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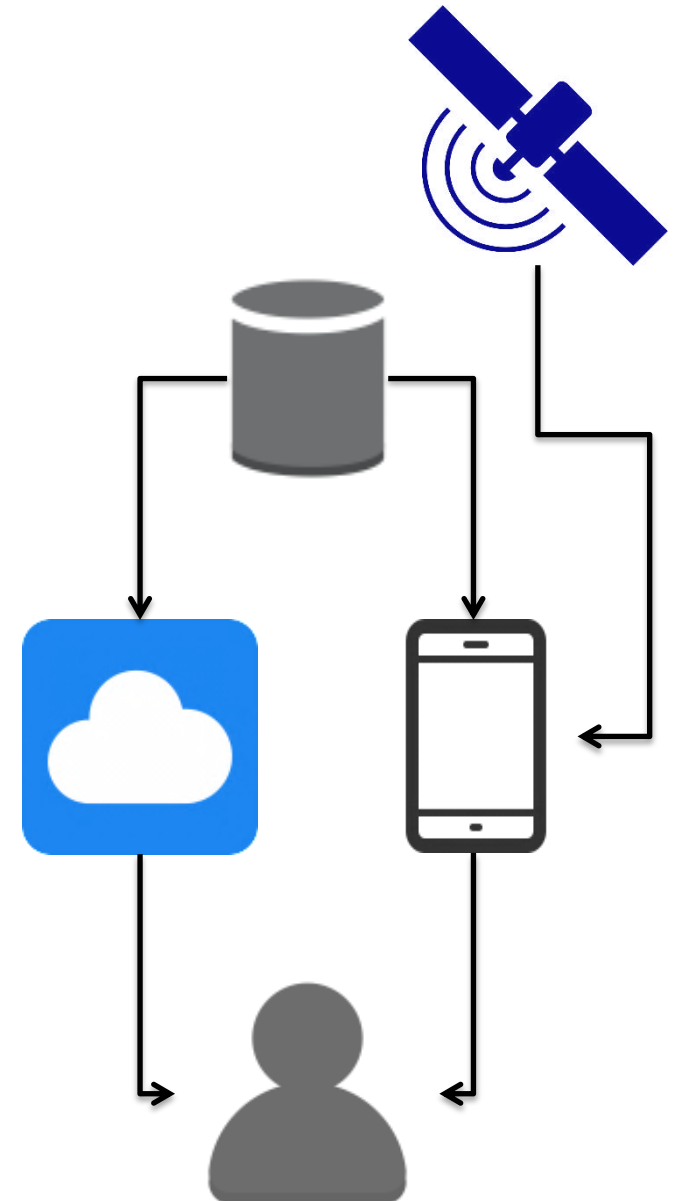


Location Privacy Protection & Tools

Mayra A. Zurbaran Nucci

Location-Based services

- ✓ It is a service that is usually offered through a mobile or web application
- ✓ These applications provide users with information based on their geographic position
- ✓ The user's location can be obtained from the mobile device they are carrying and accessing the service





- ✓ **Context-aware** news in real time
 - e.g. Traffic information, local news
- ✓ **Nearest place** of interest
 - e.g. siri-like applications; querying nearest gas station, library, etc.
- ✓ **Tracking** of goods in transit
- ✓ **Finding** lost devices
- ✓ **Buddy finder** applications or friend locator
- ✓ **Geo-fencing:** To know whether or not a subject is inside a delimited region, e.g. Monitoring children on amusement parks



“A special type of information privacy which concerns the claim of individuals to determine for themselves when, how, and to what extent location information about them is communicated to others...” [1]



Modern communications mean most individuals today walk around with a beacon that transmits their location

Through **location information data mining** could be inferred:

- ✓ User's home, place of work and residence of close friends
- ✓ Establish an estimated routine of daily activities
- ✓ **Your current physical location**
- ✓ User's economic status, health condition, social relationships
- ✓ When a user is out of town or away from home

Data mining uncovers some risky military spending habits

Some military and civilian Pentagon employees spent more than \$1 million on casinos and adult entertainment using government credit cards.



