Making GPS-like localization work indoors

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You're in a hurry. You've rushed to the nearest shopping mall during your lunch hour, looking for one item, one item only. It's a five-minute task, except for finding the store with the right item—and you're not familiar with the location of the store. Uh-oh.

You're shopping for groceries. The shopping list is on your mobile phone, and you visit this store all the time, so you know where everything is—except for that one special request your spouse made. Where in the world could that be? Uh-oh.

GPS technology has altered forever the way people navigate their outdoor surroundings. With GPS, the above scenarios would be easily overcome. If only we had GPS available indoors … but we don't. Some have tried Wi-Fi-based approaches to indoor localization, but those efforts have encountered challenges.

That could change, though, in the wake of FM-based Indoor Localization , a paper to be presented during The Tenth International Conference on Mobile Systems, Applications, and Services (MobiSys 2012), to be held June 25 to 29 along the shores of Lake Windermere in the U.K. Lake District. The paper—written by Dimitrios Lymberopoulos, Jie Liu, and Bodhi Priyantha of Microsoft Research Redmond, along with Yin Chen of Johns Hopkins University, then a Microsoft Research intern—offers an alternative technique.

"Accurate indoor localization can change the way we navigate in indoor environments," Lymberopoulos says, "the same way that GPS

technology revolutionized the way we navigate outdoors."

Initially, it was thought that Wi-Fi would be the technology to enable such navigation. Its received signal-strength indicators (RSSI) are widely available and popular, and mobile devices have Wi-Fi receivers, so additional hardware deployment is not needed. But as such systems have been tried, four problems have emerged:

• The operating-frequency range of Wi-Fi signals makes them susceptible to variability in indoor locations; this lack of consistency leads to high error rates.
• Commercial Wi-Fi access points can employ optimizations that can result in variations in observed RSSI and, therefore, the localization process.
• Wi-Fi RSSI vary widely over time, diminishing localization accuracy.
• The presence of walls and metallic objects reduces Wi-Fi coverage indoors, creating blind spots. FM signals, on the other hand, penetrate walls and buildings with ease, even though the actual FM antennas might be located several kilometers away.

Lymberopoulos, though, notes that the work by him and his colleagues has made three significant contributions:

"We demonstrated that:

• "Commercial FM-radio signals can be used to achieve similar or better indoor localization accuracy compared with the state-of-the-art Wi-Fi-based approaches.
• "We can leverage information about how wireless signals reflect to increase indoor-localization accuracy. In general, signal reflections always exist and make wireless communications noisy. In our work, we embrace this noise to achieve better localization accuracy.
• "The localization errors of FM and Wi-Fi signals are complementary.

When these signals are combined, we consistently achieve the highest localization accuracy when compared with using any of these signals independently."

The last part might be the most significant. It illustrates the truism that research is an iterative process, in which one team builds on the work of another. That game of innovative leapfrog continues until significantly improved technology emerges.

The FM-based localization work has been tested in commercial office buildings, and, in such settings, it was able to identify individual rooms correctly with accuracy rates consistently surpassing 92 percent. Combined with Wi-Fi, the success rate climbed as high as 98 percent.

"Commercially available signals in the range of 100 megahertz, such as FM signals, can be used along with Wi-Fi signals to achieve the most accurate indoor localizations," Lymberopoulos says. "This finding becomes important as networking over white spaces becomes a reality."

In 2009, Microsoft Research Redmond demonstrated that networking over the UHF spectrum works, and white-space networks are being deployed in the United States and the United Kingdom, using portions of the TV spectrum gradually being rededicated for wireless networking.

"The rise of white-space networking will ensure that devices will continue to have the necessary hardware to accurately sense analog signals at these frequency ranges—TV, FM, and AM," Lymberopoulos concludes. "Combining these low-frequency signals with the existing, high-frequency Wi-Fi signals could enable highly accurate indoor localization."

Source: Microsoft Corporation