GPS and LBS applications

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Enemy of The State

"In God we trust. The rest we monitor."

Location, Location, Location

YOUR PHONE KNOWS WHERE YOU ARE

With E911, your cellphone's location can be tracked within seconds. Sounds great for emergencies, but is there a dark side?

1 | 2

In February 2001, while driving on the state turnpike to her home in Miramar, Florida, 32-year-old Karla Gutierrez lost control of her BMW 328i and skidded into a canal. She dialed 911 on a cellphone and explained her predicament as the vehicle slowly sank. But since Gutierrez couldn't describe her precise location—"I'm not sure where I am," she told the operator—Miami-Dade County rescue units didn't know where to go to save her. By the time a passing patrolman noticed a busted fence by the accident site and found Gutierrez, she was dead.

Cases like this give emergency workers the shivers. If Gutierrez had called 911 from her home, the dispatcher would have instantly seen her exact location on a computer terminal, because landlines are matched to household addresses in emergency-services databases. But mobile phones are untethered to any network and provide no clue about where an SOS is coming from.

With more than 200,000 emergency calls coming from cellphones daily, the Federal Communications Commission is eager to remedy this defect. In 1997, the agency ordered wireless

Mobile.LBS.Google.Com?

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Google Maps

What e.g., "pizza" — pizza

Where e.g., "poughkeepsie" — 10225 Willow Creek Road, San Diego, CA

Search Businesses

Search the map | **Find businesses** | Get directions

Search Results | My Maps

Print | Send | Link to

Text View | Map View

Refine by: Distance | Cuisine | User Rating

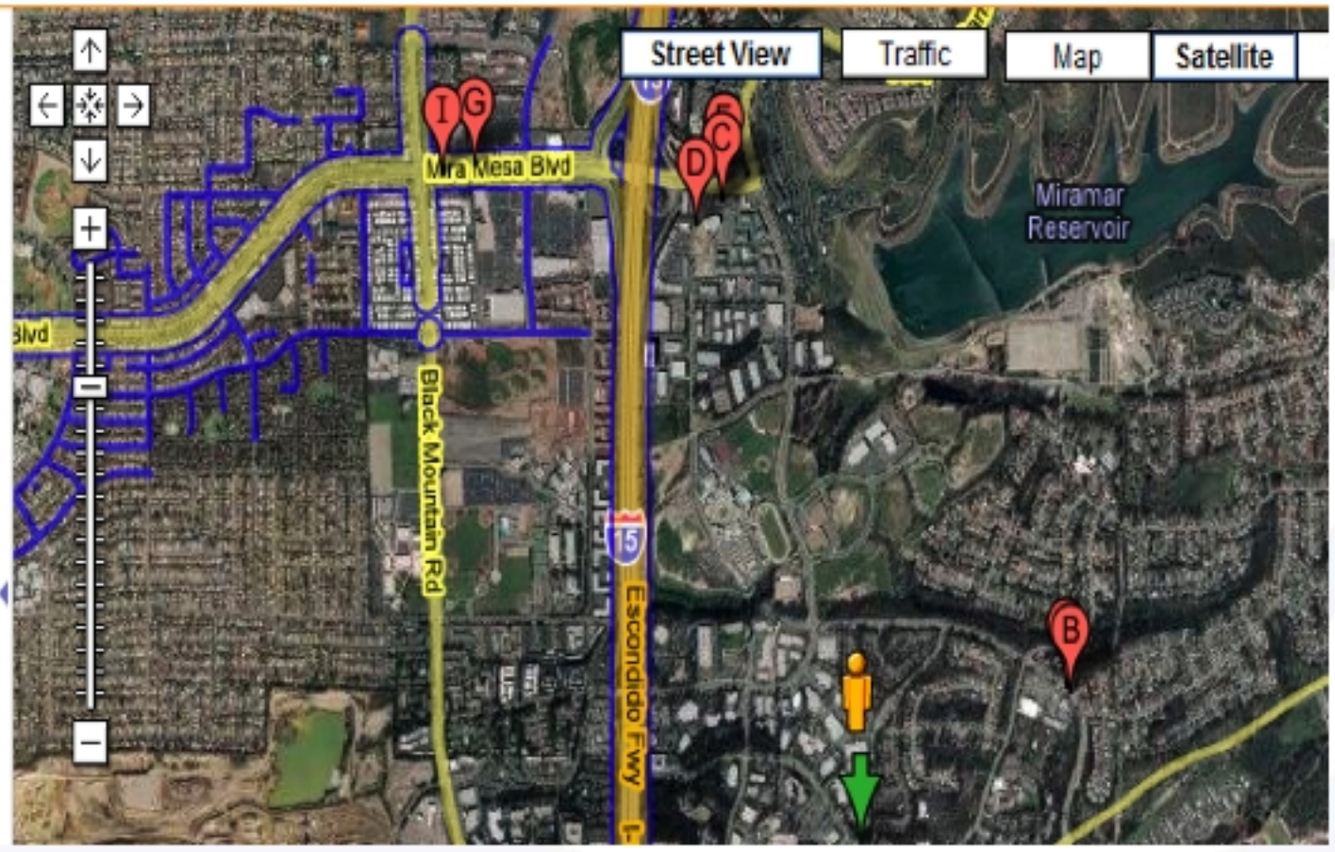
Results **1-20** of about **9,273** for **pizza** near **10225 Willow Creek Rd, San Diego, CA 92131**

Categories: Pizza Restaurants

A **Z Pizza** - more info »
10006 Scripps Ranch Blvd, San Diego, CA
(858) 689-9449 - 2 reviews - 0.6 mi NE

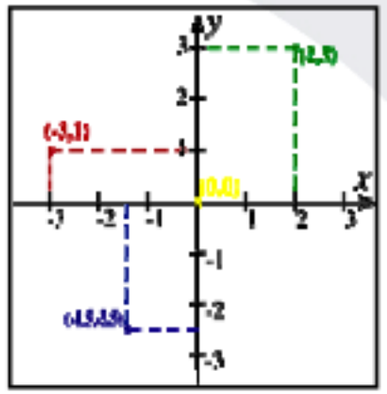
B **Pernicano's Family Restaurant** - more info »
9988 Scripps Ranch Blvd, San Diego, CA
(858) 271-5250 - 3 reviews - 0.6 mi NE
Category: Pizza

C **Filippi's Pizza Grotto** - more info »



Concepts in LBS

- **Position**
  - *"32° 49' 49.7964"-116° 49' 9.9228""*
  - Position appears to developers in the form of spatial coordinates.
  - It can be represented as a single point in the Cartesian coordinate.
- **Location**
  - *"San Diego downtown gas lamp quarter"*
  - Location is associated with a certain place in the real world.
  - If positioning delivers a spatial location, it will be mapped onto a descriptive location in order to be interpretable by the LBS user.
- **LoCation Service (LCS)**
  - *"Where am I?"*
  - LCS should be distinguished from LBS as it exclusively deals with the localization of target, and also makes the resulting location data available to external actors.
  - It is responsible for the generation and delivery of location data.
- **Location Based Service (LBS)**
  - *"How can I go to the gas lamp quarter from here?"*
  - LBS is the service that adds value to target locations provided by LCS. It uses knowledge of a mobile device's location to offer value to the mobile subscriber or to a third party.

