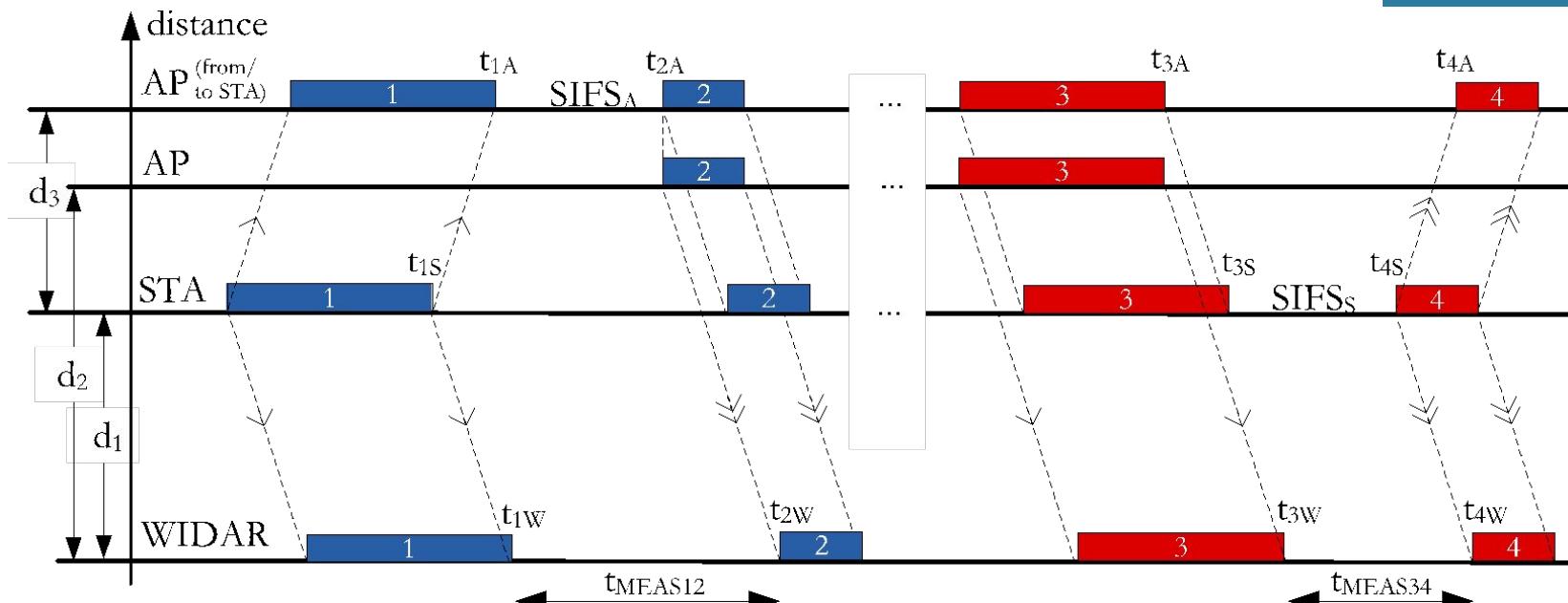


WIDAR: WI-fi Detection And Ranging

- Given the position of the APs and of the WIDAR(s), it estimates the target position



WIDAR: ToA and bistatic radars

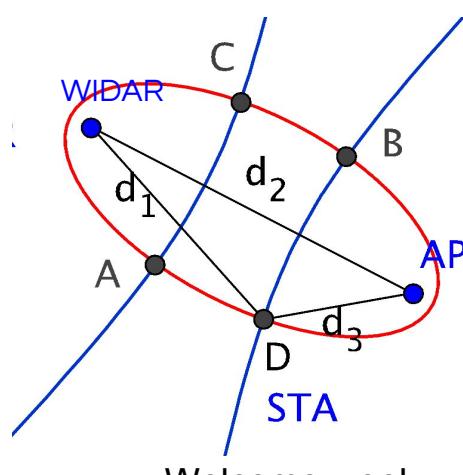


$$\left\{ \begin{array}{l} t_{MEAS12} = t_{2W} - t_{1W} \\ t_{2W} = t_{2A} + t(d_2) \\ t_{2A} = t_{1A} + SIFS \\ t_{1A} = t_{1S} + t(d_3) \\ t_{1W} = t_{1S} + t(d_1) \end{array} \right.$$

