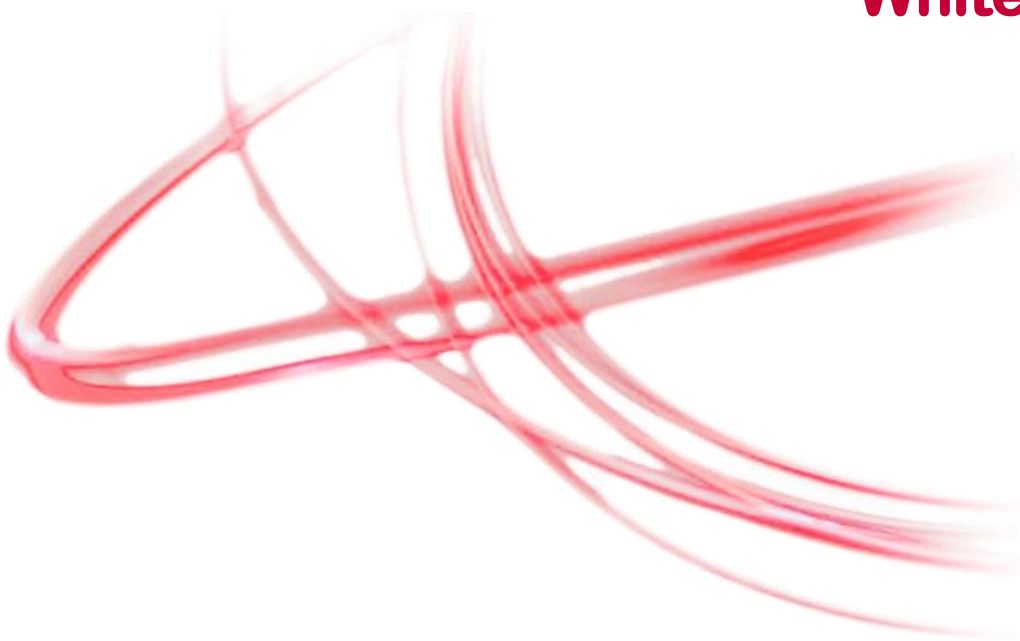




SeekerLocate™

White Paper

V1.2



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1. Introduction

1.1. Purpose

This document provides an overview of the SeekerLocate™ solution with a target audience of:

- Solution and system architects
- Marketing (Product Managers, Technical Marketing)
- Project Managers
- LBS delivery managers
- Radio network engineers

2. Solution Overview

SeekerLocate™ is a versatile location platform for locating or tracking mobile wireless devices on any cellular or Wi-Fi network. It supports a broad range of location capabilities, including mobile-originated, network-originated, periodic and even movement-triggered location requests/updates. It provides medium to high accuracy location determination to address the majority of the spectrum of location-based services and applications.

SeekerLocate™ offers considerable flexibility in deployment configurations, enabled by a user plane location architecture in which a client application deployed on the mobile device collects the radio measurements for location processing. This flexibility also means that location information can be obtained efficiently, enabling mass-market location services in a cost effective manner. Client implementations are provided for the majority of mobile application platforms, including SIM Toolkit, Symbian®, Windows® Mobile and other major smartphone families.

The user plane approach also means that a richer set of measurements can typically be obtained for location processing. As an example, an STK based client can periodically collect measurements and maintain a buffer of recent measurements ready for use in any location request.

This richer set of measurements enable a range of benefits and performance enhancements, including:

- Minimal latency or time to first fix (TTFF)
- Enhanced location accuracy
- More reliable reporting of the confidence range
- Higher yield
- Greater robustness against spurious information, including network database errors
- Automatic network monitoring and discovery

For geo-fencing and similar applications including location triggered advertising, a mobile client based approach offers dramatic improvements in precision and efficiency, with all the monitoring processing done offline without need for periodic polling of each device.

SeekerLocate™ supports a variety of implementations to address different requirements. For deployments in which a generic location capability is required to support a range of services, SeekerLocate™ offers a standards-based interface for applications to obtain location. This interface can be coupled with any third party LBS middleware or privacy management products as required, to support location applications (as illustrated in Figure 1).

For some location based applications however, a middleware layer may not be required. Additionally, if the location is exploited in a purely individual basis (i.e. users only access their own location), access and privacy management requirements may be simplified. In such cases, a tighter coupling between the application and SeekerLocate™ (as illustrated in Figure 2) can yield significant improvements in performance, while also decreasing cost and complexity. In certain scenarios, the SeekerLocate™ client may be directly integrated into a location-enabled mobile application.

