

It's All About Location

A Location Technology Tutorial

Introduction

In the mid-1990s, mobile location services appeared to be one of the next natural steps in our move towards a truly unwired, permanently connected society. The ability to link a user's content and personalized services with his geographic location seemed like a killer application—an application with the potential to bring new waves of revenue and customer loyalty to an industry already riding high.

Backed by venture capital and fueled in part by the dot.com frenzy, the potential of location services appeared limitless, bringing together customers, service providers, technology vendors, content owners and application developers to create new and innovative value chains. Higher-speed data services, which were just around the corner, also added considerable momentum to the location and content concept.

Since the manic optimism of that time, the industry has learned many important lessons about developing, launching and managing successful location-based services. A very different commercial environment, as well as changes and choices in technology over the last few years, put pressure on location platform vendors to develop appropriate new solutions.

Key issues addressed by industry included:

- The harsh financial realities affecting mobile service providers around the world
- The increased emphasis on return on investment and reduced integration costs
- The growing complexity of the underlying radio, data, and application infrastructures
- The fragmented nature of the whole content and value chain with many different partners involved
- The relative uncertainty about which handset or network-based positioning technologies should be used
- The cost implications of upgrading existing proprietary switching infrastructures

Collectively, these factors prompted an industry-wide re-examination of location-based services. As a result, new solutions are emerging.

The industry's experience is now proving invaluable as mobile service providers seek to use location services to exploit their existing investments in both branding and infrastructure—as well as capture additional revenue streams while positioning themselves for a far more content-oriented future. On top of these business drivers, government-mandated requirements that location information be delivered to emergency service providers—known as E1-1-2 in Europe and E9-1-1 in the United States—are stimulating an industry-wide focus on location issues. Additionally, standardization work in a range of areas is starting to erode many historically difficult interface and interworking issues.

TCS has been at the forefront of location innovation since its ground-breaking work carried out in the U.S. E9-1-1 environment. TCS continues to lead the industry advancement of location-based services for the mobile community, with recent launches including Location JumpStart™, an all-in-one location services package for service providers, and Xypages™, a location-enabled mobile directory service.

This white paper examines the key issues within the location services arena for mobile service providers, application providers and content partners. Additionally it highlights developments and strategies that can cut the cost of entry, speed return on investment and grow profitable alliances with other partners in the value chain.

1. The Backdrop

Location-based services depend on a seamless interworking of a number of different technologies, communication infrastructures and information technology (IT) environments. The prime challenge facing the telecommunication services community lies increasingly in the smooth integration of a wide variety of component parts and systems, each with its own particular traditions, limitations, and business objectives. What have been largely missing until now are perspectives and platforms that can unite this diversity to deliver profitable services rapidly and cost effectively—without imposing heavy costs and delays through systems integration overhead.

In their simplest form, location services depend on three basic components: a positioning technology, a location services platform, and applications. Each of these components is described in detail in the sections that follow.

Positioning Technologies

Positioning technologies calculate the physical location of the user and communicate this to the location services platform. They range in type from purely handset-based approaches to those that only utilize information from the network. Currently most positioning technologies use some portion of the network, which allows service providers to own the data and to ensure that its use generates revenue for them. A key benefit of network-centric solutions is that all handsets can utilize the positioning technology without modification. But network solutions are more expensive than handset-centric solutions, since each base station must be upgraded—and they are less accurate in rural areas, where base stations are situated further apart. Alternatively, handset-centric solutions are more accurate and less expensive to deploy than network-centric solutions, since the handset expense is passed on to the subscriber as a one-time charge. However, handset-centric solutions are only available to subscribers who purchase the new handsets.

The choice of positioning technologies also involves evaluating a number of complex factors such as the signaling load on the network, the impact of the technology on handset performance, and issues of privacy and ownership of location data. Descriptions of some of the key network and handset technologies—either in active use or awaiting wide-scale deployment—are described below.

Network-Centric Solutions

Cell-ID/Cell Site Sector – Currently the most widely deployed solution, this network-based technology uses existing data from the network to identify which radio cell site and sector a user is in. As a result, location accuracy is dependent on cell size. While this solution works well in dense, urban areas—enabling positioning down to a city block or so—it is far less accurate in country areas where a cell might cover many square miles. Its main advantage is that it requires no new functionality to be added to handsets.