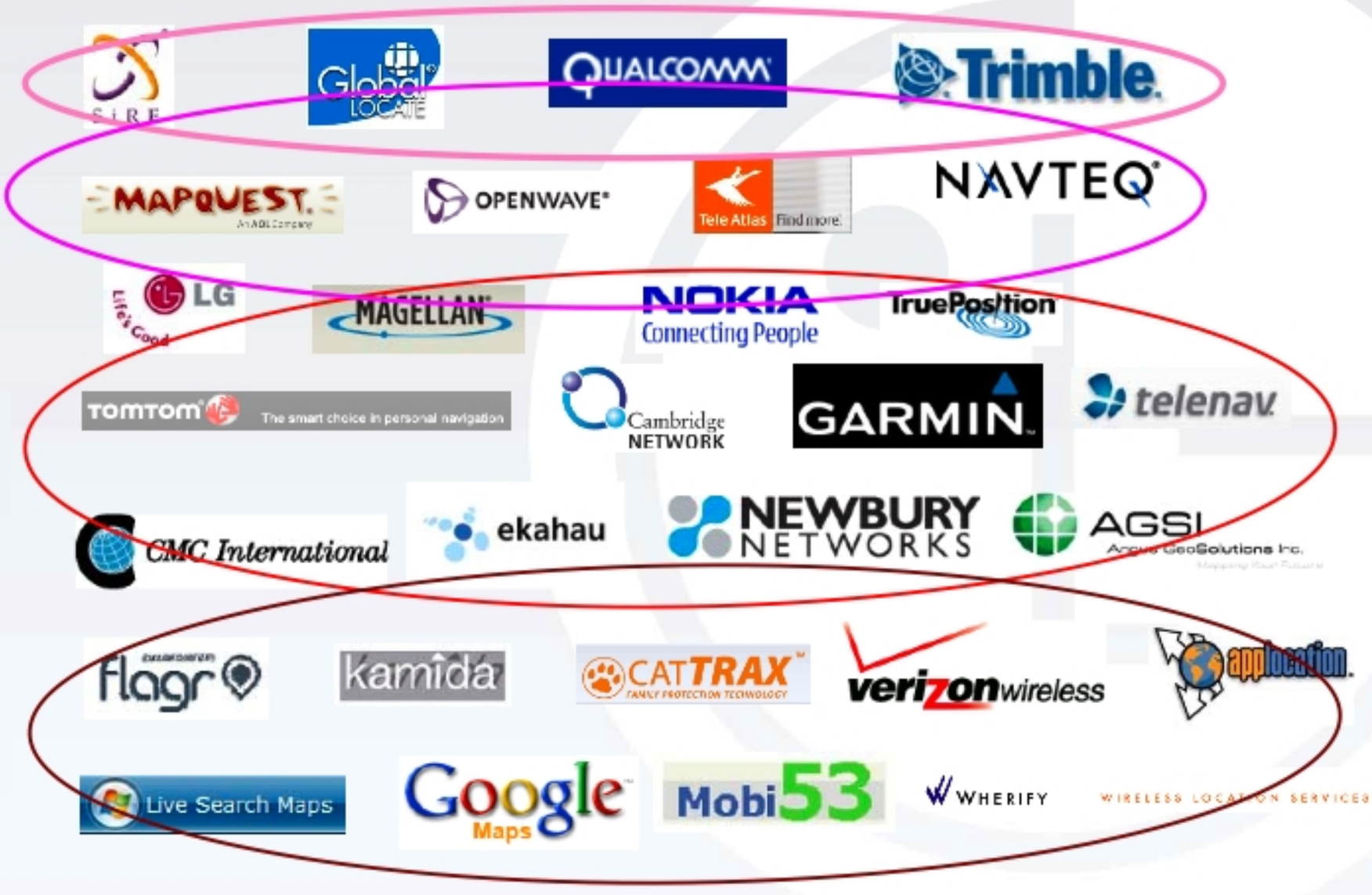


LBS Applications

- Emergency Services
  - E-911
  - Roadside Assistance
- Tracking
  - Commercial: workforce, fleet management
  - Family locator
  - Personal asset tracking
- Navigation
  - Direction
  - Planning
  - Assistance
- Billing
  - Road tolling
  - parking
- LBS Alert
  - Promotion alert
  - advertising
- Social Networking
  - Friend-finder
  - Instant messaging.

- Network Operator Applications
  - Location sensitive billing
  - Cellular fraudulent detection and prevention
  - Wireless network optimization
  - Cellular inter-network border negotiation.
- Service Provider Application
  - Fleet navigation and management
  - Wireless M2M
  - Remote access/management – mobile data/television
  - Auto insurance
  - Promotion and advertising
- End-User Application
  - Tons of it.

LBS Companies

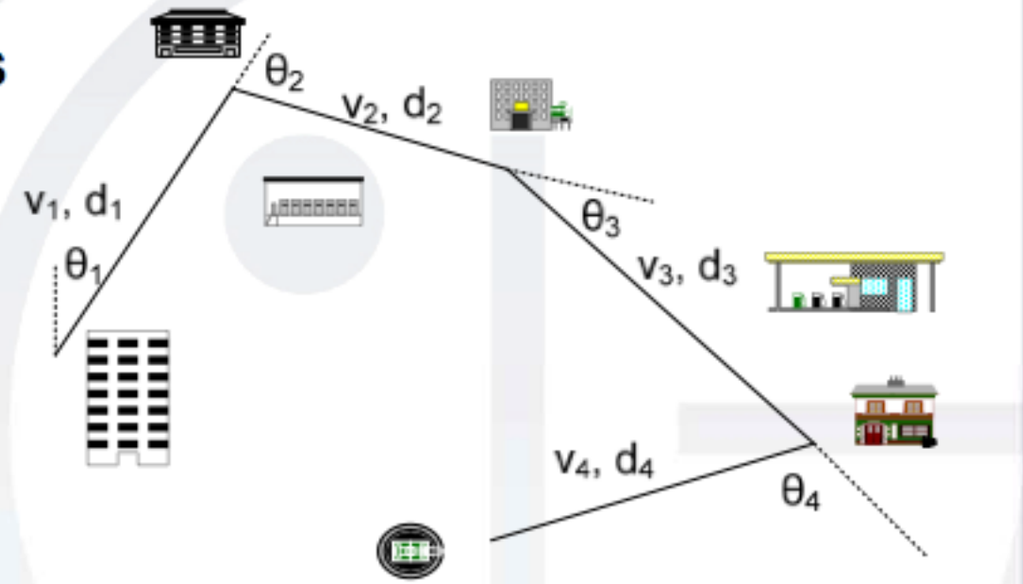


to Deploy an LBS application, your Location must be known!

HOW?
HOW?
HOW?

Dead Reckoning

- Dead reckoning is the processing of estimating one's current position based upon
  - previously determined positions
  - known speed and acceleration
  - moving direction
  - elapsed time
  - traveled distance
  - courses.



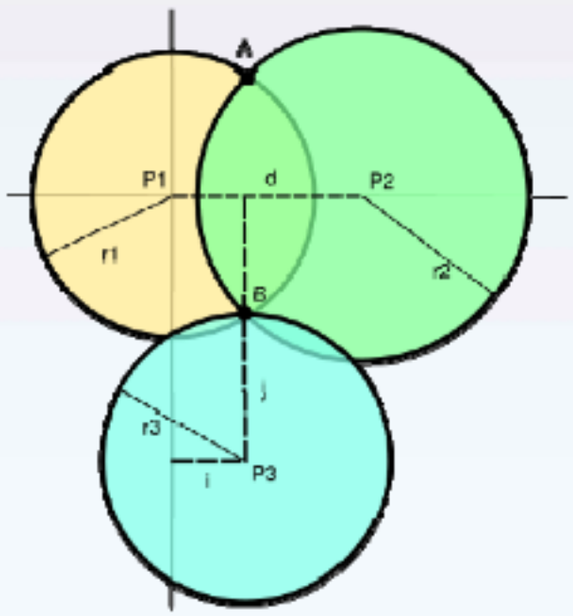
- It is well known to be the method used by Christopher Columbus for discovering the New World and modern inertial navigation systems, for example, for marine navigation and air navigation.