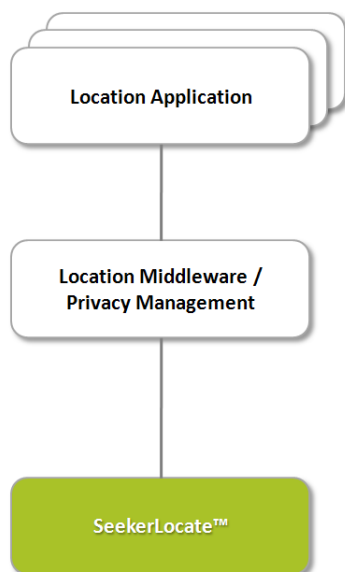


Figure 1 - SeekerLocate™ deployment for generic location capability

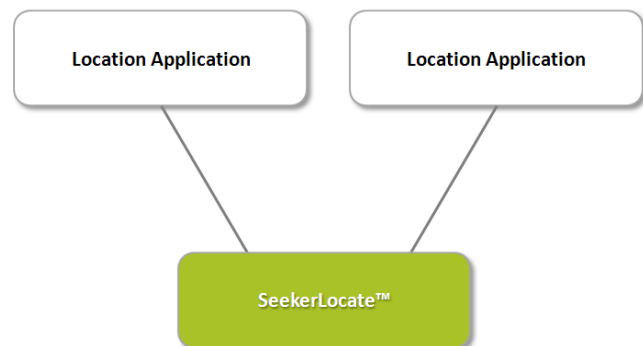
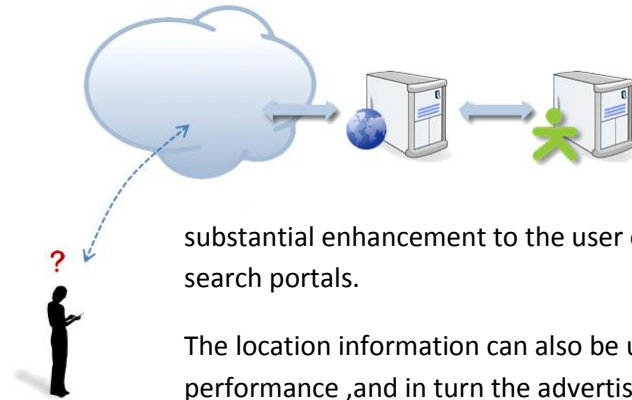


Figure 2 - SeekerLocate™ deployment for specific applications, without middleware

SeekerLocate™ features a patent-pending, sophisticated hybrid location engine, which can use any combination of wireless network and GPS measurements seamlessly to deliver the best possible performance. For cellular networks, it can utilise any combination of serving cell, signal level and timing measurements. It also exploits associations between observations from different sources, such as cellular networks and public and private Wi-Fi, to improve its performance. The hybrid location capability extends the reach of many current LBS to non-GPS handsets, and improves usability of GPS-enabled devices in terms of latency, coverage and yield.

2.1. Example applications

The following paragraphs describe a small selection of the applications and services which can be supported by SeekerLocate™ as an illustration of the versatility of the solution.



Contextual search : SeekerLocate™ can be used to location-enable mobile search services, whether browser, smartphone client or SIM based in a cost effective manner. For carriers, the benefits include a

substantial enhancement to the user experience, providing differentiation from other search portals.

The location information can also be used in targeting the search ads, improving their performance ,and in turn the advertising revenues.

The award-winning **Rednano Locate**¹ is an example of the application of SeekerLocate™ for contextual mobile search.

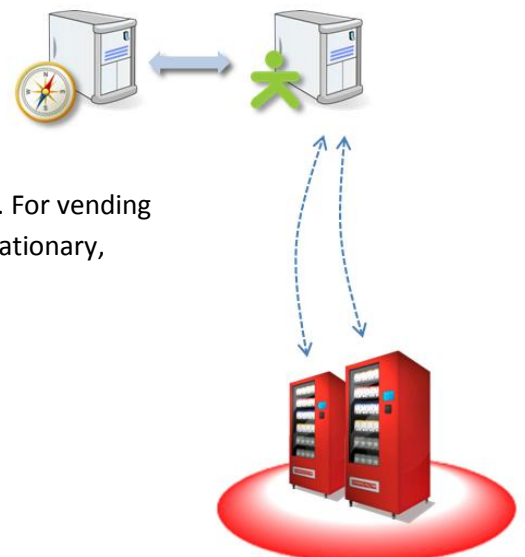
Fleet and workforce management : The SeekerLocate™ client can be deployed either as a SIM-based applet, or as a smartphone application. Using SMS or packet data, the client can enable the location of the user's handset to be integrated into monitoring or dispatch systems. For more sophisticated service requirements, Seeker's industry leading zone detection technology can be integrated for geo-fencing and movement based triggering.