$$t(d_3) - t(d_1) = \alpha$$

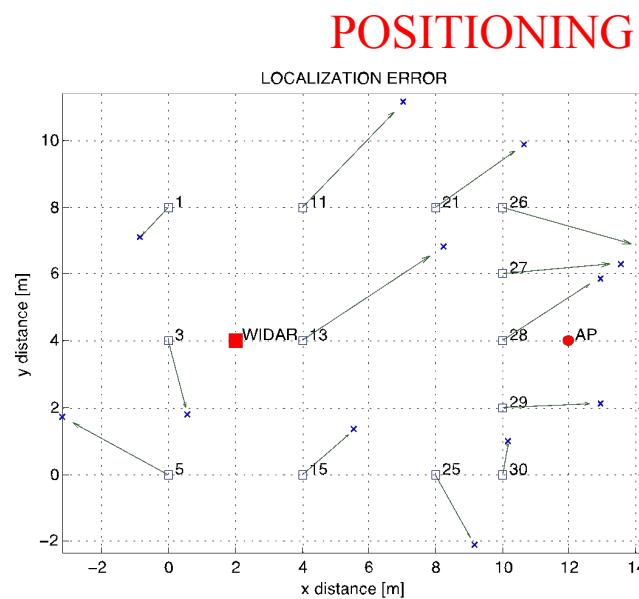
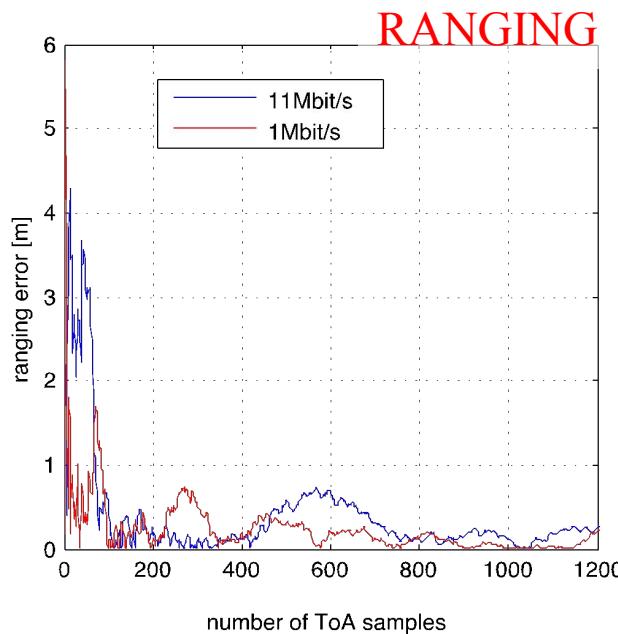
$$\left\{ \begin{array}{l} t_{MEAS34} = t_{4W} - t_{3W} \\ t_{4W} = t_{4S} + t(d_1) \\ t_{4S} = t_{3S} + SIFS \\ t_{3S} = t_{3A} + t(d_3) \\ t_{3W} = t_{3A} + t(d_2) \end{array} \right.$$

$$t(d_3) + t(d_1) = \beta$$



WIDAR

- Bistatic WI-fi Detection And Ranging [1]
- Ranging passivo (il target non sa di essere localizzato)
- Misura rapida (> 100 pacchetti scambiati tra target ed AP)
- Sufficientemente accuratezza già con un solo WIDAR



[1] P. Gallo, S. Mangione, G. Tarantino, "WIDAR: bistatic WI-fi Detection And Ranging for off-the-shelf devices" to appear in proceeding of WoWMoM2013, Madrid, Spain

WIDAR: componenti del sistema

- Chi deve localizzare un target deve:
 - Conoscere la propria posizione
 - Conoscere la posizione degli AP



Un numero maggiore di USRP2 consente una migliore precisione ed elimina l'incertezza nella pseudo-localizzazione



RSS-eye: 'guardare' la potenza ricevuta in base all'angolo

One image for each position, which includes RSSI profiles from all visible APs in [0,360].

