IT@Intel White Paper

Intel IT
IT Best Practices
Employee Productivity and Compute Continuum
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Getting a Headstart on Location-based Services in the Enterprise

Building on the success we've already achieved with our location-based services, we are actively working to enhance and expand those services.

Executive Overview

Intel IT recognizes a great opportunity for the use of location-based services in the enterprise, and we are already piloting three location-based applications—FriendFinder, WayFinder, and You Are Here mapping—that use location-based services. Employees can choose to use location-based services to help derive value from their own location and the relative location of other resources in the work environment.

Using location-based services in the enterprise offers the following benefits:

- Employees can more efficiently connect to the resources around them and find the right resources at the time they need them.
- Employees enjoy a more seamless and continuous experience across platforms, devices, and operating systems, whether outdoors or indoors.
- Our efforts support Intel's strategic objective to develop location-based services for mobile platforms, as part of the overall compute continuum vision.

As our location-based services implementation continues to mature, we are building a scalable, extensible framework based on standard APIs that can support a wide variety of location-based service use cases. While there is still much work to be done, we are making good progress by focusing on primary solution components. Building on the success we have already achieved with our use cases, we are actively working to enhance and expand those services.

Rob Colby
Location Based Services Architect, Intel IT

John Dunlop
Enterprise Architect, Intel IT

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BACKGROUND

In the consumer market, Global Positioning System (GPS) and outdoor navigation applications have become ubiquitous. These applications connect the present location of users with the geographical position of points of interest (POIs), and are part of daily life for many and an integral part of merchants' business models. There are applications to help consumers navigate while driving and locate restaurants, stores, local gasoline prices, and even friends. However, in the predominantly indoor enterprise environment, location-based services are rare despite the potential value they offer for employees and the business.

We see a great opportunity to use indoor location applications in the enterprise, despite the initial technological and organizational challenges we have identified. Location-based services can enable the development of applications that provide employees an efficient and seamless way to find the work-related resources they need at the exact time they need them.

As part of Intel's overall compute continuum vision, deployment of location-based services supports one of Intel's strategic objectives: developing location-based applications for mobile platforms. For example, these capabilities and requirements may be used to enhance the Compute Continuum Location Services API, part of the Intel® Cloud Service Platform that provides POI, mapping, and navigation for outdoor locations and will evolve to support indoor locations. Likewise, our efforts are validating enterprise usages under consideration by Intel's product development groups. We also have a production validation environment that is used to accelerate time to market and quality validation for new products.

Our vision for implementing location-based services within the Intel enterprise includes the following goals:

- Develop a modular and scalable location-based service framework that provides location information independent of the underlying sensor type or application that uses the information.
- Establish an internal developer community, and encourage Intel application developers to add value to their applications by utilizing location-based services and developing new, privacy-aware location-based services that other developers can use.
- Continue to improve accuracy levels related to determining location and enable new use cases.

Location-based Services Use Cases

We have identified many use cases within Intel for location-based services. Below are some examples.

- **Find current location.** Employees can launch a mapping application to determine their current location on the map, similar to the "you are here" markers found on maps and evacuation signs in buildings.
- **Search for and navigate to a POI.** Employees at unfamiliar Intel campuses can use an application to find a particular conference room, lab, PC service center, supply cabinet, printer, exit, or other POI and see the route to the room or other resource on the map.
- **Save a POI for future use.** When at a different campus, employees must often navigate unfamiliar hallways and buildings. A mapping application could mark the location of a cafeteria or auditorium, so the employee can easily return to that location later in the day or on a future campus visit.