Importantly for large scale services, the geo-fencing and movement triggering are implemented within the handset, which means that no active connection to a location server is needed. This also eliminates any need for periodic requests from a location server, which is expensive, and doesn't scale well.

Compared to network-based solutions, another significant benefit of client-based geo-fencing is the real time response (no delay until the next scheduled refresh). The SeekerLocate™ client can also record movement histories and routes efficiently. SeekerLocate™ can either be deployed instead of GPS, to give a low cost option which works where GPS coverage is poor, or in addition to GPS, combining GPS and radio based location to provide high yield, even when GPS coverage is poor (e.g. indoors).

Machine 2 Machine (M2M): a growing range of appliances are being equipped with a wireless terminal for remote operation and monitoring. SeekerLocate™ allows the easy integration of location monitoring and tracking into such devices. For vending machines and other similar assets that are expected to remain stationary,



¹ <http://www.rednano.sg/sfe/mobile.action>

SeekerLocate™ can provide an automatic alert if the device is moved. The movement alert can also be used to activate tracking mode with periodic location updates. The ability to monitor for movement passively, while the wireless terminal is in idle mode, enables substantial savings in network traffic and associated costs for the carrier and end user.



Mobile social media : location information plays an increasingly significant role in social media applications, whether it be for geo-tagging places or events of interest, or searching for friends nearby. In the majority of such applications however, the location capability is not something subscribers are prepared to pay additional fees for – making it difficult to recover the costs associated with the location platform. The efficient implementations supported by SeekerLocate™ enable carriers and other service providers to include location information as a differentiator in their offerings without blowing the business case.



Emergency caller location : While emergency caller location is regarded as a vital capability in the majority of mobile markets, relatively few have deployed solutions. One of the key reasons is the capital investment required, of which the location infrastructure is a significant component. In some markets, where lower cost solutions have been deployed based on Cell ID, performance problems exist due to the poor quality of the cell site data. SeekerLocate™ offers a low cost level similar to other Cell ID based systems but with enhanced performance in terms of accuracy and yield, enabled by the richer measurement sets reported by a STK applet. The network quality monitoring and discovery also provide a more reliable network model for the location determination.

3. Key features

SeekerLocate™ incorporates groundbreaking technology developed by experts with over 50 years experience in wireless location. This technology has been developed to address key challenges in delivering the quality of location service that users require, within the constrained budgets for location determination technology.

3.1. Hybrid Location Engine

SeekerLocate™ features a sophisticated hybrid location engine – the first of its kind to be deployed commercially. It accepts any combinations of Cellular, Wi-Fi and GPS observations, and integrates them seamlessly for superior location and quality estimates.

This feature enables wireless carriers to achieve substantially greater accuracy for Wi-Fi enabled devices than is available with a purely cellular solution, by exploiting the myriad commercial and domestic Wi-Fi access points in the wireless landscape.

3.2. Geo-Fencing and Movement Detection

The ability to detect entry or exit of a wireless terminal from certain regions or zones is a key requirement in a number of location-based services. Similarly, some services require the movement

of a normally stationary device to be detected. Some existing solutions achieve this by simply repeating location requests periodically. One limitation with this approach is the latency due to the limited polling interval. A greater limitation is usually the cost associated with the repeated requests, and the fact that this approach does not scale well for mass market services.

SeekerLocate™ offers a superior solution to address geo-fencing and movement detection requirements, based on the patent pending technology featured in Seeker's award-winning SeekerZone™ product. This is achieved using a user-plane client in the terminal or SIM to perform the location monitoring processing. Clients using this technology can monitor multiple geo-fences or zones while the terminal remains in idle mode, avoiding any signalling load on the network. The client also maintains a buffer of measurement history, enabling a more sophisticated filtering algorithm for location monitoring than can be applied with a periodic poll request for a network-based solution. The result is very high stability without compromising responsiveness. The client-based processing also means that changes in position can be detected and reported promptly without having to wait for the polling interval to expire. For carriers or service providers wanting to deploy geo-fencing applications, this feature offers a cost effective, truly scalable solution.

