Developing Web 2.0 Mapping Applications

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Goal

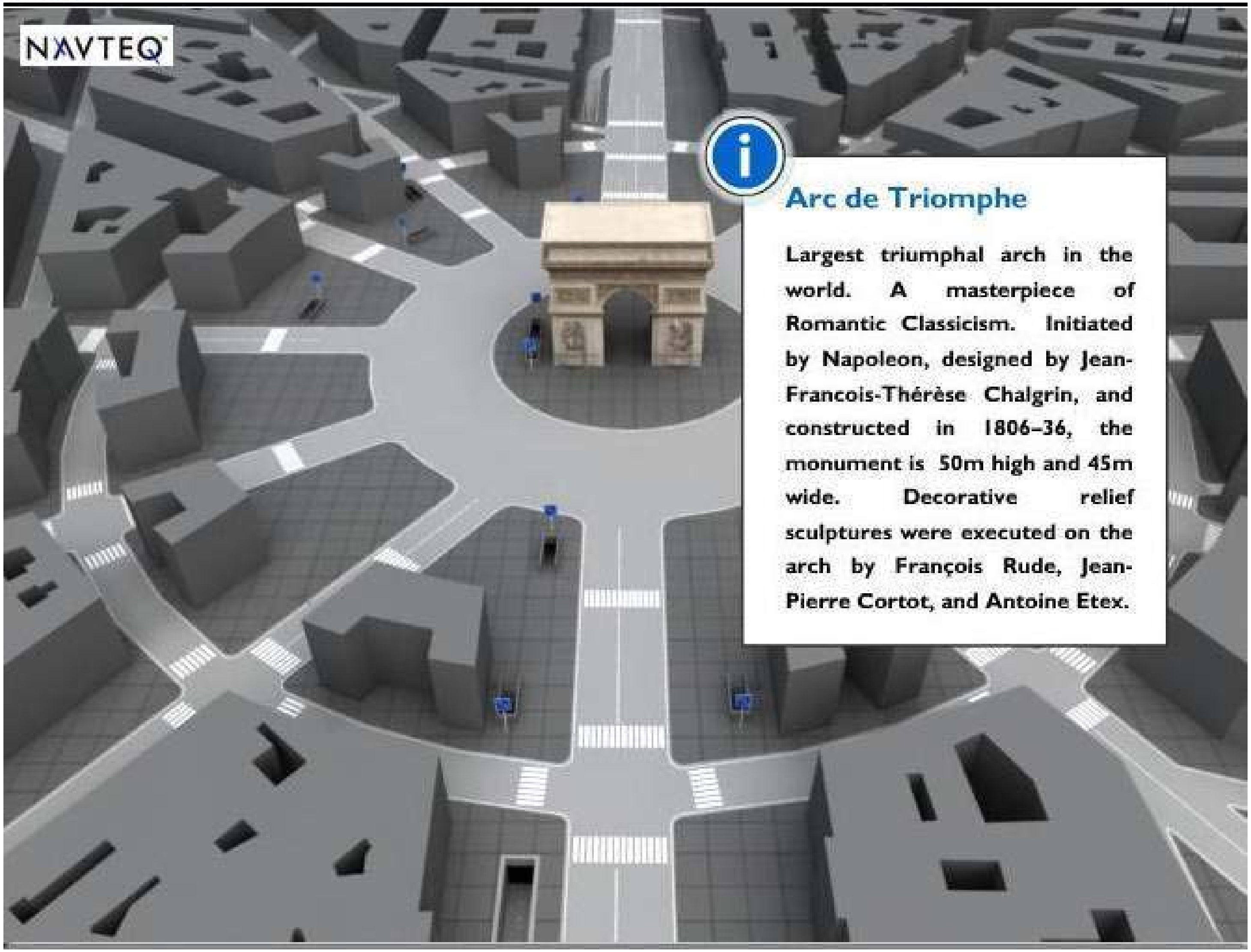
Provide a technical introduction to NAVTEQ geospatial data, AJAX mapping APIs, and Web Services best practices.

Agenda

- **Location Is Everywhere**
- Global Specification and Data Model
- Use Case: Zone in GDF
- Developer Support
- Use Case With Java™ Platform: deCarta

Introduction to NAVTEQ

- Leading global supplier of digital maps for vehicle navigation, portable navigation, Internet mapping, enterprise systems, and a variety of wireless location-based services applications
- Over 90 million consumer touch points every day
- 60 countries on 6 continents— and counting
- More than 600 geographic analysts worldwide driving the roads to collect up to 200 attributes per road segment



Arc de Triomphe

Largest triumphal arch in the world. A masterpiece of Romantic Classicism. Initiated by Napoleon, designed by Jean-Francois-Thérèse Chalgrin, and constructed in 1806–36, the monument is 50m high and 45m wide. Decorative relief sculptures were executed on the arch by François Rude, Jean-Pierre Cortot, and Antoine Etex.