Proximity Sensing: Signal Signature

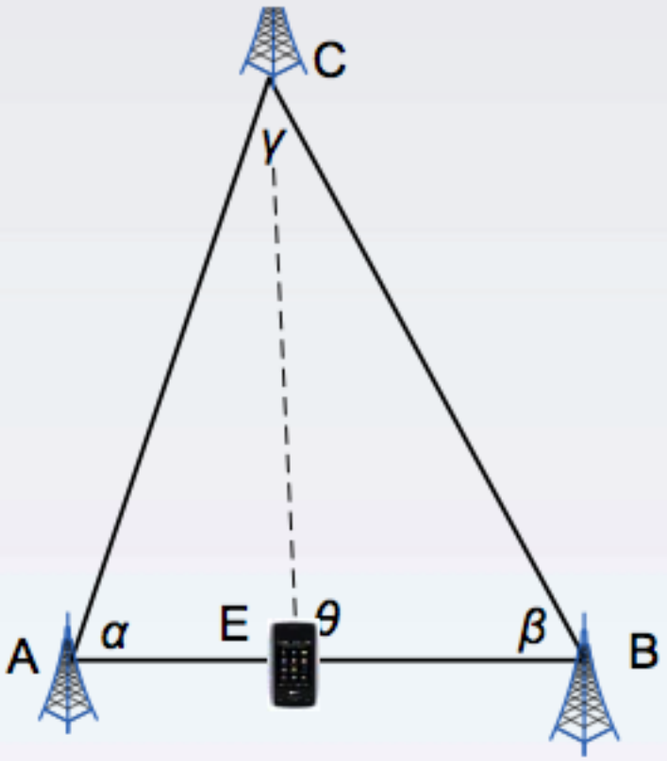
- In the proximity sensing, the mobile position is derived from the base-station coordinates. It is usually determined by tracking signal signatures or cell identity (Cell ID) of neighboring base stations.
- Every base station has its own signal pattern, which is usually embedded into its pilot and some synchronization channels.
- Signal signature based technologies usually comprise
  - signal signature estimation
  - neighbor list update
  - mobile location analysis
- Traffic Pattern Theory.
  - A person's daily activity pattern is pretty regular, which comprises several major events, such as school, work, home and shopping.

Trilateration

- **Trilateration**: it determines the relative positions of objects using
  - the known locations of two or more reference points, e.g. base stations.
  - the measured distance between the mobile and each reference point.
- **Trilateration with signal strength analysis**:



Triangulation: AOA



$$\frac{\sin(\alpha)}{BC} = \frac{\sin(\beta)}{CA} = \frac{\sin(\gamma)}{AB}$$

$$\frac{\sin(\theta)}{BC} = \frac{\sin(\beta)}{CE} = \frac{\sin(\pi - \theta - \beta)}{EB}$$

- Triangulation is the process of positioning a mobile with measuring
  - Angles of arrival (AOA) between the mobile and reference points, and
  - sides of the mobile and reference points.
- Triangulation is used for many purposes, including survey, navigation, astrometry, etc.
- The AOA is usually determined by using multiple antennas at a base station
  - The fundamentals are well established in the context of array signal processing.
- Many schemes are developed for estimating AOA, such as
  - Maximum output power,
  - Maximum likelihood estimation,
  - Subspace-based approaches.

GPS: Overview

- GPS is a Global Navigation Satellite System for determining the positions of receivers using signals broadcast by satellites.
  - The first experimental Block-I GPS satellite was launched in 1978.
- It was developed and operated by US government to enhance the effectiveness of allied and US military forces.
  - As of September 2007, there are 31 actively broadcasting satellites in the GPS constellation.
  - Satellites orbit 20,163 kilometers above the earth at 3.87 km/s
  - 6 orbital planes, each with 4+ satellites. Typically 6 to 12 satellites are visible from any place on the earth.
- Since 1983, GPS has become an aid to civilian navigation worldwide, and a useful tool for survey, commerce, and scientific uses.

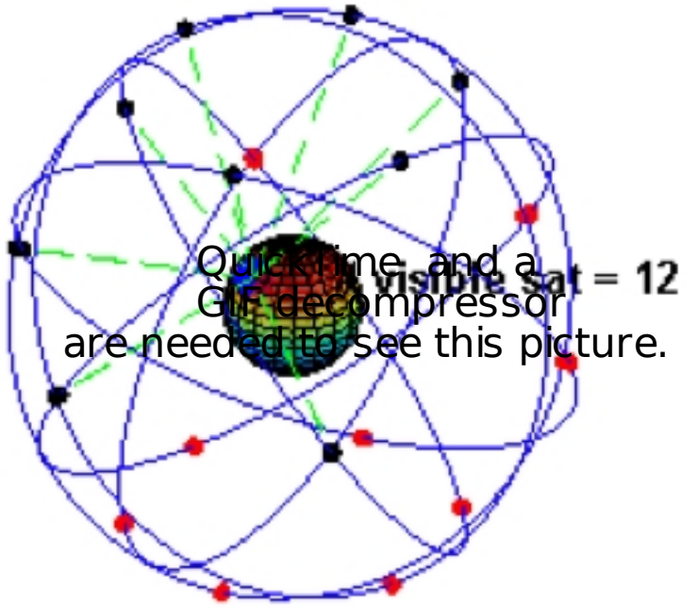
GPS: System Structure

The flight paths of the SVs are tracked by **the control segment**, which consists of multiple monitoring station operated by US Air Force and National Geospatial- Intellignece Agencey

The space segment was originally designed to have 24 time synchronized space vehicles (SVs) with 4 each in six orbital planes. Now it has 31 SVs or possibly more

The GPS receiver is **the user segment**, which is composed of an antenna, a highly reliable local clock, processor's) and I/O interfaces.

GPS: Satellites and Control



QuickTime and a
GIF decompressor
are needed to see this picture.

GPS constellation. Wikipedia

Navstar GPS
Satellite IIR-M

GPS Master Control Station TKSC, Japan

GPS Receiver

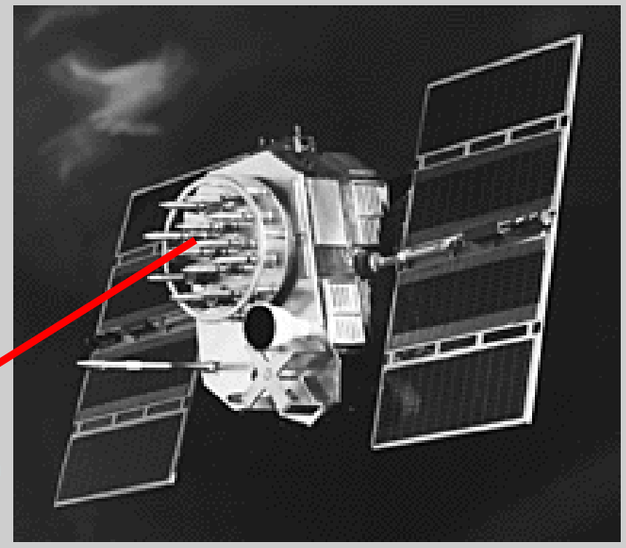
- Measure approximate distance to 3 or more satellites.
  - The receiver measures the time required for signal to get from the satellite to the receiver.
  - Calculate the distance.
- Obtain satellite positions from satellite broadcasts.
  - Almanac: approximate positions used to set approximate satellite search ranges, etc.
  - Ephemeris: precise position used in trilateration calculations.
- Calculate the position using trilateration.
- Correct for errors to improve accuracy.
  - Calibrate the clock bias.
- (Optional) Apply differential correction.
  - Correct deliberate noise, such as selective availability.
  - Caliberate variable ionospheric and tropospheric propagation delays.

GPS Recievers

- Many GPS receivers can relay position data to a PC or other device using the NMEA 0183 protocol.
- Open source tools like gpsd allow developers to read the protocol.