The movement detection capability of the SeekerLocate™ clients also enables a smart location cache, which means the subscriber's location stored on the server can be updated automatically by the client when the device moves. Compared to systems where only elapsed time is used to assess the validity of the cache contents, this smart cache in SeekerLocate™ offers finer-grained refresh of the cache, while retaining the efficiency that caches enable.

3.3. Network Discovery

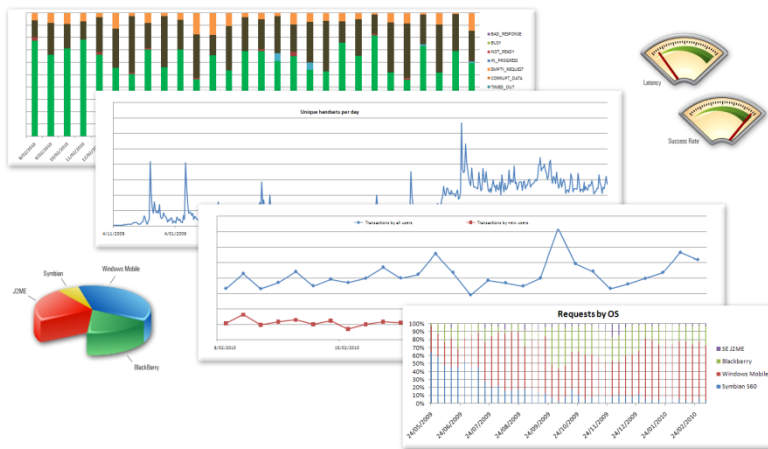
SeekerLocate™ features breakthrough, patent-pending capabilities for automatic wireless network discovery and monitoring based on any wireless measurements. This includes all sequences of measurements from SeekerLocate™ clients, as well as logs from drive tests or other capture methods. The network discovery processing operates seamlessly across different types of observations, exploiting (for example) all relationships between simultaneous Cellular, Wi-Fi and GPS observations. This feature integrates automatically with manual operator management of radio network databases, so that historical network learning measurements that are superseded by a more recent reconfiguration in the network are automatically overridden.

Combined with the robust location processing algorithms, this capability significantly enhances the user experience, through greater yield as well as protection against spurious location results caused by erroneous radio network information. For carriers, the network discovery and monitoring features can also lower the operational costs required to maintain a certain level of location service.

3.1. Location Statistics Dashboard

SeekerLocate features a comprehensive, real-time location statistics dashboard, displaying a wide range of operational data, including accuracy statistics, transaction figures, handset type distribution, latency, and location request success rates.

The dashboard provides a quick and intuitive means for viewing performance and user data across the whole system, allowing the easy identification of marketing opportunities and/or performance tuning.



The dashboard can be configured to display data across specific date and time ranges, and to filter out data subsets as required.

3.2. Shared/Hosted Deployment

For location-based services that are offered across multiple cooperating operator networks, SeekerLocate™ supports a shared/hosted configuration that can deliver considerable cost savings. A single-server installation is used with secure connections towards SeekerLocate™ clients and location applications. This type of configuration can be attractive for operator groups looking to consolidate enabler and service platforms in a single hosted deployment. Shared deployment also offers substantial operational savings, requiring only a single support team, and minimising training requirements.

A shared SeekerLocate™ installation can also simplify roaming requirements for services designed to operate internationally, for example within a group of cooperating networks.

3.3. Summary of Key Benefits

- Versatile solution addresses a broad range of location requirements. Flexible architecture enables different services to be supported from the same platform.
- Hybrid location engine maximises location performance by exploiting all available sources of information.
- For GPS enabled devices, the hybrid combination overcomes *Time to First Fix* issues, ensuring that a fix is available immediately based on cell and/or Wi-Fi observations. For *always on* applications, battery life can be conserved by using cellular observations, and selectively activating GPS.
- Complete coverage, anywhere that either GPS, cellular or Wi-Fi signals are available.
- Sophisticated consensus processing, using all available observations, protects against errors in cell network databases, cell network changes, or Wi-Fi Access Point relocations.
- Uncertainty estimation for each location request yields a consistent indicator of the uncertainty associated with the location result. This enables downstream applications to

adapt their operation for the best user experience (setting zoom level on maps, indicating a friend's proximity, setting spatial trigger alarm thresholds, etc.)

- The system can be scaled efficiently, enabling an initial low-cost deployment to be scaled rapidly to supports thousands of transactions per second.
- Can be extended with zone detection capability where required, for services requiring geofencing or movement detection.