Enhanced Cell-ID – Enhanced Cell-ID is a network technology that combines Cell ID (CI) with one or more additional technologies. The level of accuracy is increased over basic Cell ID, ranging from 75 - 500 meters. In GSM networks, CI can be combined with Timing Advance (which measures handset range from the base station, including whether or not the handset is connected to the nearest cell) and/or Received Signal Level (which measures average signal

strength). In W-CDMA networks, CI can be combined with Round-Trip-Time (W-CDMA version of Timing Advance) to improve accuracy.

Enhanced Observed Time Difference (E-OTD) – E-OTD is a network technology that requires additional software on the mobile device and the addition of GPS receivers to base stations.

The mobile device calculates a user's position by triangulating the differing arrival times of network synchronization data regularly transmitted between handset and base station; it can provide accuracy to tens of meters.

Time Difference of Arrival (TDOA) – TDOA is similar in concept to E-OTD in that it also uses triangulation and time delay, but the processing is carried on the network side. While this has the advantage that older, legacy handsets can be supported, such a strategy does involve the installation of GPS receivers at all base stations.

Handset-Centric Solutions

Global Positioning Systems (GPS) – Using GPS satellites, this handset-based technology provides high accuracy, but has poor in-building coverage and either draws heavily on battery life if position is determined regularly, or delays results by tens of seconds (or even minutes) if the handset calculates position on-demand.

Assisted-GPS (A-GPS) – A-GPS is primarily a handset-based technology that uses enhancements to the network to provide additional accuracy and speed of location fix. GPS receivers are connected to the network at various known geographic points to provide additional data to the handset, greatly reducing the time needed to get positioning information and thereby allowing longer battery life. Certain A-GPS variants can provide better in-building location coverage and accuracy as well.

There are a number of additional technologies that use similar concepts to analyze the radio behaviors involved in cellular communications, to position the handset, and to calculate distances, angles of reception and signal strengths. These technologies are often combined to create hybrid approaches by incorporating the strengths of each technology.

Irrespective of which systems are adopted by service providers, it is likely that a mix of hybrid technologies will be used to meet the very different demands for accuracy and performance required by the different location service market sectors. As a result, flexibility will become an increasingly vital attribute of the supporting location platforms. In this context, it should also be remembered that the radio infrastructure of mobile service providers is constantly changing, and the effects of this on positioning performance must be easily manageable.

Location Service Platforms

The location services platform is the heart of the location offer, providing the essential functionality needed to link the user's location information with all the other services and systems involved in delivering location-based services and applications. The location services platform acts as a central nervous system by gathering, integrating and transmitting data between a variety of different components, including the actual positioning technologies, the network, MMS and SMS servers, billing and service management systems, Geographic Information Systems (GIS), the end user's handset and the actual location applications. All of this is accomplished while implementing privacy rules that insure proper and authorized use of the end user's location information.

The technical environment in which location platforms operate has grown considerably more complex, with new standards bodies and new application areas continuing to appear. For the

industry to fully exploit the revenue potential of location services as well as provide all the related management and support functions, a wide range of APIs and features must be supported in as seamless a way as possible.

Examples of these interfaces include APIs, defined by the Open Mobile Alliance (OMA) which now includes the Location Interoperability Forum (LIF), and through the 3GPP's Open Service

Access initiative; old and new telecommunications signaling and messaging protocols, such as SS7 and SIGTRAN, as well as those supporting applications and services using Java; security and tools involving Public Key Infrastructure (PKI) certification; emerging open Geographic Information System (GIS) standards; as well as all the other interfaces to Operation Support Systems (OSS), billing and m-commerce systems required to properly integrate operations with the back office and with related payment mechanisms. New radio environments such as Wireless Local Area Networks (WLANs) and Bluetooth must also now be considered.

In addition, platform choices are heavily affected by a variety of business-related issues. While the multi-vendor network has become an industry cliché, continued industry consolidation combined with increasingly mobile and demanding customers has created a requirement for successful inter-working between different systems with minimal systems integration overhead. Additional issues must be factored in, such as content and applications that come from third party environments over which the service provider has little or no control, and Quality of Service performance issues.