Input data:

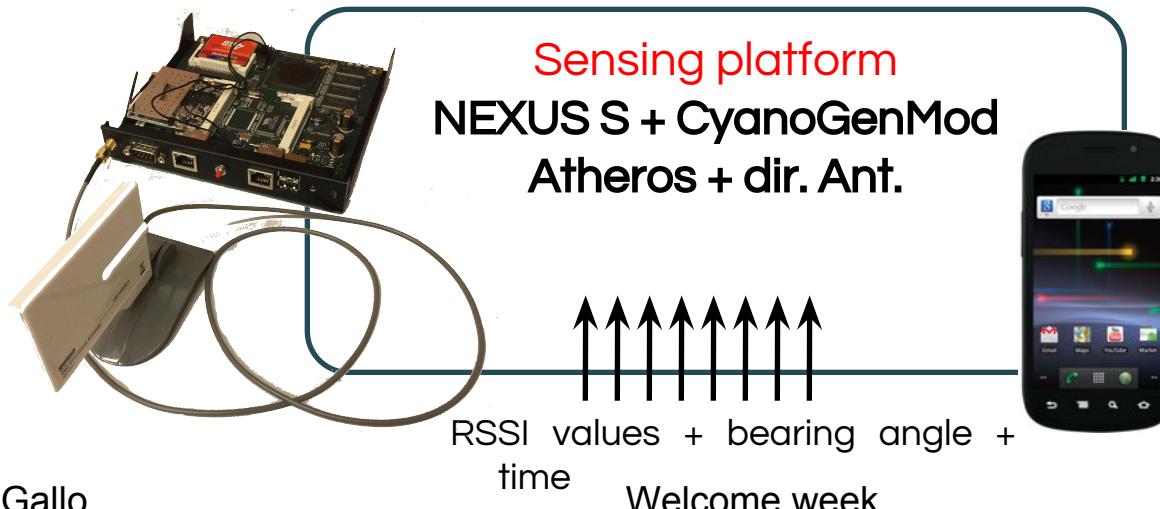
$$\{(x_{AP_i}, y_{AP_i}), i=1,2, \dots, N\}$$

**Localization algorithm
triangulation (among sectors)**

Output data:

$$\text{Target position } (x_T, y_T)$$

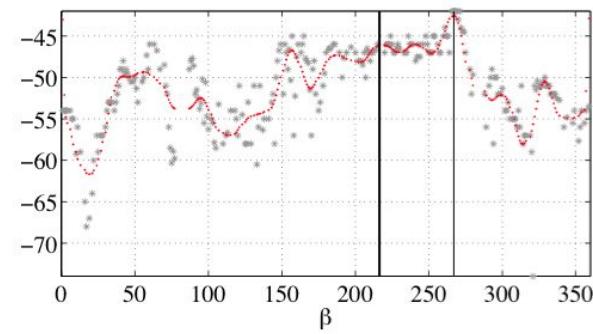
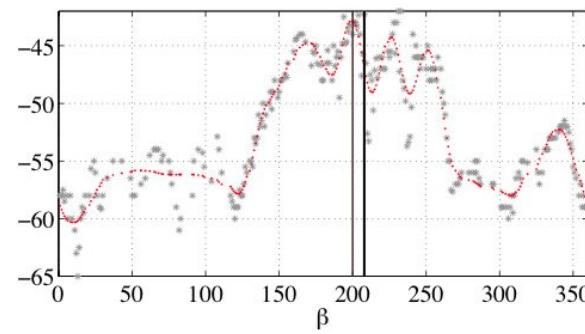
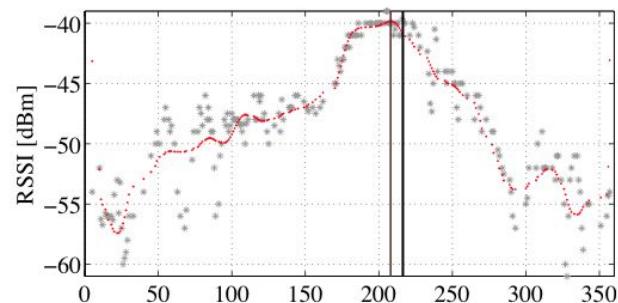
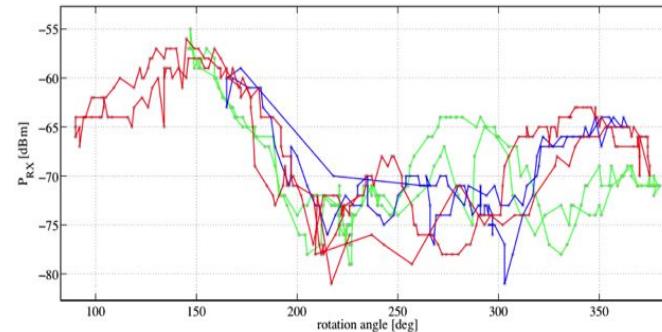
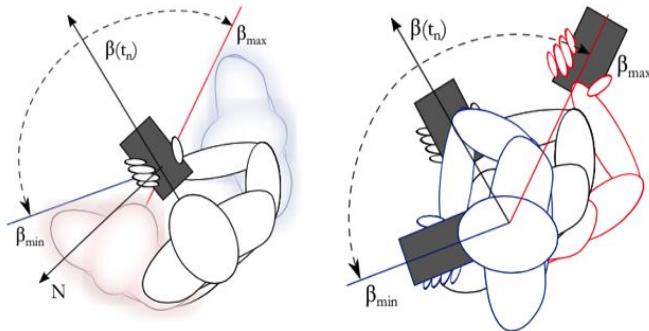
**Direction finding function
RSSI profile analyzer
AoA and Angle of direct path**



