National Cartographic Center

UBIQUITOUS AND MOBILE GIS

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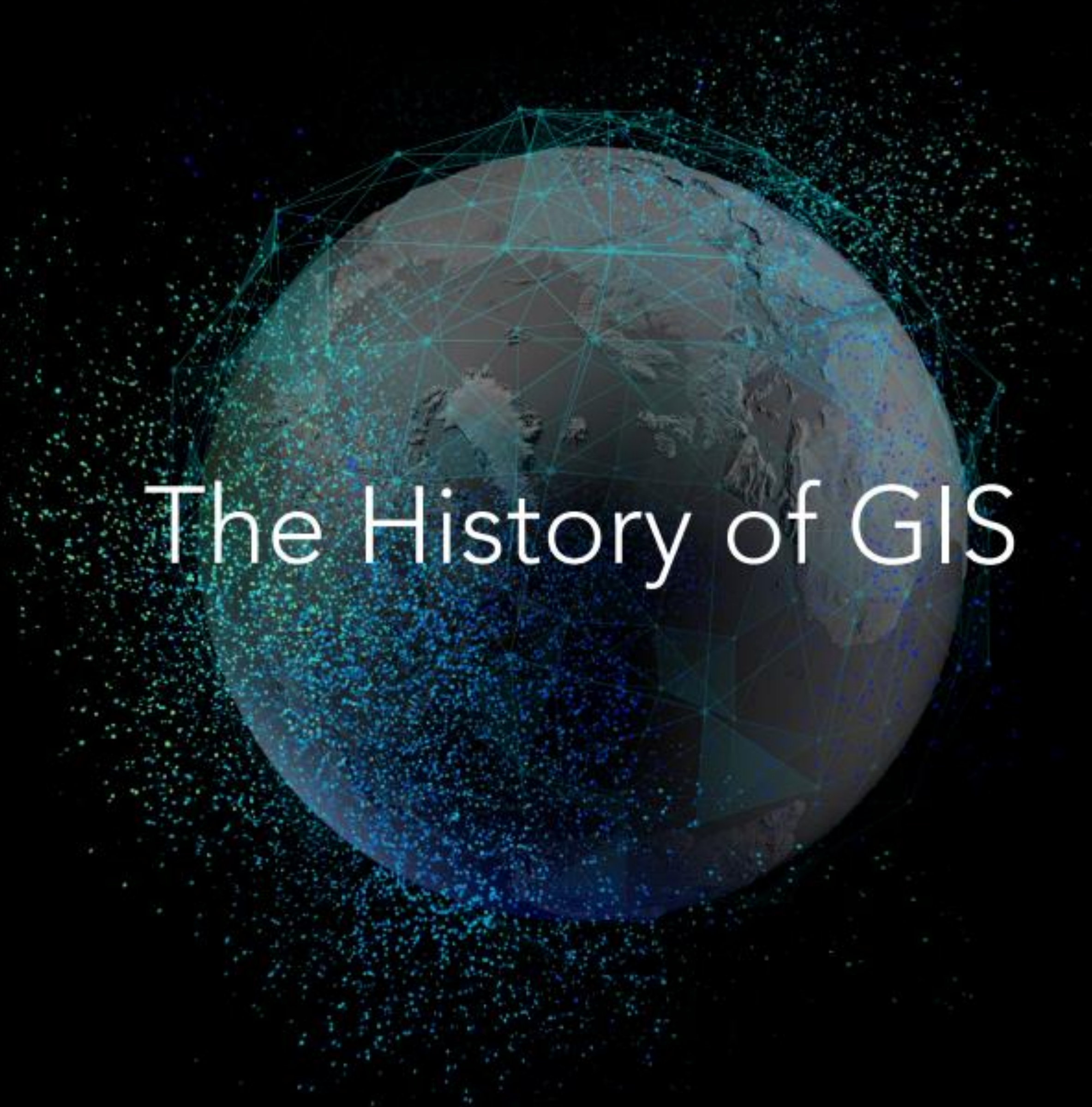
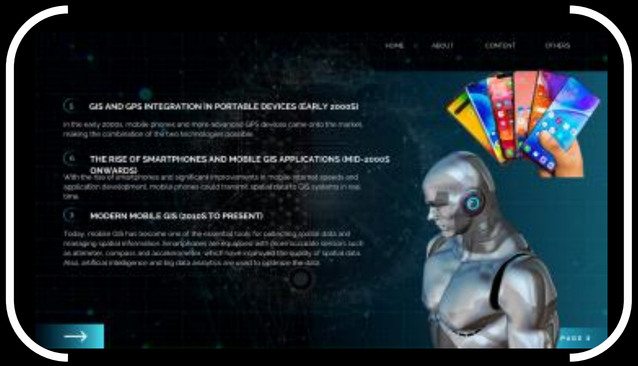
Cartography and National Atlases Departement

The History of GIS





HISTORY

1. THE FIRST MAPS

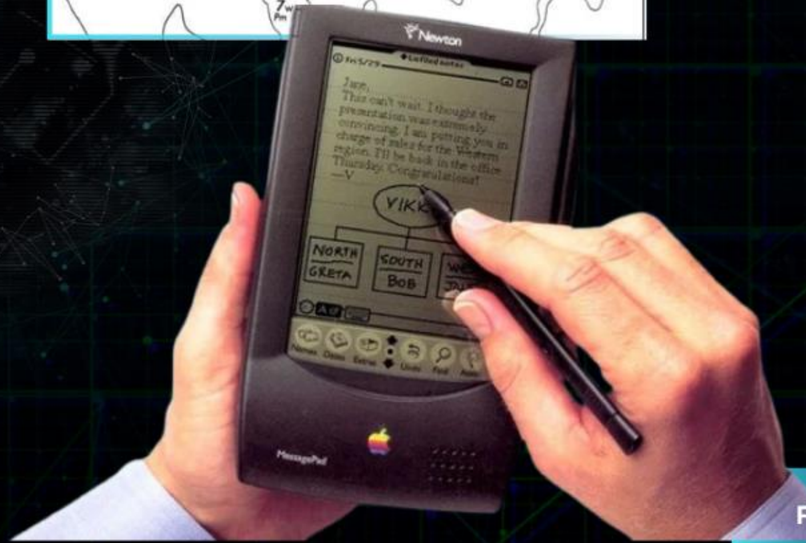
The roots of GIS go back hundreds, even thousands of years in the fields of cartography and mapping. Early maps are used for exploration, strategy, and planning.

2. THE BEGINNING OF GIS (1960S)

The first GIS applications were mainly used for processing and analyzing geographic data on mainframe computers and were severely limited by heavy hardware and software.

2. THE EMERGENCE OF PORTABLE GPS DEVICES (1980S)

In the 1980s, GPS technology entered the market, marking the first steps toward using location data on portable devices. GPS allowed users to determine their geographic location, but it was not yet connected to GIS systems.



2. DEVELOPMENT OF EARLY GIS ON SMALL COMPUTERS (1990S)

In the 1990s, computers became smaller and more portable. During this period, GIS was available on laptops and personal digital assistants (PDAs), which users could use to store and analyze geographic information for field projects.

5. GIS AND GPS INTEGRATION IN PORTABLE DEVICES (EARLY 2000S)

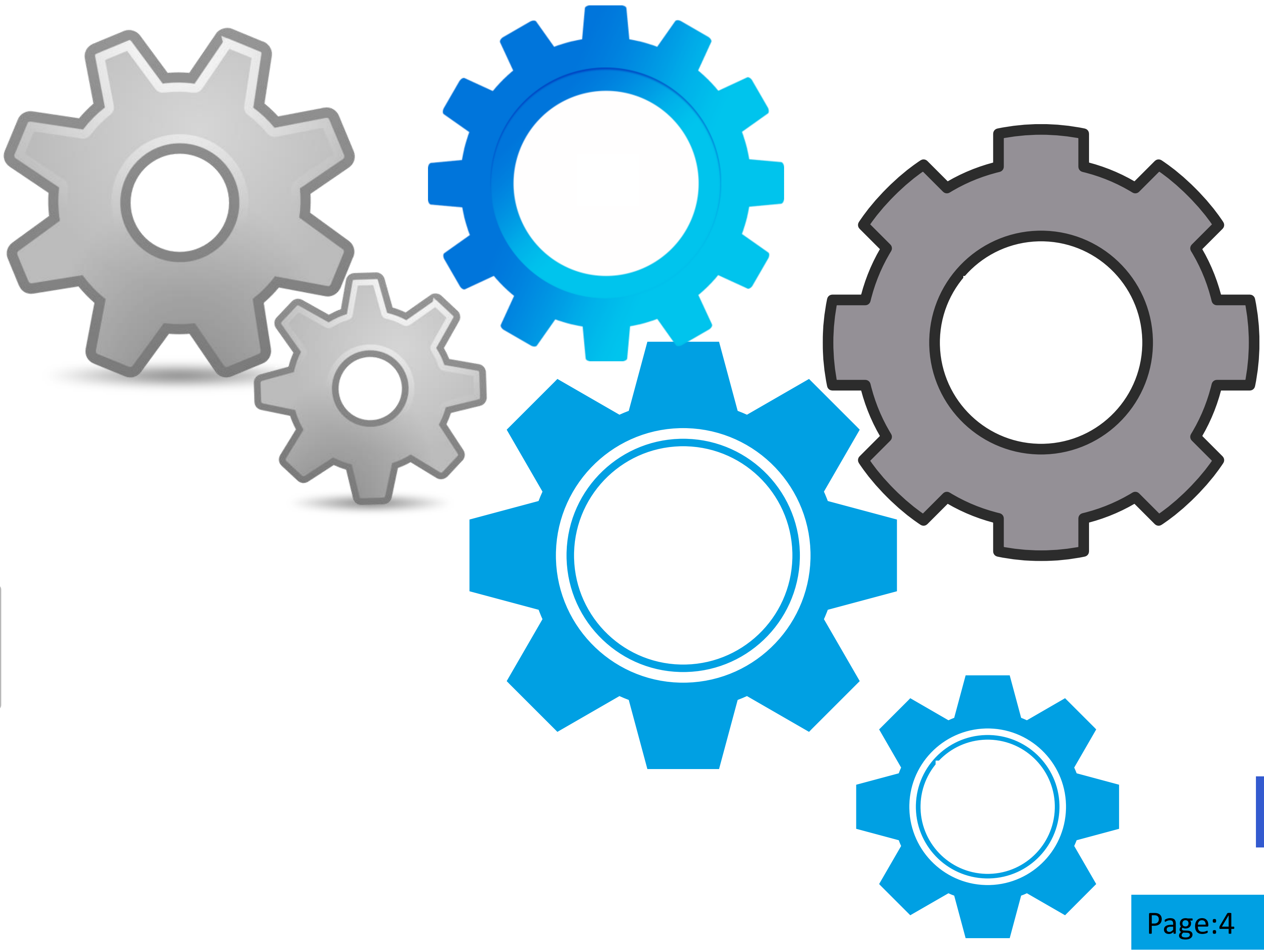
In the early 2000s, mobile phones and more advanced GPS devices came onto the market, making the combination of the two technologies possible.

6. THE RISE OF SMARTPHONES AND MOBILE GIS APPLICATIONS (MID-2000S ONWARDS)

With the rise of smartphones and significant improvements in mobile internet speeds and application development, mobile phones could transmit spatial data to GIS systems in real time.

7. MODERN MOBILE GIS (2010S TO PRESENT)

Today, mobile GIS has become one of the essential tools for collecting spatial data and managing spatial information. Smartphones are equipped with more accurate sensors such as altimeter, compass and accelerometer, which have improved the quality of spatial data. Also, artificial intelligence and big data analytics are used to optimize the data.



