# Assignment for theme 4.

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# What effect did the US FCC’s regulation in 1996 have on the mobile phone locationing services development?

US FCC regulation in 1996 madated that all the commercial mobile cellular networks to provide emergency 911 services for its users. This is in similar lines to service offered by landline providers where calls emergency 911 calls to public safety answering point (PSAP) are accompanied by calling party location information. Determining the location information of mobile device without user getting involved has some challenges when compared with similar service from fixed landlines users. The realization of FCC order was technically difficult to achieve in a single go. Also the accuracy parameters of the location information was also modified which contributed to delay in execution of the order. Therefore addressing of FCC regulations on the location information from mobile carriers was taken in two phases.

**Phase 1**: Location information provided by commercial mobile service provider shall to public safety access points (PSAP) shall include cell id or location of the cell or base station that receives the call. This requirement is relatively easier to implement as it does not involve any distance measurement of the mobile.

**Phase 2**: This phase mandates using distance measuring method that estimates to a specific degree of accuracy the location of the mobile from where 911 call is made. Regulation mandates the service provides to pass latitude, longitude information of the mobile during the time of the call as part of location information to public safety access points in conformance with certain accuracy levels.

Accuracy levels stand at 100 meters for 67% , 300 meters for 95% for network based service , For handset based technology accuracy is 50 meters for 67% of call and 150 meters for 95% calls.

# The features of the cellular network affect on the location services (Bensky, 9.2.). Answer the following questions:

## Which interface has the biggest role in locationing properties?

Air interface between mobile station (MS) and the Base Station (BS) is the one that predominantly affects the accuracy and performance of the location functionality.

## Which network element is usually added to BS subsystem and what are its main functions?

Networks that support location services have Location Measurement Unit (LMU) as part of the base station (BS) functionality . LMU is capable to collect the TOA data from the mobile station via air interface.

# Why is a parameter called timing advance needed in GSM and other TDMA-based networks? How is it useful in positioning?

In GSM technology, Timing Advance (TA) is used to compensate for the propagation delay as the signal travels between the mobile station and base station.

The time at which the phone is allowed to transmit a burst of traffic within a timeslot must be adjusted accordingly to prevent collisions with adjacent users. Timing Advance (TA) is the variable controlling this adjustment. The Base Station system assigns the TA to the mobile station based on how far away it perceives the mobile station to be.

TA is a function of the base station controller and can be handled anywhere in the BSS.

TA is a calculation of Path (Propagation Delay) which is primarily the distance covered by signal from Mobile terminal to BTS either on direct Path or multipath. It value is 0 to 63 ,Default value is 63 .

Timing advance can be treated as maximum distance between MS and BTS. TA value of 1 equal to 550m, and value of 63 means MS and BTS i.e 0.5×63 =31.5km.

A continually adjusted TA value avoids interference to and from other users in adjacent timeslots, thereby minimizing data loss and maintaining quality of service.

Timing Advance is also significant for privacy and security, as its combination with other variables can allow GSM localization to find the device's position of the mobile phone user.

# Why is power control making positioning more difficult in CDMA-based systems? How is it overcome in the UMTS system?

In CDMA technology, for the multiple access to be effective a strict power control methodology is used to overcome the near far effect. Under CDMA, transmission from same cell or adjacent cells happen on same frequency channel. The spread spectrum principle of processing gain allows reception of desired signal in the presence of interference in the same frequency, but maximum number of users is governed upon the necessity for all received signals at the base station to have the same signal level. To achieve this , mobile terminal at close vicinity to base station will have to reduce the power levels and farther ones will have to increase the power. Mobile terminal located close to base station will have the power level low due to which it signal to noise ratio is too low for location service equipment in other cells whose TOA data from the mobile terminal in other cells is required to calculate target position.

This problem is further elevated during handovers across base station and power adjustments are stopped during this time frame allowing location measurement units to calculate TOA.

Coming to UMTS , location accuracy information is better compared to both CDMA and GSM systems because of increase bandwidth and shorted bit rate period. In UMTS forced handovers are used to get rid of near-far problem caused as a result of power control problems

# Which operating principle (handset-based or network-based) is better from the following points of view? Give also good reasons.

Two major categories in use for location positioning are Network based and handset based systems. Network based systems employ and use cellular base station measurements to calculate location position of the handset with out any role of handset. Handset based systems calculate location position with in the handset using hardware and software intended for this purpose with no role of cellular network. Both the systems have their own advantages and disadvantages , let us their role regarding above questions.

## Operator’s capacity and cost management

Considering the operator bandwidth usage and costs involved, I see handset based system is better that network based one . In handset based systems , calculation of position is solely done in the handset by its software and hardware with out any help from the cellular service providers bandwidth and capacity usage as the network capability is not involved.