4. Technical Overview

The SeekerLocate™ system consists of two main components:

- **SeekerLocate™ server** – a high availability scalable, modular platform, which accepts Location Requests from SeekerLocate™ clients, performs location calculations and returns Location Responses.
- **SeekerLocate™ client** – executes on the mobile terminal or SIM. The basic client collects radio measurements and forwards them to the SeekerLocate™ server, using a highly efficient encoding scheme, for location processing. The basic client can also be extended with zone and movement detection capabilities as required.

Seeker Wireless offers client implementations for a range of platforms to address a wide variety of location service requirements. Supported platforms include SIM Toolkit, Symbian® S60, Windows® Mobile, BlackBerry®, Android® and J2ME. Support for other platforms will be available shortly.

The wide range of available client implementations means that virtually any wireless mobile device or application can be location-enabled.

In addition to the standard platforms listed above, operators can also location-enable application-specific mobile terminals, or other embedded devices, using a client port for that platform, based on a reference client implementation from Seeker Wireless.

Figure 3 below illustrates the Conceptual Architecture for the SeekerLocate™ solution.

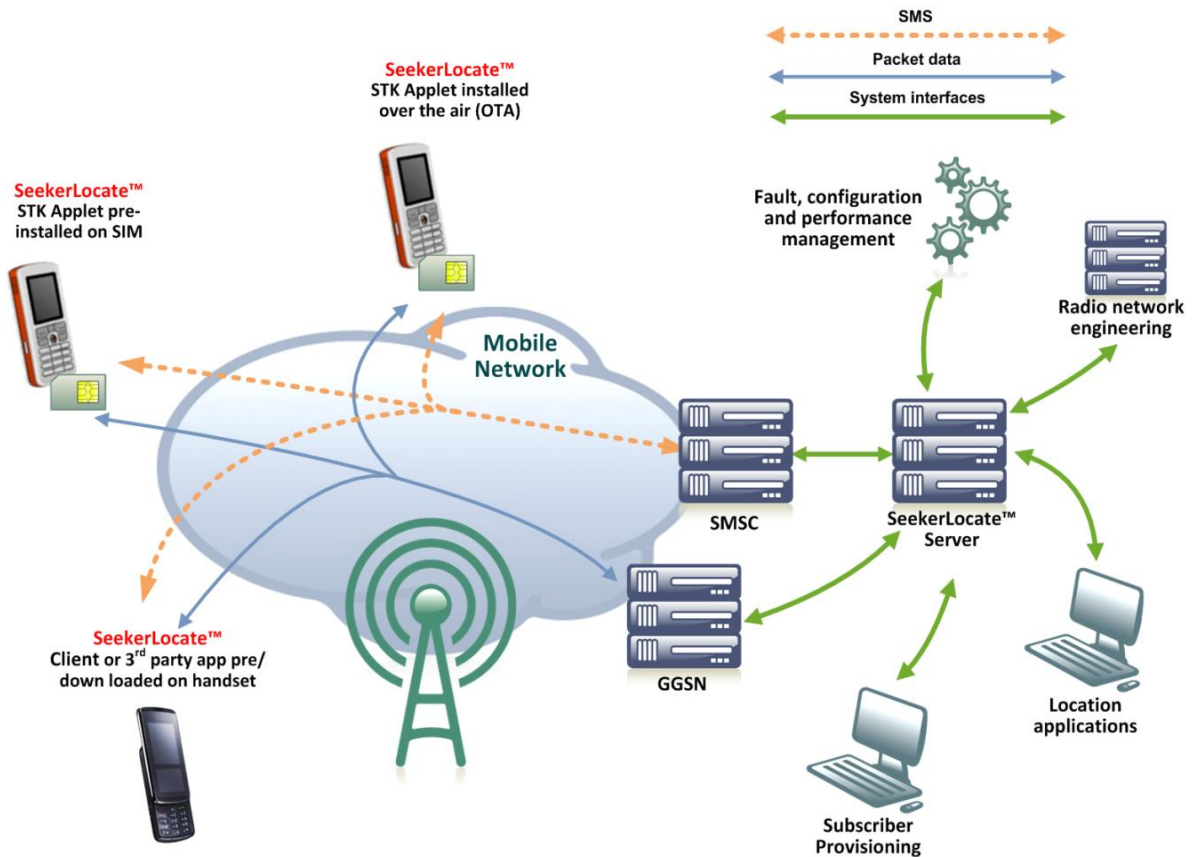


Figure 3 – SeekerLocate™ Conceptual Architecture

4.1. SeekerLocate™ Server

The SeekerLocate™ server manages communication with SeekerLocate™ clients in order to satisfy location requests originating from either network based or mobile location applications.