Position is Based on Time

Signal leaves satellite at time “T”



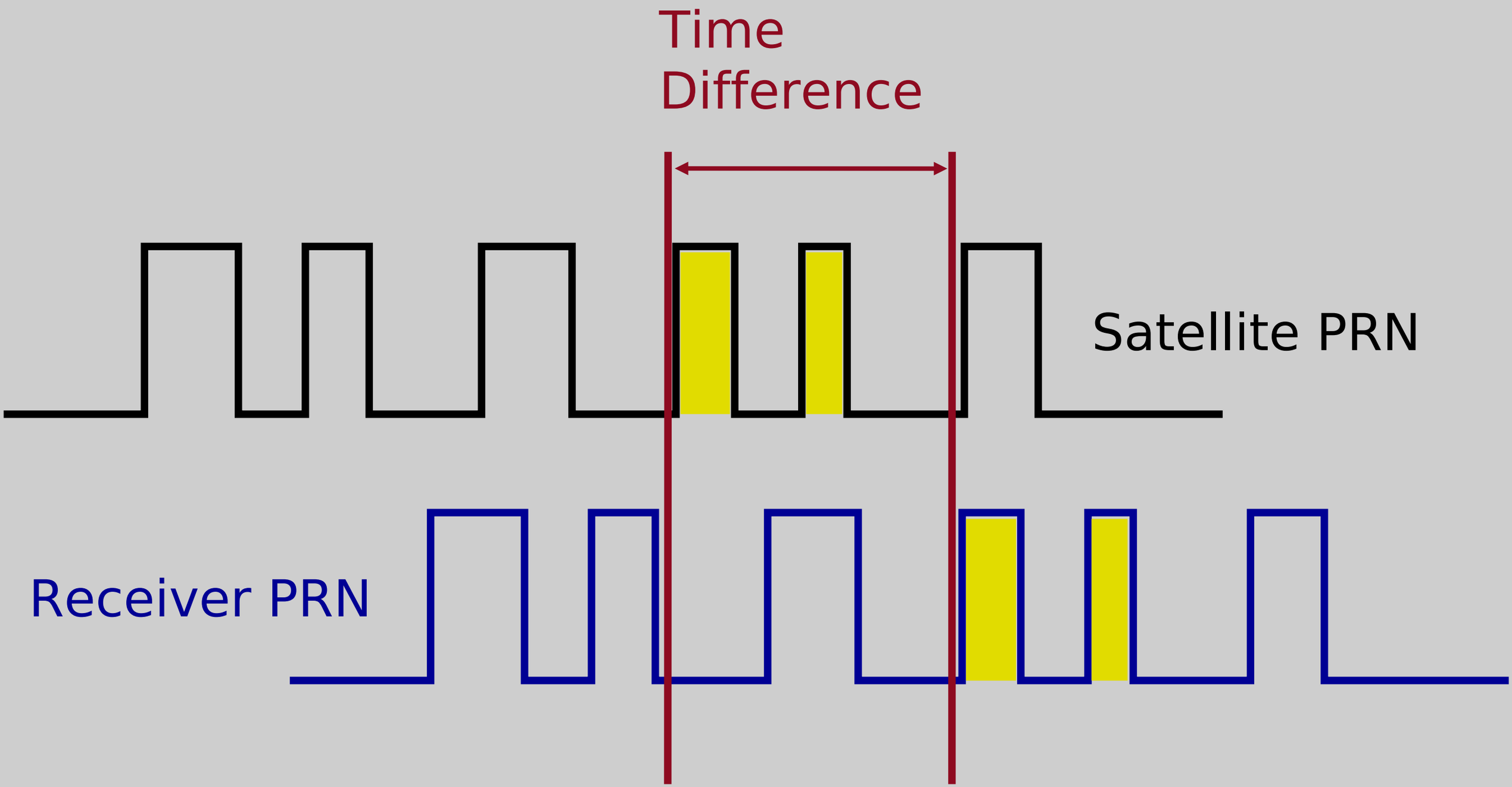
T

T + 3

Signal is picked up by the receiver at time “T + 3”

Distance between satellite and receiver = “3 times the speed of light”

Pseudo Random Noise Code



What Time is it Anyway?

Universal Coordinated Time

Greenwich Mean Time | GPS Time - 13* | Zulu Time

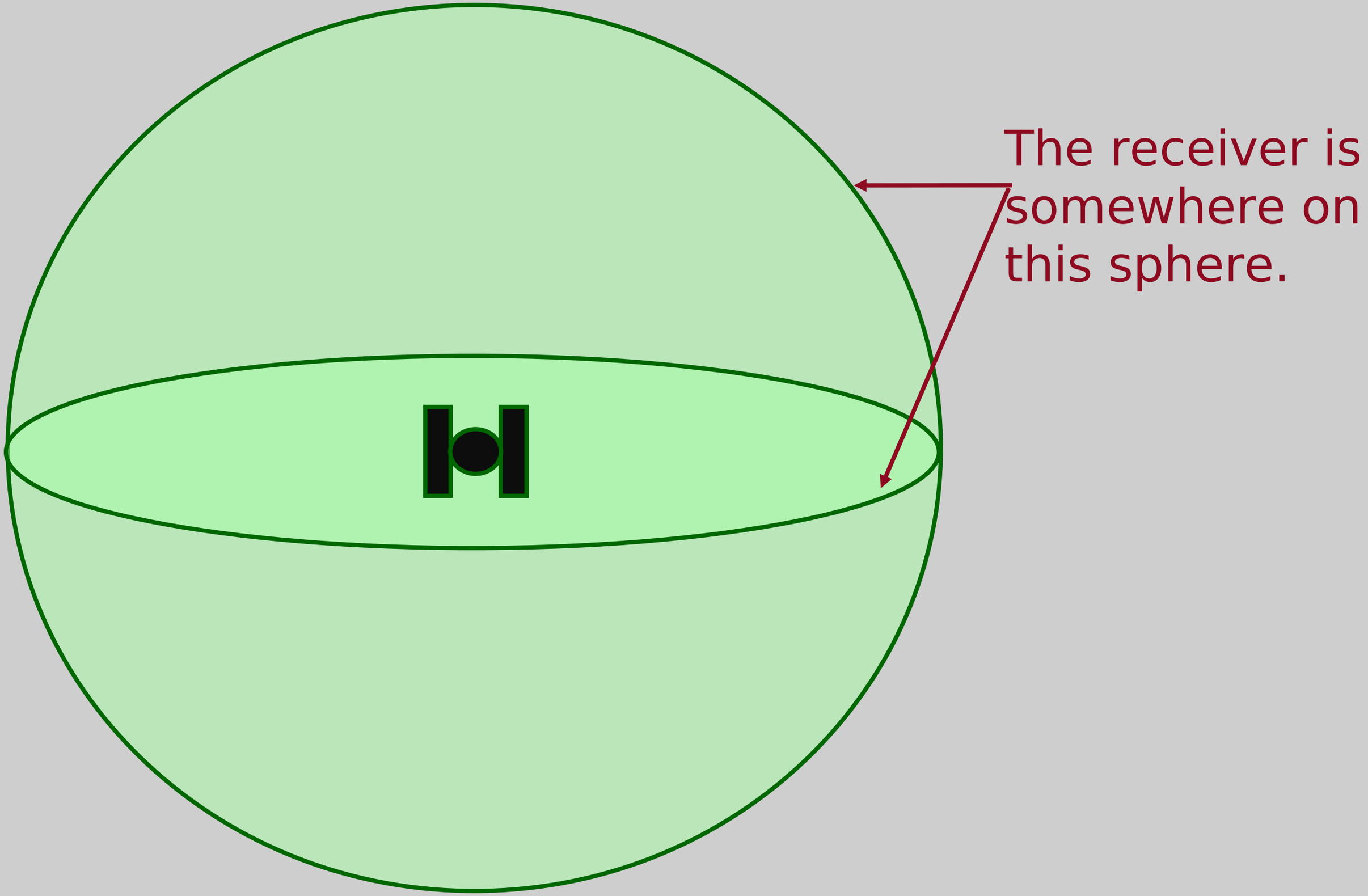
Local Time: AM and PM (adjusted for local time zone)