- **Share POIs.** A factory employee might notice an alert light on a particular tool or machine on the factory floor. The employee can use an application to mark the equipment's location and then share that location with other employees, for subsequent follow-up. If other employees approach the equipment location, they receive an alert that they can respond to. Furthering this use case, employees could share locations regardless of the platform they are using. For example, an employee could broadcast an email invitation to an on-campus event and include a geotag for the event location that recipients can click to navigate to the event.
- **Look up a co-worker's location.** Whether determining if someone is enroute to a meeting or finding a co-worker's location, location-based services can help employees connect with one another faster and more efficiently. For privacy, users would need to opt-in to share their location with other employees, and safeguards will be implemented to ensure an employee's location and movements are not able to be tracked.
- **Location-based alerts.** These alerts can remind employees to take action based on their arrival at a specific location. For example, if a lot on the factory floor needs to move to the next tool, an alert notifies the next authorized employee approaching the area. Or, employees can be notified when they arrive on campus that flu shots are available that day, and a map can show them where the shots are being given.
- **Location reminder.** Cameras are not allowed in Intel factories. As employees come within 30 meters of the factory entrance, a geo reminder can be proactively sent to alert them that they must turn in their smartphone before entering the factory floor.
- **Location-based security.** Some Intel confidential documents may only be read at specific sites. If employees attempt to read these documents from their smartphones off-site, they receive an error message. However, if employees are onsite, they can open the document because the location-based service can recognize and validate the device's onsite location.

Challenges for Location-based Services within the Enterprise

There are some important differences between consumer- and enterprise-oriented location-based services. During the process of developing and deploying location-based services in an enterprise environment, we've identified several challenges.

DETERMINING AN EMPLOYEE'S LOCATION

Accurately determining the location of employees as they move throughout their day can be difficult because the GPS is not suited for indoor use. To address this challenge, we have developed new technologies and integrated existing solutions that allow us to accurately determine indoor location within three to five meters. These capabilities required that we first build a supporting infrastructure based on a modular and scalable framework (see "Location-based Services Framework").

IDENTIFYING POINTS OF INTEREST

We also needed to determine the POIs that employees would most likely search for, such as available conference rooms, printers, restrooms, vending machines, or cafeterias. For example, some employees consider a supply cabinet a POI. Location information for items selected as POIs is accessible through a web services API, allowing applications to identify the location of the resource. Some resources, such as factory tools, change location and may use radio-frequency identification (RFID) tags to help identify their current location. For other resources, such as restrooms, we currently must manually enter information into a POI management application directly, but we are working to find a better way of collecting and distributing this type of static POI data.

MANAGING POINTS OF INTEREST

Many consumer location-based applications are focused on outdoor locations. In the enterprise, virtually all location-based applications will focus on indoor POIs. The differences between consumer and enterprise navigation are significant enough that consumer applications would require extensive modifications in order to be used for indoor navigation. Table 1 summarizes these differences.

Table 1. Summary of differences between outdoor (consumer) and indoor (enterprise) location-based services

	Aspect of Location-based Service		
	Consumer	Enterprise	Enterprise Challenge
Primary usage	Outdoor	Indoor	Ability to identify geodetic position in the absence of the Global Positioning System and lack of indoor maps
Frequency of change in point-of-interest location and metadata	Rare	Often	Improve the accuracy of determining indoor location
Data consistency (user experience)	Managed by independent service vendor	Managed by business unit or site services	Provide a consistent user experience across the compute continuum and across the enterprise
Location system of record	Single subscriber access	Tiered database(s), role-based access	Deliver the right aggregation of point-of-interest information to authorized users

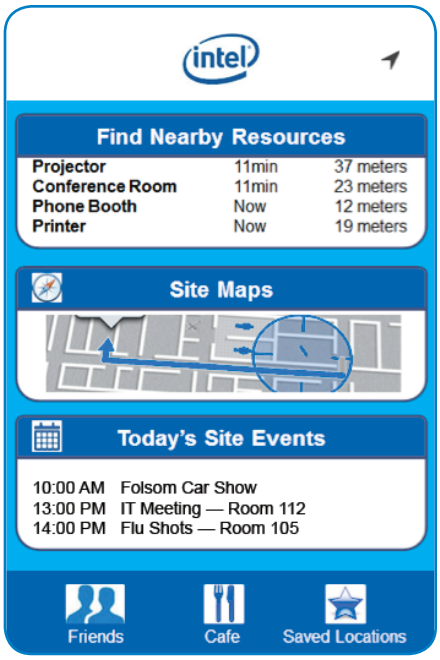

Figure 1. Enterprise-level location-based services might provide site maps, co-worker locations, saved locations, and information about resources and events.