Further challenges lie in the near future. In the area of Presence and Availability Management (PAM), a company's enterprise IT system will need to interact with a service provider's location data to provide useful corporate applications that use end-user's location information. As well, the enormous potential that location services have in supporting personal safety and asset tracking also must ensure information privacy, security and reliability. Both of these scenarios emphasize the need for ease of use by the end-users in setting up and controlling their own location services in both pre-packaged and custom-built offerings. Early adopters of technology will feel more comfortable if they can directly interact with their service profiles through fixed Internet portals or "on the fly" via their handsets, and these control mechanisms must be built into the management systems from the start.

Beyond fulfilling the perennial system requirements of stability, scalability and performance, location platforms will often be employed to support experimental services, as service providers and their partners explore this new market sector. In order to gain recognition for the revenue potentials of new services, platform vendors must show flexibility in the billing models that they offer their clients.

Location-Based Service (LBS) Applications

Applications drive the usage of the location offer and range from simple push services, such as weather and traffic alerts, to more complex or interactive services, such as location-based personal safety, dating, and gaming applications.

While the potential breadth of location-based services is enormous, finding business cases to support these original visions can be challenging. As with so many other mobile services, it is unlikely that there will be one true killer application. Instead, service providers must understand how different applications can be mixed and matched to suit specific market niches as they emerge and are recognized. It should also be noted that the benefits and revenue that location services offer can flow in both directions. Many business sectors, from entertainment to tourism, are coming to understand that location information can become an invaluable tool in their marketing armory, and therefore they will pay to attract new customers.

Whether the application area is personal safety, one of the main drivers behind the purchase of mobile services for many users, or lifestyle support involving gaming, dating and entertainment or travel resources, many mobile service providers will be reluctant to commit significant internal resources to build their own application solutions from the ground up. Technical issues, market understanding, and legal and financial value chain complexities will continue to encourage them to rely on vendors with experience and existing links to the content and applications community.

This issue is particularly important, given the experimentation and flexibility that happens during the initial stages of location services rollout. The members of both the service and the content chain will be concerned with the success of the new services, as well as the assignment of benefits and revenues generated. For some participants, there will be direct cash flows, while for others, location services may translate into branding opportunities that will generate money further down the transaction line, or service stickiness that reduces churn and attracts more premium customers.

2. The Challenges of History

Until recently, mobile operators have focused on connecting what was essentially a classic Internet service model, which included content provisioning from multiple sources, with the architectures and limitations of traditional, voice-oriented telecommunications infrastructures.

First, telecommunications application development involved the use of particular protocols specific to the industry, which led to a reliance on scarce and expensive skills. These standards often varied in small but important ways from region to region and equipment supplier to equipment supplier, adding to the costs of solution development and integration.

Second, because of organic industry growth and consolidation of much of the telecommunications industry – and the requirement to continue to inter-work with legacy systems – systems development often took a silo approach to new initiatives. This added more layers of complexity to an already complex world and resulted in location systems that had to be shoehorned in to work alongside existing switching, billing and operations support systems, which culminated in attendant errors, vulnerabilities and inefficiencies.

Finally, reliance on the familiar, network-centric worldview of telecommunications caused headaches when it came to solving issues of scalability and security – especially when third parties were involved in the content and service chain. Systems, business and technology cultures that had grown up with straightforward voice services – provided largely on credit and regular billing – found themselves strained when coping with multi-party payment flows, pre-paid services, differentiated pricing models, and a richer portfolio of offered services.

3. The New World Environment

Since the early days, developments in both the mobile communications industry and the location services sector have come a long way. The issues that once challenged widespread adoption of these new sources of revenue and market differentiation have been resolved. However, new issues have inevitably arisen that now must be addressed.

Old models of location service architectures betrayed their telecommunications heritage in being overly rigid and too prescriptive in terms of the interfaces, services and business ideas that they were designed to support. While they may have been presented as an essential glue to hold the

new services together, many operators found themselves locked into fossilized approaches that were difficult and expensive to re-engineer in the face of whole scale industry change.

A far more realistic model to adopt in the face of today's pressures should be oriented around the idea of a peer-to-peer model, easily adaptable to deal with new handset, network and application partner technologies. Just as with many other areas within the "industry previously known as telecommunications," location services are no longer based around the idea of a single, straightforward, bi-lateral value chain. Instead, the creation and delivery of truly compelling location services to the end user will involve integrated access to many network facilities simultaneously.