↕

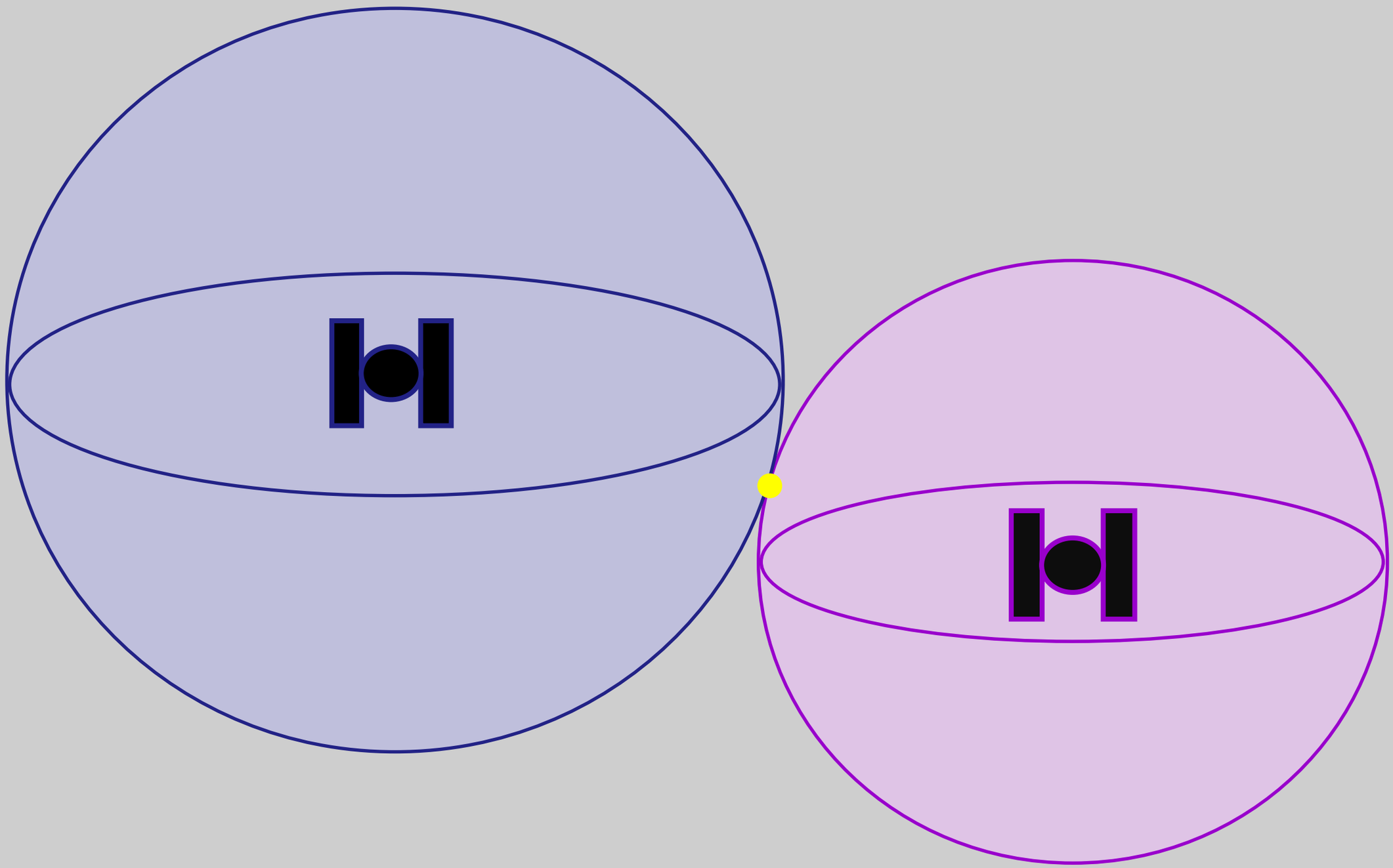
Military Time
(local time on a 24 hour clock)

* GPS Time is currently ahead of UTC by 13 seconds.

