A Review of 2 Papers Related to Location Based Services

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Geospatial Mapping and Navigation of the Web

Kevin S. McCurley

Kevin S. McCurley

- He received a Ph.D. in Mathematics from the University of Illinois.
- He joined IBM Almaden Research Center in 1997.
- His current research interests include information security and web technologies.

Approaches for discovering Geographic Context for Web Pages

- Entity Based
  - Feature of user or computing system.
- Content Based
  - Context provided by content.

GIS Terminology

- Geoparsing
  - Process of recognizing geographic context.
- Geocoding
  - Process of assigning geographic coordinates.

Recognizable Geographic Content of Web Pages

- Zip Code & Phone Number
  - 4.5% contain recognizable US Zip Code
  - 8.5% contain recognizable phone number
  - 9.5% contain one of the above
- Recognizable place names
  - Can be ambiguous
- Other methods…
  - Contact info
  - Employment info

Geospatial Context for Hosts

- Whois Database
  - Contact address info may be unrelated to content of page.
- Traceroute
  - Some routers have names that give away their location.
- DNS
  - About 25% of second level domain belong to a Top Level Country Code for URL.
    - Of course my personal URL ends in .cx (Christmas Islands)
  - LOC resource record (not really used)
- Geocoding of HTML
  - Not widely used.

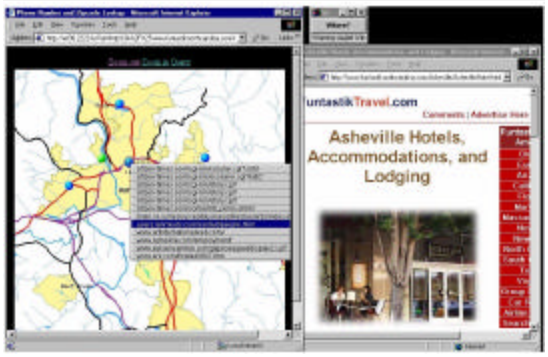
Traceroute example

```
C:\WINNT\SYSTEM32>tracert google.com
Tracing route to google.com [216.239.33.100]
over a maximum of 30 hops:
  1   <10 ms   <10 ms   <10 ms  192.168.2.1
  2   <10 ms    16 ms    31 ms  192.168.2.1
  3    31 ms    16 ms   <10 ms  dststwr1-vlan2.rh.pswynj.cv.net [67.83.249.33]
  4   <10 ms    16 ms    16 ms  67.83.249.1
  5   <10 ms    15 ms   <10 ms  ool-4353ef32.dyn.optonline.net [67.83.239.50]
  6   <10 ms    16 ms    16 ms  r1-srp5-0.in.nycmny83.cv.net [167.206.12.117]
  7   <10 ms    15 ms    16 ms  dcr1-so-5-2-0.NewYork.cw.net [206.24.207.25]
  8    78 ms    94 ms    94 ms  dcr2-loopback.SantaClara.cw.net [208.172.146.100]
  9    78 ms    94 ms    94 ms  bhr2-pos-0-0.SantaClarasc3.cw.net [208.172.156.214]
 10    78 ms    94 ms    93 ms  csr1-ve241.SantaClarasc3.cw.net [216.33.153.188]
 11   125 ms   141 ms    93 ms  google-exodus.exodus.net [64.68.64.210]
 12   109 ms   141 ms    94 ms  216.239.47.2
 13    78 ms    94 ms    94 ms  www.google.com [216.239.33.100]
Trace complete.
C:\WINNT\SYSTEM32>
```

Spatial Web Browsing

- Database operations can take a lot of processing
  - Solution: keep our experiment smaller then reality.
- Add spatial functionality to browsing
  - "What's near" button
- Unresolved precision and reliability issues
  - How to handle large numbers of web pages (700+) at one location.

Spatial Browser Prototype



Conclusions

- You can add spatial functionality to web browser
- It may even be useful
- Lots of unresolved issues
  - No method clearly works for assigning location in all (or even most) cases.
  - Precision and accuracy problems.