While standards will remain important, it should also be recognized that these are often more accurately "discovered" than imposed, evolved and adopted as a result of real world pressures, rather than through a top-down process. Standardization processes are still extremely vulnerable to pressure from large vendors with their own particular interests to support, and for mobile service providers these factors can in turn limit their own freedom to innovate and respond rapidly to threats and opportunities.

Just as with location applications and the end customer, there is no single, preconceived system that is suitable for all service providers in all parts of the world. Instead, the optimum strategy must be to use an open architecture and platform that is capable of uniting and integrating different features and functions in a highly distributed way to create a rich variety of different value propositions for an extremely diverse customer audience.

It is for this reason that TCS has developed its Voyager™ distributed architecture, merging the three cornerstones of the next stage in mobile services – messaging, location and content access – into one consistent, coherent and ultimately flexible whole.

4. TCS: The Present and Future with Voyager™ and the Xypoint® Location Platform

Developing effective location service solutions is extremely challenging. As standards bodies are continuing to define network nodes, functionality, and interfaces, mobile operators are faced with the reality of integrating their location servers with network elements that have varying levels of standards compliance and back-end systems with unique interfaces. No "one-size-fits-all" solution will work.

Over the last seven years TCS has developed an architecture and platform that are specifically designed to enable the development of location server solutions in this challenging environment. The Voyager distributed architecture provides a carrier-grade foundation for TCS solutions, while the Xypoint Location Platform uses the Voyager distributed architecture to provide a suite of location technology components that are designed to be integrated into systems that meet the mobile operator's needs.

Voyager Distributed Architecture

The Voyager distributed architecture is at the heart of every TCS location server solution. The advantages of Voyager are realized in a robust, state-of-the-art server platform that is inherently flexible, scalable, highly available, and cost-effective, allowing installations in configurations that meet the wireless operator's current and future needs. TCS Voyagerbased systems are built using C++ on the Sun Solaris platform, with the Voyager framework providing

common facilities for database access, messaging, transaction management, logging, management and configuration (see Figure 1, next page). These systems in their entirety are a mix of proprietary and third party software.

Voyager has been extensively field proven in a variety of applications (including commercial and emergency location services), and it is under constant improvement based on feedback from TCS customers as well as from experience operating the Xypoint E9-1-1 service within TCS data centers. This hands-on operational experience ensures that TCS solutions meet the high operation and performance requirements of the wireless operator environment.

Features of the Voyager distributed architecture include:

Common Operational Support Systems (OSS) – TCS solutions use a common set of OSS tools and interfaces for system monitoring, management, provisioning, reporting, and billing. This means features can be added or removed from installations without requiring re-integration with the wireless operator's OSS or re-training operations staff.

Peer-to-Peer (P2P) – Solutions built on the Voyager platform operate as a collection of redundant individual processes that interact with each other as peers, as opposed to a clientserver model in which client processes communicate with centralized server processes. Processes are automatically aware of and can communicate with any other process running across any number of machines. By eliminating single points of failure and congestion, this architecture drastically improves system performance, resiliency, and ease of maintenance.

Multi-Threading – Voyager is heavily multi-threaded. Systems are designed to support thousands of concurrent sessions, each operating in its own thread of control. This optimizes system performance and resiliency by minimizing resource conflicts between concurrent requests.

Internal Messaging – Voyager uses proprietary binary encoded message protocol (similar in structure to TCAP) for all internal process communication. Messages are carried via TCP/IP for inter-machine messages and via the Sun Doors IPC mechanism for intra-machine messages. System load information is used to route internal messages to the least utilized systems to optimize overall performance. As new systems are added, traffic is automatically routed to them. Likewise, machines that are taken down either for maintenance or due to fault are automatically removed from the routing tables, and messages are re-routed to other machines. With this feature, system resiliency is dramatically improved while scaling and maintenance activities can occur extremely rapidly with little or no down time.

High Availability – In addition to the benefits of peer-to-peer distribution and internal messaging mechanisms, Voyager provides additional measures to ensure high-availability. Every piece of the system (hardware, network, database, and process) is redundant. There are no single points of failure. Unlike other solutions with stand-by systems that are only used in the event of primary system failure, TCS solutions use an "all-hot" model in which all systems are active. This eliminates the risk associated with fail-over to inactive back-up systems that may themselves be inoperable. Keeping all systems active ensures that all systems are constantly used and monitored. In addition, the system has capabilities such as automatic process de-registration and alternative database selection to adapt to single element failures, while SNMP alarms notify operations staff so that appropriate measures can be taken as soon as possible.