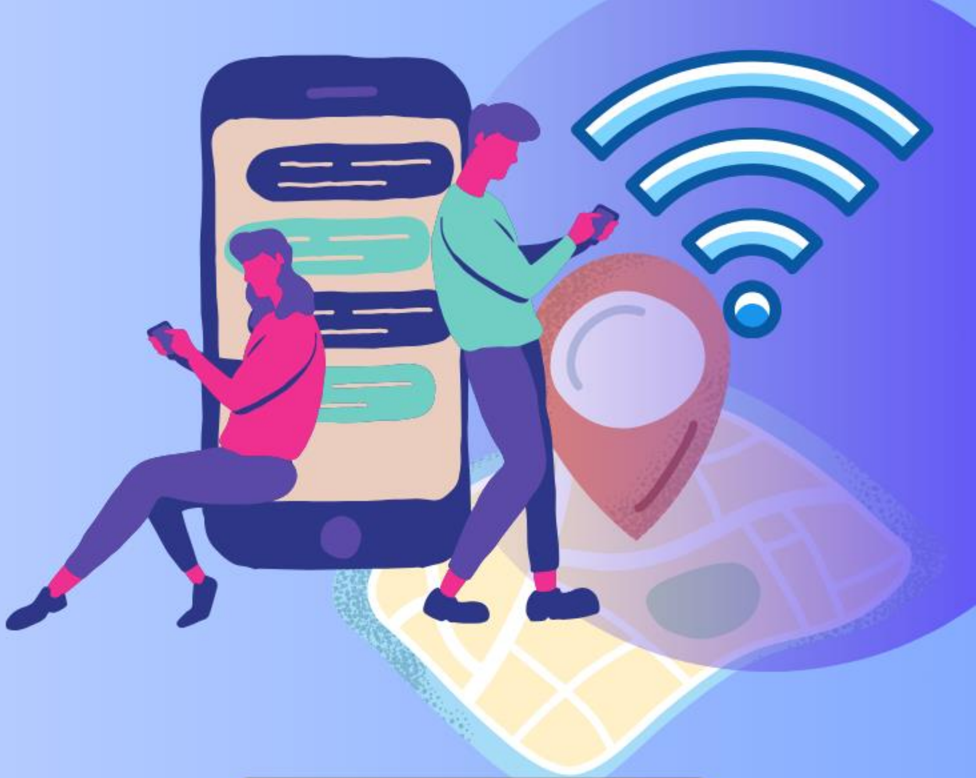
Mobile **GIS**

Mobile Computing is a generic term describing the application of small, portable, and wireless computing and communication devices.

Explore Now

Play Video

MOBILE COMPUTING

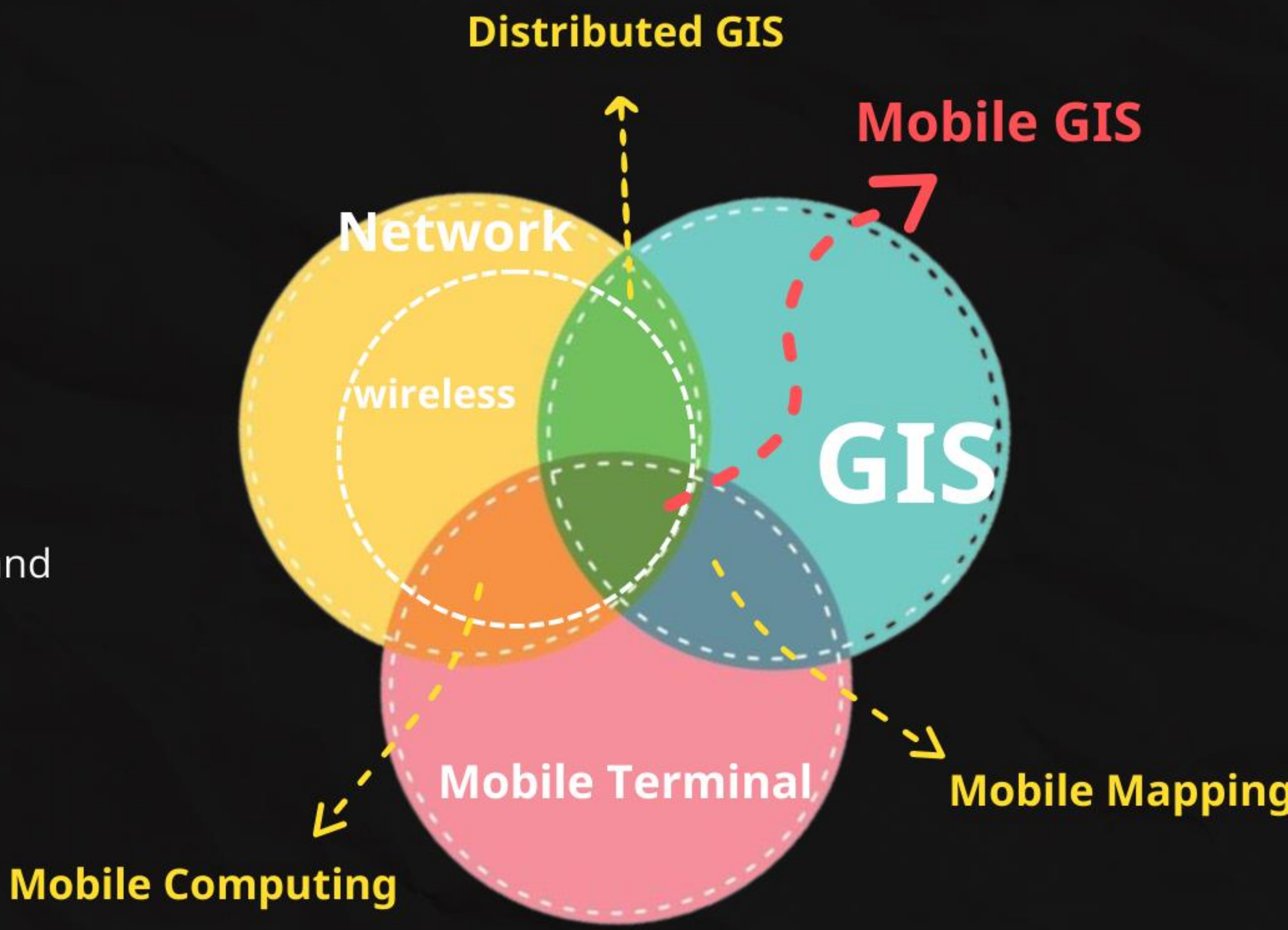


Mobile Computing is a generic term describing the application of small, portable, and wireless computing and communication devices.

- User Mobility
- Network Mobility
- Bearer Mobility
- Device Mobility
- Service Mobility

MOBILE GIS

- "Holy Grail" for GIS, A GIS in "post-PC" era, etc.
- Mobile GIS refers to the access and use of GIS data and functions through mobile and/or wireless devices.
- A GIS about non-geographic objects.
- A personalized (who) , timely (when), location-based (where) Geo-service for mobile objects.



The mobile GIS is not a conventional GIS modified to operate on a smaller computer but is a system built using a fundamentally new paradigm.

LIMITATIONS

- Computational resources (processor speed, memory, etc.)
- User interfaces (display, pointing device, etc),
- Network problem (bandwidth, latency, etc)
- Energy source
- Shortcoming of a theoretical framework

4 main components of mobile GIS

PERSONALIZATION

GIS is a general word, when we say mobile gis, we have personalized it in some way, for example routing algorithms

TIME

The environment should be dependent on time. Do not give the same answers at different times.

GEOSERVICE

In the sense that it is towards services and supports services

LOCATION BASE

Location is important in all GIS, but here it is like the location of the user

UBIQUITOUS GIS

Wireless NETWORKS

Home | Video | About Us | Contact

01 Wireless communications is an important networking infrastructure of the world.Wireless networks have unique challenges and network operations not seen in wired networks.

02 Elements: hosts, base station, wireless link

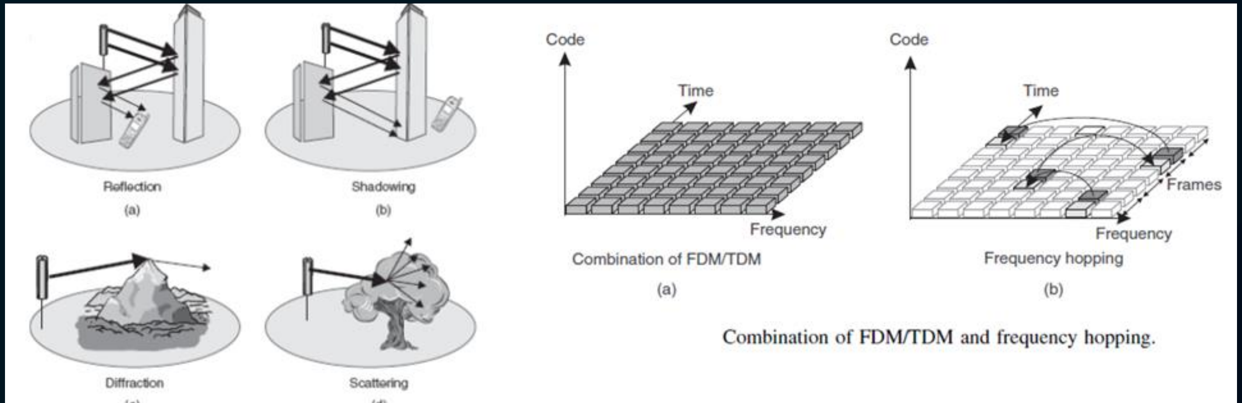
03 **Differences from wired link ….**

- decreased signal strength:radio signal attenuates as it propagates through matter (path loss)
- interference from other sources:standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- –multipath propagation:radio signal reflects off objects ground, arriving ad destination at slightly different times