A Hybrid Location Model with Computable Location Identifier for Ubiquitous Computing

Changhao Jiang and Peter Steenkiste

Changhao Jiang

- He received a MS from Department of Computer Science & Technology, Tsinghua University, Beijing, China.
- He has been a research programmer at CMU since 2001.
- His research interests include context-aware applications and software model checking.

Peter Steenkiste

- He received his Ph.D. degree in Electrical Engineering from Stanford University in 1987.
- He is currently an Associate Professor in the School of Computer Science and the Department of Electrical and Computer Engineering.
  - His research interests include high-performance networking and distributed computing.

2 Types of Location Models

- Hierarchical
  - 110 Frelinghuysen Road
    Piscataway, NJ 08854-8019
    USA
- Coordinate
  - Latitude and longitude

Hybrid Model

- Start with a hierarchical model.
  - "we view the world as a hierarchy of spaces and each level further refines and subdivides the spaces of the previous level"
- Each space in hierarchical model has its own coordinate system.

Aura Location Identifier (ALI)

- Used to represent locations based on this hybrid model.
- Similar to URL.
- Contains both hierarchal and coordinate information.

Model Representation

Fig. 3. Hierarchical Space Tree

Syntax of Aura Location Identifier

```
<ALI>      ::= [ ali:// ] <Path> ["#" <Position>]
<Position> ::= <Pt-3D> | <Area> ["~" <Height>]
<Path>     ::= <Space> {"/" <Space>}
<Area>     ::= "{" <Pt-2D> "," <Pt-2D> "," <Pt-2D> {"," <Pt-2D>} "}"
<Height>   ::= "(" <Float> "," <Float> ")"
<Pt-3D>    ::= "(" <Float> "," <Float> "," <Float> ")"
<Pt-2D>    ::= "(" <Float> "," <Float> ")"
<Space>    ::= <Char> {<Char>}
<Float>    ::= ["+" | "-"] <Digit> {<Digit>} ["." <Digit> {<Digit>}]
<Char>     ::= <Alphanum> | "~" | "_"
<Alphanum> ::= <Alpha> | <Digit>
<Alpha>    ::= "a"|"b"|"c"|"d"|"e"|"f"|"g"|"h"|"i"|"j"|"k"|"l"|
               "m"|"n"|"o"|"p"|"q"|"r"|"s"|"t"|"u"|"v"|"w"|"x"|"y"|"z"|
               "A"|"B"|"C"|"D"|"E"|"F"|"G"|"H"|"I"|"J"|"K"|"L"|"M"|"N"|"O"|"P"|
               "Q"|"R"|"S"|"T"|"U"|"V"|"W"|"X"|"Y"|"Z"
<Digit>    ::= "0"|"1"|"2"|"3"|"4"|"5"|"6"|"7"|"8"|"9"
```

ALI example

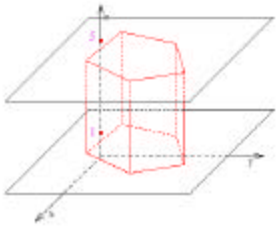


Fig. 2. "ali://cmu/wean-hall/floor3#{(1.0),(-1.5,-0.5),(0.0),(0.5,2.5),(3.1,1.5)}~(1.5)" represents an area within the 3rd floor of Wean Hall.

Coordinate System

- Sub space coordinates can be translated into that of super space by linear algebra.
  - Sub space coordinate system defined by origin point and rotation of axes from super space.
- Local coordinates make it easier to compute position of objects when services such as GPS are not available (indoors).
- Can tie two different local coordinate systems together by simply finding common super space.

Local Coordinate System

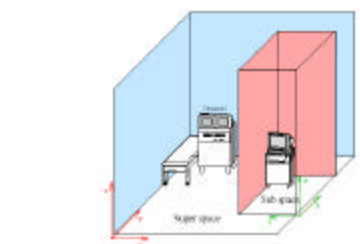


Fig. 4. Each space has its own space coordinate system, defined by specifying the origin point and three axes of "x", "y" and "z".