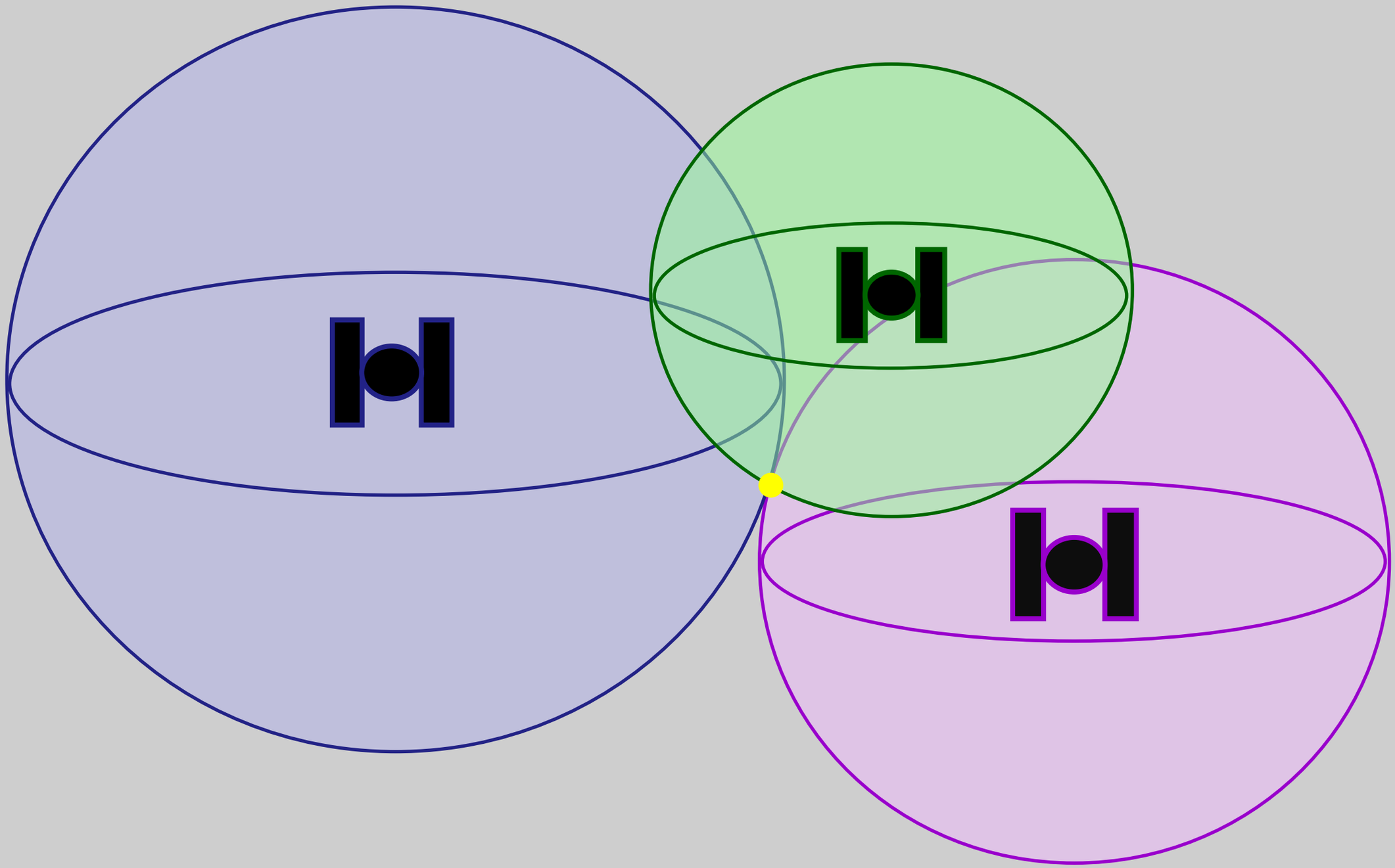
Signal From One Satellite



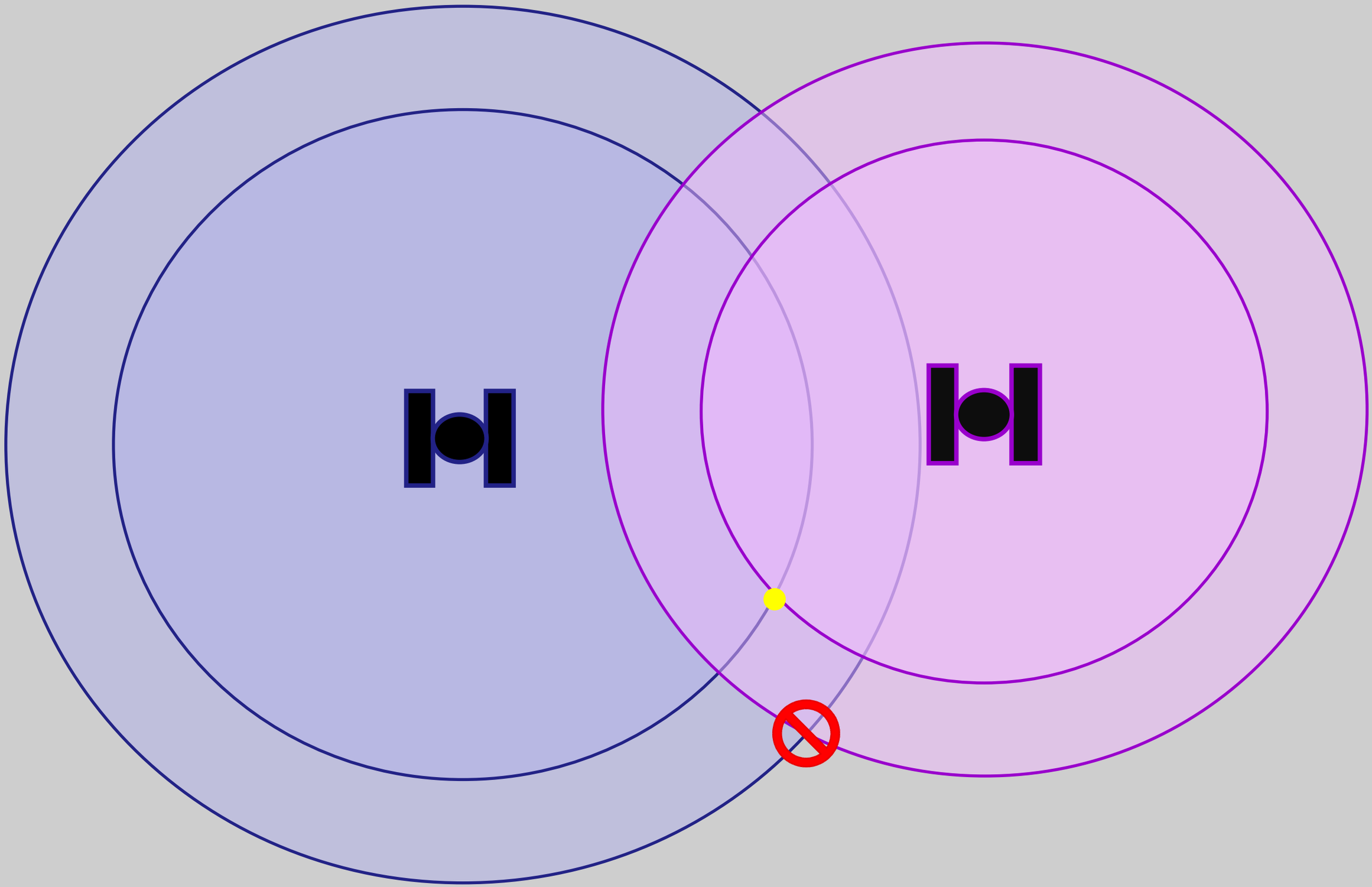
Signals From Two Satellites



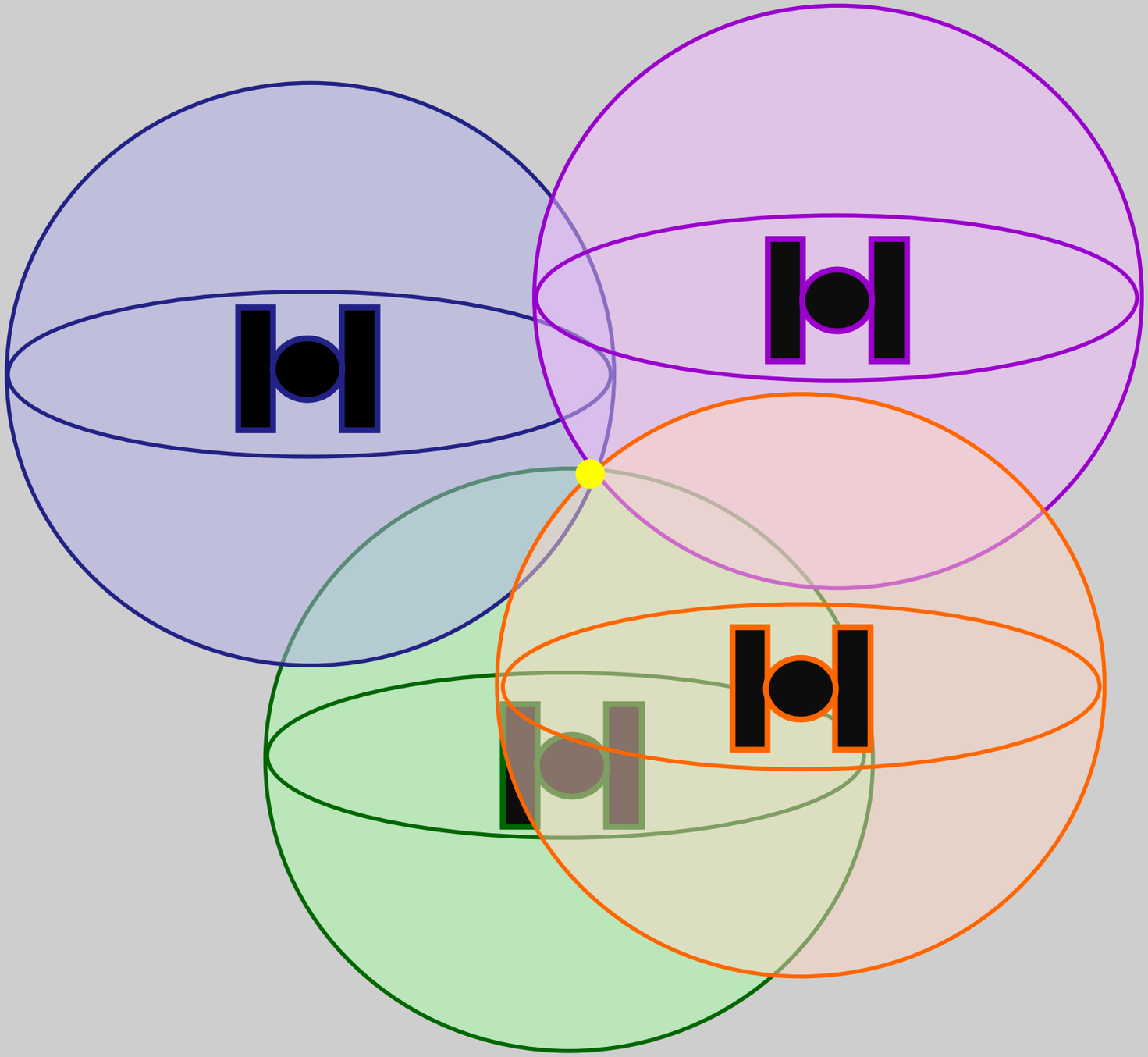
Three Satellites (2D Positioning)