modulatin:FM, AM, PM

MultipleAcsses: SDMA, FDMA,TDMA, CDMA

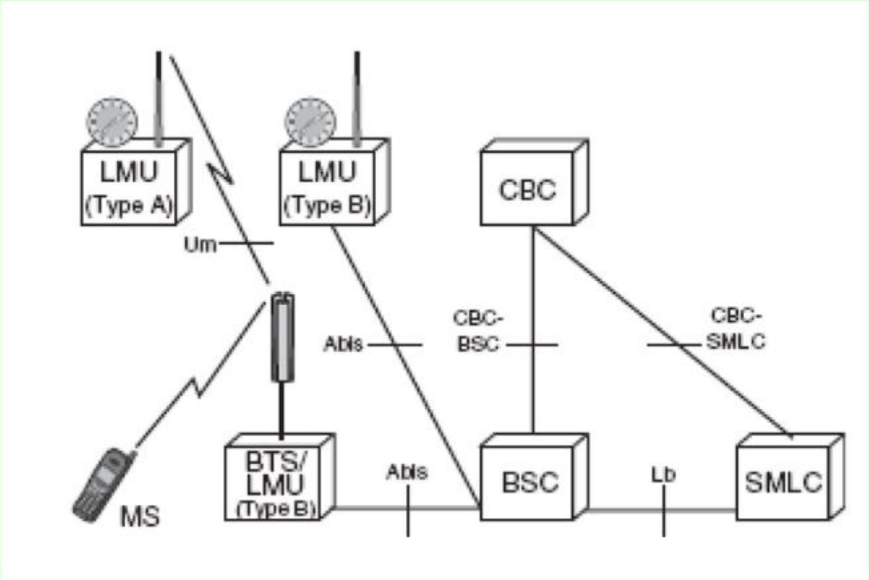
multipath

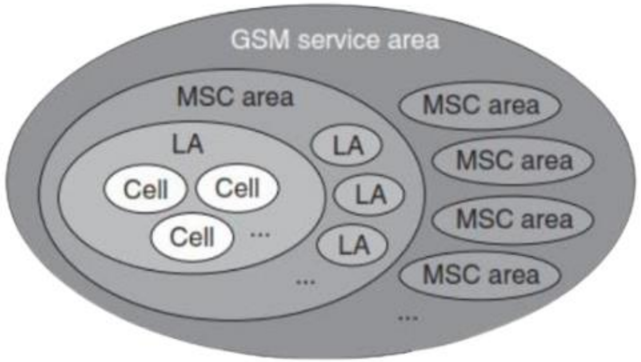


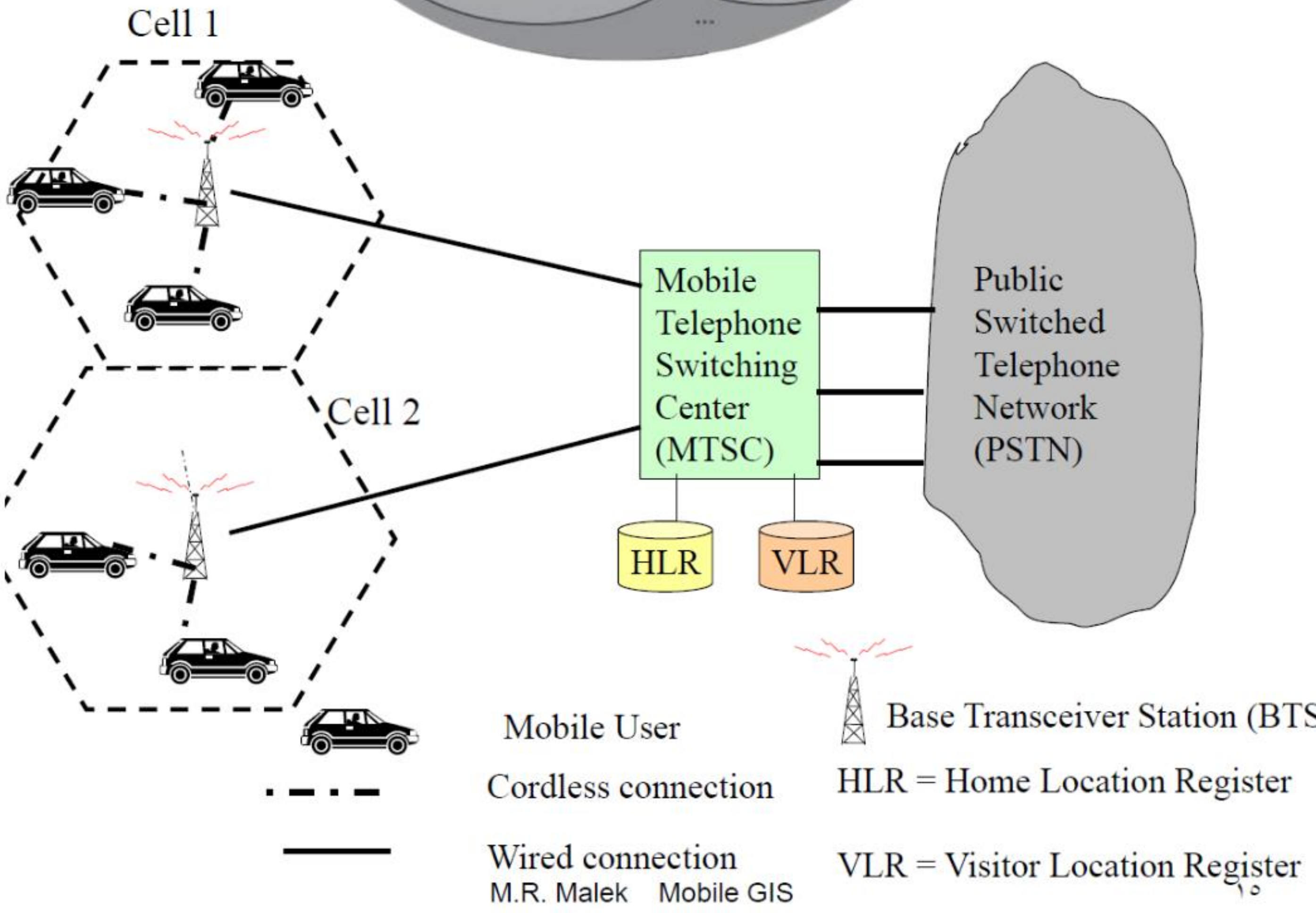
Combination of FDM/TDM and frequency hopping.

Wireless Wide Area Network

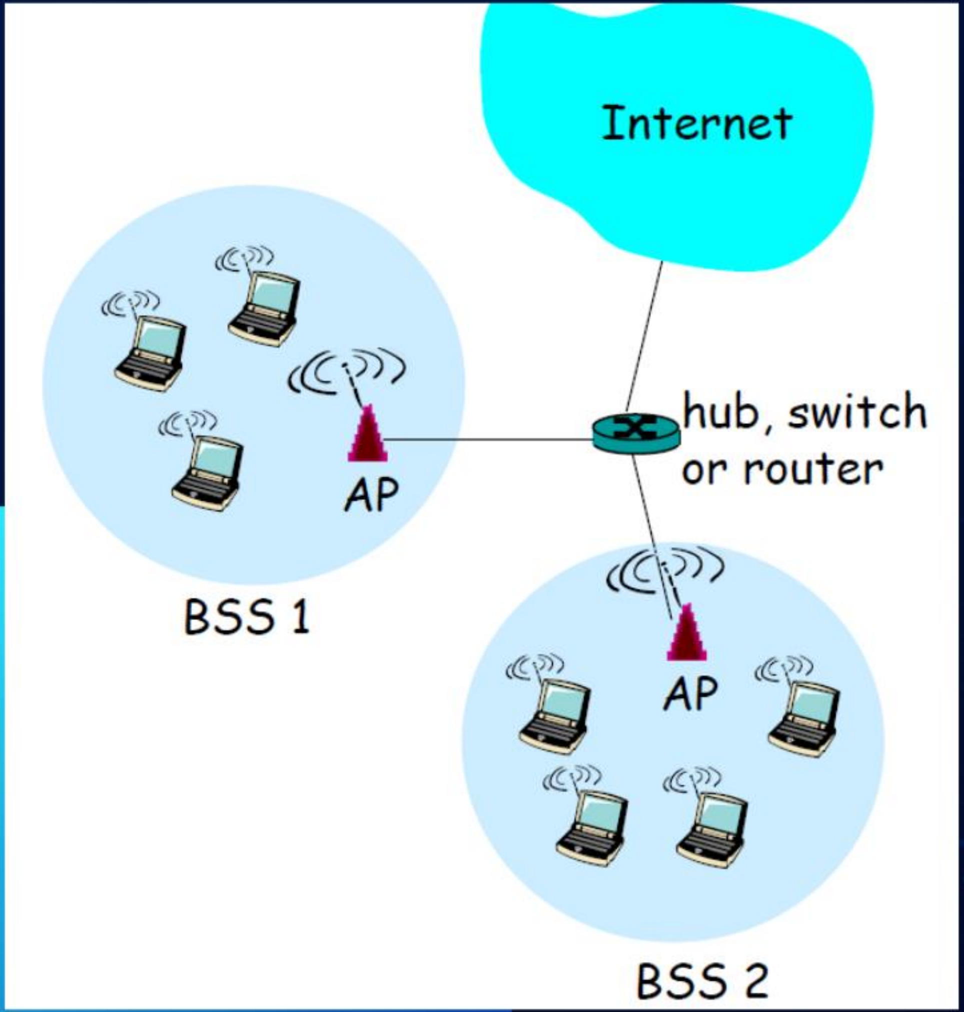
WWAN is a form of wireless network. The larger size of a wide area network compared to a local area network requires differences in technology. Wireless networks of different sizes deliver data in the form of telephone calls, web pages, and video streaming.







WIRELESS LOCAL AREA NETWORK



- WLAN is used within a small geographical area, which is usually limited to one building.
  Advantages and disadvantages (speed, cost, need, …)
  There are different type of WLAN
  - IEEE 802.11 a, b, g
  - Open Air
  - Home RF
- 1.wireless host communicates with base station
  - base station = access point (AP)

  2.Basic Service Set (BSS) (aka cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

Personal Area Network

IRDA

- Established in 1993
- Infrared connection (same basic technology as is used in a TV remote control)
- Low power (doesn't burn battery very fast)
- Cheap
- Requires devices to be in close proximity and lined up
- Very short range (1 -4 M)

BLUETOOTH

- Introduced in 1998
- Emerging replacement for IrDA to connect peripherals/devices to computers or cell phones
- Can connect up to 8 devices
- Very low power
- Short range (typically within a room)
- Standard controlled by Bluetooth Special Interest Group (Bluetooth SIG)

ZIGBEE

- Global, license free ISM band operation
- Unrestricted geographic use
- RF penetration through walls & ceilings
- Automatic/semi-automatic installation
- Ability to add or remove devices
- Cost advantageous

NEAR FIELD COMMUNICATION (NFC)

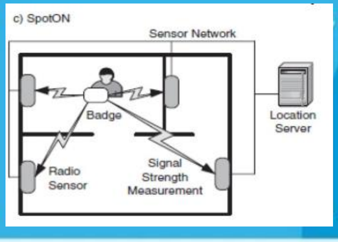
What are the blockers you're facing? What are factors outside of your control?

Overview of Methods and Infrastructure

	Positioning method	Observable	Measured by
1	Proximity sensing	Cell-Id, coordinates	Sensing for pilot signals
2	Lateration	Range or Range difference	Traveling time of pilot signals Path loss of pilot signals
3	Angulation	Angle	Traveling time difference of pilot signals
4	Dead reckoning	Position and Direction of motion and Velocity and Distance	Path-loss difference of pilot signals Antenna arrays Any other positioning method Gyroscope Accelerometer Odometer
5	Pattern matching	Visual images or Fingerprint	Camera Received signal strength

MOBILE INDOOR POSITIONING

01
Systems based on radio signals



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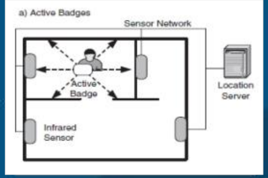
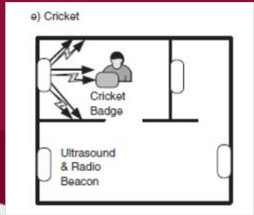
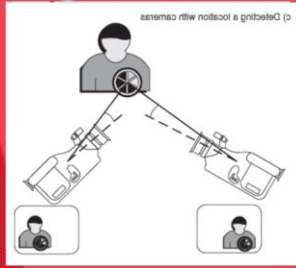
Systems based on infrared signals



03
Systems based on sound waves



04
Systems based on light waves



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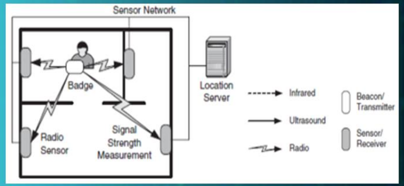
Spot ON

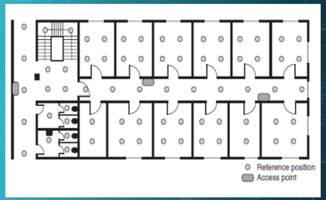
- A project that uses signal strengths to determine a location is SpotON.
- The system achieves a precision of 3 m.



WLAN Fingerprinting

Online:
- How to measure similarity with a database
- Types of ACSSes points
- Using Bluetooth
- Class recognition

Offline:
- Designging points
- How to collect points
- Time to collect points



Signal strength

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-L_0 is the path loss in decibels (dB) at the reference distance d_0This is based on either close-in measurements or calculated based on a free space assumption with the Friis free-space path loss model.

-d is the length of the path.