Road Geometry

+ Lane Markings
+ Pedestrian Crossings
+ Pedestrian Stairwells
+ 3D City and Landmark
+ Textured Landmark
+ Landmark Metadata

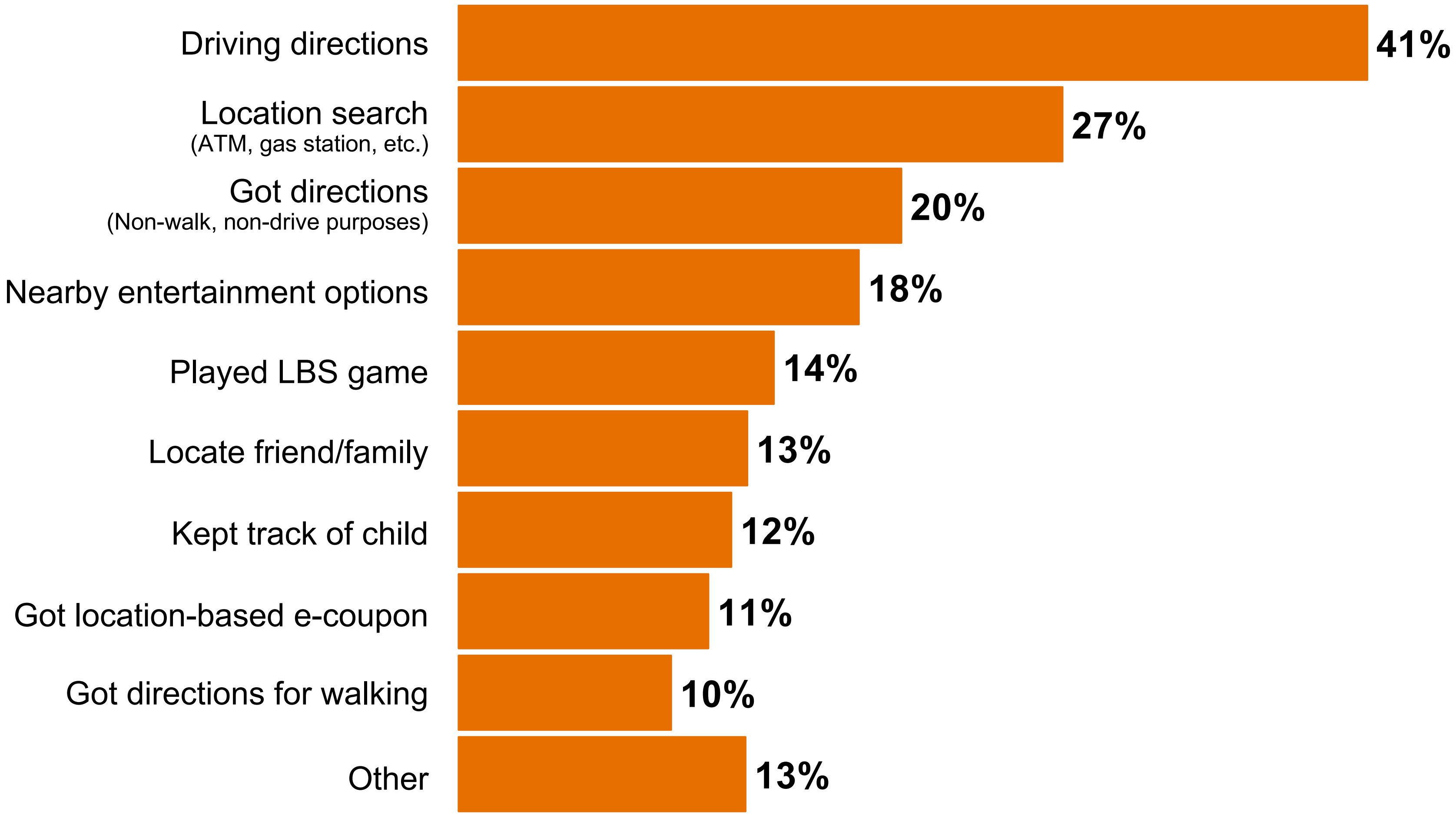
Location Is Everywhere

- Adoptable, Convenient, Pervasive

Maps/Directions Make Up 33% of Mobile Application Downloads by Revenue—The Largest Segment*

Source: Telephia's Mobile Application Report (Q1-06 to Q4-06).

How Consumers Use Location on Mobile Devices



* Source: Telephia's Mobile Application Report (Q1-06 to Q4-06).

