Location Linked Information:

A framework for emergent, location-based content deployment

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ABSTRACT

This thesis proposes the creation of a scalable architecture to support the access and creation of *Location Linked Information*– the coupling of physical location with arbitrary virtual information nuggets. The proposed system dynamically links a physical space/time moment with a distributed database containing information that describes that moment's surroundings. This hybrid virtual/physical space, called *glean space*, is owned, managed, and rated by the public, for the benefit of the populace. Imagined as initially being embodied by an interactive, dynamic map viewed on a handheld computer, the system provides two functions for its urban users: 1) the retrieval of information about their surroundings, and 2) the optional annotation of location for communal benefit. It is our hypothesis that Location Linked Information will enhance the urban experience, just as access to transportation dramatically altered the sensation and form of the city. By making inhabitants hyper-aware of their surroundings, they get the benefits of a small town citizen (omniscience of space and society) while possibly being situated in a much larger megalopolis with the social mobility and features that go with it.

MOTIVATION

The city of bits forgot about its atoms

As ubiquitous computing moves from theory to practice, the once-clear demarcation between the virtual and the real worlds is increasingly difficult to visualize, especially when visiting real-world mainstays such as urban streets. The deployment of wireless networking technologies such as Wi-Fi and GPRS in these outdoor arenas is accelerating the permeation of digital data; but meaningful applications are noticeably lacking from hybrid digital/physical landscapes [46]. One possible reason for the lag is a void in the technical glue that ties together the digital and physical worlds. This thesis suggests one such implementation that maps physical space to virtual data and, in so doing, creates a toolset that technologists, the professionals of location [45], and inhabitants themselves can use to significantly impact urban life [22].

The Dark and Stormy Night: A Possible Usage Scenario

It is a dark and stormy night. You are walking home from a stressful day at the office. The weather is so horrible that you duck under an overhang, pull out your PDA, and tap on the "Janus Map Browser" button to see if there is anything you can glean about the vicinity from the digital annotation map. Viewing the simple version of the map (as apposed to the 3-dimensional binocular Janus you use as a tourist), you see a plan of your current location with nearby streets surrounded by a flood of tiny multi-colored dots of various levels of translucency that make the map look like a Seurat painting. The legend in the corner tells you that various colors are used to identify the type of information– with classifications that vary from location identification to historical text for tourists to alerts and public warnings. A click of a dot follows the link to more information.

As you let go of the display filter switch you are shown only locations with activities– all the other marks and comments disappear. Most of the information includes things you have done before, but one bright circle a few blocks away labeled "Open Yoga Tonight" interests you enough to click on it. Your PDA then shows you the class schedule and after reading other people's annotation nuggets in the area around the entrance to the yoga center, you decide to take this opportunity to explore this unknown part of your neighborhood. After clicking on one of the annotations you realize that it is not really a yoga participant's comment as it says it is, but *Location Spam* – an advertisement for the Starbucks across the street. You quickly correct the classification and demote its relevance so others in your position will not have to look at it.

Before leaving the dry safety of the overhang, you set an alert message for any of your friends who happen to walk by the overhang to join you at the local oxygen bar afterwards to complete your evening of fun. On your way through the new streets, your Janus satisfies your curiosity by showing you all the apartments that are available for rent on the street, but you decide that it is too expensive of an area. Directly before arriving at the street of the Yoga Center you begin to feel uneasy and change the Janus view to show a video feed from a web cam that a resident has pointed outside his window, which reassures you that the area is safe and it is just the rain and your overactive nerves at work.

BACKGROUND

The childhood game hide-and-seek received a high-tech makeover in May 2000 when the sport *Geocaching* was first played [18]. Instead of a live participant seeking another player located somewhere nearby, geocachers visit a web site to find their objective cache's latitude and longitude, then utilize handheld Global Positioning System (GPS) receivers to navigate to the hidden treasure. Geocaching is just one in a class of applications [2,12,18,23,51] that straddle the division between the physical and virtual worlds, and this thesis proposes to describe a more general and scalable implementation that links global position and time with data. Geocaching serves as the impetus for the work outlined herein – the pastime has inspired the formulation of a framework that takes geocaching to the next level, creating the more general Location Linked Information system, which couples physical location with arbitrary virtual information nuggets as authored by local cognoscenti.