-d_0 is the reference distance, usually 1 km (or 1 mile) for a large cell and 1 m to 10 m for a microcell.[1]

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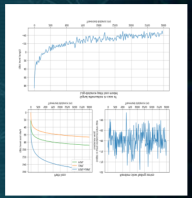

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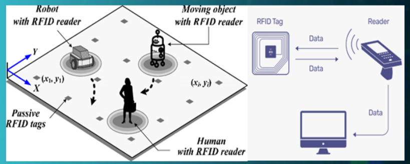

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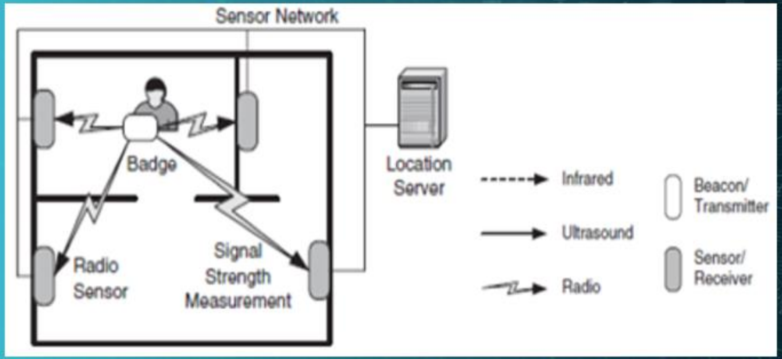

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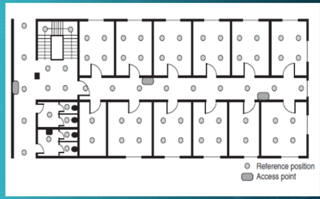

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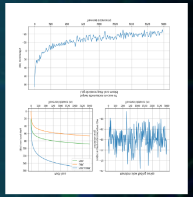

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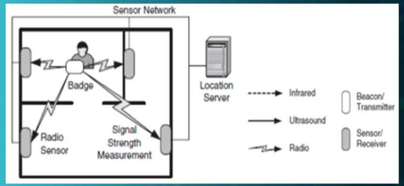

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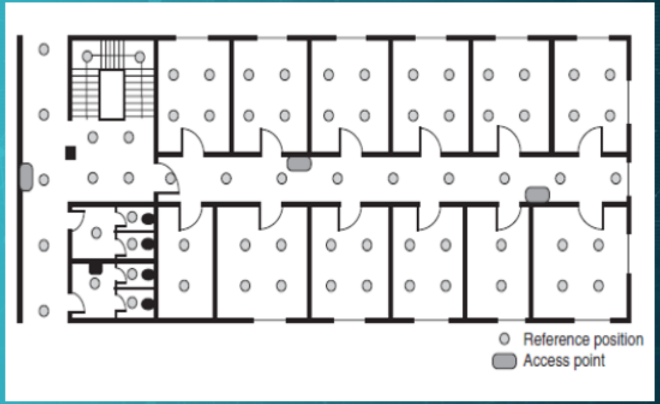

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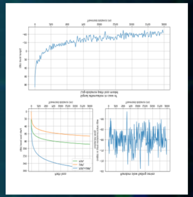

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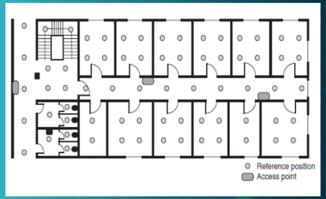

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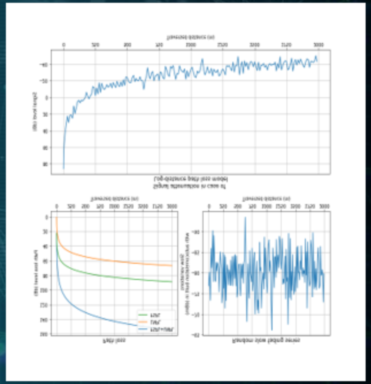

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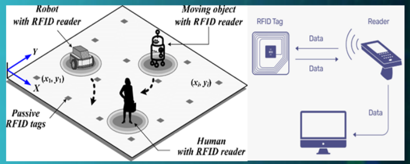

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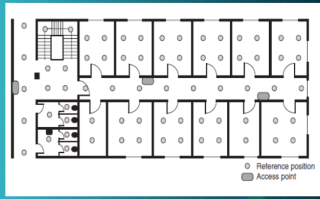

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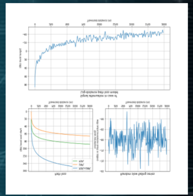

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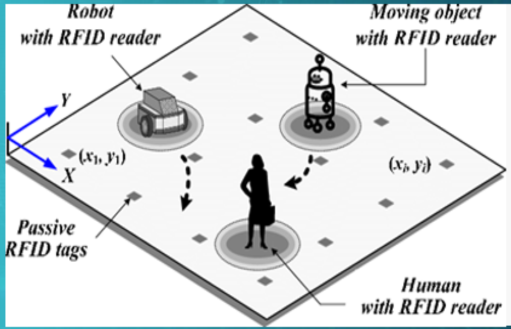

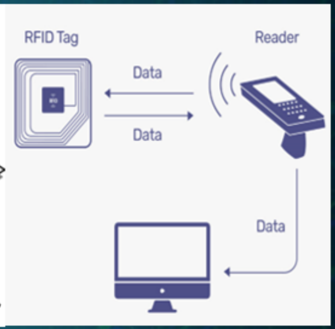

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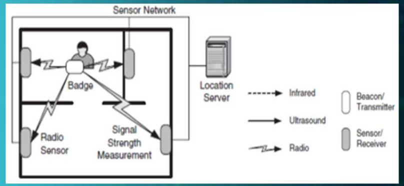

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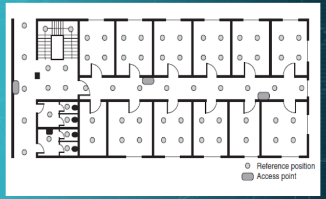

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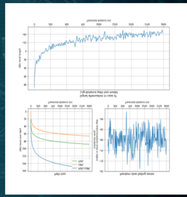

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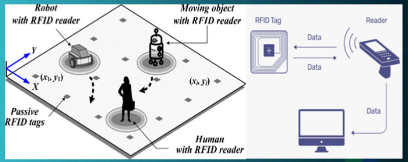
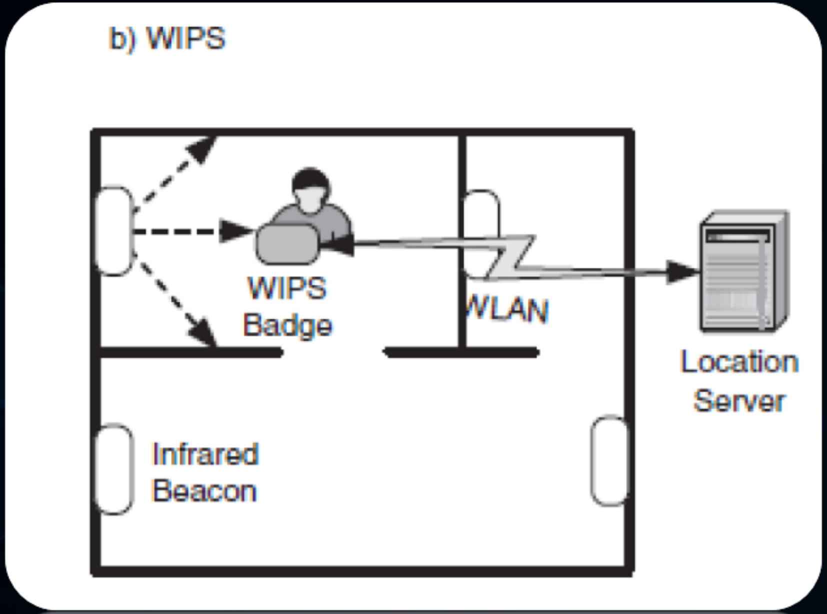
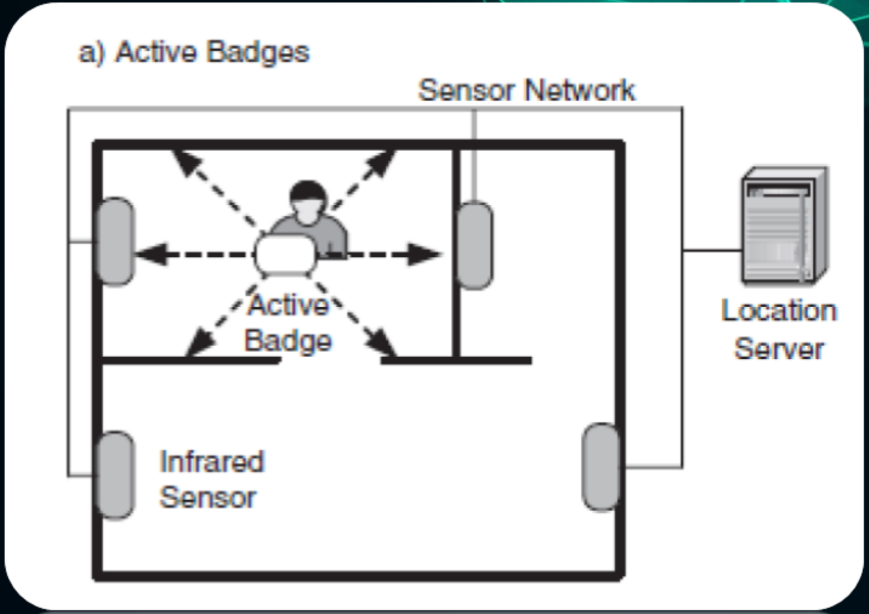
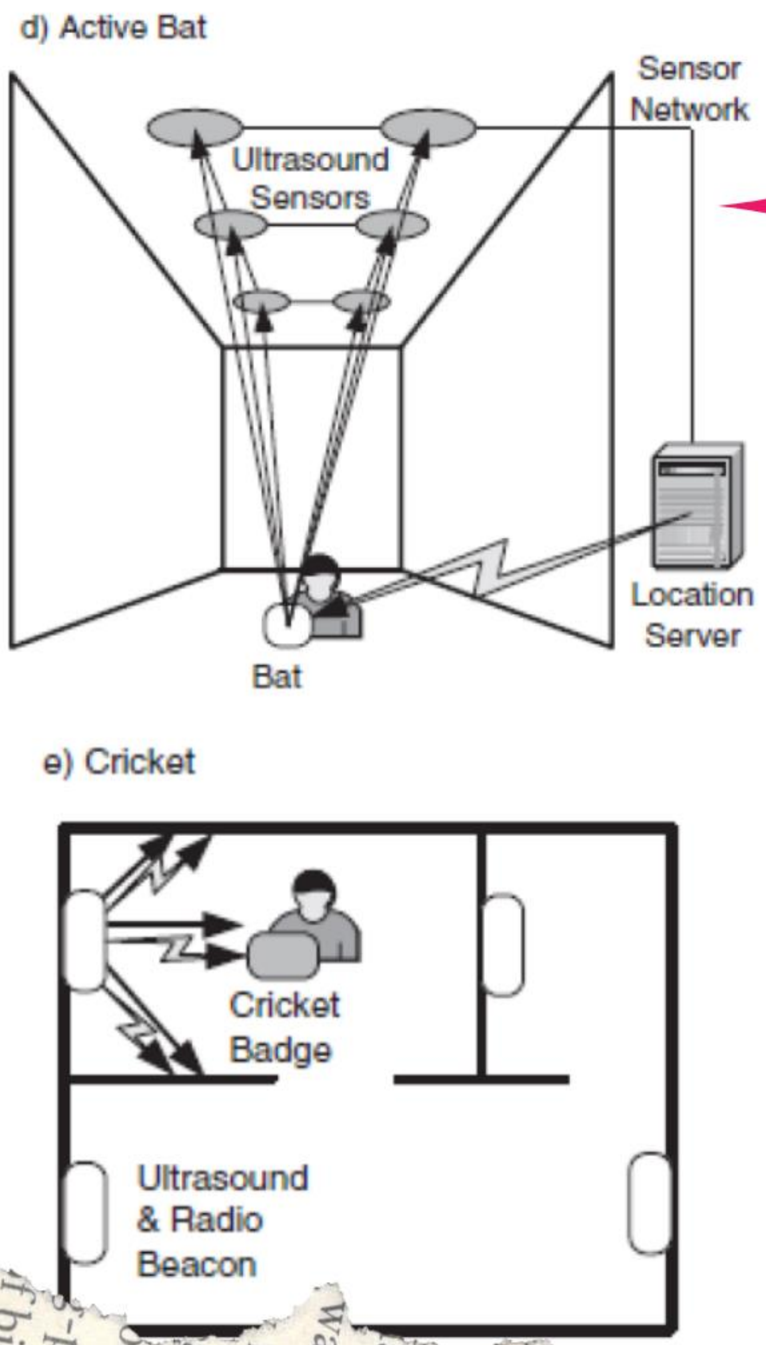


INFRARED-BASED SYSTEMS

The pioneer not only of indoor positioning but also of location-based applications in general is the ActiveBadge system developed by Olivetti research at the beginning of the 1990s.

