

## ***Location-Aware Computing***

**EDUCAUSE Evolving Technologies Committee**

**A. Michael Berman, Independent Consultant (amichaelberman@gmail.com)**

**Sue M. Lewis, University of Illinois at Urbana-Champaign (sml@uiuc.edu)**

**Anthony Conto, University of Maryland (conto@umd.edu)**

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### *Introduction*

*Location-aware computing* refers to systems that can sense the current location of a user or device and change behavior based on this location. The best-known example is the Global Positioning System (GPS) navigation device. Since a GPS device knows its current location, it can give directions to the GPS user for how to get to a new location, and it can update these directions continuously as the device moves.

The reduction in price of location sensors, combined with the widespread availability of highly sophisticated portable devices (particularly smartphones), has resulted in the increased impact of location-aware systems in recent years. Most commonly, a location-aware system will determine its location through one of the following methods, ordered from least precise to most precise:

- *Mobile-phone triangulation*: determines its location by estimating its distance from multiple cell towers using the strength of each signal
- *Wi-Fi triangulation*: uses the same principle as mobile-phone triangulation but estimates the distance from Wi-Fi access points
- *GPS*: determines a location based on signals from multiple satellites
- *Radio-Frequency Identification (RFID)*: uses the signal from one or more RFIDs

Other location-aware devices have been based on TV signals, Bluetooth, infrared light, vision, ultra-wideband radio, and ultrasonic signals.<sup>1</sup>

Once a location-aware device determines its location, it can then take action or update content based on that information. A range of applications—from "friend finders" to surveillance systems—can track the location of individuals with location-aware devices and report them. This does, however, raise important privacy issues. Smart-guide systems can give the user information as he/she passes through an environment, such as a museum or a college campus. Rich-media systems can offer sounds, sites, and data associated with specific locations to bring a historic event to life. Simulation games can change behavior based on the choices that users make to move through a space. Location information can be "mashed up" with systems such as Google Earth to create new applications relatively rapidly and inexpensively.

While applications have been implemented via a range of devices, there has been

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<sup>1</sup> Mike Hazas, James Scott, and John Krumm, "Location-Aware Computing Comes of Age," *Computer*, vol. 37, no. 2 (February 2004), pp. 95–97.

an explosion of interest in location-based services as the cell phone has become ubiquitous, particularly among the college-aged population. Since 2005, virtually every cell phone sold in the United States has incorporated location-finding technology. As so-called smart-phones, particularly the Apple iPhone, have become extremely common, the processing power of even the most inexpensive cell phone has made it a “smart” device. In this paper, we use the term “mobile device” to refer to the entire range of products from simple cell phones to BlackBerries to iPhones to location-aware laptops and e-book readers, all of which can determine their location and have computing power sufficient for at least some location-based response.

### *Why Is Location-Aware Computing Important to Higher Education?*

Some colleges and universities have begun offering services to students based on location-specific information. The now-ubiquitous mobile device has also created many opportunities to tailor relatively low cost location-aware services to campus users. Spending on cell phones has nearly reached that of residential phone services.<sup>2</sup> Indeed, the predicted demise of landline phones is greatly stimulating the growth of location-aware services. These services will also provide an inexpensive entry into research efforts that have a mapping component.

From their first visit to a campus, students can use services built around their mobile devices to enrich their knowledge of the campus landscape. Campus visitor centers can provide tours via mobile devices to augment existing student-led tours. Some campuses have used mobile devices to provide audio tours of their museums and libraries. These services personalize the student experience and can augment, or in some cases replace, existing offerings. These services are very useful for institutions that want to provide anywhere/anytime response but that lack the budget for twenty-four-hour staffing.

A number of campuses currently use mobile devices along with signage capable of receiving and displaying location-aware information as delivery devices for information, such as campus bus locators. It may also soon make sense for a campus to implement geo-tracking services to accomplish such tasks as helping with traffic management—for example, when 20,000 people arrive within a few hours of one another for a campus football game. Letting such visitors know, via mobile device, which parking lots are open and the least congested streets by which they can be reached could mean that fewer police will be necessary to manage traffic.