RSSI +
AoA +
human
interaction

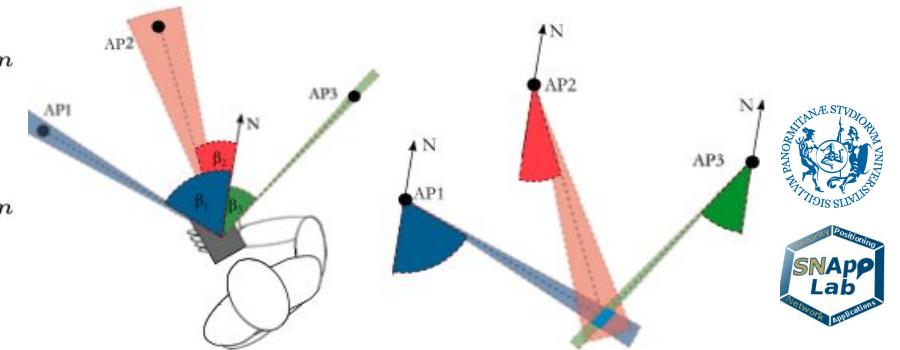


RSS-eye: RSSI + AoA + human interaction

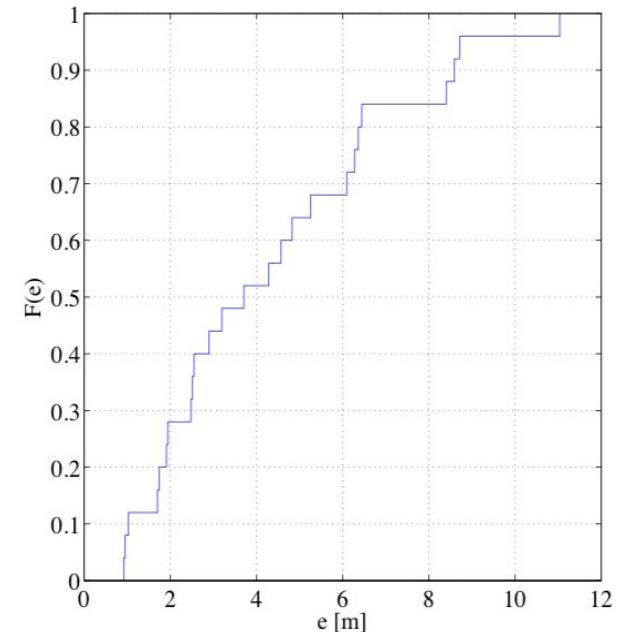
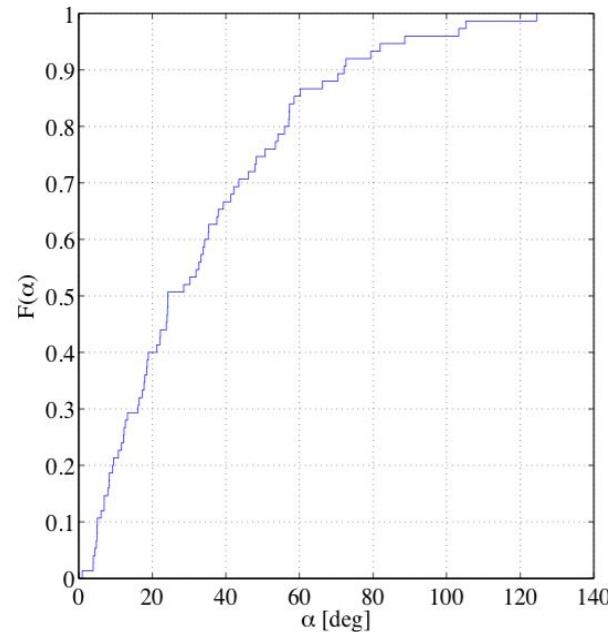
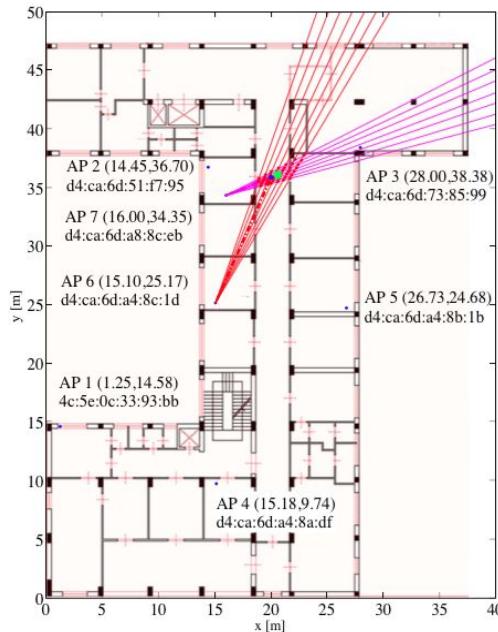