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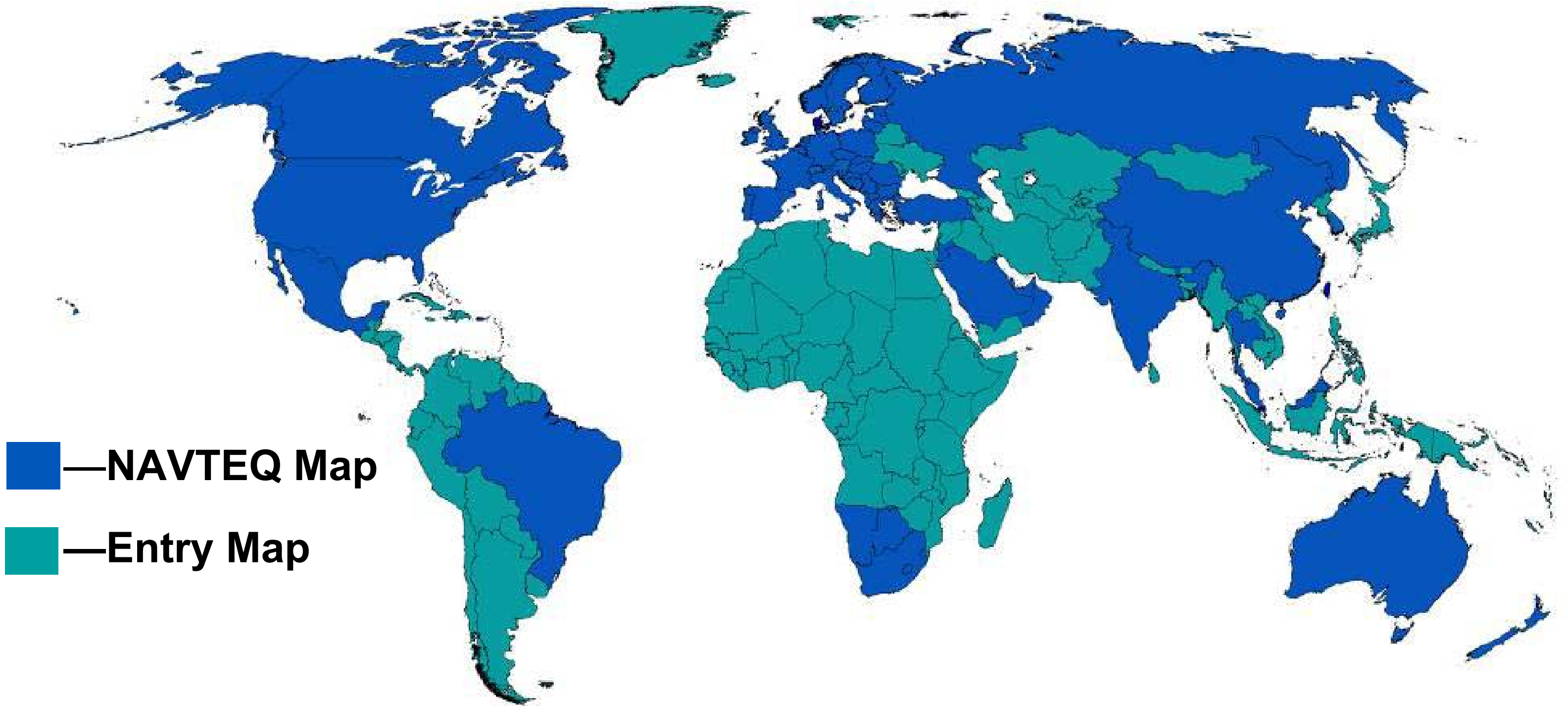
Global Specification



- Coverage in 60 countries and counting
- One global specification
- 144 offices in 27 countries
- Approximately 12 million miles of roadway in the NAVTEQ® database
- Approximately 600 geographic analysts updating and verifying around the world

One Global Specification

- Consistent data saves time and money!
- Coverage means relatively the same thing in one country vs. another:
  - “Detailed City” coverage in the U.S. is similar to that in Brazil, meaning full inclusion of addresses, turn restrictions, dividers, etc.
- Differences based on reality are documented by country in our Country Profiles, e.g., The U.S. has 4 administrative levels, while Canada has 5

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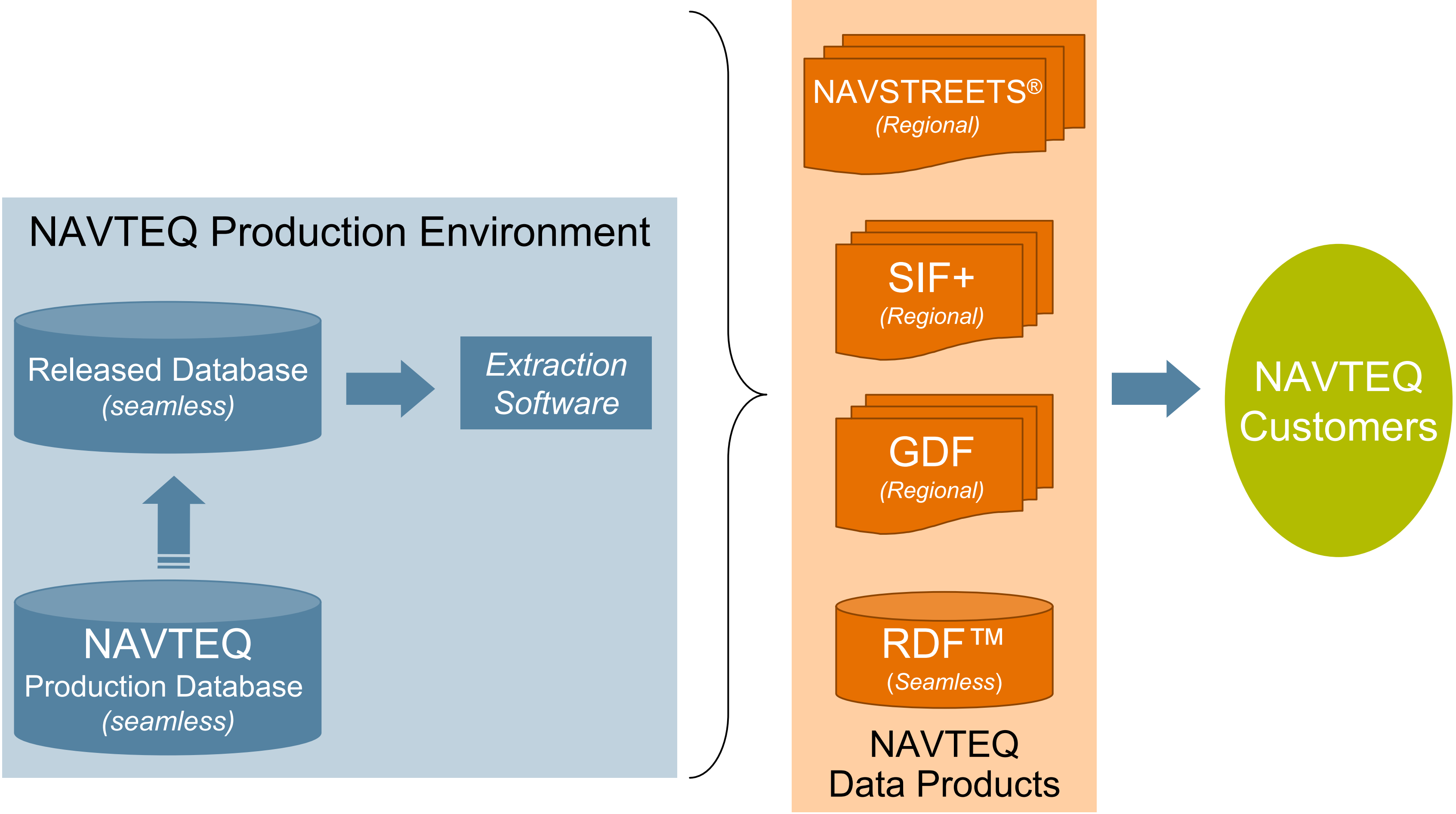
NAVTEQ Production and Extraction