In addition, GPS-equipped mobile devices can be used in tabletop exercises for emergency operations training, offering simulated experiences based on location. Colleges and universities have already begun to use GPS-enabled mobile devices to provide enhanced security services to their students.

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<sup>2</sup> Spending on Cell Phone Services Rapidly Approaching That of Residential Phone Services” from the Bureau of Labor Statistics (31 Dec 07) <http://www.bls.gov/cex/cellphones.htm>

### *What are the Implementation Challenges?*

While many location-aware commercial services are already available, most of these services require devices with specialized features. Not only do these devices cost more, many of the on-going services also require a monthly charge. At present, these services can hardly be said to have ubiquitous uptake among the student population. However, as prices for services and phones drop and as cell phones replace landline phones, students may arrive at campus with these enhanced-service mobile devices.

Some of the practical concerns related to location-based services are accuracy of location information<sup>3</sup>, visualization<sup>4</sup>, timeliness of the information, and transparency of location information.<sup>5</sup> Privacy concerns must be a part of the design for location-based services. Users must be aware of when they can be uniquely identified, who has access to their location data, and how long this data may persist.

### *How Is Location-Aware Computing Evolving?*

Location-aware services are beginning to transcend specific devices and proprietary services. Costs are coming down, and many more technologies and applications support these efforts. There is a shift from dedicated GPS devices to the GPS-enabled cell phone for data collection and distribution. With GPS-enabled cell phones, geo-tracking photos, and Google Earth, anyone can be in the business of providing these services to others. And with the recent availability of a free development environment for the iPhone, interest in building location-aware systems will be on the rise.

In the last 12 months, Google has launched “My Location,” and Microsoft “Find My Location.” These services are based on mobile-phone triangulation to deliver information about the surrounding area to mobile device users. Google has a Geolocation API available that will provide the location of a device running a Gears-enabled web browser.<sup>6</sup>

Although the potential for location-aware services is great,<sup>7</sup> the tracking capabilities have raised concerns that the technology, in particular RFID tags, can be used maliciously to track people without their knowledge. Since RFID tags can be read from a distance, they could be placed surreptitiously in items of clothing, for example, so that people can be covertly tracked wherever they might travel. Some experts discount privacy issues by noting that these issues can be easily addressed by using chips that permanently destroy RFID capability at the point of sale of items. Others believe that these privacy issues are real and will take a combination of technology and policy to

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<sup>3</sup> J2ME and Location-Based Services, Qusay H. Mahmoud, March 2004.

<http://developers.sun.com/mobility/apis/articles/location/>

<sup>4</sup> Leif Oppermann, Gregor Broll, Mauricio Capra, Steve Benford: Extending Authoring Tools for Location-Aware Applications with an Infrastructure Visualization Layer. Ubicomp, Orange County, 2006.

<http://www.mrl.nott.ac.uk/~sdb/research/downloadable%20papers/layered%20authoring.pdf>

<sup>5</sup> <http://www.andrewgrill.com/blog/index.php/2008/05/microsoft-live-providing-real-time-location-based-search/>

<sup>6</sup> <http://code.google.com/p/gears/wiki/GeolocationAPI>

<sup>7</sup> Simson L. Garfinkel, Ari Juels, and Ravikanth Pappu, “RFID Privacy: An Overview of Problems and Proposed Solutions,” *IEEE Security & Privacy*, vol. 3, no. 3 (May/June 2005), pp. 34–43.

safeguard.<sup>8</sup>

Non-RFID-based systems pose privacy issues as well. If an application is built to track the location of students or others on campus using cell phone location, who has access to this information? Do “friend finder” systems increase the risk of stalking? As these applications become more widely implemented, campuses will have to be alert to the privacy implications and will need to address them through policy and practice. How easy will it be for individuals to be “on” or “off” as they wander about?