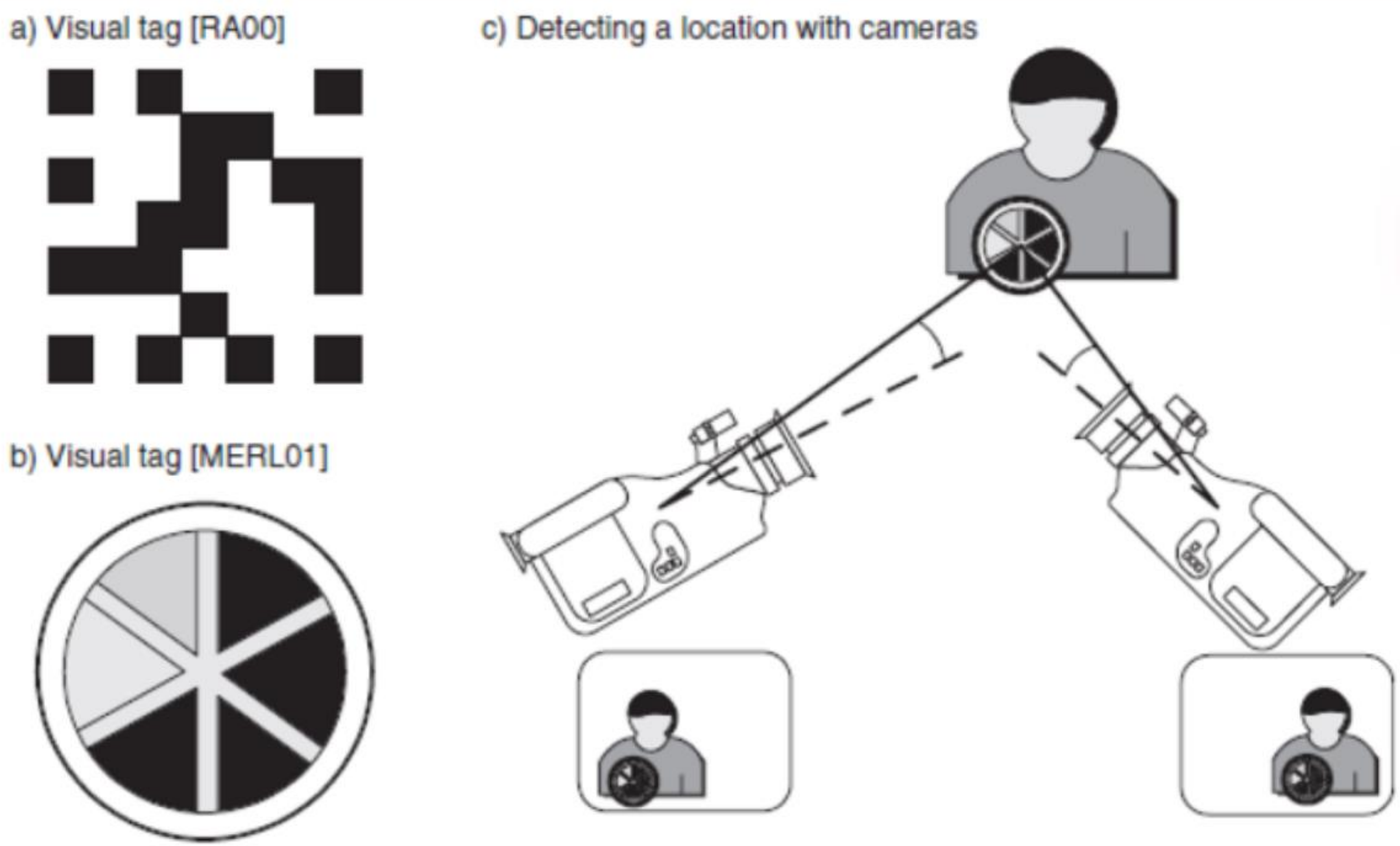






ULTRASOUND-BASED SYSTEMS

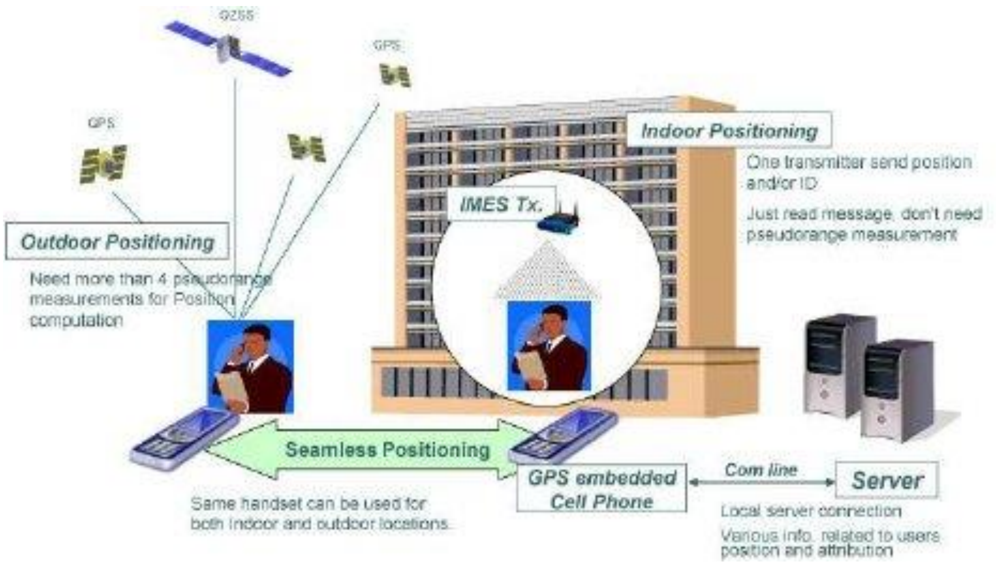
- The major advantage of ultrasound signals is their propagation velocity of 1,243 km/h, which is very low when compared to that of infrared and radio signals of approximately 300,000 km/s.
- An example for the former is the ActiveBat system, which was developed at the University of Cambridge and by Olivetti.
- The Cricket system implements a terminal-based approach for proximity detection with ultrasound.

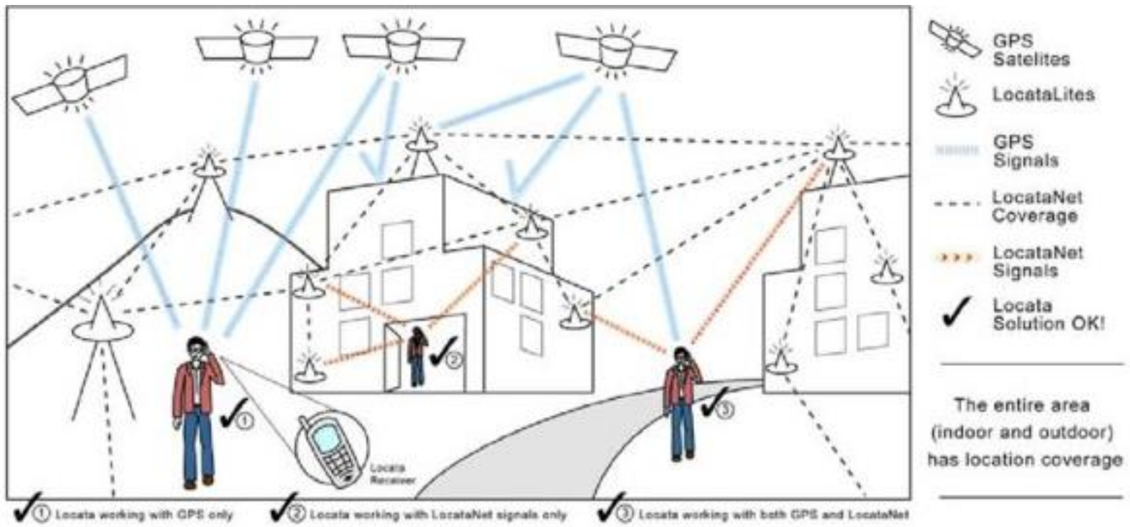


VIDEO-BASED

POSITIONING

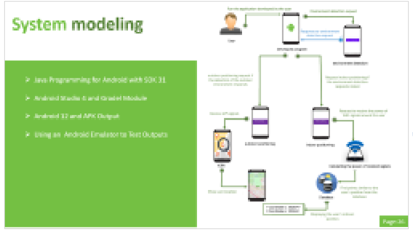
1. Universal positioning systems: Locata and quasi-satellites
2. Combination of indoor and outdoor positioning methods:
   - GPS-based
   - Indoor-based
   - Acceptable positioning accuracy but no service (accuracy-based)
   - Environment detection:
     - ✓ Number of satellites
     - ✓ DOP: HDOP, PDOP
     - ✓ Signal strength
     - ✓ Light intensity
     - ✓ Sound
     - ✓ Magnetism

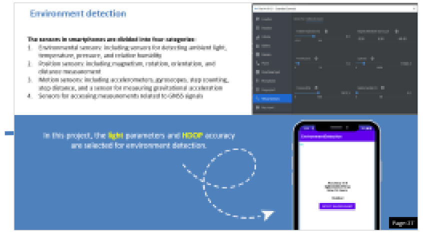


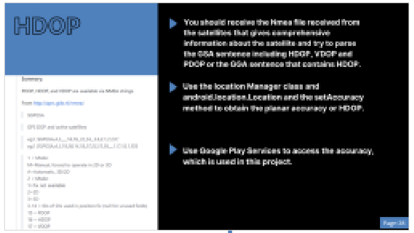


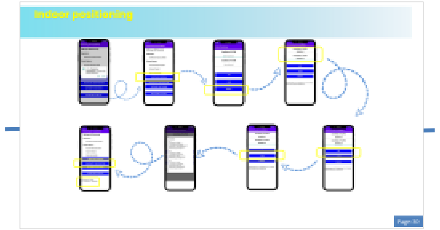
UNIVERSAL POSITIONING

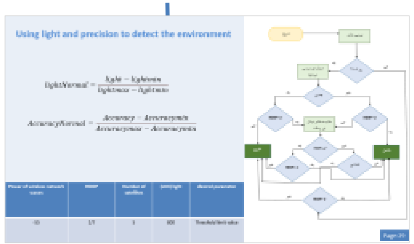
Design and implementation of a borderless positioning system