Visualization of Big Data

Through the city on a cloud of data

Whether we are phoning, looking for a partner online, networking via Facebook and Twitter or presenting our customer card when we go shopping – we leave digital traces everywhere. This adds up to veritable mountains of data – Big Data. A treasure trove. Yet how the treasure can be recovered

Where do people photograph what? Discovering patterns by geolocating images

By jeroen.barendse / June 20, 2013 / # references (visualization) / One Comment

Some initial tests to see if the geolocation of a picture has influence on its topic and distance of focus. In these examples you see very obvious differences in what people photograph on which location. The pictures here are taken from Flickr.com and represent the area around Schiphol International Airport. We will explore this further in the project, with different data sets.

Crowds 'could be counted' with phone and Twitter data

By Jonathan Webb
Science reporter, BBC News

27 May 2015 | Science & Environment



Where do people tweet during the Taksim-square protests in Istanbul?

By jeroen.barendse / July 8, 2013 / # references (visualization) / No Comments

Small test using 48 hours of geolocated tweets in Istanbul, gathered during the protests at Taksim-square in Istanbul. Although there is a clear density at the square, it is even more obvious that people tweet most from the bars and clubs along the Bosphorus, showing a distinct border of land and water and even the bridge over the Bosphorus. Tweets are color-coded for the time they have been send. This is a first iteration of a series, which will be elaborated further.