The server also manages the active wireless network databases. Facilities are provided for radio network databases to be uploaded either manually or automatically (using, for instance, extraction scripts from radio planning databases). Drive test logs can also be collected using a GPS enabled handset, and uploaded to the server to extend or refine wireless network models in particular regions.

The server also features sophisticated network learning technology, which exploits all measurements received from SeekerLocate™ Clients to monitor the quality of the network models, and update the models as required. Outputs from the network learning processing can also be transferred via email or FTP to radio network engineers, so that planning databases can be corrected in the event of errors or omissions.

A service-level web interface is provided for system configuration and monitoring, and radio network management.

4.2. SeekerLocate™ Client

The client is responsible for collecting and marshalling wireless measurements, and forwarding them to the server for location processing. This can be initiated upon request from a mobile application, upon a timer-event for periodic update, or upon a request originating from the location server (i.e. a request from a network based application).

Implementations include:

- Smartphone client: this is a static library for a range of different smartphone platforms, including Symbian® S60, Windows® Mobile, BlackBerry®, Android® and J2ME. It is designed to be integrated into 3rd party applications requiring a location capability. For deployments requiring basic locate and tracking capabilities, without customised, branded UI, Seeker Wireless can also offer a complete client implementation.
- SIM ToolKit (STK) applet: this is a Javacard STK applet which has been tested for interoperability with (U)SIMs from virtually all current vendors. The applet has also been tested and optimised extensively to maximise compatibility with handsets from all vendors. Two deployment options are available for the STK client: the first is a complete applet, supporting both Mobile Originated (MO) and Mobile Terminated (MT) location requests. The alternative is a location class implementing the location capability for integration into 3rd party applets. The applet can also expose a Javacard shareable interface, enabling other applets deployed in the future to access its location capabilities.
- Network adapter: for cases where no mobile client is available, a gateway can be deployed to interface with network elements via SS7, or alternatively to integrate with signalling probes, to obtain radio information for location determination.

For terminal-based clients, the client processing also includes monitoring of the cellular radio and Wi-Fi connections, and maintaining a collection of observations. When required, these observations are assembled into a Location Request (LR) to be transferred to the server. All data exchanged between client and server is encrypted before transfer. The basic operation of the client is the same for all platforms – however, the exact form that the client software takes depends on the capabilities of the particular mobile platform on which it is deployed.

On platforms that support running background processes, the client can optionally be partitioned in two: an always-on background process, and a library that is linked with the customer application. For certain applications, this enables enhanced performance by producing a richer set of measurements.

In applications where background measurement collection is not required, or where the platform does not support background applications, the client software consists solely of a static library that is linked with the remainder of the mobile application.

5. Conclusion

SeekerLocate™ is an innovative location platform that offers carriers an unprecedented level of efficiency and flexibility in deploying location-based services.

With its broad range of deployment options, covering smartphone, SIM and purely network-based modes, it enables any LBS application to be operated effectively and efficiently.

With minimal requirements for network integration, SeekerLocate™ can be deployed rapidly and cheaply compared to competing solutions.

The option to integrate Wi-Fi measurements provides carriers with the option of very high accuracy in residential and commercial areas, including indoors.

The integrated network monitoring and discovery capabilities enable carriers to maintain the levels of service demanded by customers, while minimising the operational overheads associated with checking and maintaining radio network configuration databases.

The modular, scalable, user-plane SeekerLocate™ architecture provides maximum flexibility for carriers and other service providers to minimise costs during the early stages of service launch, and ramps easily as demand grows.

6. Terms and Definitions

Term	Description
3GPP	Third Generation Partnership Project
FTP	File Transfer Protocol
GPS	Global Positioning System
GSM	Global System for Mobile communications
HTTP	Hypertext Transfer Protocol
MLP	Mobile Location Protocol
OTA	Over The Air
RAN	Radio Access Network
SIM	Subscriber Identity Module
SMLC	Serving Mobile Location Centre
SMPP	Short Message Peer to Peer Protocol
SMS	Short Message Service
SMSC	Short Message Service Centre
SNMP	Simple Network Management Protocol
STK	SIM Tool Kit
USIM	UMTS SIM
UTRAN	UMTS Terrestrial Radio Access Network
Wi-Fi	IEEE 802.11 standard for wireless networking in unlicensed spectrum