Multi-Site Support – An extension of the peer-to-peer capability, multi-site support allows implementation of TCS solutions across multiple geographically redundant data centers, in a variety of configurations. Sites may be operated as separate entities with fail-over capabilities or together as a single "federated" system, depending on the wireless operator's capacity and

availability requirements. Multi-site installations are resilient to inter-site network failures, with the ability to function, be managed, and be monitored independently while the connection is down, as well as recover with minimal human intervention when the network connection is restored.

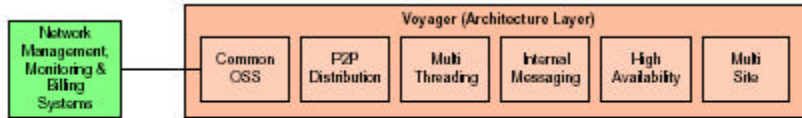


Figure 1 – Voyager™ Distributed Architecture

The Xypoint® Location Platform

The Xypoint Location Platform (XLP) was first launched in the commercial market in 2002, with the initial deployment in Hutchinson's 3G (H3G) UK network; XLP® deployments are currently underway in eleven additional H3G networks, including Italy, Sweden, Austria, Hong Kong, and Australia. The XLP has been operating in TCS' own data center since 1997, providing E9-1-1 services to over 25 mobile operators in the US covering an estimated 30M wireless subscribers.

In operation, the XLP is a uniquely integrated solution that gathers and manages data from the core network, the precise positioning solution, and the various applications – as well as providing centralized privacy controls and customer profile management. The XLP is a mature, state-of-the-art, standards-based system that delivers high performance and flexibility based on modular functional elements that include a standards-based Gateway Mobile Location Center (GMLC) and Mobile Position Center (MPC), Privacy Server, Profile Manager, Watcher Module, Application Interface Module, and positioning technology such as PDE, A-GPS server or SMLC. The XLP's modular architecture is designed to isolate core functionality from specific interfaces and standards. This flexible design enables the XLP to be integrated easily with equipment from various manufacturers or enhanced to embrace new and emerging protocol standards.

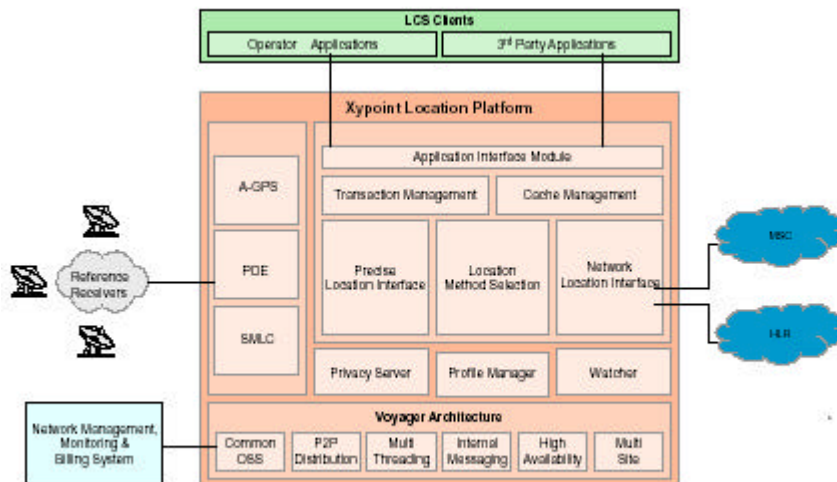


Figure 2 – Xypoint® Location Platform

The XLP's design supports a wide range of service strategies, enabling the mobile operator to deliver a broad set of cost-effective location applications. In addition, the XLP gives the mobile

operator the opportunity to generate revenues from value-added services with minimal systems risk and uncertainty.

Having already been deployed in analog, 2G (digital), 2.5G (high speed digital), and 3G (ultra high speed digital) environments, the XLP is designed to evolve alongside both changing technologies and operator requirements. The XLP supports 3GPP standards for GMLC and SMLC, while within the Application Interface Module support is also provided for the 3GPP OSA interface and the OMA-LIF Mobile Location Protocol (MLP) interface to Location Services (LCS) clients. The XLP also has OSS functions for provisioning, usage data collection, configuration management, fault management and performance management.