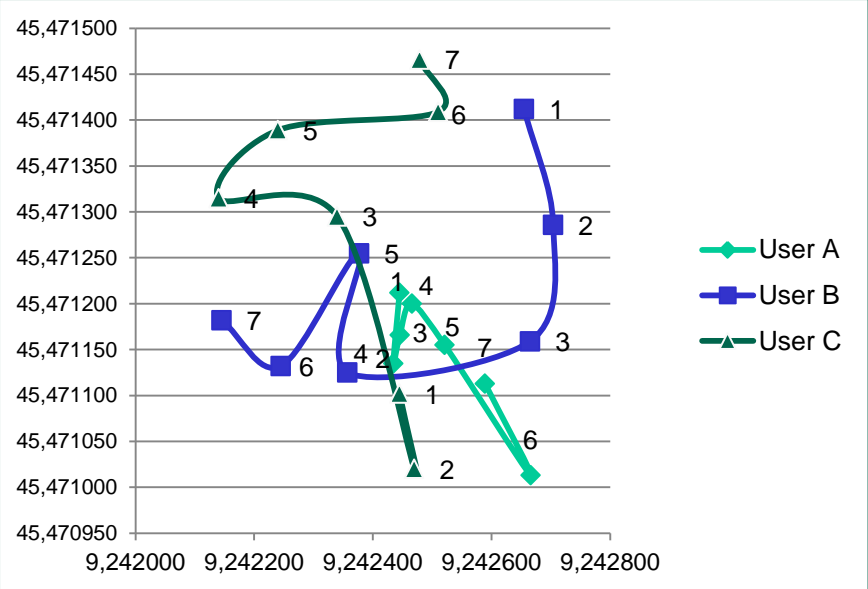




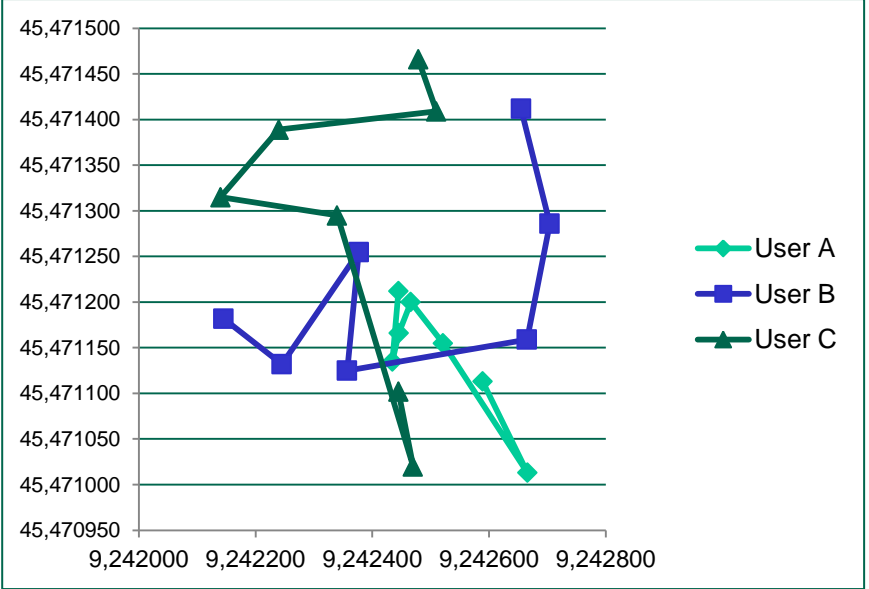
- ✓ On 2010 EU developed the European Union Directive on Privacy and Electronic Communications [2]
- ✓ On 2014 in the US was presented the Location Privacy Protection Act in congress by senator Al Franken
 - ✓ It is not official yet