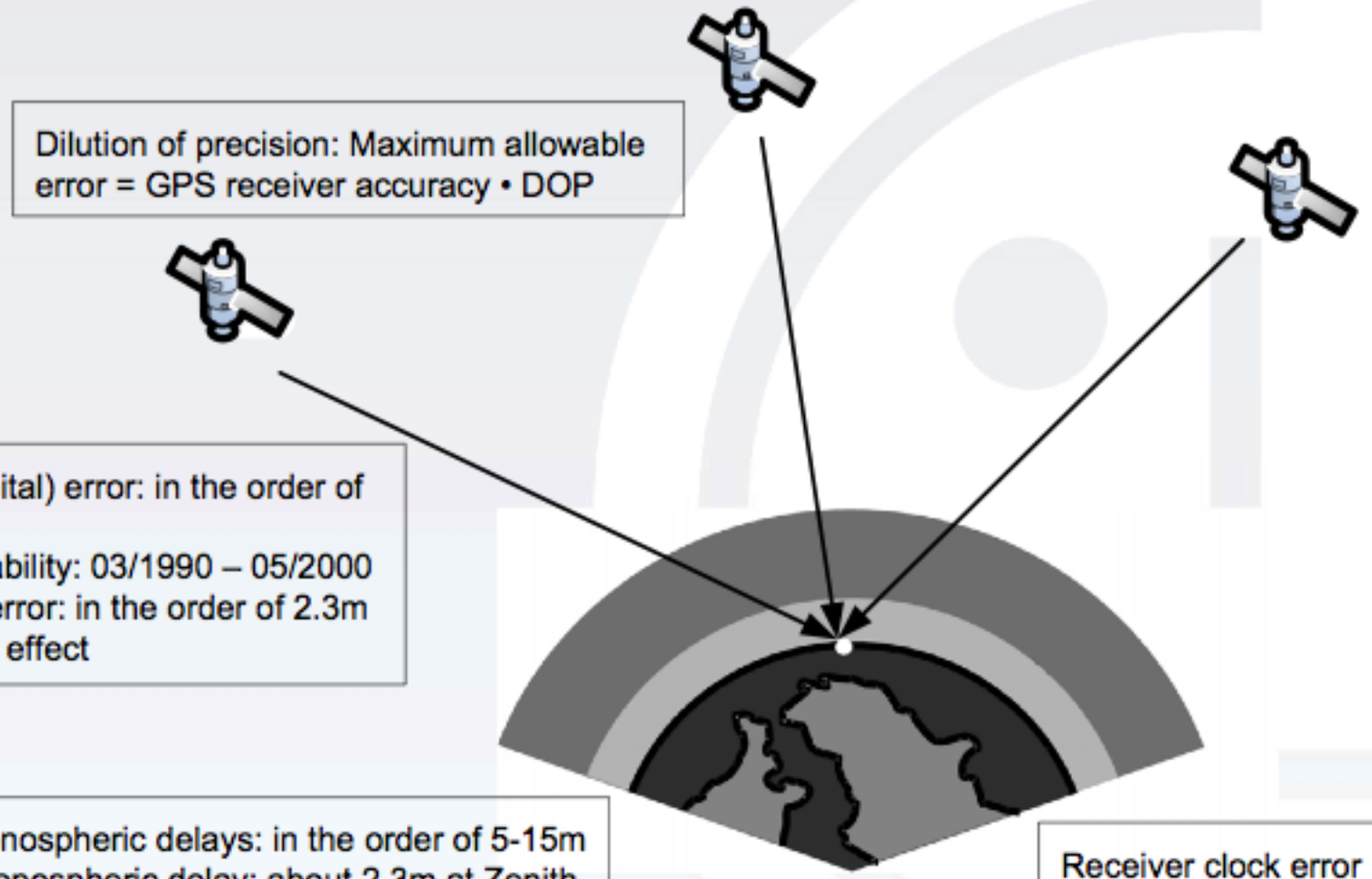
Triangulating Correct Position



Three Dimensional (3D) Positioning



GPS Positioning Error Sources

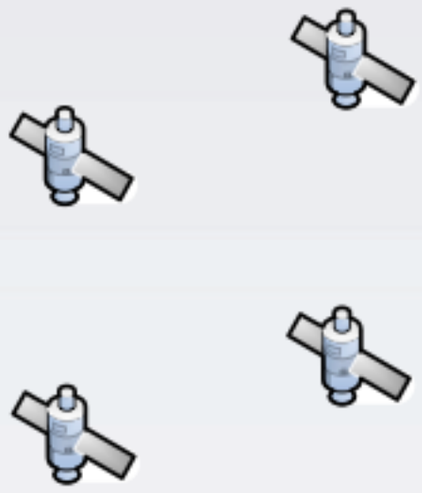


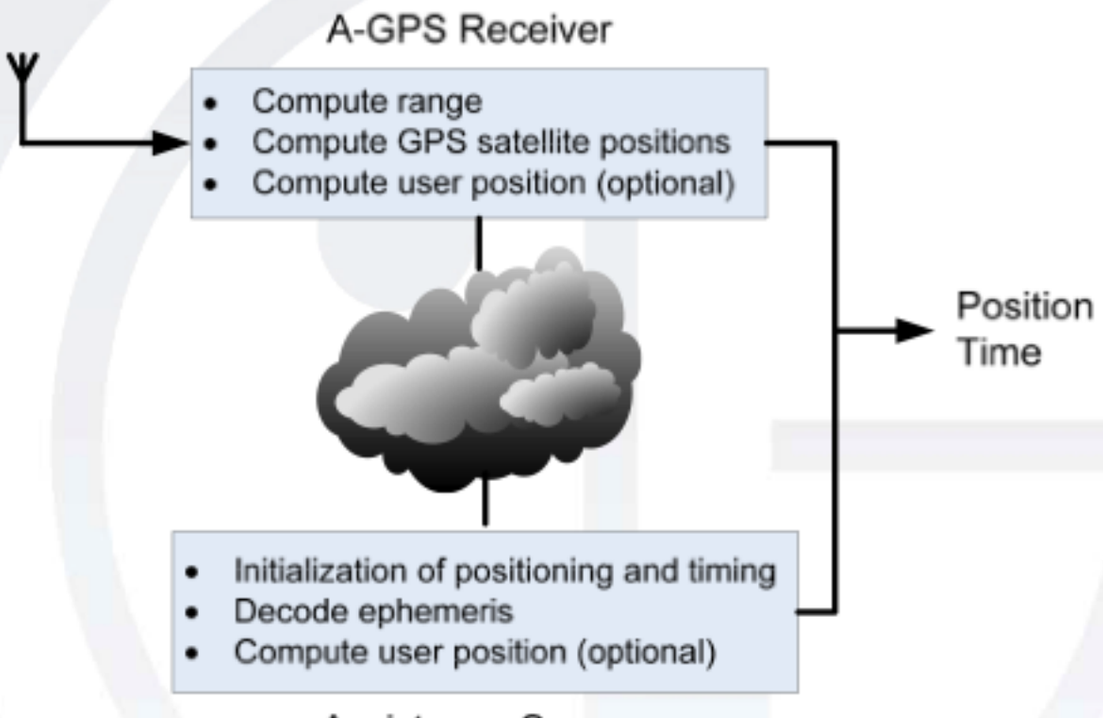
Assisted GPS: Overview

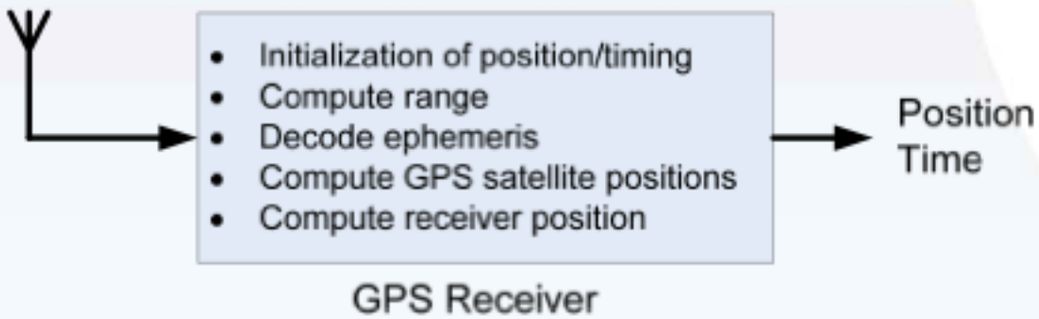
- A-GPS with assistance server were developed to enhance the positioning performance of a GPS receiver and satisfy FCC's E911 mandate.
  - It was firstly come out by Bell Labs before the 1996 FCC ruling.
- Assistance server can increase the capability of a stand-alone receiver.
  - It can roughly locate mobiles along by itself.
  - It can supply more GPS orbital data to the mobile.
  - It has better knowledge of atmosphere conditions and other errors as well as better augmentation capability.
- A-GPS help improve positioning in terms of
  - Location accuracy: the positioning error.
  - Yield: the positioning success rate.
  - Time to fix: the time for positioning.
  - Battery consumption: power consumption for positioning.
  - Mobile device cost.