$$\text{Non-uniform FFT} \quad R_k = \frac{1}{N^{(\beta)}} \sum_{n=0}^{N^{(\beta)}-1} r(\beta_n) e^{-jk\beta_n}$$

$$\text{Smoothed RSSI profile} \quad \tilde{r}(\beta_n) = \sum_{k=1}^K R_k W_k e^{jk\beta_n}$$



RSS-eye performance evaluation



Good accuracy on angle estimation (median error 24°)

Sufficient accuracy on localization (median error 3.7m)

RSS-eye accuracy is comparable with methods that use fingerprinting but it doesn't use radio maps



Panoramic fingerprinting

50

Input data:

{RSSI, bearing angle}



Output data:
 (x_T, y_T)

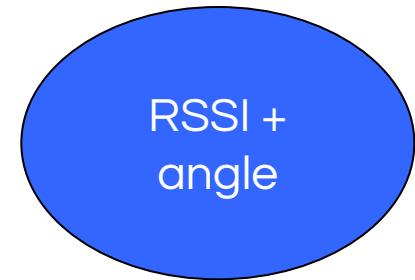


Sensing platform
NEXUS S + CyanoGenMod

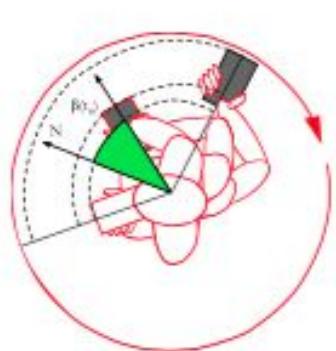
RSSI (Radio) +
angle (magnetometer)



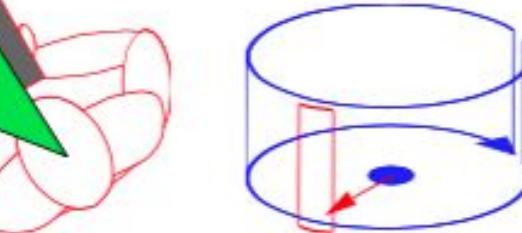
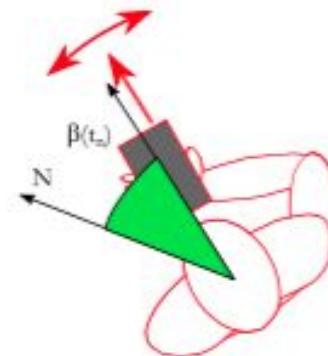
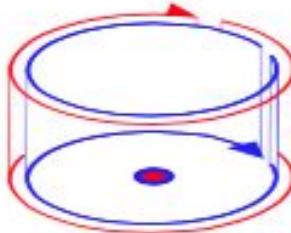
Welcome week