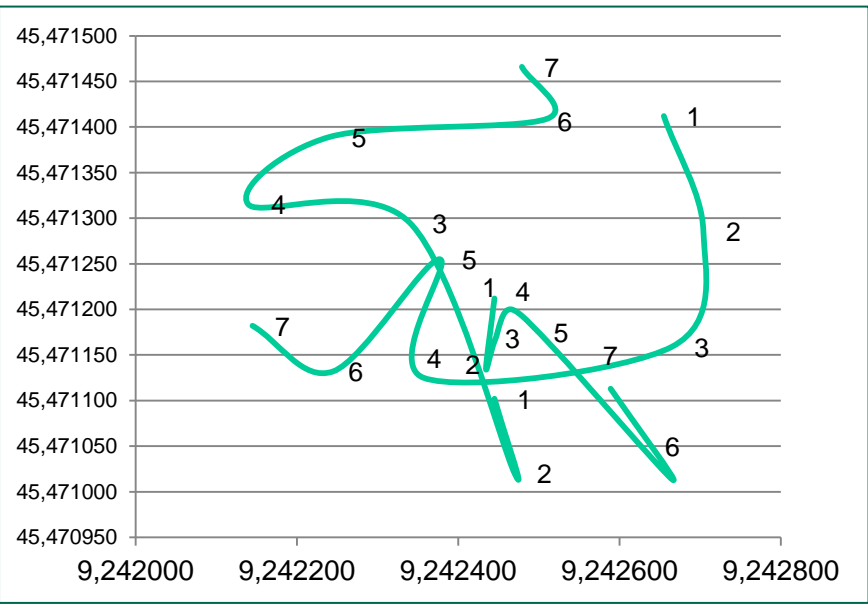
Location Information Components



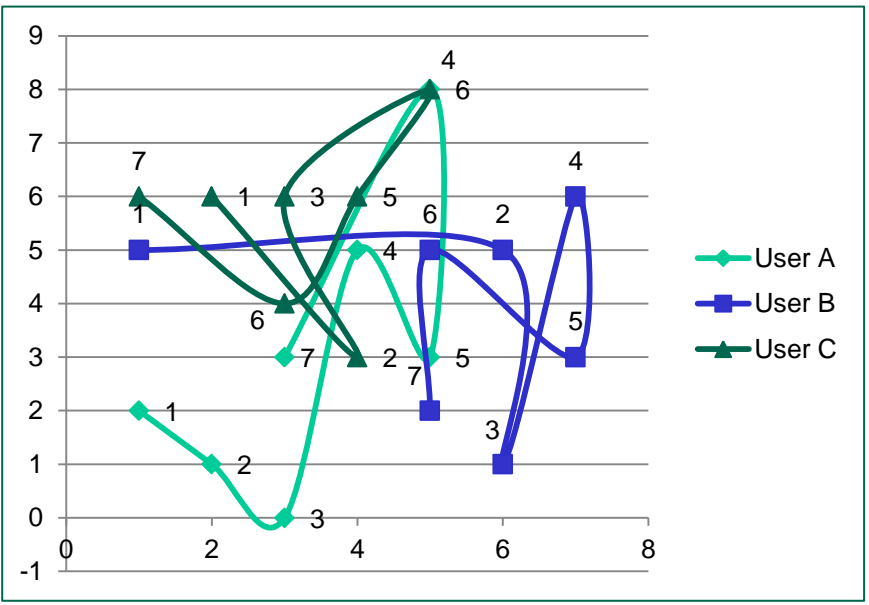
Location Information Without Protection



Location Information Without Time



Anonymous Location Information



Location Obfuscation



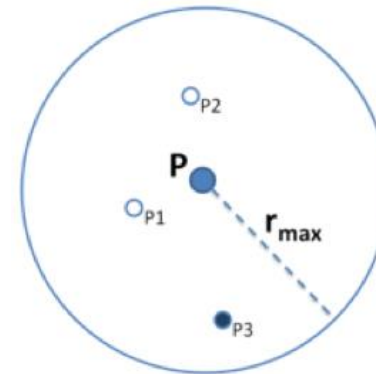
“The means of deliberately degrading the quality of information about an individual's location in order to protect that individual's location privacy”[4]



- ✓ Cryptography [5][6][7]
- ✓ Private Information Retrieval [8][9][10]
- ✓ Anonymity [11]
- ✓ K-Anonymity [21][22]
 - ✓ Temporal/Spatial Cloaking
- ✓ Noise-Based [12][13][14][15][16][17]
- ✓ Dummy Queries [18]
- ✓ Pseudonyms [19]
- ✓ Spatial Transformation [20]

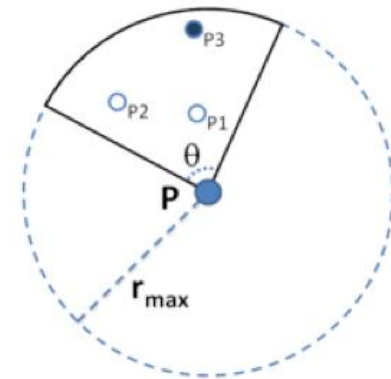


a) N-Rand: Generates n random points within a circular area where $r=r_{\max}$ and chooses the furthest generated point from the original [15].



(a) N-RAND

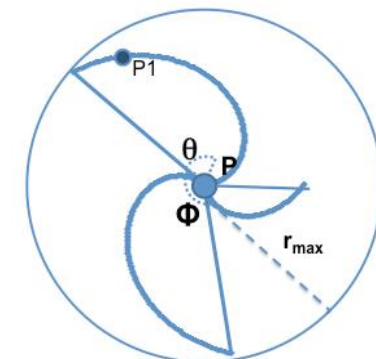
b) θ -Rand: The dominion is limited to a circle sector with a θ angle [14].



(b) θ -RAND

c) Pinwheel: Determines the radius for a given angle in the circle with the formula [16]:

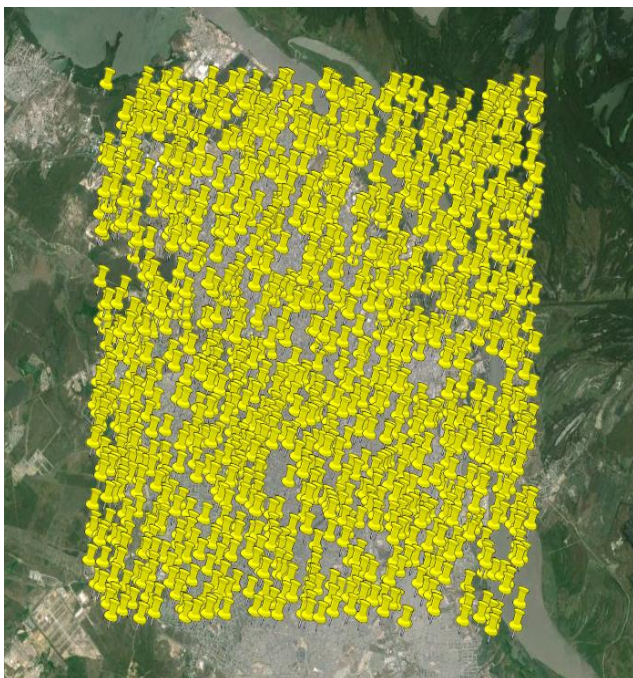
$$r_{\theta} = (\theta \bmod \varphi) / \varphi \cdot r_{\max}$$



