IT@Intel Technology Tips

Intel Information Technology
March 2011

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How it Works: Going from 'lost' to 'here at last' with GPS

With this search tool, you'll always know where you're headed

The Global Positioning System – better known as GPS – is hardly a surprise item anymore. If you need to find your way somewhere – such as from an airport to a business – this 21st century compass can point you in the right direction, offering block-by-block instructions that can make getting lost nearly impossible. It's also being used to prevent auto theft, help complete the United States 2010 Census and enable golfers to improve their swing. And the system is available in your cell phones, in your cars, on your boats and on planes.

Yes, truly amazing, this GPS. But how exactly does it work?

Here's a look at what's under the hood of this pocket-sized marvel.

Give me space

The GPS is actually a receiver pulling in signals from 29 Earth-orbiting satellites (24 standard plus 5 backups) making up the NAVSTAR system. The U.S. military originally developed and implemented this satellite network—often referred to as an "Earth constellation"—as a military navigation system in 1978, but in the 1980s opened it up for public use. At any given time, at least four satellites are visible in the sky (see Figure 1). Designed to last for about 10 years, these satellites are constantly being replaced by newer, more efficient models.

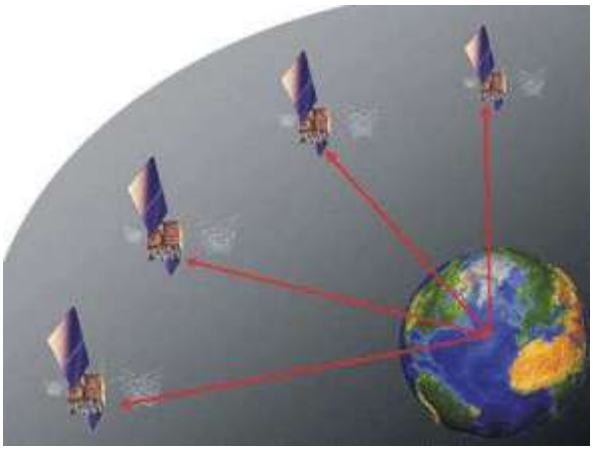

Figure 1: Thanks to NAVSTAR's "Earth constellation," at least four GPS satellites are visible at any one time.

GPS determines your location via a mathematical principle called "trilateration" (not to be confused with "triangulation"). In essence, a signal places your location within a specific radius; the corresponding signals overlap until they narrow down that location to within a few feet of where you happen to be (technically, "trilateration" is the wrong term, as there's always at least four satellites in use at any one time. The more appropriate term would be "multilateration").

Let's assume you're completely lost—as in, "I have no idea where I am"—and you ask someone for your location. They tell you, "You're 625 miles from Boise, Idaho." You ask someone else, and they tell you you're 690 miles from Minneapolis, Minnesota. You now know you're at one of two locations: 625 miles from Boise and 690 miles from Minneapolis. Then a third person tells you you're 615 miles from Tucson, Arizona. Voila! The radius around Tucson only intersects at one place with the previous two, meaning you're at that location—Denver, Colorado.

While the true process used by GPS is a bit more complicated than this example (primarily because it involves three-dimensional distance locating), you get the general idea.

When the receiver makes the distance calculation, it can tell the user the latitude, longitude and altitude of their current position. To make this info a little more user-friendly, most receivers plug this raw data into map files stored in the receiver's memory.

As you move, the GPS receiver stays in constant communication with GPS satellites to see how your location is changing. The receiver can then tell you how far you've traveled, how long you've been traveling, your current speed, your average speed, and the estimated time of arrival at your destination if you maintain your current speed.

Keeping track of it all

Originally used as a location-plotting device for boats, cars and planes, over the years, more and more uses have been found for GPS tracking devices. Now, numerous versions of GPS receivers exist, including:

Figure 2: Most new cars come with the option of activating a GPS system for easier navigating on roads.

- General purpose handheld, as in the kind used by consumers in everyday travel on roads.
- Vehicular, similar to general purpose, but integrated within a car or truck for travel on roads (see Figure 2).
- Aviation navigation, which can also display aeronautical charts.
- Marine, intended for navigation on water.
- Space, for use on satellites for navigation and altitude determination.
- Surveying, for high-accuracy land surveying and mapping solutions.
- Timing, for calibration of test instruments by various laboratories.

Some GPS trivia

As the caretaker of all things GPS, NASA offers these trivia tidbits:

- The first GPS satellite was launched in 1978. The oldest existing GPS satellite was launched in 1990.
- A "full constellation" of 24 satellites was achieved in 1994.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- Transmitter power is a mere 50 watts or less.
- Current transmissions come from about 12,000 miles above Earth, or one-twentieth the distance to the moon. By 2014, NASA hopes to double that range.

In addition, the GPS receiver can include a tracking unit, a device that determines the precise location of a vehicle, person, or other item and record that position at regular intervals. There are three types of GPS trackers:

- Data loggers, which log the position of the device at recorded intervals. This is typically the type of device carried by a jogger,

for example, to calculate the length and speed of a morning run, or to compare their run with that of other joggers.

- Data pushers, used by the security industry. They "push" (i.e. "send") the device's position, at regular intervals, to a specific computer server that can analyze the data. This is the type of tracker used when locating stolen vehicles or lost pets, or when detecting speeding vehicles on a freeway.
- Data pullers, which send position data only when requested. They are rarely used.

Here, there and everywhere

Despite their small size, some GPS units are obvious—cell phones, smartphones and handheld navigation systems, for example. But GPS has also made its way into other everyday applications, including:

- Backyard telescopes
- Physical training systems
- Pet tracking
- Air traffic safety
- Video and arcade games
- Wireless computer equipment
- Farming (such as pesticide application and seed planting)
- Sporting events (see Figure 3)
- Weather prediction/climate analysis
- Tracking systems worn by convicted felons

Figure 3: Golfers are using GPS to help improve their swing – and lose a few less balls.

GPS isn't perfect

Despite its tremendous potential, there are things GPS can't do. Here are some common myths about GPS:

1. **With a GPS, I'll never get lost again.** GPS devices are good at telling you where you are. They won't keep you from getting lost. A GPS can't read your mind and doesn't tell you where you want to go. And, they rely on batteries for power. When your batteries die, you will still need to navigate.
2. **GPS receivers don't work well when it's cloudy.** People often describe GPS receivers as "needing a clear view of the sky." However, the "clear view" refers to not having any obstructions to the view of the sky, such as mountains, tall buildings, or dense canopy. A cloudy day will not prevent your GPS from working.
3. **If you buy a GPS today, it will have up-to-date maps.** Updated and corrected maps often take years to reach consumer devices despite claims from the manufacturer that they are up to date. The maps provided may be the newest ones available, but they won't be 100 percent accurate with the physical world. Don't throw out that paper

map just yet.

4. **The factory-installed GPS navigation system in my car must be better than the "aftermarket" GPS devices.** Factory-installed navigation systems can be difficult to operate. They're also more expensive than an aftermarket portable navigation device (PND). The factory-installed units are more difficult to steal, but they're also more difficult to upgrade with new maps, databases and features.
5. **Auto GPS navigation systems will always pick the best route to your destination.** Most of the time, GPS will get you where you need to go. But the GPS system is mechanical. For example, it won't know if the most direct route sends you into rush hour traffic, or if the road in the GPS database has just been closed for repair work. It also lacks "local knowledge." You'll still be in those debates about the best way to get from one place to another.

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