The Missing Links

Location-Based Services (LBS) is a sub-genre of mobile computing applications closely related to this thesis [13]; LBS is a nascent area of study that is devoid of both a killer app and a sizable user base [45]. We propose that the reason for this lack of adoption is twofold: 1) content development is costly and time consuming [8]; and 2) the Internet is missing a piece of infrastructure to map spatial location to information, similar to how the Domain Name System maps words to IP addresses [24,27,37].

The Approach

The proposed system dynamically links a physical time/space moment with a distributed database containing information that describes that moment's surroundings. Imagined as being embodied by an interactive, dynamic map, called the Janus, which serves as a bi-directional portal to cyberspace from space, the system provides two functions for its urban users: 1) the retrieval of information about their surroundings, and 2) the optional annotation of location for communal benefit. In addition to the client software, the following infrastructure is constructed: 1) a hierarchical location directory service [26], and 2) a location directory server [51].

Key Differentiations

Conceptually, location linked information is not a novel idea– signposts, maps, epigraphs, geographic information system (GIS) databases, murals, digital marquees, and architecture [5] are all part of a class of asynchronous communication devices that have interjected social cues into the urban environment [31]. However, the design as put forth is distinctive through its synthesis of the following notions:

1) The tuple (Time, Space, URL, Location type) is the "primary key" of all data [28].
2) A hybrid virtual/real space is created, called "Glean Space," owned and managed by the public, for the benefit of the populace.
3) All content, apart from that which is part of the Glean Space, is owned by private individuals and kept on their own web servers.
4) Data entry is bottom-up. Data retrieval starts by asking a central infrastructure "who knows about here?" Content storage is distributed. Information structure is inspired from the Xanadu architecture [34] (virtual spatial views, realistic copyrights).
5) Adding and changing information links is open and without restriction.

Maturation of several application domains, technologies, and techniques– ideas from the WWW, GIS, urban planning, story telling, cyber culture, wireless networking, and computer science– amalgamate to manifest this thesis' hypothesis: public control of location linked information forms better urban living experiences. In an effort to demonstrate this hypothesis, we will implement the LLI framework, seed the system through bottom-up data entry, and then perform a real-world test scenario. Once complete, we will reflect on our design and generate a framework that other researchers can use when presented with a similar design challenge.

CONTEXT

At present we are able to realize this proposal because of the state of three trends: 1) the maturation of mobile technologies; 2) the indoctrination of Internet rituals and the rise of the active consumer [15]; and 3) discontent of present technological forms and tools.

First, the deployment of location based information applications (and by this we specifically mean outdoor location based information, although the basic principles apply globally) has recently been given three new classes of tools that promise to take its work to a new level: 1) precise electronic positioning systems (GPS, E911); 2) handheld computation, communication, and display equipment; and 3) ubiquitous, low-cost Internet network connections (GPRS/CDPD/Wi-Fi). With these technological advances it becomes feasible to access and generate information that resides in both the city of bits, and the city of atoms [31]– coincidentally satisfying urban planner Kevin Lynch's definition for a good urban place: one that is both *legible* and *remembered* [29].

Second, our society has begun to mirror itself after the prevailing media technology of the day: the Internet. Rather than being a television fed, passive consumer society, we are becoming an Internet-guided, active consumer/designer society [15]. Having been given the opportunity to micro-define their consumption and social patterns, city dwellers have taken on the dual role of designer/consumer as they utilize technologies of mass customization to engage in personally meaningful activities [15]. Furthermore, the rise of the Internet has introduced social rituals for the manufacture and maintenance of asynchronous communities [32]. Netizens are accustomed to posting comments (the authoring of content) to forums like Slashdot [43] or the Wikipedia [49] where their messages are subject to the whims of the community's readers (rating and editorial discretion lies in the hands of the populace). Another praxis legitimized by the invention of the blog, is the acceptance of everyone as content developer– a concept at the core of this proposed system. Without these established social principles and trends we would find it a monumental task to suggest such a cocktail of behavior changes.