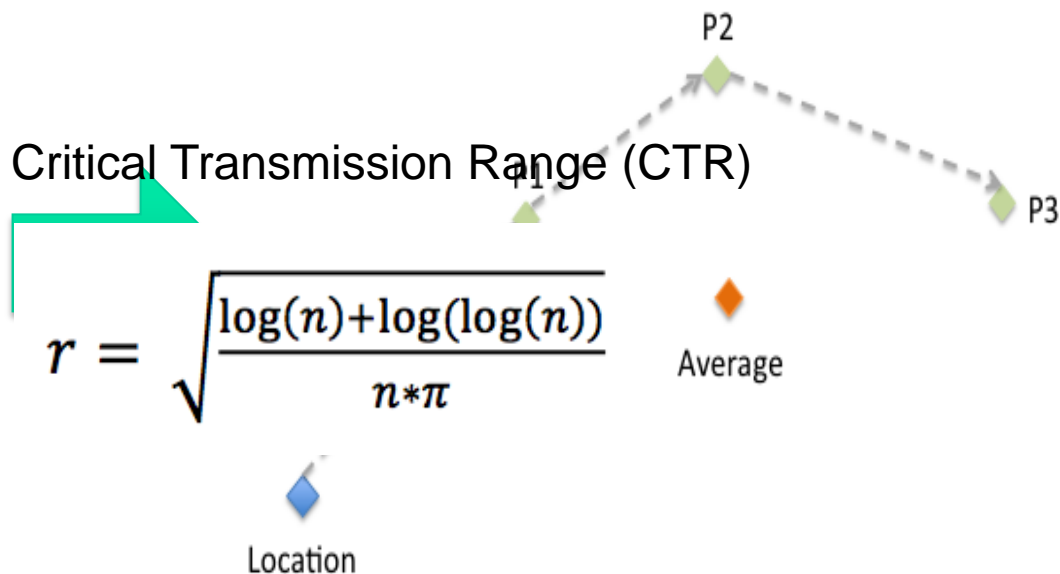
(c) Pinwheel



1. Setup of p points in the city of Barranquilla



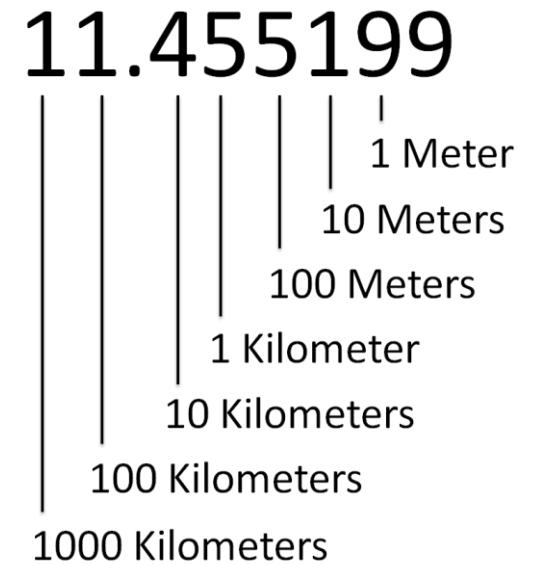
2. Average point calculation





- ✓ Private information retrieval (PIR) mechanism
- ✓ Uses query replication to obfuscate user's location in a squared grid
- ✓ MaPIR needs two basic operations:
 - Location reduction
 - Calculates an ID to represent the location
 - Must have geographical meaning
- ✓ Mapping function
 - Uses the reduced location to create an ID for the location of the user
 - IDs are not unique and are arranged in a symmetric appearance inside the large grid.

