# Hybrid positioning and CellLocate™

**Increased reliability and indoor positioning based on mobile network attributes**

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Although GPS is a widespread technology, GPS positioning is not always possible, particularly in shielded environments such as indoors and enclosed park houses, or when a GPS jamming signal is present. The situation can be improved by augmenting GPS receiver data with mobile network cell attributes to provide a level of redundancy that can benefit numerous applications.

CellLocate supports positioning even in places where GPS satellites are blocked

u-blox, through its in-house development of wireless transceiver modules, has embedded cellular positioning technology, CellLocate™, into its LEON family of 2G and LISA family of 3G wireless modules. The technology enables stand-alone location estimation based on surrounding GSM cell information in conjunction with GPS positioning data to improve positioning in several use cases:

- **GPS signals are blocked:** a GPS receiver cannot determine a position when satellite signals are unavailable, such as within tunnels, buildings, or metallic containers. For fleet and supply chain management, this condition can be unacceptable. In this case a cell-based positioning system using GSM cell information can provide an estimated position. This is attractive for vehicle or container tracking applications where an approximate location of valuable assets is preferable to no position fix at all. This system is functional within warehouses, rail stations, airports and tunnels.

- **GPS signals are jammed:** GPS jamming devices are easily obtained for less than a hundred dollars. These devices can neutralize GPS receivers, and are often employed during vehicle theft. A backup cell-based system in this case acts as a secondary system, as GSM cell signals are available even when satellite signals are blocked by jamming. The GPS receiver can also add intelligence to the system as u-blox GPS receivers can detect when a jamming signal is present, putting the system into an “attempted theft” condition.

- **Machine-to-Machine (M2M) applications:** Many M2M applications require positioning capability within a bounded area such as within a city, along main vehicle or rail links, or within specific venues such as an exhibition, entertainment or healthcare facilities. Positioning reliability in these areas can be improved by using cellular signals as well as

GPS to provide accurate positioning. Based on an extension of u-blox' AssistNow Online GPS assistance service, u-blox' CellLocate technology is used to match cellular positioning data coupled with previously successful GPS fixes.

This "learning" solution can be practical for M2M applications where units are repeatedly used in specific areas such as a taxi fleet in a city, or containers and palettes travelling between warehouses. In these cases a specific database of useful cell data is quickly generated and the service is able to reliably give the current position to the user.

The above scenarios exploit the combination of Cellular and GPS positioning data (Hybrid positioning) to deliver better results than GPS technology could accomplish alone:

- **Positioning performance can be improved and extended** to areas where GPS satellite signals are 100% blocked, especially within buildings
- **Eliminate "no-fix" scenarios** by providing at least an approximate fix wherever cell phone coverage is available
- **Overcome GPS jamming** scenarios to improve antitheft system performance

LEON 2G module with CellLocate™

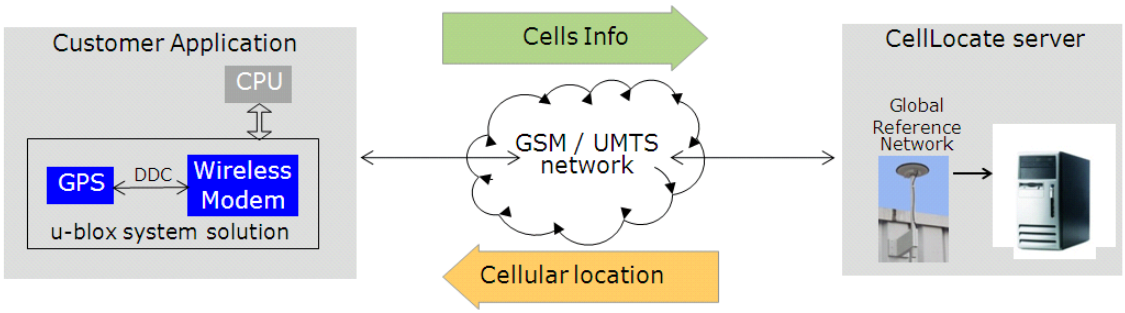
u-blox' CellLocate™ cellular positioning technology is an embedded feature implemented in u-blox' LEON 2.5G and LISA 3G wireless modem families.

**How CellLocate works**

LISA 3G module with CellLocate™

For any given location with cellphone coverage (2G or 3G), a specific combination of basestations will be visible. CellLocate is a proprietary feature embedded in u-blox' 2G (LEON) and 3G (LISA) wireless modems which allows them to report which basestations are visible at any specific location. With this information available, a device (for example a stolen vehicle tracker) can transmit the data to u-blox' online CellLocate server.

The CellLocate server then matches the visible basestation data with observations made when a GPS fix taken previously at the same (or nearby) location. The server can then return an approximate location to the receiving device. The device can then forward the location to an end-application, for example an emergency response center for further action.




CellLocate block diagram

CellLocate thus requires that a database of network cell attributes and corresponding GPS fixes has been previously seeded to function over specific areas of operation, for example:

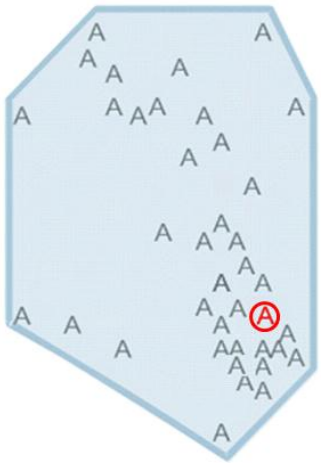
a) at the customers' depots, for a device monitoring application where the devices may be indoors, for example for M2M transport applications
b) within a specific local area, for caring for people who may wander such as hospital patients or the elderly.
c) along motorways for tracking stolen vehicles.