Panoramic angular fingerprinting



Panoramic fingerprinting



Angular fingerprinting

$$\Delta(k, h) = \frac{PPI^{(k-h)}}{\sum_{i=1}^M \sum_{j=1}^{360} x_{ij}}$$

where:

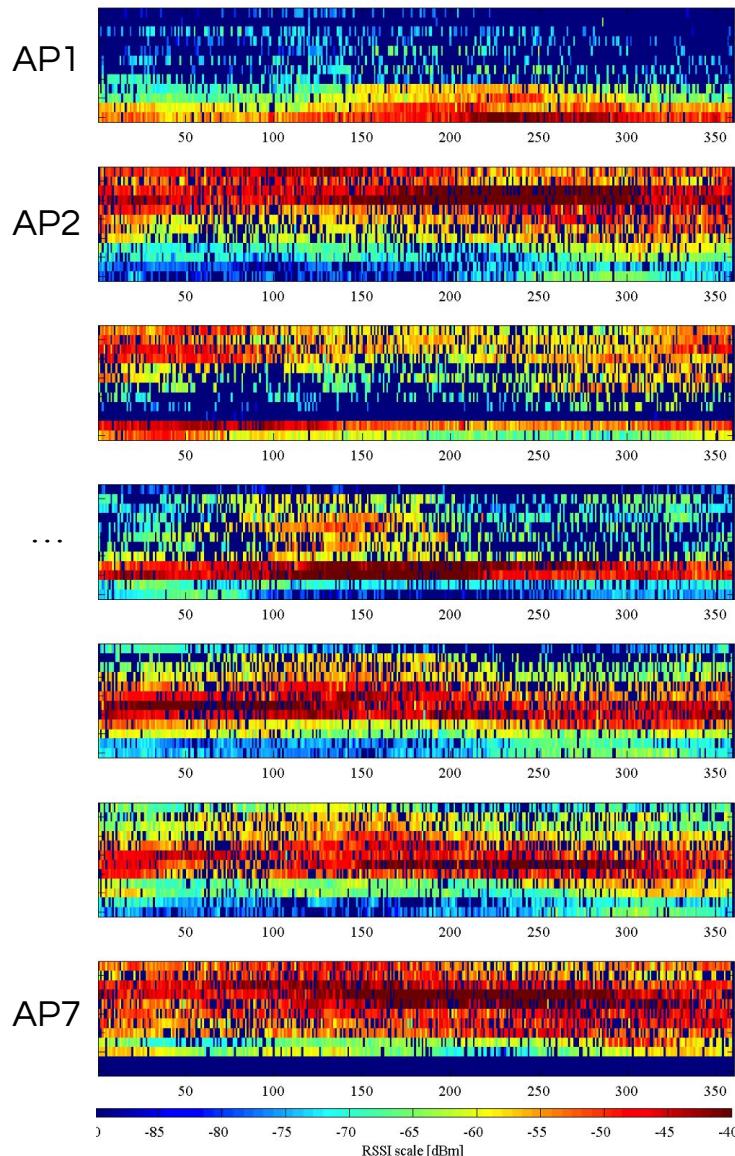
Difference between Panoramic Power Images (PPIs)

$$PPI^{(k-h)} = \begin{cases} abs(r_{ij}^{(k)} - r_{ij}^{(h)}) & if \exists r_{ij}^{(k)}, r_{ij}^{(h)} \in \mathbb{R} \\ 0 & otherwise \end{cases}$$

$$x_{ij} = \begin{cases} 1 & if \exists r_{ij}^{(k)}, r_{ij}^{(h)} \in \mathbb{R} \\ 0 & otherwise \end{cases}$$