Kth digit Location Reduction



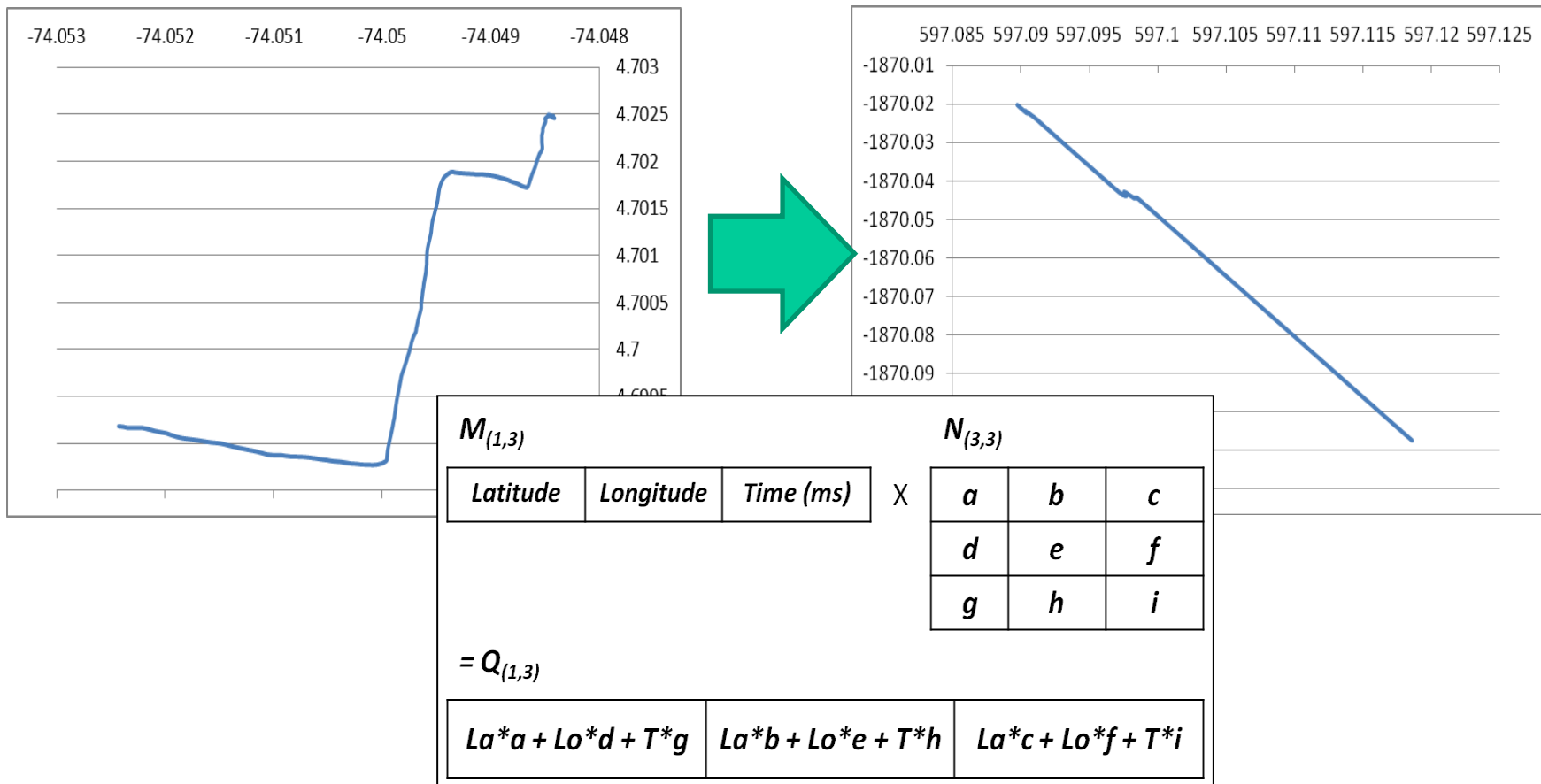
	10	9	8	7	6	5	4	3	2	1
10	1	2	3	4	5	6	7	8	9	10
9	2	4	6	8	10	1	3	5	7	9
8	3	6	9	1	4	7	10	2	5	8
7	4	8	1	5	9	2	6	10	3	7
6	5	10	4	9	3	8	2	7	1	6
5	6	1	7	2	8	3	9	4	10	5
4	7	3	10	6	2	9	5	1	8	4
3	8	5	2	10	7	4	1	9	6	3
2	9	7	5	3	1	10	8	6	4	2
1	10	9	8	7	6	5	4	3	2	1