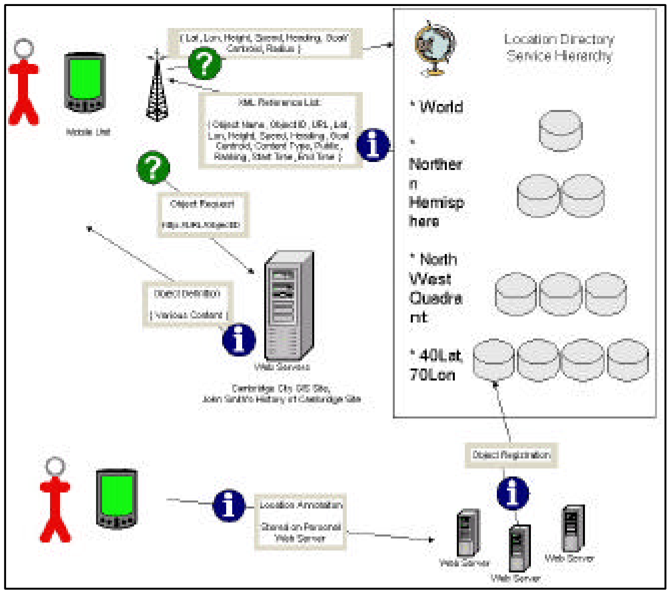
Finally, we note that futurists touted LBS as an area ripe for explosive growth in the late 1990s. To date, the technology has been marginalized, in use in several niche application domains (in-car navigation, tracking truck fleets, virtual tour guides [10,41]), but remains largely out of mainstream usage. Certainly ease of use and access is part of the problem, as Mark Weiser [47] noted, "Desktop publishing… is fundamentally not different from computer typesetting, which dates back to the mid 1960s, at least. But ease of use makes an enormous difference." Anthony Townsend suggests that a possible reason for the lack of adoption is because only technologists have been involved in the deployment of these services. He suggests that those in the location professions– architects, urban planners, and geographers– need to be more closely tied to the construction process [45]. As Michael Benedikt posited about the production of cyberspace, "The door to cyberspace is open, and I believe that poetically and scientifically minded architects can and will step through it in significant numbers" [11]. We take the view that the doors to *real* development of LBS have yet to be pried from the hands of technologists– the simple foundation for LBS targeted at the populace does not exist: current methods are too technologically heavy.

CHALLENGES

In this case, the challenge of the project is not so much in the implementation of the underlying technologies– while not trivial, they are largely understood processes and procedures– but in discovering the impediments to adoption in terms a professional of location would understand. Is this a space that can withstand aesthetic critique? What will be the relationship between form and function in this new space? Do people want to come to enter the space? How will the space stand up to the test of time? Will people be willing to apply social rituals learned from the Internet in the netherworld of glean space? What do people really want to know as they navigate the city? How does the role of government, and the privacy of its citizenry, play into the design of the system? What modifications to the form factor are applicable for displaying location specific information? How will this system scale to millions of simultaneous end users, databases, and mobile objects? How might such a system be deployed, and what changes could this have on the city?

IMPLEMENTATION

The implementation is divided into three technical layers: the *display*, *link*, and *storage*. People interface with the location information nuggets via the display or Janus layer, currently implemented in a PDA form factor, but which could vary widely to provide more appropriate access to the information. The link layer ties together the Janus with the data or storage layer. The link layer is a logical hierarchy of points that run a Location Resolver service. The Location Resolver is a point-to-point service (currently running on the JXTA P2P platform) that maps physical location with a list of URLs containing further information about those spaces. The storage layer is implemented as a grouping of web servers that contain location-based information.



As users move around the city, a GPS receiver determines current position and time. A location resolver service is then called, which maps a region on the surface of the earth with an XML/RDF document of nearby spatial references that conforms to the Semantic Web specifications for metadata [44]. Included in this document are physical location parameters (represented as points), temporal limitations, MIME types, and a URL for further description information. When the XML spatial description file is received, the Janus browser renders it as appropriate– as a plan map, as a 3D model, etc. If the user selects any of the spatial points, the Janus browser goes to that URL and displays the information. Should the user wish to annotate the surroundings, she presses the annotate button on her device and either leaves a note directly, or saves the area as a waypoint for later annotation. Annotations are then uploaded to the user's personal web space, which registers the content's reference with the Location Directory Service for others to see. Similarly, any existing spatial databases can implement a layer that registers their content with the LDS for end users to access. All link-level data is public and fully editable by citizens– citizens can mark content as "bad" or "good," which clients can use to filter out noise and encourage quality annotations. To accommodate dynamic, spatial data, a UDP interface is implemented alongside the standard HTTP interface on the LDS.