NAVTEQ Production Environment

Released Database *(seamless)*

Extraction Software

NAVTEQ Production Database *(seamless)*

NAVSTREETS® *(Regional)*

SIF+ *(Regional)*

GDF *(Regional)*

RDF™ *(Seamless)*

NAVTEQ Data Products

NAVTEQ Customers

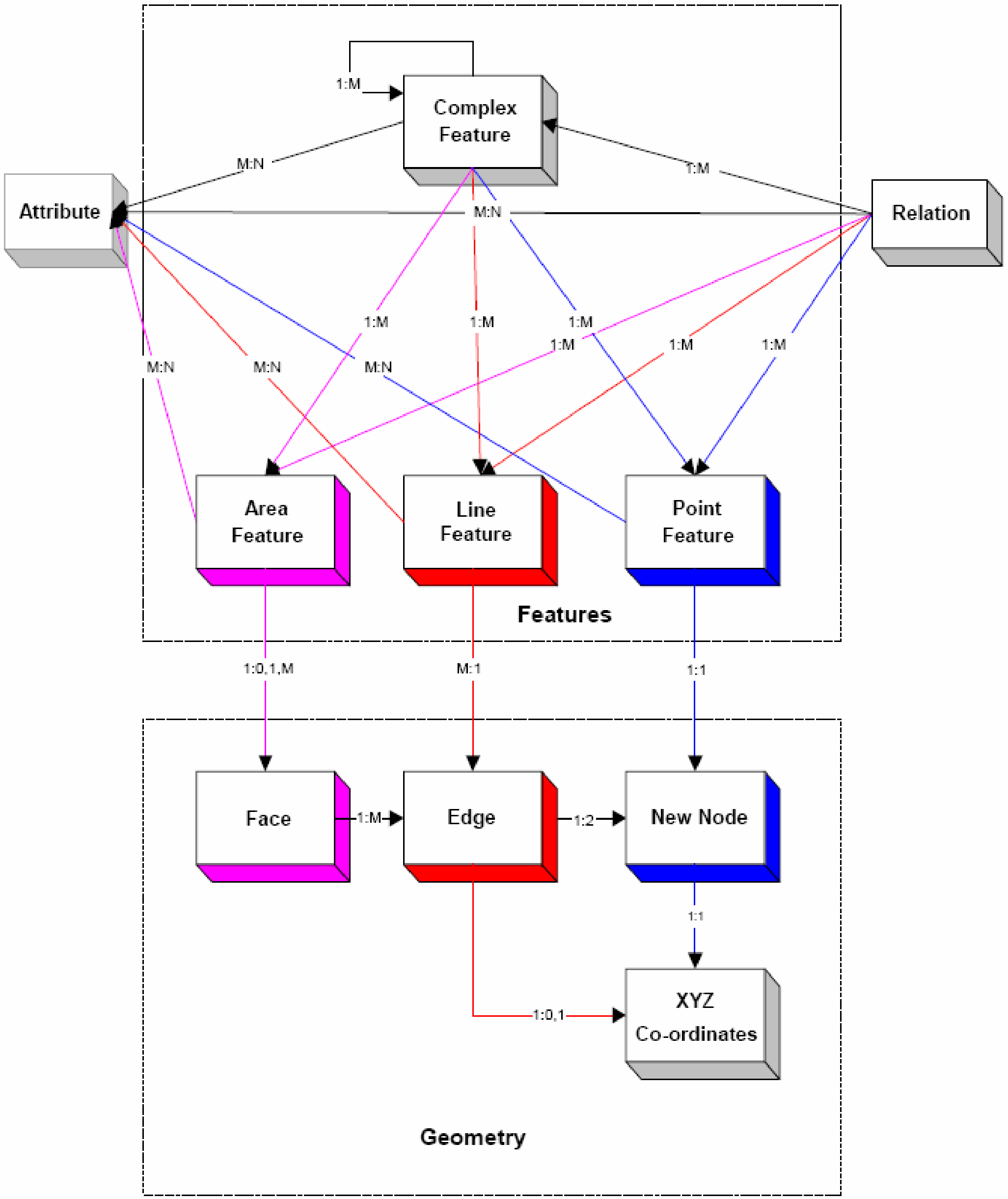
High Level Extraction Format Characteristics