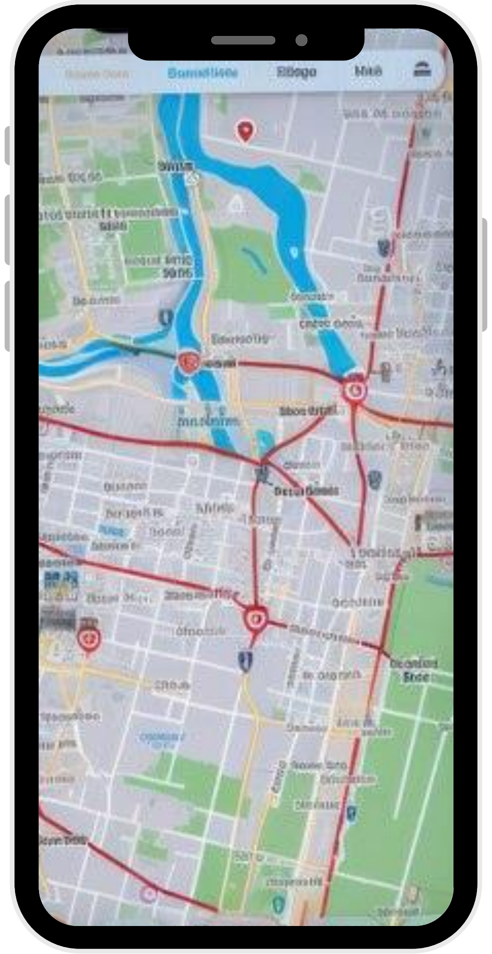






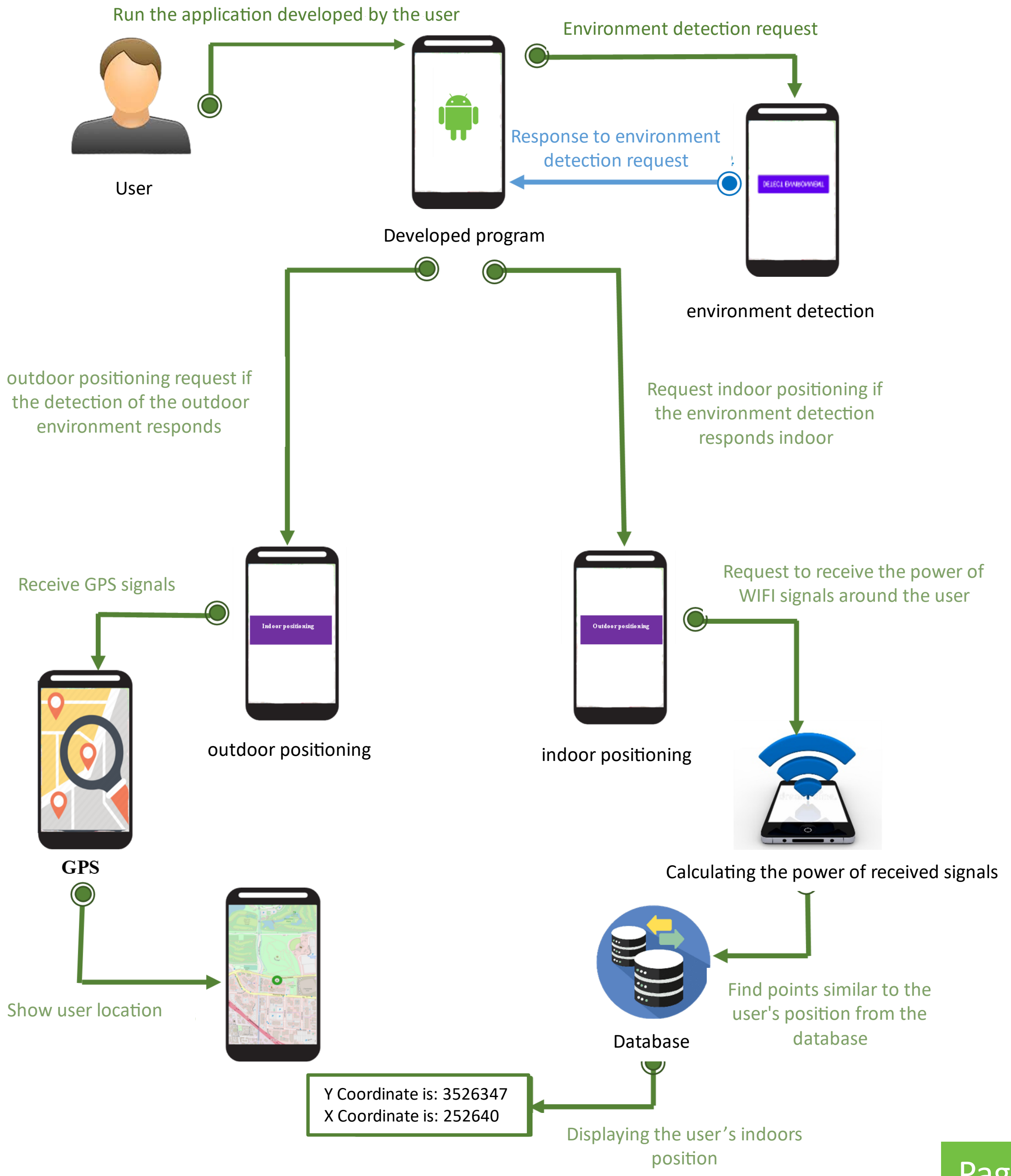




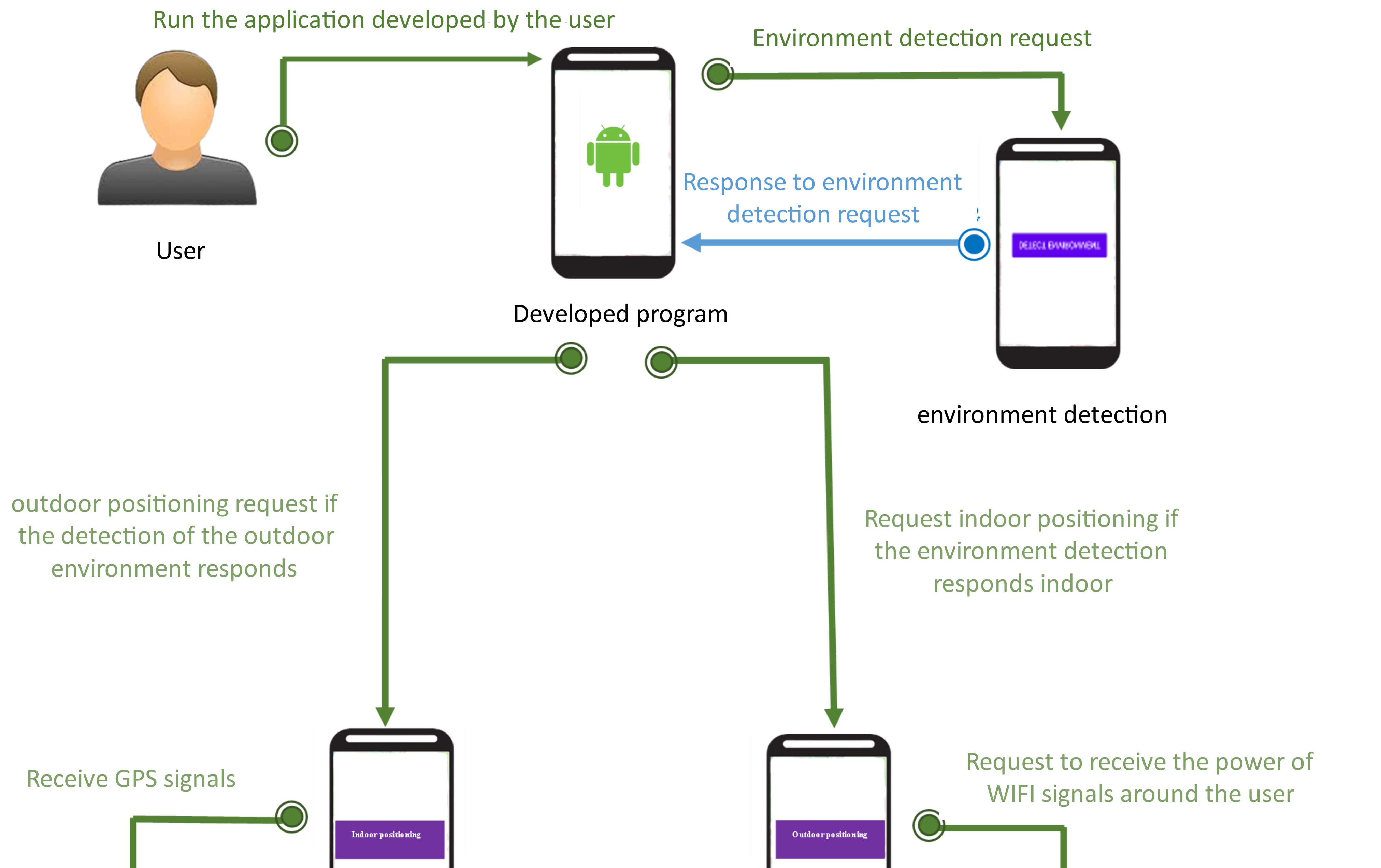


System modeling

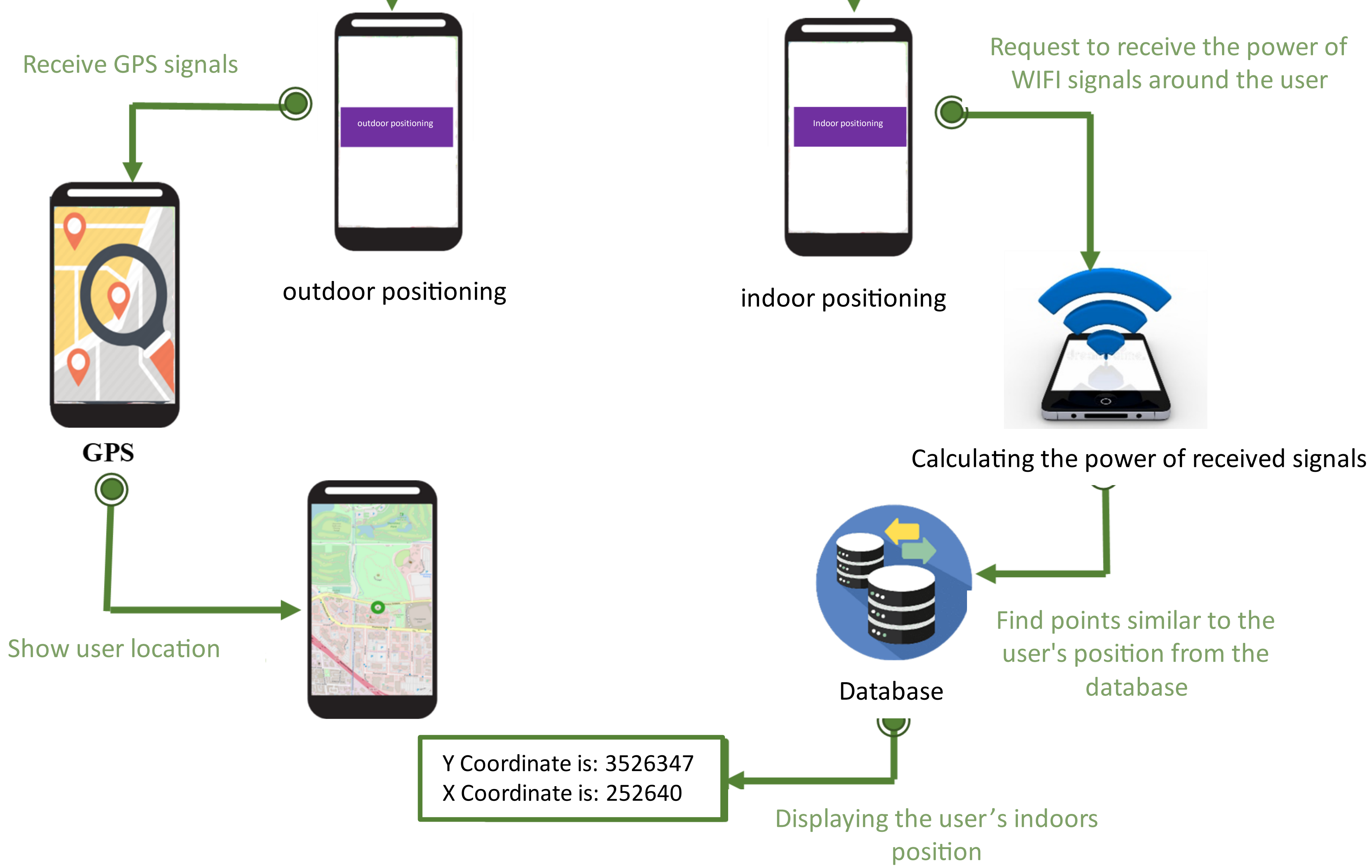
- Java Programming for Android with SDK 31
- Android Studio 4 and Gradel Module
- Android 12 and APK Output
- Using an Android Emulator to Test Outputs