RESEARCH GOALS AND DELIVERABLES

- Finish functional technical framework, as outlined above, with the Janus client implemented on iPaq PDAs, including an example Location Resolver client, LD query interface, and LD Object registration interfaces (HTTP, UDP). *November 2002 – February 2003*
- Design proposals for three alternative Janus form factors and usage methods. *February 2003*
- Sample content deployment for typical application domains (data from static, dynamic, legacy sources). *February-March 2003*
- Encourage Internet users to deploy spatial content on the system (Slashdot/weblog posting). *March 2003*

- ?? Trial and analysis of real world test scenarios. *March 2003*
- ?? Thesis write up and revision. *April-May 2003*

RESOURCES

Both server and client resources are required to finish this proposal. Current development is ongoing on an Intel server running Linux, which should be sufficient for the server portions of the project. The client portion requires an iPaq handheld PDA, with GPRS and GPS cards, all of which have already been procured. It could be useful to have multiple versions of the client, in which case another iPaq would need to be purchased (approximately $700 new, or $300 used). Some assistance from NeCSys will be necessary to add a few DNS entries and coordinate firewall IP level access– this should not be a problem. When we test outdoors, a GPRS wireless Internet account will be necessary, at a cost of $50/month. To summarize, most of the resources required to finish the project have already been procured, and the ones that have not been are within reach.

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OUTSIDE READER BIOGRAPHY

Tim Berners-Lee

A graduate of Oxford University, England, Tim now holds the 3Com Founders chair at the Laboratory for Computer Science at MIT. He directs the World Wide Web Consortium, an open forum of companies and organizations with the mission to lead the Web to its full potential.

With a background of system design in real-time communications and text processing software development, in 1989 he invented the World Wide Web, an internet-based hypermedia initiative for global information sharing while working at CERN, the European Particle Physics Laboratory. He wrote the first web client (browser-editor) and server in 1990.

ADDENDUM - FAQ

Q: *What is your contribution to your area of study?*

A: My particular contribution is in the creation of the distributed link layer, that ties together the data with the location. In my implementation this layer (which basically is a public pointer to actual data) is distributed across multiple computers rather than being retrieved from a central server. The second key difference is that the pointer from the link layer can point to URLs that exist anywhere in the world (to date there has been little seperation between the location query server and the actual data). So together we have two levels of distribution– one on the reference (link) layer, and the second on the data layer. I propose that these two factors together make the system more scalable and ultimately more usable.

Q: *What part of the system are you actually building?*

A: Most of the work will be on writing server-side software that creates the link layer. This software utilizes peer-to-peer routing and data awareness techniques that tie together a distributed set of data. P2P systems, like the link layer, lookup data based on a primary key dependent on the application– my primary key will be a location key.

Q: *If most of the work will be on a middle layer, how will you demonstrate the system?*

A: A working, end-to-end (that is person to data) system will be deployed. That means that you should be able to wander around outside with one of my Janus devices and view some location linked information– information that exists on at least two different databases, running two different instances of the link layer server. To date I have the US Census Tiger database which has demographics information based on your current census block. Numerous other databases exist and time permitting I will enable as many of them as I can. A final criterion for a successful deployment will be the ability to add some location linked information of your present area so that others can find it later.

Q: *What's all this Janus business?*

A: Janus, the Roman god of passage and beginnings. He's got two heads, one looking forward and the other looking back. Or maybe one head is looking into the physical world and one into the virtual. It's just the piece of software that does the translation between physical and virtual. I could call it whatever… if anyone thinks of something better, I'm game for changing it. But the Janus thing is what I am building. I would like to include at least a few possible sketches for alternative embodiments of the Janus layer besides the PDA– I think current devices have not been designed with this use in mind, and there are possibly better form factors. The Janus is presently a server side dynamic map.

Q: What do you mean by evaluation?

A: Firstly, does the system work? By this I mean: 1) Armed with the appropriate software, can you get an answer to 'What information is available about or near *right here*?" 2) Can two or more link layer servers exist, each of them jointly providing the following basic services a) answering queries based on location, b) adding new information links, and c) providing public quality of data retrieval/editing capabilities. Secondly, an evaluation should include coverage of the problems that arise from the first generation design– what user interface problems exist? How is system usage different than was expected? Lastly, a simple load test should be performed to see how well such a system could scale– are there flaws in the basic design that would cause the system to be difficult to scale to thousands of simultaneous requests in a given city block radius?