## Handset’s battery and processor capacity

Employing handset based location system can drain more power and have negative impact on the processor load in the handset. This is because handset based systems calculate the location position with the help of software and special hardware residing in the handset. These calculations can take considerable power and processing capacity which can be costly when the handset is low on power. In network based systems , this additional power and processor capacity from handset is not needed.

## Security or government needs; how to locate e.g. terrorists

From security and government needs , Network based systems take precedence compared to network based systems. In network based systems handset users does not have any control on the operations for calculating location position nor can neither initiate or terminate the location position calculation. In this way governments and securtity agencies can track the terrorists movements. A network based system can imitate the target positioning and tracking without intervention of the target. Conversely in handset based systems , users have control on location position calculation.

## A runaway prisoner

A runaway prisoner can be tracked similarly as explained above by network based location position calculation system. As we know network based system can initiate the target positioning and tracking without intervention of the target or the user of the handset.

Also as the network would have more power and resources at its disposal it can use enhanced algorithms and effective positional techniques and provide location information with better accuracy that can be not practically feasible with handset based systems . This information can track the runaway prisoners and expose their locations.

## A tourist far away from home in a developing country

A tourist away from home can use handset based capability to know his location when roaming out side his own home country. Here handset based location positing systems can become pretty handy as they work with out any help of the network in the developing country.

# Why is a plain GPS receiver not very suitable to a mobile phone? How are these restrictions overcome with A-GPS system?

Plain GPS receivers inside a handset can have negative impact on handset in terms of power drain ,may need some powerful hardware , consume more processor power which are by nature pretty costly especially in handheld devices. Also by their nature and area of usage , they can be at places where GPS satellite signals are strong enough because of blockage or indoor environments and greater time to fix . There can be inordinate delay for Location based services (LBS) if there is any in ordinate delay in calculating time to fix.

‘These above problems can be overcome via Assisted GPS (AGPS) , where the needed location coordinates can be transmitted over the cellular network as SMS and packet data that can be used for LBS systems. In AGPS , most of the functionalities of GPS are performed by remote GPS receivers in the network and computed data gets transmitted across cellular network. This data can be Satellite orbit and clock information, Initial position and time estimates , Satellite selection their range and position computation.

So the AGPS handsets can result in lower power consumption , rapid location determination and can be used in indoor locations as well unlike traditional GPS receivers.

# Explain picture 9.6 in Bensky’s book. How is the accuracy of cell-id method increased with sectoring, RSS or timing advance?

Most simplest and basic positioning technology available to cellular systems is Cell-ID systems . This is can be used in both handwork based and network based systems.

This technology works on the principle deriving the location position of the handset based on base station transceiver the handset is connected to.

As the cell identity and location as known to the base station, this information can be obtained by handset from the network. Accuracy of this method depends on the cell dimensions and also can be enhanced by employing other location methods.

* Using directional antennas for base stations:
  + Using specific beam directional antennas for ex 120 , the cell areas and their accuracy can be reduced by one third approximately. We can clearly see this from picture a for the diagram in the book.
* Received signal strength
  + Location accuracy can be improved by received signal strength. This is based on the principle that signal strength varies depending on the factors like topography, antenna patterns, radiated power and operating frequency. We can clearly see this from picture b for the diagram in the book.
* Timing advance
  + Location accuracy can be improved by using timing advance which is primarily the correction that network makes to the mobile station timing to account for propagation delay so that slots allocated for handset do not ovelap with others.

Picture c in the diagram of the book explain this.

# What is the biggest problem in cellular positioning using different TDOA-based methods?

Network based positioning systems can use TDOA to estimate the location of mobile.

The cross correlation that is transmitted by the mobile must be received by at least three base stations. Then the received time of arrival is calculated by the base stations and sent to location measurement function which knows the location of itself and base stations through which it estimates the position of location of the mobile.

The biggest problem in implementing TDOA cellular location systems is ensuring that multiple base stations hear from the mobile in multilateral systems and in unilateral systems moble terminal hears from multiple base stations. Unilateral systems is easier to achieve as the base stations can broadcast control signals that are received by mobile terminal to determine which cell it is located in.

# Explain the main idea in

## E-OTD

Enhanced observed time difference (E-OTD) was one of the primitive location position calculation technologies employed by cellular systems. Unlike handset based systems where the location position is calculated in the handset , in E-OTD observed time difference measurements from downlink signals from multiple base stations is routed from the mobile to mobile location center (MLC) that calculates the location of the mobile station.

## OTDOA-IPDL

Observed tome difference of arrival is similar to E-OTD primarily used in UMTS networks.