Coordinate Systems Relationships

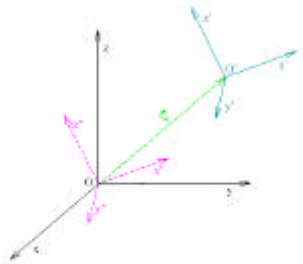


Fig. 5. Super Space Coordinate and Sub Coordinate System

Coordinate System Translation

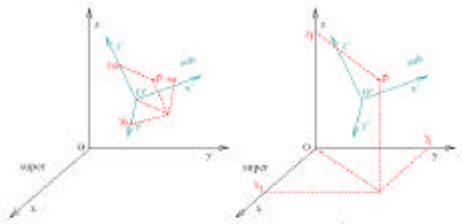


Fig. 6. Coordinate translation between super space and sub space

Model Representation

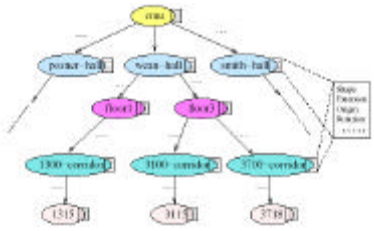


Fig. 7. Geometric space tree

Implications of this Coordinate System

- Since we can tie any two local coordinate systems together we can perform operations between any two ALI's that have a common super space.
- If the root of the model is tied into a global Coordinate system (lat/long) we can have operations involving any two ALI's even from different locations (not mentioned in paper).

ALI Operators

- Distance(ali,ali)
- Contains(ali,ali)
- Within(ali,ali)
- Super(ali)
- Sub(ali)

Space Service

- A service that provides information of physical environment.
- A service that provides information about spatial relationships between locations.
- Implements ALI operators.

Aura Services

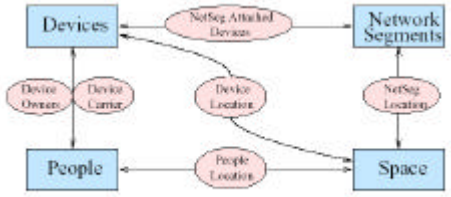


Fig. 1. A set of Aura contextual services for context-aware applications

Service-Level Implementation

- Implemented in PostgreSQL
- Single query may take several queries to data base.

Table 1. Relation definition for geometric space tree in PostgreSQL database

Geometric Attributes	Column Name	Column Type
NA	id	varchar
NA	name	varchar
NA	type	enum
Extension	extent	polygon
Height	height	double
Centroid	cx, cy, cz	double
Origin	dx , dy, dz	double
Rotation Matrix	m00, m01, m02 m10, m11, m12 m20, m21, m22	double

Database-Level Implementation

- Created user defined data type of ALI in database.
- Defined operations on this new data type.

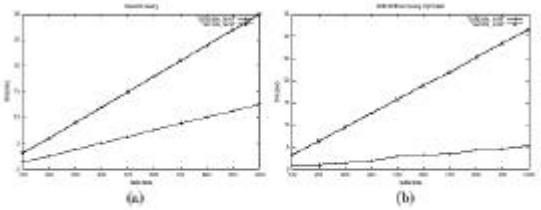
Table 2. Realized ALI functions and its appointed operator

Functions	Operators
distance(ali,ali)	<=>
within(ali,ali)	<<
contains(ali,ali)	>>
nearest(table, table)	##
left(ali,ali)	<|
below(ali,ali)	<=

Benefits of Database-Level Implementation

- Performance
  - User defined data type can take advantage of database optimizations.
- Flexibility
  - More complex queries possible by defined operations on new data type.

Performance Comparison



(a) (b)

Fig. 9. Performance comparison between service *level* and *database level* implementation of ALL. In above figures, two different queries are executed separately on two ALL implementations. Query for fig a) is *"find the nearest printer to location A"*, query for fig b) is *"find the printer within 3rd floor of Weon Hall, whose job queue is less than 3 jobs"*

Conclusions

- Viable approach for context aware applications.
- Combines best of both hierarchal and coordinate based location models.
- Implementation at the database-level realizes real benefits.