Panoramic power images

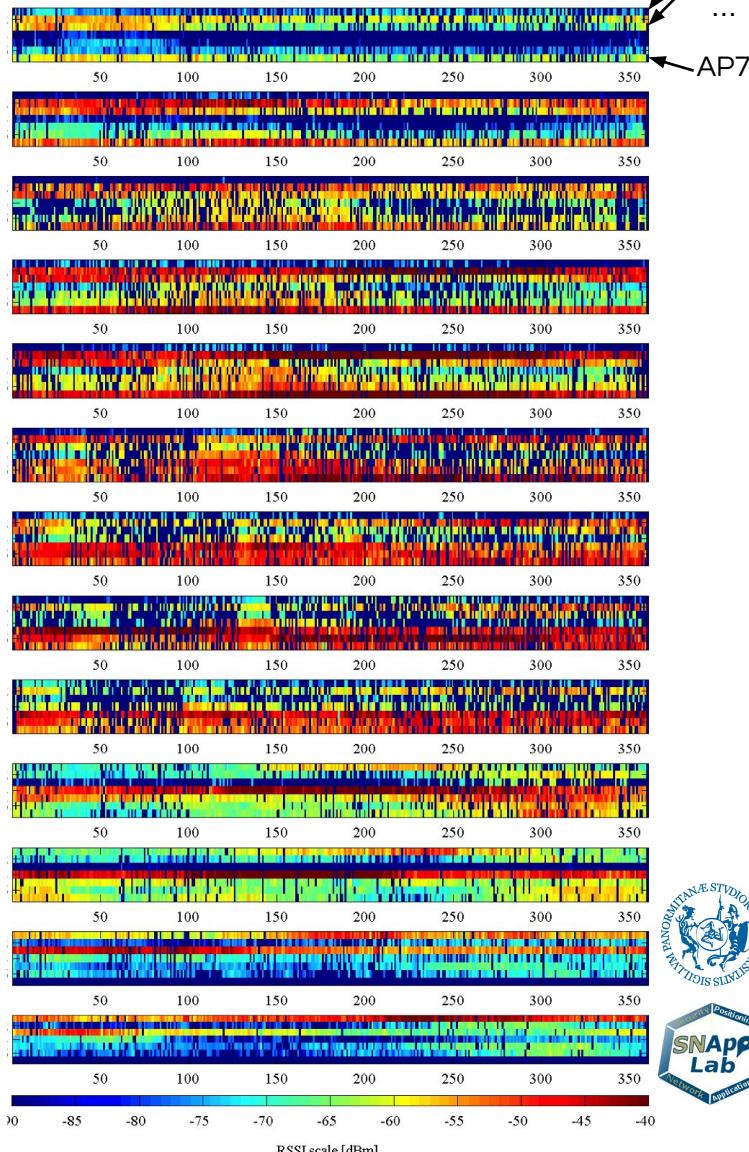


Positions
along a
path

Position 1

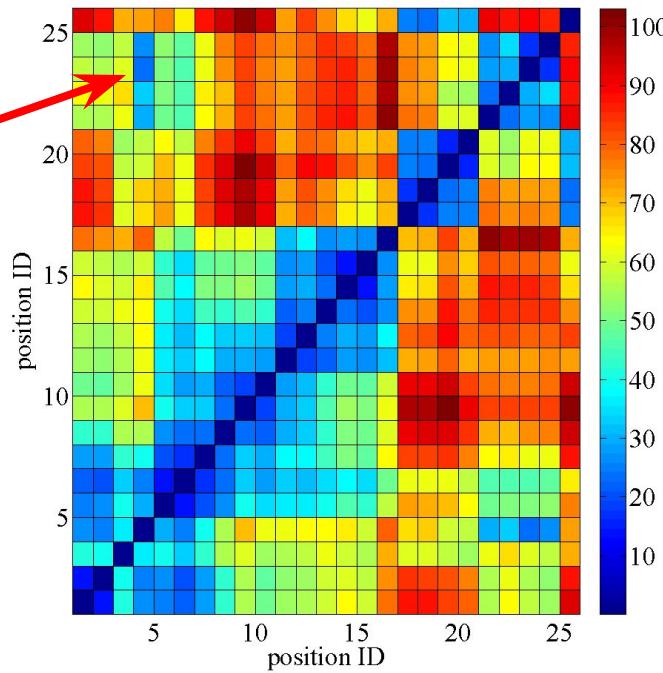
Position 2

Position 13



Panoramic fingerprinting: risultati sperimentali preliminari

The true position is (almost)
always get
In one case the
approximated position is
not the closest to the
ground truth.



Grazie per la vosta attenzione

Q&A

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