The differences between outdoor (consumer) and indoor (enterprise) navigation include the following:

- **Frequency of POI change.** Unlike outdoor resources that change infrequently, such as addresses and store types, indoor resources, such as workspace locations, inventory, and projector equipment, can change frequently, making it more challenging to keep location data up-to-date in the enterprise environment.
- **Data consistency of user experience.** In the consumer environment, the independent software vendor or application provider controls the user experience, including the availability, depth, and integrity of the data. In the enterprise environment, each business unit or site services group manage their own POI data; therefore employees may have a varied experience depending on the diligence given to managing the POI information within a building or on an Intel campus.
- **Location system of record (SOR).** For consumer location-based applications, the SOR for POIs is usually a single database, and the data is available to all subscribers. In the enterprise, SORs will be tiered across multiple public and internally-managed databases. Access controls will determine the level of access the user has to POI information. For example, every employee will see information about site services such as the location of the cafeteria, but only certain factory workers will find information about equipment in a fabrication facility.

MAINTAINING SECURITY AND PRIVACY LEVELS

Maintaining appropriate levels of security and privacy are also significant challenges. In a public environment, location information is freely exchanged and even promoted for advertising purposes. However, location information in the enterprise is often controlled and secured, which is a critical factor in the overall user experience. For example, directions to locations may change if a campus is undergoing construction. The site's services group must ensure all applications that contain location data have up-to-date routes, while at the same time ensuring that unauthorized people do not have access to that same location data.

Enterprise POI information, such as the location of workspaces or factory tools, and inventory and asset data, is usually confidential, so access management is essential. In addition, employees who choose to use the location-based services must be able to maintain the level of privacy they want. For example, an employee may want only team members to be able to access his or her location when on campus.

SOLUTION

Our vision for location-based services includes providing location information that is not application-specific. Ideally, employees will not have to search for a different application each time they want location information. Instead, all applications use the location data, which business units and site services groups directly manage. Figure 1 shows an example of how an application that integrates with our location-based services might look.

While achieving the complete solution is still a work-in-progress, we are currently piloting three location-based applications that use location-based services.

- **FriendFinder.** Allows employees to see the locations of other employees, depending on an employee's privacy preferences.
- **WayFinder.** Shows employees how to navigate from their current location to a desired POI, such as a printer, cafeteria, or conference room.
- **You Are Here mapping.** A basic directory that shows the employee's current location.

Indoor location-based navigation is available at three sites, and we have an additional three sites planned for 2013.

In addition to our three applications, there are approximately 20 other indoor location-based applications under development at Intel, ranging from mobile asset management to the ability of mobile workers to reserve workspace. These projects are helping to improve employee productivity and provide a better user experience while also validating usages and technologies that may eventually lead to market opportunities for Intel® products.

Key Location-based Services

Location-based services are back-end components that form the building blocks to enable location-based applications. We have identified six key location-based services at Intel: mapping, navigation, and zone services; sensor-agnostic location identification; and security and privacy capabilities. As part of our location-based framework, we are currently working to implement four of these services: mapping, navigation, location identification, and privacy capabilities.. We plan to implement the remaining two services in the future.

MAPPING SERVICE

Implementing the mapping service involves obtaining or manually creating maps, creating and maintaining lists of facility and static POIs, and managing metadata. Our long-term strategy is for web service APIs to provide this information to applications so employees can receive the most up-to-date data, including the following:

- Maps. Currently we have maps for three campuses and are working on the maps for three additional campuses. Eventually, maps associated with every Intel campus, which include campus, building, and floor maps, will be available.
- POI metadata. There are facility POIs that are specifically associated with the building and floor layouts, such as restrooms, workspace locations, building entrances, and café locations. The site's services group manages the location information for these POIs. POIs that are mobile, such as vending machines or printers, must be tagged and are managed by the business units that own them.
- Map metadata. Other metadata information can be associated with maps, such as map name and map geodetic zone. "Geodetic" refers to an absolute location using longitude, latitude, and in some cases altitude.

Because few employees can read blueprints or CAD drawings, we must convert maps to a user-friendly design. We must also account for the fact that most existing building maps do not identify POIs such as printers, what rooms are conference rooms, or walking routes.

After we have created a readable and usable map, we must be able to easily update it when the layout of space or the location of POIs change. Access control raises another issue—some employees have privileges to see certain information that other employees are not authorized to access.