System modeling



System modeling



System modelling

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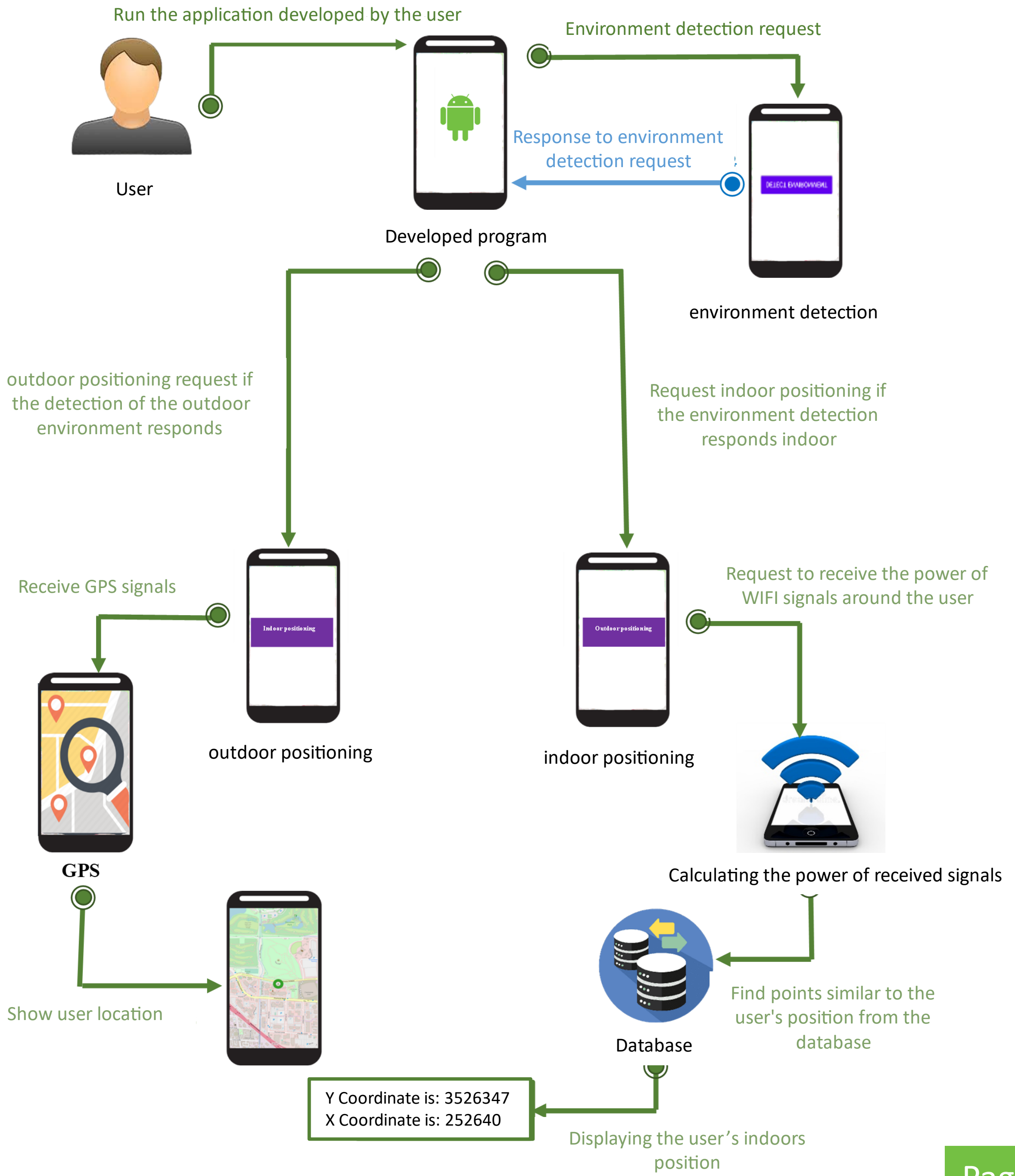
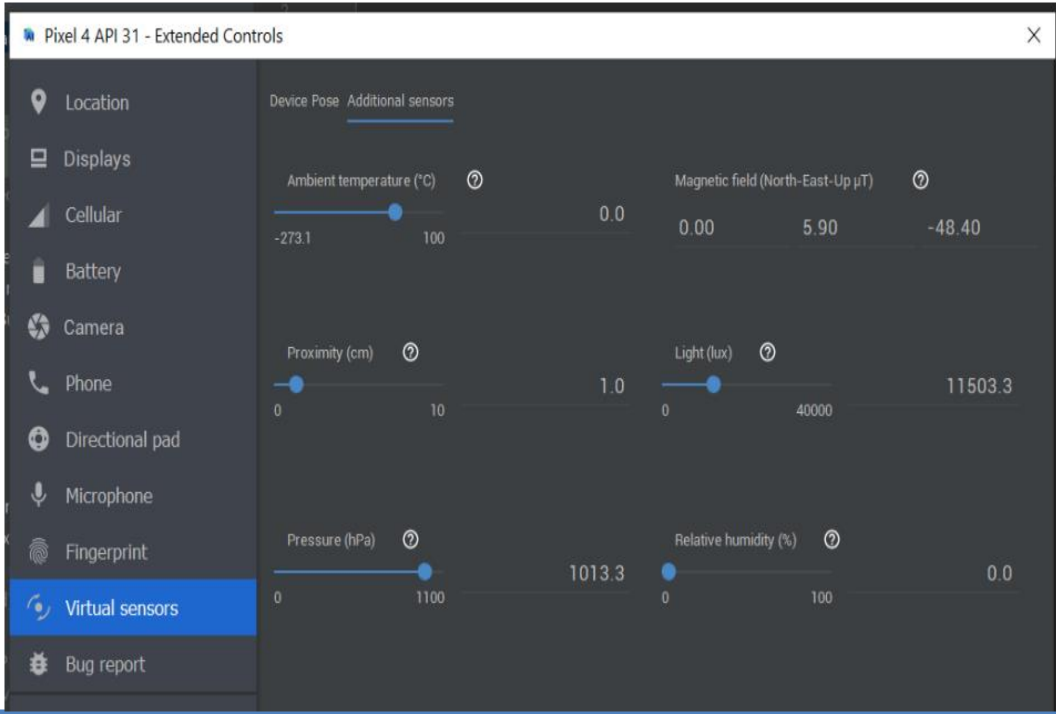


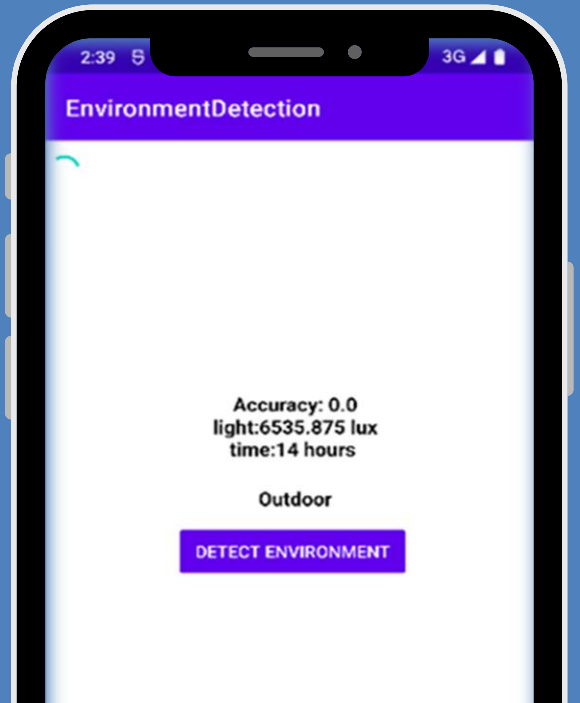
Environment detection



The sensors in smartphones are divided into four categories:

1. Environmental sensors: including sensors for detecting ambient light, temperature, pressure, and relative humidity
2. Position sensors: including magnetism, rotation, orientation, and distance measurement
3. Motion sensors: including accelerometers, gyroscopes, step counting, step distance, and a sensor for measuring gravitational acceleration
4. Sensors for accessing measurements related to GNSS signals

In this project, the **light** parameters and **HDOP** accuracy are selected for environment detection.



HDOP

Summary:

PDOP, HDOP, and VDOP are available via NMEA strings.

From http://aprs.gids.nl/nmea/:

> $GPGSA

> GPS DOP and active satellites

> eg1. $GPGSA,A,3,,,,,,16,18,,22,24,,,3.6,2.1,2.23C
> *eg2. $GPGSA,A,3,19,28,14,18,27,22,31,39,,,,,1.7,1.0,1.335*

> 1 = Mode:
> M=Manual, forced to operate in 2D or 3D
> A=Automatic, 3D/2D
> 2 = Mode:
> 1=Fix not available
> 2=2D
> 3=3D
> 3-14 = IDs of SVs used in position fix (null for unused fields)
> 15 = PDOP
> 16 = HDOP
> 17 = VDOP

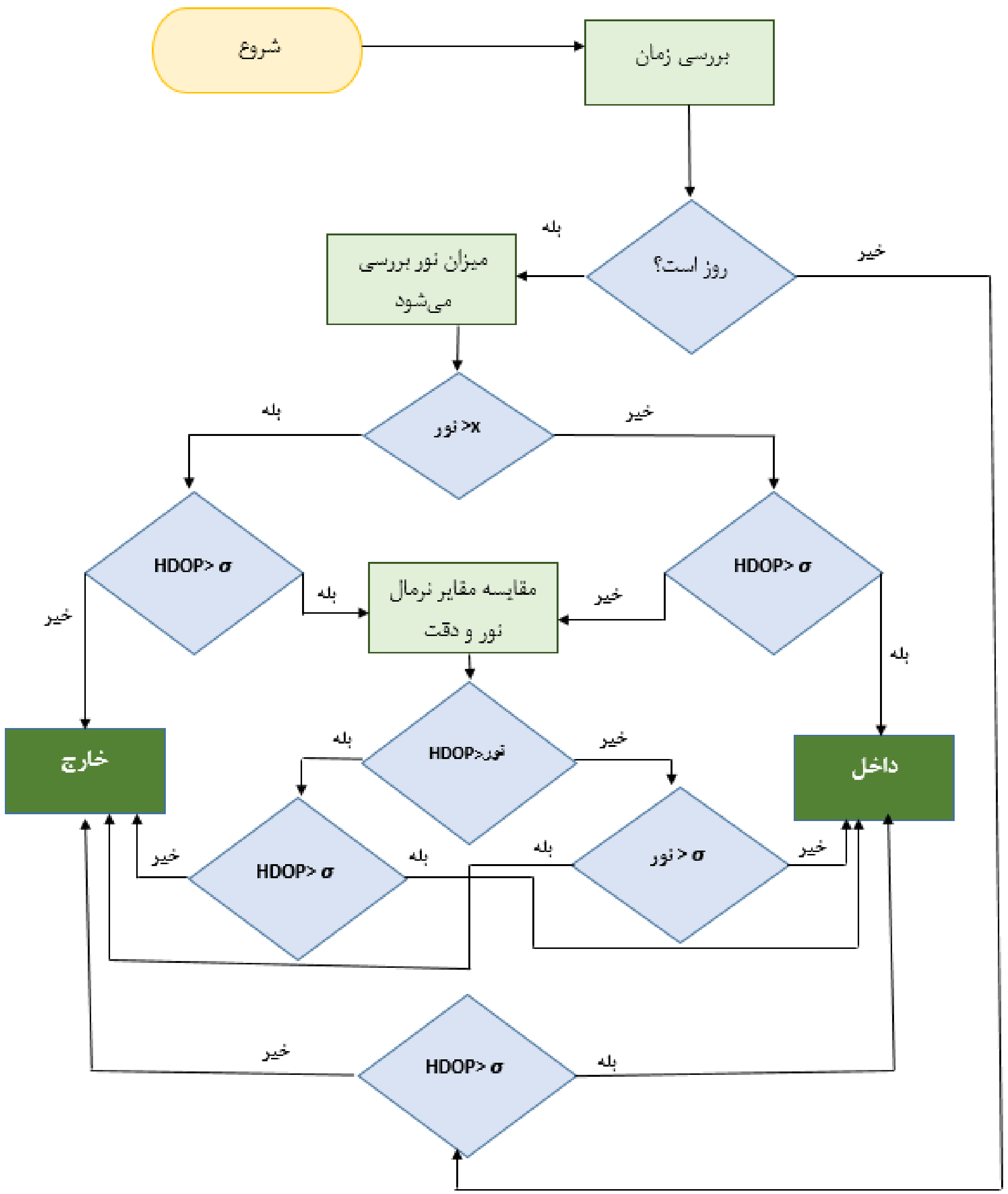
- **You should receive the Nmea file received from the satellites that gives comprehensive information about the satellite and try to parse the GSA sentence including HDOP, VDOP and PDOP or the GGA sentence that contains HDOP.**
- **Use the location Manager class and android.location.Location and the setAccuracy method to obtain the planar accuracy or HDOP.**
- **Use Google Play Services to access the accuracy, which is used in this project.**