  - swang@lge.com

Assisted GPS: GPS vs. A-GPS







Assisted GPS: Assisting Information

- Precise GPS satellite orbit and clock information
  - Reference time
  - Reference location
- Initial position and time estimate
  - Almanac
  - Acquisition assistance
  - Real-time integrity.
  - Universal Time Co-ordinates
- Satellite selection and range information
  - Differential GPS (DGPS) corrections
  - Navigation model (contains satellite ephemeris and clock corrections)
  - Ionospheric model
  - UTC model

Galileo : Overview

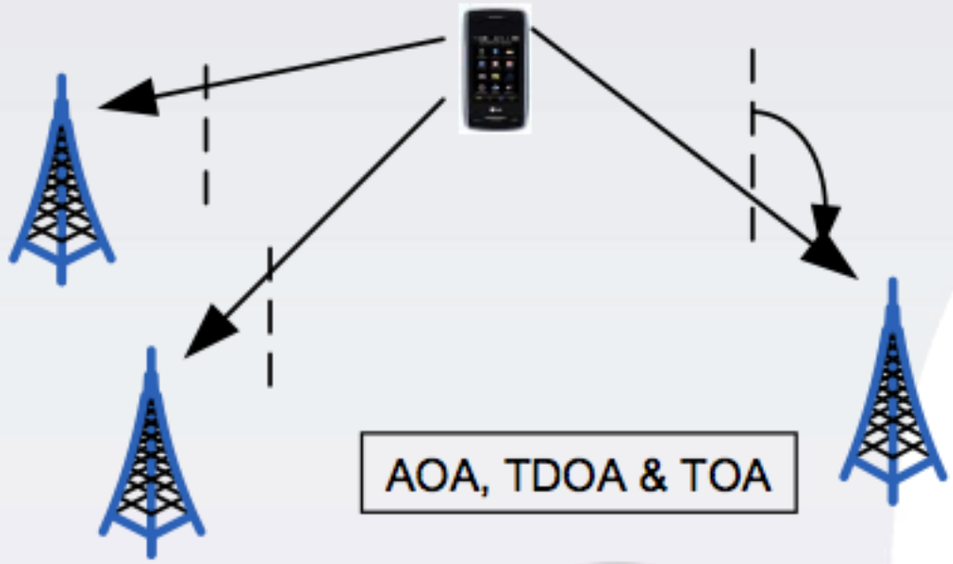
- Galileo is a Global Navigation Satellite System by the European Union.
  - It is a joint initiative of the European Space Agency and the European Commission.
  - The goal is to provide an accurate, guaranteed global positioning service under civil control.
- With Galileo, the European Union wants
  - to control the geopositioning system and guarantee the access.
  - to develop more civilian applications including new paid services and have it under civil control.
- The current status of Galileo project
  - Participants: the 27-state European Union, the 15-state European Space Agency and some non-EU country partners.
  - Budget: €5.4 billion.
  - Schedule: constellation deployment around 2011; full operation around 2013.

Positioning Technologies for Mobiles (1/2)

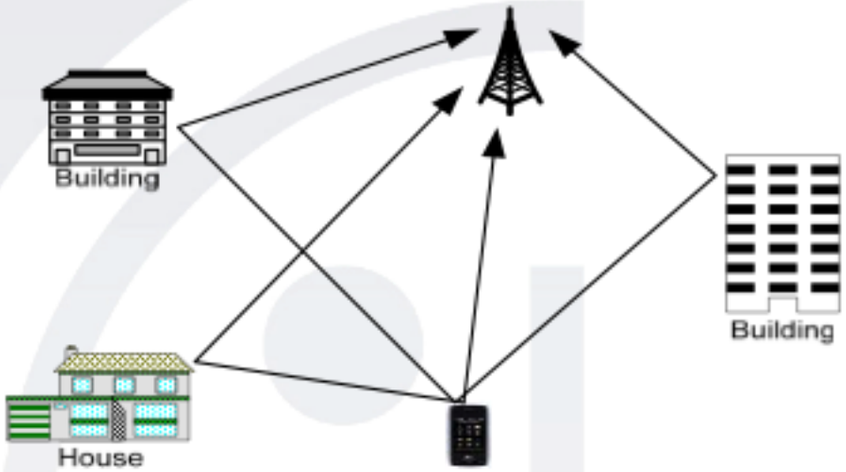
- **Mobile-based solutions**
  - positioning is carried out in handset and sent back to the network.
  - Potential security risk
- **Mobile-assisted solutions**
  - Handset makes the measurements, reports these to the network where the serving mobile location center node calculates the handset position.
  - Location information is not stored in the handset and remains in the network.
- **Network-based solutions**
  - Positioning is done by the network.

	Cell ID	Cell-ID/TA	EFLT	AFLT	AOA	TDOA	EOTD	GPS	A-GPS
Network-Based					■				
Mobile-Assisted			■			■	■		■
Mobile-Based	■	■		■				■	■

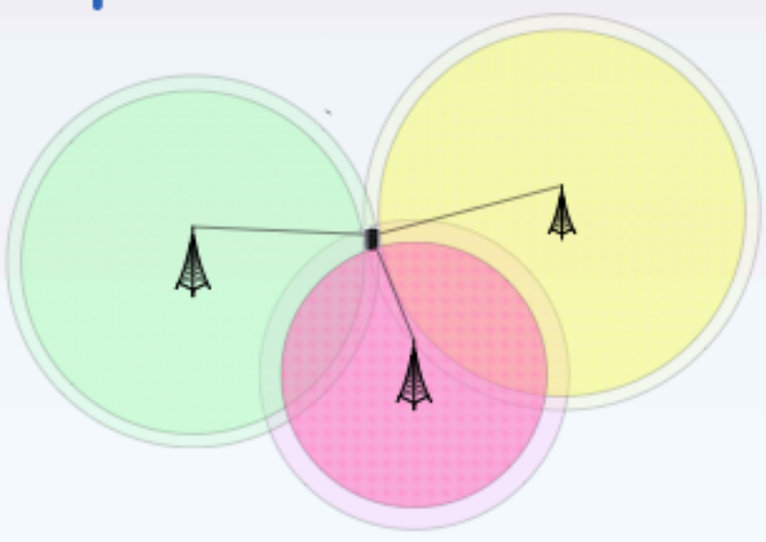
Positioning Technologies for Mobiles (2/2)



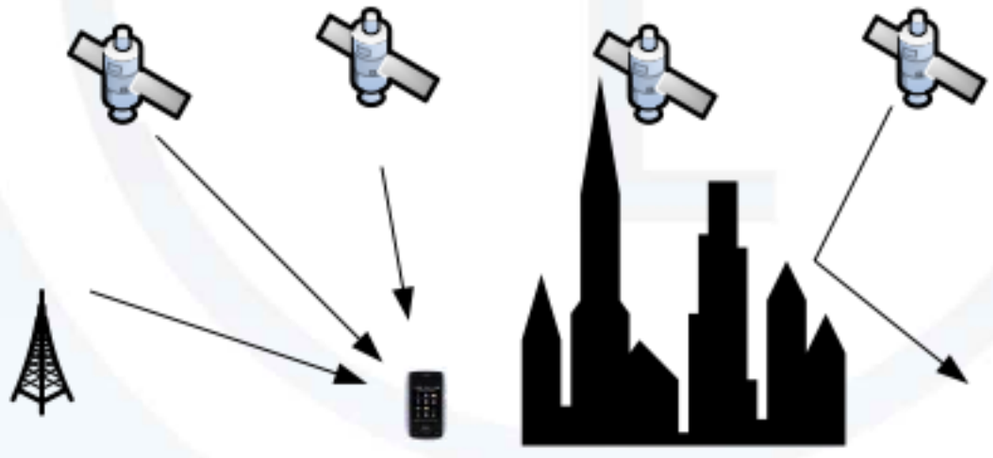
AOA, TDOA & TOA



Multipath or Signal Strength Analysis



E-OTD & A-FLT



GPS & A-GPS

Positioning Technologies Comparison

	Attributes	Network	Handset	Accuracy
Cell ID	Obtains Cell ID based on pilot measurements	All	Both	100m-3km, depending on cell size and density
Cell ID + TA	Combines Cell ID with time advance	GSM	Both	Default is 500m. Depends on bandwidth
EFLT	Mobile measures the forwardlink pilot timing.	CDMA	Both	250-350m
AFLT	Mobile measures the forwardlink pilot timing.	CDMA	Upgrade	50-200m
AOA	Network measures the angle of arrival.	All	Both	100-200m
U-TDOA	Network measures the timing difference.	All	Both	< 50 m.
EOTD	Mobile measures time difference.	GSM	Upgrade	50-200m
GPS/A-GPS	GPS receivers in handsets and/or network.	All	Upgrade	5-30m

Challenges!

Thank You.

- http://to.swang.googlepages.com/ICC2008LBSforMobilessimplifiedR2.pdf

- www.nps.gov/gis/gps/gps4ics/2_PreWork/PreWork.ppt

- http://en.wikipedia.org/wiki/Global_Positioning_System

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