$$ID(i, j) = ((i + 1) * (j + 1)) \bmod 11$$

- ✓ Kth digit reduction and Pseudo-random Map
- ✓ The combination of mapping and reduction allows for multiscale mapping
- ✓ Location (10.964824,-74.804778) may have different cell IDs depending on the scale

<i>k</i>	Reduced Latitude	Reduced Longitude	<i>i</i>	<i>j</i>	Id
3	4	4	5	5	3
2	6	0	7	1	7
1	9	8	10	9	2





Location Information Available in Lombardia

Name	URL	License	Data	Examples	Tool
Geoportale della Lombardia	http://www.geoportale.regione.lombardia.it/en/download-dati#	Open	Vector or raster. Limited to 5 downloads		Downloads
Flickr	http://flickr.com	Open	Geotag in photos		API
TripAdvisor	https://developer-tripadvisor.com/content-api/	Open for travel apps or websites	Geolocated places		API
Instagram	https://instagram.com/developer/endpoints/locations/	Open for applications different from media viewers	Geolocated photos	https://sparkloftmedia.com/blog/case-study-instagram-usage-in-milan/	API
OpenStreetMaps	https://www.openstreetmap.org	Open	Roads information, trains and metro lines, cities information		API
Twitter	https://dev.twitter.com/	Open (public tweets)	Public geolocated tweets	http://www.bbc.com/news/science-environment-32883015	http://aidr-prod.gc.org_API
EveryTrail	https://www.everytrail.com	Open	Public tracks of users	http://www.everytrail.com/view_trip.php?trip_id=1541974	Downloads
BikeMap	http://www.bikemap.net	Open	Public tracks and type of road		Downloads
GPS Tour Info	http://www.gps-tour.info/en	Open (has to be registered)	Tracks available in different formats		Downloads
OpenRunner	http://www.openrunner.com/index.php	Open	GPS coordinates of tracks		Downloads
GPSies	http://www.gpsies.com	Open	GPS coordinates of tracks		Downloads
WikiLoc	http://www.wikiloc.com	Open (has to register)	GPS coordinates of tracks		Downloads
Single Tracks	http://www.singletracks.com	Open	Image of track (hiking), no GPS coordinates available to download		Downloads



Location Information Available in Lombardia

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Name	URL	License	Data	Examples	Tool
WanderMap	http://www.wandermap.net	Open	GPS coordinates of tracks		Downloads
Giscover	http://www.giscover.com	Open	GPS coordinate of different kind of trips (sports mainly) and Pols		Downloads
Strava	https://www.strava.com	Private	Images of the most concurred tracks in the world and the number of people		
Telecom Data	https://dandelion.eu/datagems/SpazioDati/telecom-sms-call-internet-mi/resource/	Open for research	Information of 2014 of Telecom data by time intervals and squared grids. Specifies the nation.		Downloads
ATM Milano	http://www.atm.it/en/ViaggiaConNoi/Pages/ATMMobile.aspx	Private	Information on bus stops, train stations, bike parking, etc. In Milan		App



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