NAVIGATION SERVICE

The navigation service delivers routing information to the employee. The employee's position is generally determined by device sensors such as GPS, A-GPS, Wi-Fi*, or cell tower triangulation. Ideally, we will be able to input two geodetic locations, and the engine will deliver navigation between the location points, with a seamless transition from outdoor to indoor navigation. For example, an employee at an airport could request directions to a specific conference room, and receive driving directions to the campus and then walking directions from the parking lot to the closest entrance and ultimately to the conference room.

ZONE SERVICE

When completed, the zone service will enable the use of geofencing—the ability to create specific zones and associate attributes with that zone on which an application can take action. For example, we might allow an employee to view certain secure data from a mobile devices while on campus, but not allow this action if the employee is off-site. Or we might create a zone at a factory dock that triggers an alert if an asset is removed from the factory without authorization.

SENSOR-AGNOSTIC LOCATION IDENTIFICATION

We use sensor-agnostic middleware, which can receive input from various sensor technologies such as Wi-Fi tags, Wi-Fi on smartphones, passive RFID, and GPS to consolidate the various location information. Each sensor type must have a central query location to facilitate searches. For example, if an employee is looking for a factory tool, it is impractical to query all of the Wi-Fi tags in the company. Instead, we provide a central system that employees use to specify what they are looking for. The middleware then identifies the location of the POI and checks the POI's security and privacy attributes. If these attributes allow, the middleware reports the location to the application in a standard form that the application can use.

SECURITY CAPABILITIES

In an enterprise, much of the information regarding the location of employees, printers, available conference rooms, and even factory tools is confidential, and may be restricted even within the company or have privacy concerns. Therefore our security engine will require user validation before providing location information. The engine will also use role-based access controls to ensure access by only authorized employees. For example, we can't allow the general public to know the location of our factory tools, but there are legitimate reasons to route an engineer to a factory tool when there is an outage.

PRIVACY CAPABILITIES

Handling information related to a person's location requires that appropriate attention be given to security and privacy. Our framework allows employees to manage their personal privacy preferences through a portal interface. It informs employees how their personal information will be used, allows them to opt-in to using a location-based service, and lets them manage who can view their location information and under what circumstances. For example, an employee may decide to share his or her location only when in a specific area, such as a cafeteria, or when he or she is traveling and wants to be available to meet with coworkers. When an employee no longer wants to use a location-based service there is a central place to revoke the sharing of his or her location information. The framework also provides a common service interface where application access can be enforced. Guidance has been developed for application developers to ensure that privacy features, such as ambient notification, are included in any application that use location-based services.

Location-based Services Framework

While building the framework that supports our location-based services, we emphasized aspects that would optimize the solution based on value, scalability, and extensibility to additional use cases.

- A modular design allows us to build out the most important capabilities first to enable priority use cases and then to add capabilities as the technology matures and additional use cases become viable.
- The use of standard web service APIs enables many applications to use the same location data. This approach allows developers to seamlessly embed location data into any application that may need it.
- A standard set of web services APIs also allows applications to use location data without needing to be aware of the specific interfaces for each service or how to interpret and aggregate all the various sensor input data. In this manner, we can easily and quickly replace solution components, such as the sensor middleware, when necessary.

Figure 2 illustrates our location-based services framework.

In Figure 2, the sensors determine the true location of POIs. "Sensors" include embedded technologies, tags placed on items, or even a database if the asset is not mobile. For example, conference room locations are not mobile and can be stored in a database. The sensors are connected to a sensor-agnostic middleware system.

The application layer contains the business logic that makes location information relevant and useful to the application such as specific geofencing triggers and personal saved location tags.

The security and privacy modules are hosted in the demilitarized zone, which allows employees to be able to access the information from either inside or outside the company.