*What are the likely impacts of the emerging technology in the next one-to-three years?*

One can expect colleges and universities to embrace location-based services in many pilot projects. For the cost of an inexpensive mobile device and some student programming time, classroom applications can easily be created. There are many existing applications that can be utilized in other disciplines.

*What are the related Higher Education projects?*

Many colleges and universities have already deployed location-based services. Some of these projects like the Dartmouth University library tour<sup>9</sup> simply replace the handsets used for museum tours with cell phones and require individuals to locate themselves within an environment.

Montclair State University required students to purchase a specific cell phone so they could provide safety, bus location and campus specific information services through their partnership with Rave Wireless. While their applications required a specific cell phone, other applications from Rave Wireless, such as Guardian, have been implemented by over a hundred schools and do not require a specific handset.<sup>10</sup>

Duke University is using both cell phones and handheld GPS devices in their research, using the GPS capabilities to track primates at the campus’ Lemur Center<sup>11</sup> and to create augmented realities in the Digital Durham web project.<sup>12</sup> The MIT Scheller Teacher Education Program has been creating augmented reality simulations using Windows Mobile devices to layer information about an area as people physically move through it.<sup>13</sup> They are collaborating with the Local Games Lab and the Games, Learning and Society and the Harvard Graduate School of Education funded by the U.S. Dept. of

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<sup>8</sup> Tom Karygiannis, Bernard Eydt, Greg Barber, Lynn Bunn, and Ted Phillips, *Guidelines for Securing Radio Frequency Identification (RFID) Systems*, Recommendations of the National Institute of Standards and Technology, April 2007, [http://csrc.nist.gov/publications/nistpubs/800-98/SP800-98\\_RFID-2007.pdf](http://csrc.nist.gov/publications/nistpubs/800-98/SP800-98_RFID-2007.pdf).

<sup>9</sup> Library Tours, Courtesy of Your Cell Phone <http://www.dartmouth.edu/~vox/0708/1105/tours.html>

<sup>10</sup> Mobile alert provider steps outside comfort zone <http://www.ravewireless.com/news/09/04/2008>

<sup>11</sup> Visualizing an animal’s movement in real-time, Kenneth Glander, <http://cit.duke.edu/ideas/projects/2007/05/04/visualizing-movement/>

<sup>12</sup> Visualizing historical Durham using Google mapping tools, Trudi Abel, <http://cit.duke.edu/ideas/projects/2007/05/04/visualizing-durham/>

<sup>13</sup> <http://education.mit.edu/drupal/ar><sup>13</sup>

Education's Star Schools Program to research augmented reality simulations for mathematics and literacy learning.<sup>14 15</sup>

Mediascapes<sup>16</sup>, from Hewlett-Packard, is a suite of tools that allows easy content creation that overlays a physical reality. Examples of existing mscapes include a game that simulates prisoners escaping from the Tower of London<sup>17</sup> and campus tours from such campuses as San Jose State University<sup>18</sup>, Menlo College<sup>19</sup>, University of Massachusetts,<sup>20 21</sup> and Miami University.<sup>22</sup> For Halloween enthusiasts, there is a mediascape entitled Hatchet Park<sup>23</sup> in San Jose, CA.

A number of universities are involved in location-aware WiFi trials<sup>24</sup> and will explore such issues as location accuracy and security, context aware security, maps and asset tracking. There are also tracking competitions conducted at augmented reality conferences.<sup>25</sup>

### *Who are the major vendors?*

Since the application platforms are merging, the major hardware vendors include, or have the potential to include, all cell phone manufacturers, GPS device manufacturers such as Datalogic, Honeywell, HP, AT&T and Dell, PDAs and small-form computers. Several of the applications require Mobile Windows platforms. Google, Microsoft, and HP provide APIs and applications that can be augmented by others. Over 30 companies have formed the open handset alliance to develop the G1 with Android "the first complete, open and free mobile platform."<sup>26</sup> Apple is rolling out new applications for the iPhone at a rapid rate. These two platforms should result in new applications being developed to explore the rich functionalities of these devices, including location aware services.