Such a database can be quickly generated by users, or by a short survey using the device to collect cellular observations, tagged with their GPS positions.

The CellLocate server adds intelligence by extrapolating location based on the areas where network cells are visible. A simplified example follows:

**Step 1, seed the database:** Observations of network cell A are reported, each matched with its corresponding GPS location. The data is transmitted to and stored on the CellLocate server. This is repeated over the desired region (also for network cells B, C, etc) where CellLocate should operate.

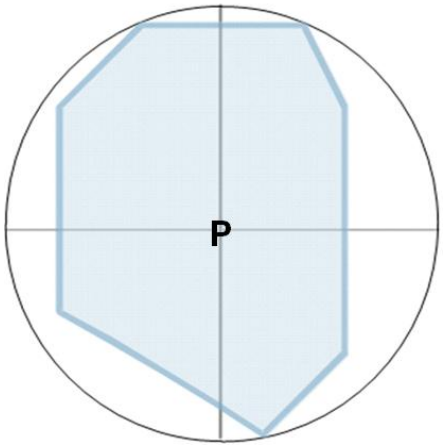
Note that in some applications this process occurs automatically as part of normal system usage.



**Step 2, a new observation in an unknown place**

When a device enters the area of Cell A visibility and a CellLocate fix is required (circled red A, actual location), the cellular environment is observed, and the visible cells (here cell A), reported to the CellLocate server.

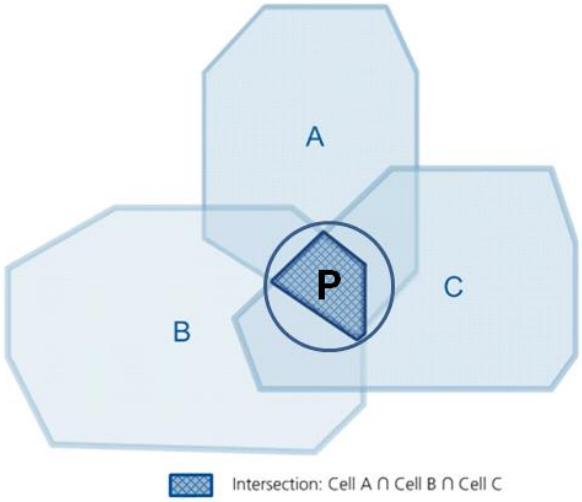
This is repeated for neighboring network cells B and C (for an example with 3 cells visible).




**Step 3, derive location by matching network cell A visibility with historical observations:** The CellLocate server uses proprietary algorithms to match the current observation with previous observations in the database, and produce a position estimate **P** (we show the middle purely for illustration purposes), as well as an uncertainty factor.

This information is then returned to the device for use by the application.

This method of hybrid positioning works for locations where no GPS fix is possible (i.e. indoors): so long as cell A visibility is confirmed, a position based on samples where the cell has been previously seen can be assigned as this approximate position.




**Increasing accuracy**
The simplified example above is based on visibility of a single network cell A. This will provide an approximate position as all observations of cell A will result in a location near the middle of the area where the cell has been previously seen.

The accuracy is increased by recording multiple cell visibilities for each location. This can be illustrated in the diagram on the left:

If the device can see the cells A, B, and C, then when it submits the request with the observation to the server, the proprietary algorithms are able to match the current

observation to the area where the 3 cells are visible, and report a more accurate location.

After initialization, the method described above may function without a GPS receiver, though typically CellLocate would be used in equipment with GPS to augment the GPS positioning in areas where GPS satellite visibility is limited or blocked (i.e. indoors), providing greater reliability and coverage.

**Performance**

The accuracy of CellLocate depends on the density of network cells and database population. Hence, the best results can be achieved in urban environments where cellular basestations are spaced a few hundred meters apart.

In rural areas the cell sizes are greater and the accuracy is less. However (and in contrast to the limited coverage offered by WiFi positioning techniques) cellular signals are still visible in rural areas, and a position estimate can still be provided by CellLocate.

The cellular network evolves, with changes made by network operators, for example during network maintenance, or to add communication network capacity. Despite this the devices using CellLocate are able to deliver best performance by scanning the cellular environment not only for the cells belonging to the serving cell network, but also for the cells of other network operators. The proprietary matching algorithms in CellLocate work equally well for the other network operators' cells, and provide a position estimate that is not only more robust against network changes, but also has increased accuracy because of the greater number of cells observed.

**Benefits of CellLocate**

The advantages of using CellLocate are the following:

- **Indoor positioning:** GPS doesn't work during indoor segments of a journey. CellLocate augments GPS by providing an approximate fix even when GPS satellites are blocked such as within warehouses, airports, or shielded containers.

- **100% positioning:** for mission critical applications such as tracking of stolen vehicles, valuable goods or people, CellLocate in conjunction with GPS will always deliver a fix, even in the presence of GPS jammers.

- **Easy initialization**: for particular applications cellular observations in the key locations or area of interest can readily be gathered – or may indeed already be available.

- **CellLocate improves over time:** as a "self-learning" system, the CellLocate database continuously improves over time, increasing the density of cellular observations with

GPS fixes during normal operation. This is also important as operators continuously add new cells, as well as change the attributes of existing ones.

**Using CellLocate**

CellLocate is a cost-free service provided by u-blox to support its 2G and 3G modem products: no license is required. As no personal or usage data is collected, CellLocate is a secure system that respects the privacy of its users.

**Availability**

CellLocate™ service is supported by the following u-blox wireless modems:

- LEON 2.5G GSM/GPRS data modules (available)
- LISA 3.75G UMTS/HSPA data modules (Q4-2011)

For more information on CellLocate, contact the u-blox office nearest you.