Engineered to interact efficiently with core network elements, the XLP's proprietary and intelligent location technology enables location applications to gather location data without placing too much of a load on core network resources, allowing new services to be introduced safely and reliably. By building its location server solutions on the Xypoint Location Platform, TCS is able to quickly and cost effectively create systems that are adapted to the unique environment of each installation, while maintaining a robust core of common functionality.

5. Conclusion

This white paper has described the key issues within the location services arena for mobile service providers, application providers and content partners. Developments and strategies have been suggested that can cut the cost of entry, speed return on investment and grow profitable alliances with other partners in the value chain. To this end, mobile operators can create a rich variety of value propositions for a diverse customer audience by utilizing an open architecture and platform capable of uniting and integrating different features and functions in a highly distributed way.

Self-Test

1. In their simplest form, location services require:
 - a. A positioning technology
 - b. A location services platform
 - c. Applications
 - d. All of the above

2. Positioning technologies calculate the physical location of the user and communicate this to the locations services platform.
 - a. True
 - b. False

3. There is one suitable preconceived system that is available for all services providers in all parts of the world.
 - a. True
 - b. False

4. The complexities of telecommunications systems include:
- a. Differentiated pricing models
 - b. Multi-party payment flows
 - c. Pre-paid services
 - d. All of the above
5. Key issues of location technology services include:
- a. Cost of entry
 - b. Return on investment
 - c. Profitable partner alliances
 - d. Feature integration
 - e. All of the above
6. Multi-site installations are resilient to inter-site network failures.
- a. True
 - b. False
7. Assisted GPS (A-GPS) is primarily a handset-based technology.
- a. True
 - b. False

Correct Answers

1. In their simplest form, location services require:
- a. A positioning technology
 - b. A location services platform
 - c. Applications
 - d. **All of the above**
2. Positioning technologies calculate the physical location of the user and communicate this to the locations services platform.
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- d. All of the above**

5. Key issues of location technology services include:

- a. Cost of entry
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- c. Profitable partner alliances
- d. Feature integration
- e. All of the above**

6. Multi-site installations are resilient to inter-site network failures.

- a. True**
- b. False

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- b. False

Glossary

1xRTT

One Times Radio Transmission Technology

3G

Third Generation

3GPP

Third Generation Partnership Project

A-GPS

Assisted Global Positioning Satellite

API

Application Programming Interface

CDMA

Code Division Multiple Access

CI

Cell ID

E1-1-2

Enhanced 1-1-2 (Emergency Services)

E9-1-1

Enhanced 9-1-1 (Emergency Services)

E-OTD

Enhanced Observed Time Difference

GIS

Geographic Information System

GMLC

Gateway Mobile Location Center

GPRS

General Packet Radio Service

GPS

Global Positioning System

GSM

Global System For Mobile Communications

H3G

Hutchison 3G

HLR

Home Location Register

IP

Internet Protocol

IPC

InterProcess Communication

IT

Information Technology

LBS

Location-Based Service(s)

LCS

Location Service(s)

LIF

Location Interoperability Forum

MLP

Mobile Location Protocol

MMS

Multimedia Messaging Service

MPC

Mobile Positioning Center

MSC

Mobile Switching Center

OMA

Open Mobile Alliance

OSA

Open Service Access

OSS

Operational Support System

P2P

Peer-to-Peer

PAM

Presence and Availability Management

PDE

Position Determining Entity

PKI

Public Key Infrastructure

RTT

Round-Trip-Time

Rx

Received Signal Level

SAI

Service Area Identity

SIGTRAN

Signaling Transport

SMLC

Serving Mobile Location Center

SMS

Short Messaging Service

SS7

Signaling System 7

SNMP

Simple Network Management Protocol

TA

Timing Advance

TCAP

Transaction Capabilities Application Part

TCP/IP

Transmission Control Protocol/Internet Protocol

TCS

TeleCommunication Systems

TDOA

Time Difference Of Arrival

W-CDMA

Wideband CDMA

WLAN

Wireless Local Area Network

XLP®

Xypoint® Location Platform