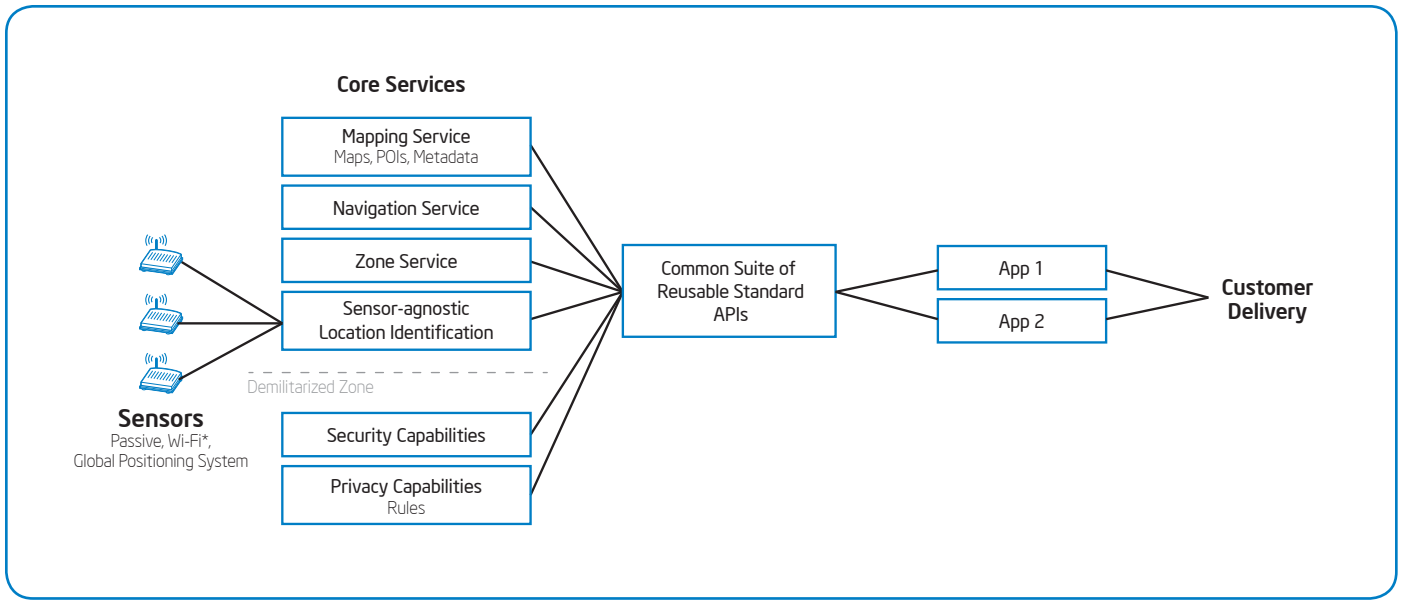

Figure 2. Our location-based services framework is modular and uses standard APIs, making it easily scalable and extensible.

NEXT STEPS

Adding to the success we've already achieved with the FriendFinder, WayFinder, and You Are Here mapping applications, we plan to enhance and expand what we've built so far.

In general, employee feedback has indicated that while employees appreciate the basic features of our existing three applications, they want further capabilities. For example, instead of showing the nearest conference room, WayFinder might show the nearest **available** conference room; in addition to showing where the cafeteria is, WayFinder might list what is on the menu.

Some of our plans include the following:

- Build out more services, such as geofencing
- Enable additional use cases, such as Virtual Assistant[1]
- Enhance the POI framework, the publishing of POIs, and maps
- Enhance privacy and policy controls
- Enhance the FriendFinder and WayFinder applications

[1] For more information, see the white paper, "Digital Personal Assistant for the Enterprise."

CONCLUSION

Similar to their usefulness in the consumer market, applications that use location-based services can provide great value in the enterprise. By using location-based services, employees can more efficiently connect to the resources around them and find the right resources at the right time.

Intel IT has developed a modular and scalable framework, built out several core services for mapping and routing, and is currently piloting three location-based applications:

- FriendFinder
- WayFinder
- You Are Here mapping

Some of the challenges we have addressed (and continue to address) while developing these services and building the supporting framework include accurately determining employees' location; identifying, tracking and publishing POIs; managing location information, and maintaining security and privacy controls.

The applications we have developed represent only three of the many use cases we have identified for location-based services at Intel, and our framework is not yet complete. Although it is a modest beginning, we see a bright future for location-based services in the enterprise and are actively pursuing enhancements to and expansion of our efforts.

ACRONYMS

GPS	Global Positioning System
POI	point of interest
RFID	radio-frequency identification
SOR	system of record

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