In assisted mode, positions calculations are carried out in a serving radio network controller (SRNC). Time of arrival measurements at UE taken from downlink messages from multiple node B terminals are forwarded to serving RNC.The relative time differences of the transmission times of the downlink signals to the UE sent from the base stations are measured by Location measurement units (LMU) and sent to SRNC. The SRNCs calculate the location UE(user equipment or mobile) using OTDOA measurement data, relative transmission time differences and the coordinates of the nodeB terminals.

UMTS network employs same air interface as CDMA where the neighboring base stations transmit concurrently on the same radio channel. In this case UE may have problems at detecting sufficient signal from needed multiple base stations for calculating time difference of arrival. This is because the base station closest to UE have stronger signal transmission than the rest participating on OTDOA calculation. In this case IPDL (idle period download link )

Where the closest or the serving node B provides idel transmission periods to allow the UE to receive transmission from other base stations.

## UTDOA

Uplink time difference of arrival is network based calculation for time difference of arrival.

It get timing messages from uplink signals received from a mobile terminal at multiple neighboring base stations. Location measurement units are distributed such that several of them can receive the measurement sequences from mobile terminals and calculate the TDOA values for estimating mobile terminal location position.

U-TDOA can deliver location position accuracy levels till 30 to 50 meters and can be supported by both latest and legacy mobile terminals with out any modifications.

# Why AOA method is expected to work better in rural environment than in urban area?

AOA (angel of arrival) is a network based system for deriving location calculations . It works on the concept of using directional beam antenna arrays for its operation. Advantage of AOA system is that it needs only two base stations with directional antennas where as other TDOA methods need at least three base stations for location position calculations.

AOA systems can be more handy in rural areas where cells are large enough and often no more that two base stations reach the mobile terminal . Also rural areas have clear line of sights when compared to urban surroundings where AOA can be more feasible to employ. Unclear line is sight is the reason why AOA is not a feasible solution in urban areas.

# What does term integrated positioning solution mean in LTE’s positioning concept?

Individual positioning technologies have several advantages and disadvantages and are highly dependent on several factors like environment, radio signals, visibility, network and handset capabilities etc. Integrated solutions can come in handy here addressing a wider range of requirements adding to efficient usage of network and device resources.

In order to enhance the accuracy of positioning information in all the environments , LTE uses many complementary positioning methods. The main location technologies used are Observed Time Difference of Arrival (OTDOA) and Assisted Global Navigation Satellite System (A-GNSS). Due to the high level of accuracy these methods can achieve with no requirement for additional radio network equipment where OTDOA is used for indoor locations and A-GNSS can be used for outdoor environments.

Individual positioning systems described above may not perform effectively at all conditions , times and environments . So these should be complemented with each other rather that using stand alone methods. So integrated positioning solutions by combination of different positioning techniques provided effective solutions that can meet a wide range of accuracy and performance requirements while allowing efficient use of network and device resources.

So the above described OTDOA and A-GNSS methods are often complemented with additional technologies such as self-learning fingerprinting or proximity location and employed as integrated solutions for positioning systems.

# Which positioning methods have been chosen to be realized in LTE? Why these methods

Demand created by Location based services (LBS) was one of the driver for LTE technologies to come up with an integrated location based systems that can deliver an accurate and effective positioning information. LTE supported wide variety of positioning methods as part of its evolution of various releases.

* Cell ID: This method utilizes cellular system knowledge about serving cell of specific user and user location is thus associated serving cell ID. Support for this method has been available from release 8.
* Enhanced-CellID: This positioning method is User Equipment (UE) assisted and network based that utilizes the cell IDs ,radio frequency measurements from neighboring cells, timing advance and angle of arrival (AOA) measurements for deriving positing information.
* OTDOA – This positing method is based on user equipment assistance on reference signal time difference measurements conducted on downlink positioning reference signals received from multiple locations, . Here UE location is calculated by multilateration method.
* A-GNSS – Assisted GNSS is an UE-based and UE-assisted method that use satellite signal measurements retrieved by global positioning systems such as Galileo and GPS.

Other positioning methods like RF Fingerprinting which uses finding user position by mapping RF measurements obtained from the UE onto an RF map, AECID and other hybrid positioning methods are introduced from release 9 onwards.

U-TDOA which is an uplink alternative to OTDOA has been introduced from release 11 onwards.

# Discuss the ethical problems that may be caused by the possibility of locationing other people’s mobile phones. What kind of problems can arise, if everyone could position anyone he wants?

If people are able to track and monitor each others locations and identify their roaming patterns , there can be issues related to violating privacy and can mean that entering into their private space.