- **GDF 3.0 (Geographic Data Format)**
- European standard, emerged as de-facto international standard for exchanging navigable databases*
- ACSII file structure, with record types related by pointers
- Data is sequentially ordered by Record Type
- No out-of-the-box tools to read format
  - A GDF Viewer is available, which allows browsing the GDF file; the viewer is not a GDF parser)
- The GDF conceptual data model comprises three entities: features, attributes, and relationships

*Despite status of international standard, GDF has flavors preventing usage of single GDF compiler worldwide to serve all map suppliers

Data Model

Legend	
1:0,1	1 to none, or 1 to 1
1:0,1,M	1 to none, or 1 to 1 or 1 to Many
1:1	1 to 1
1:2	1 to 2
1:M	1 to many
M:1	Many to 1
M:N	Many to many (N=number)



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Named Area (Zones) in GDF

- I could go into a detailed training of the GDF, but that would take all day!
- Instead, let’s focus on the challenges related to communicating the city level location of a street or POI or lat/long
- Other challenges exist when working with map data for geocoding, routing, and map display such as:
  - Washington Twp, MI existing separately in 3 counties
  - Dallas, TX crossing over into 3 counties
  - Duplicate cities within a county
  - Large areas of the US are not within an incorporated city
- But what does this have to do with Zones? Zones can help solve these problems

Named Area (Zones) in GDF

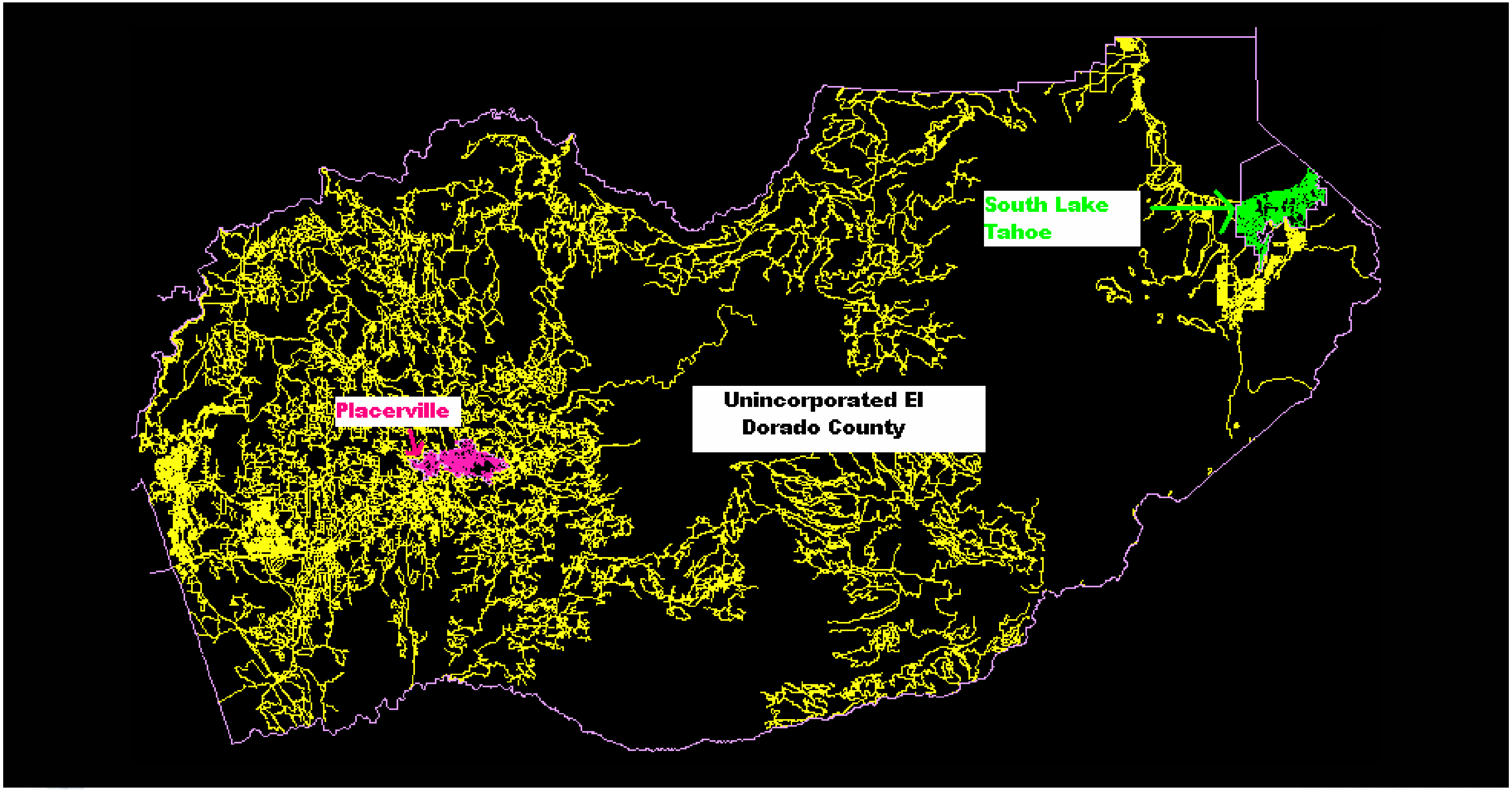
- Named Area: Postal Area (Zone type = PA)
- GDF Feature 3120
- Used in Denmark, Finland, Norway, Sweden, the U.S., Puerto Rico, the U.S. Virgin Islands, and the Netherlands only
- PA Zones reflect the names the Postal Service uses for an area; They can reflect names incorporated cities, military bases, unincorporated communities, or even O'Hare Airport
- Residents may refer to their postal area name rather than the city in which they live!