Using light and precision to detect the environment

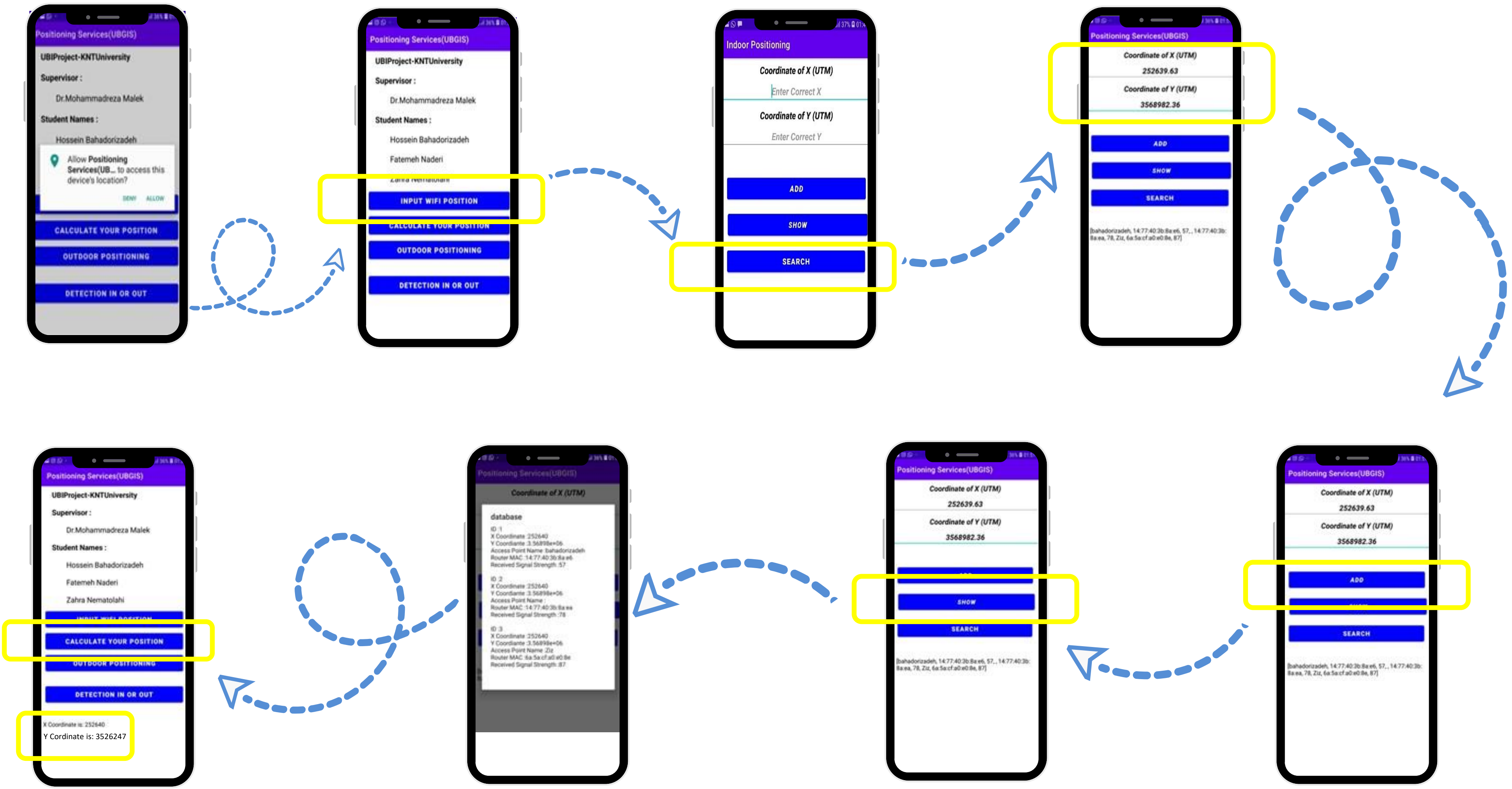
$$lightNormal = \frac{light - lightmin}{lightmax - lightmin}$$

$$AccuracyNormal = \frac{Accuracy - Accuracymin}{Accuracymax - Accuracymin}$$

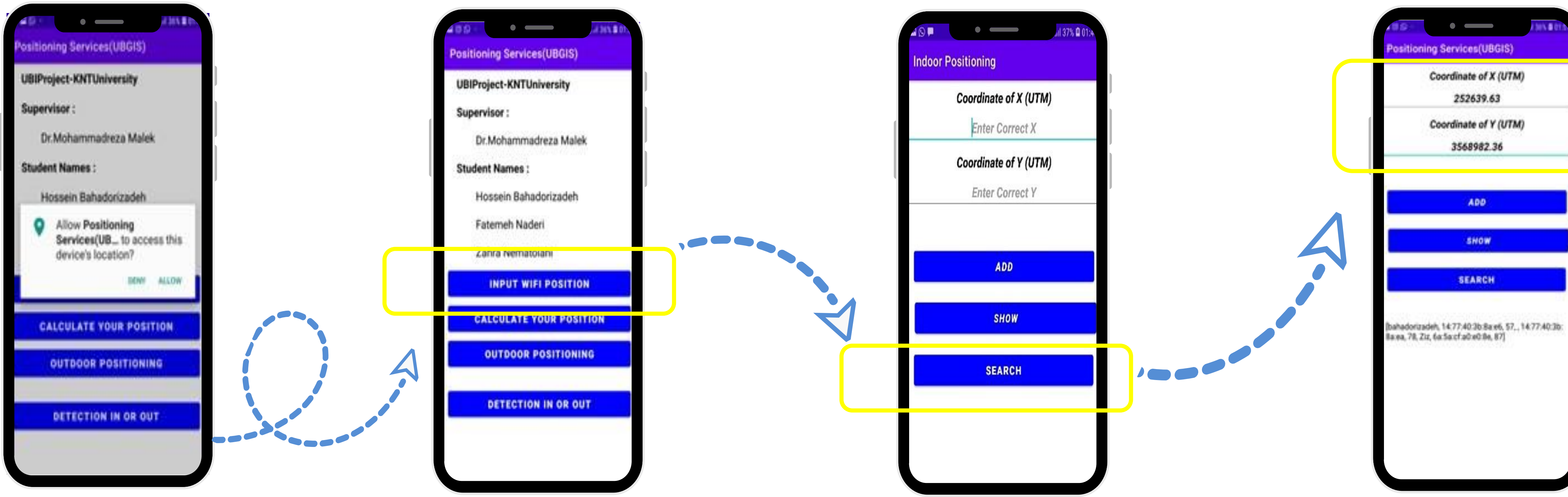
Power of wireless network waves	HDOP	Number of satellites	(LUX) light	desired parameter
-55	1/7	5	800	Threshold limit value

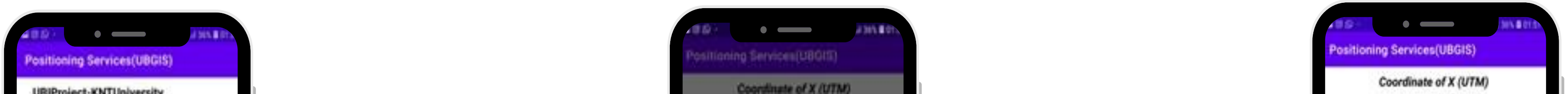


Indoor positioning

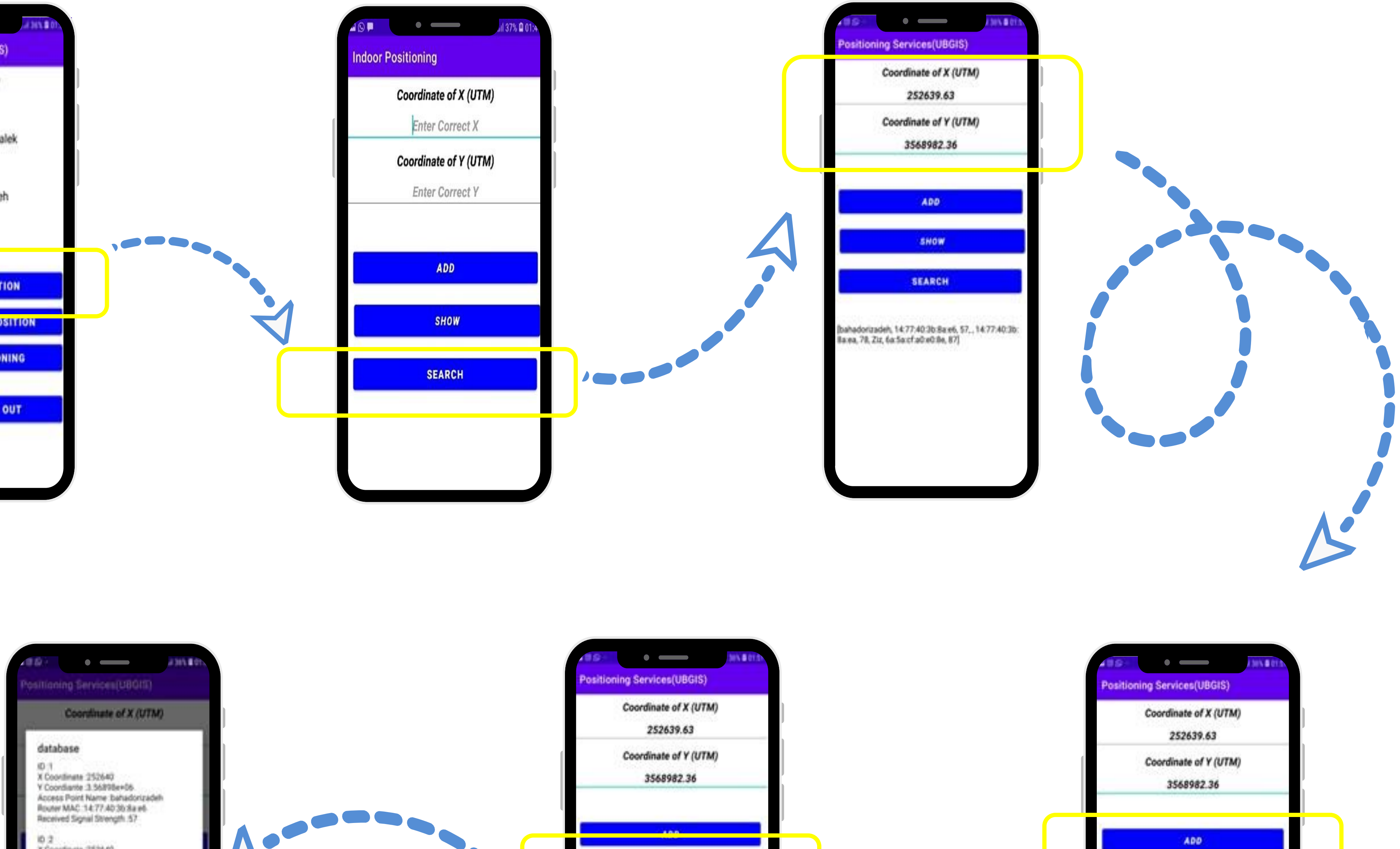


Indoor positioning





Indoor positioning



Indoor positioning

Indoor positioning

OUTDOOR POSITIONING

GPS fixing

GPS fixed

GPS not fixed

GGA message fields

Field	Meaning
0	Message ID $GPGGA
1	UTC of position fix
2	Latitude
3	Direction of latitude: N: North S: South
4	Longitude
5	Direction of longitude: E: East W: West
6	GPS Quality indicator: 0: Fix not valid 1: GPS fix 2: Differential GPS fix, OmniSTAR VBS 4: Real-Time Kinematic, fixed integers 5: Real-Time Kinematic, float integers, OmniSTAR XP/HP or Location RTK

ADVANTAG

1. **Spatial data management**: Accurately updating and collecting spatial data in indoor and outdoor environments.
2. Crisis management: Identifying and rescuing people in crises and mapping affected areas.
3. Infrastructure monitoring: Accurately recording and monitoring urban and underground infrastructure.
4. Security and surveillance: Accurately managing movements and monitoring in sensitive environments
5. Interior mapping: Preparing 3D maps of buildings and closed centers.
6. The lack of support for parametric and curved models is one of the main limitations
7. Transportation and logistics: Optimizing routes and tracking goods in warehouses.
8. Tourism and cultural heritage: Providing digital guides and maps of tourist routes.
9. Urban service development: Improving smart city infrastructure and sustainable management of cities.

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