### *Conclusion*

Location-aware computing allows institutions to offer new and exciting applications on campus. It also provides a rich environment for experimentation and for construction of interesting prototypes. Given the coming near-ubiquity of mobile phones with locative technology pre-installed, and the ready availability of software tools for developing

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<sup>14</sup> <http://www.lgl.gameslearningsociety.org/argh.php>

<sup>15</sup> Matt Villano, "When Worlds Collide: An Augmented Reality Check," T.H.E. Journal, 2/1/2008, <http://www.thejournal.com/articles/22020>

<sup>16</sup> <http://www.hpl.hp.com/mediascapes/>

<sup>17</sup> <http://www.mscapers.com/msin/ABA0000023>

<sup>18</sup> <http://www.mscapers.com/msin/ABA0000448>

<sup>19</sup> <http://www.mscapers.com/msin/ABA0000132>

<sup>20</sup> <http://www.mscapers.com/msin/ABA0000188>

<sup>21</sup> <http://www.mscapers.com/msin/ABA0000206>

<sup>22</sup> <http://www.mscapers.com/msin/ABA0000507>

<sup>23</sup> <http://www.mscapers.com/msin/ABA0000106>

<sup>24</sup> <http://www.ja.net/development/network-access/location-awareness/index.html>

<sup>25</sup> [http://ismar08.org/wiki/doku.php?id=program-competition#further\\_information](http://ismar08.org/wiki/doku.php?id=program-competition#further_information)

<sup>26</sup> <http://www.openhandsetalliance.com/index.html>

location-aware systems, the quantity and range of campus applications will expand rapidly in the near future.

### **Related EDUCAUSE 2008 Sessions**

*Seminar 03A - Digital Fieldtrips for Digital Natives: Using Google Earth and Web 2.0 Tools to Bring Fieldtrips to the Classroom*

[http://net.educause.edu/E08/Program/14627?PRODUCT\\_CODE=E08/SEM03A](http://net.educause.edu/E08/Program/14627?PRODUCT_CODE=E08/SEM03A)

Jennifer Sparrow, Assistant Director of E-Learning, Florida Gulf Coast University

*Apple – Developing Native and Web Applications for the iPhone*

*Creating Applications for Converged Devices Like the iPhone: Start with a Vision*

[http://net.educause.edu/E08/Program/14627?PRODUCT\\_CODE=E08/SESS015](http://net.educause.edu/E08/Program/14627?PRODUCT_CODE=E08/SESS015)

Hab Adkins, Programmer, Abilene Christian University

James Langford, Director of Web Integration, Abilene Christian University

*Apple-Deploying the iPhone in Higher Education*

[http://net.educause.edu/E08/Program/14627?PRODUCT\\_CODE=E08/WKSC13](http://net.educause.edu/E08/Program/14627?PRODUCT_CODE=E08/WKSC13)

*A Campus-Wide Approach for Mobile Learning with iPhones*

[http://net.educause.edu/E08/Program/14627?PRODUCT\\_CODE=E08/SESS053](http://net.educause.edu/E08/Program/14627?PRODUCT_CODE=E08/SESS053)

Kyle Dickson, Associate professor, Abilene Christian University

William Rankin, Associate Professor / Director of Mobile Learning Research, Abilene Christian University

George Saltsman, Executive Director, Adams Center for Teaching and Learning, Abilene Christian University

*Handheld and Mobile Computing*

[http://net.educause.edu/E08/Program/14627?PRODUCT\\_CODE=E08/DS35](http://net.educause.edu/E08/Program/14627?PRODUCT_CODE=E08/DS35)

Tracey L. Choulat, Director of Information and Instructional Technology, University of Florida

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Malcolm B. Brown, Director of Academic Computing, Dartmouth College

*Apple - Mobility in Higher Education*

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Jason Ediger, Sr. Group Manager, iTunes U and Mobility, Apple Inc.

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