Named Area (Zones) in GDF

- Named Area: Known As Zones (KA)
  - These Zones represent names that most end users feel is the “city” name, regardless of whether or not it really is the administrative name; An example is Manhattan; KA zones in the U.S. are located in only two areas, New York and Boston
- Named Area: Known As That Does Not Replace the Administrative Name Zones (KD)
  - An example is Hollywood; In reality, there is no city of Hollywood; The true city name is Los Angeles, but almost every visitor to LA wants to go to Hollywood
  - In all cases, the Named Area is an alternate name to the Built-up Area name for destination selection

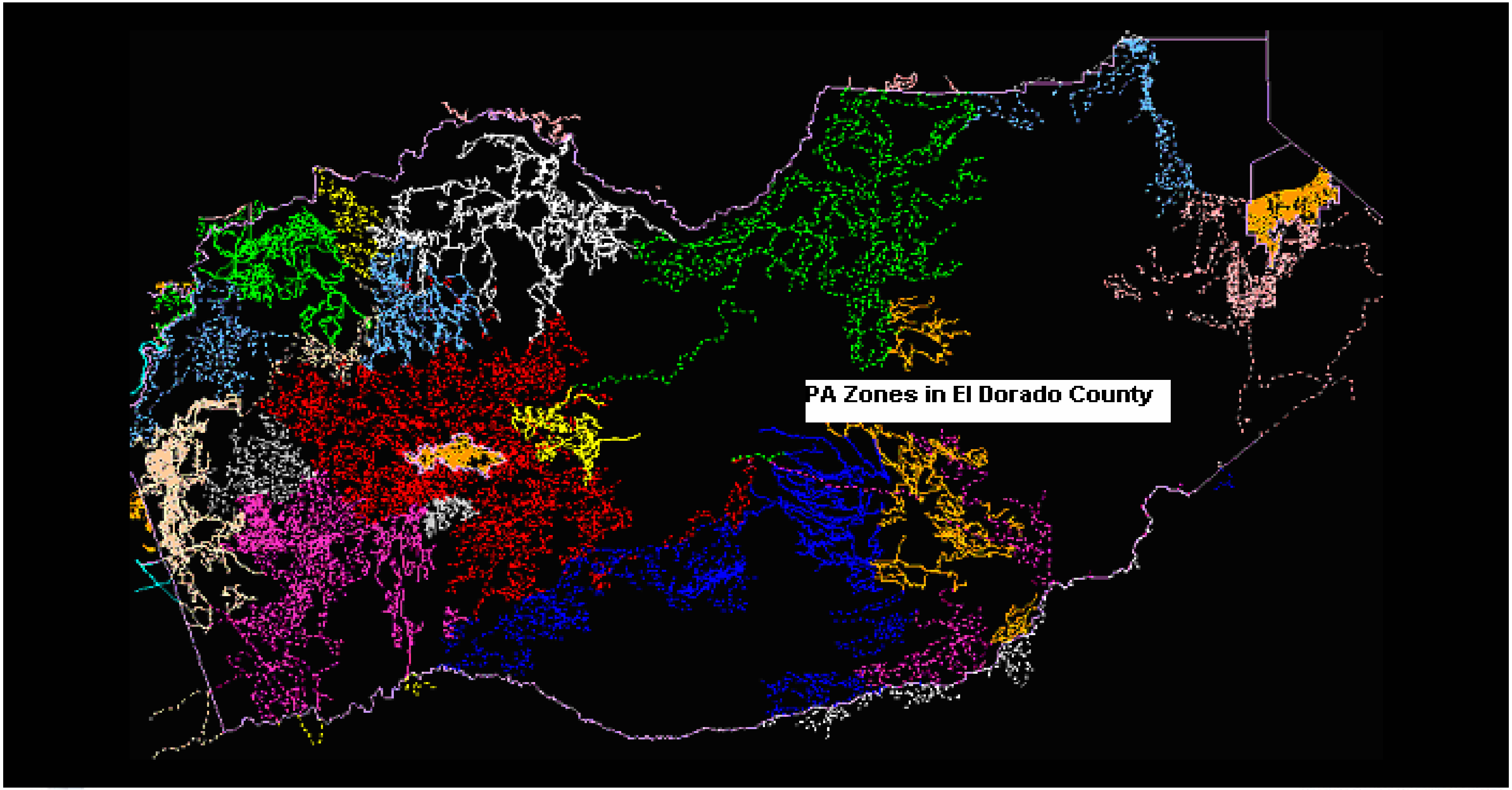
Named Area (Zones) in GDF

Example 1: There is no city name for the roads displayed in yellow. Postal Area (PA) Zones represent the primary name of an area used by the post office for mail delivery. They are VERY important for address resolution. People use them.



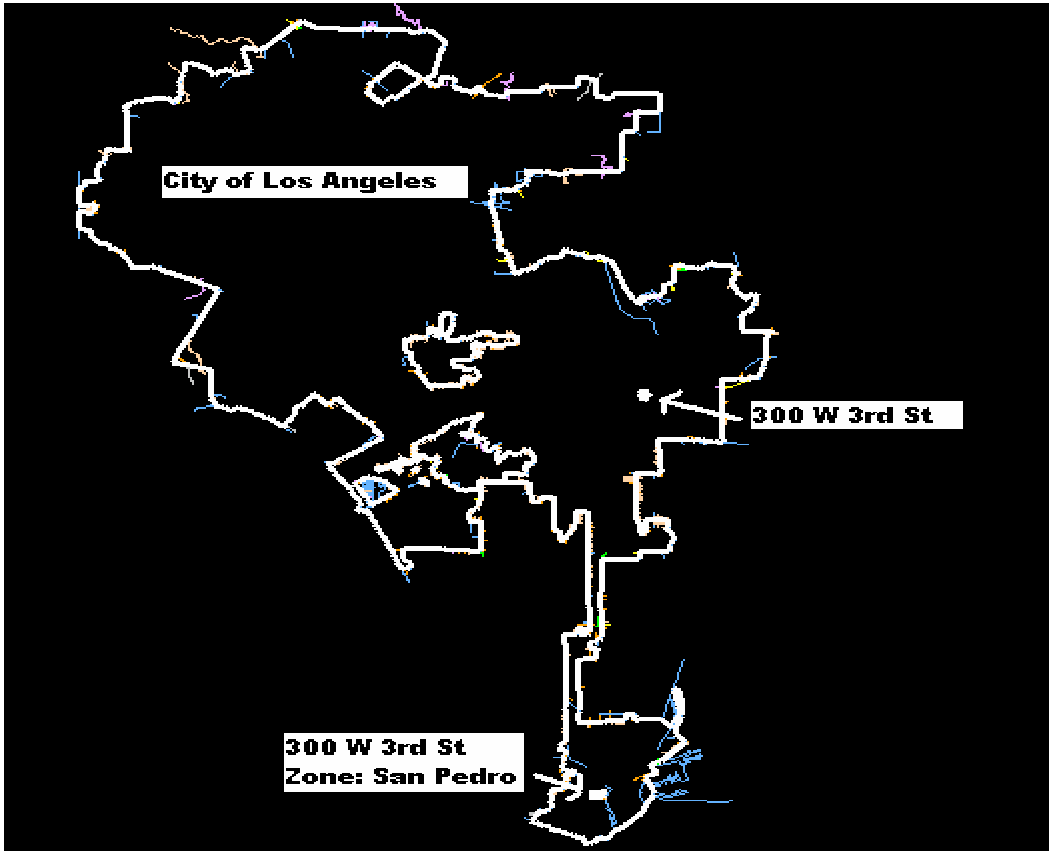
Named Area (Zones) in GDF

Here are the PA Zones: Light blue to the NE is Tahoma, while the white to the North is Georgetown. With the use of Zones, and application should geocode to Tahoma.



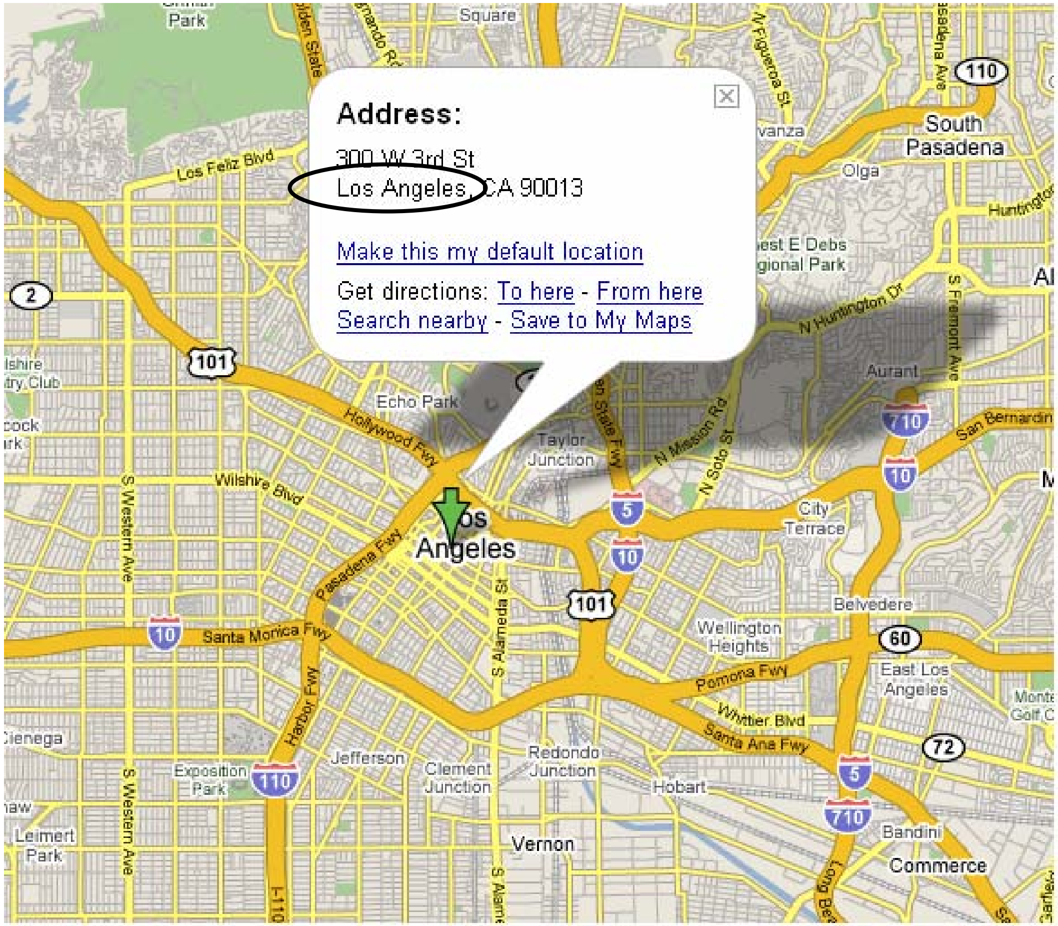
Zones in GDF

Example 2: Los Angeles, CA is the biggest offender of duplicate addresses within the city limits! Zone’s can be used to differentiate between the two.



Zones in GDF

Properly used Zones in Google Maps



Address:

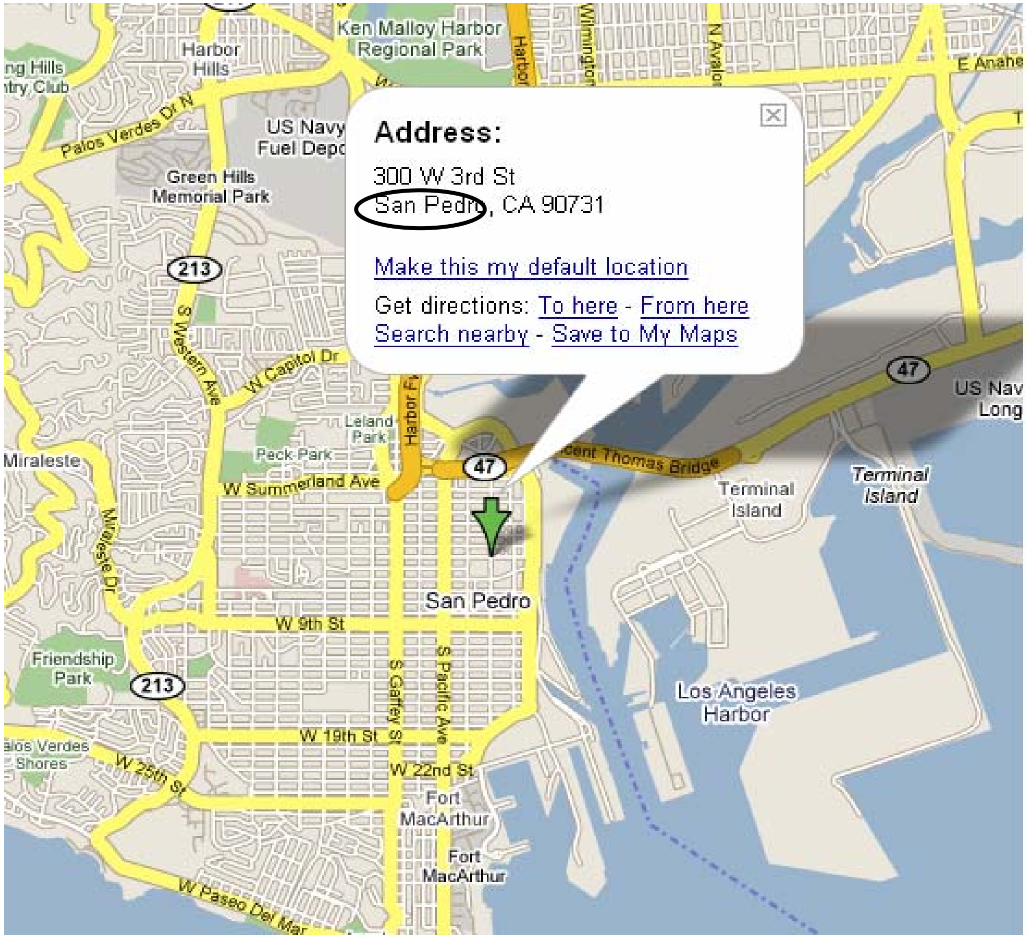
300 W 3rd St
Los Angeles, CA 90013

Make this my default location

Get directions: To here - From here
Search nearby - Save to My Maps

Zones in GDF

Properly used Zones in Google Maps



Address:

300 W 3rd St
San Pedro, CA 90731

Make this my default location

Get directions: To here - From here
Search nearby - Save to My Maps

Zones in GDF

- Merging Zones: It’s common for a city and zone of the same name to exist
- In GDF 3.0, merging the city and zone features can be done via the **Official Code (OC)**, which will be the same for both the **3110** feature (city) and the **3120** feature (zone); In the case of Los Angeles, both have **OC** =44000

```
• 53      5068     31100    1      4323    2   2154380   2154381                 0
• 44   2154380               1OC          44000                                  0
• 44   2154381               2ON         567835@4         900101                 0
• 41    567835     ENGLOS ANGELES                                                0


• 53      6198     31200    0    1   2133100                                     0
• 44   2133100               3ON         547913OC          44000#Z     PA        0
• 41    547913     ENGLOS ANGELES                                                0
```

GDF: New York City

(Based on Q303)

Legend:

→ :Components of the 1112 Feature for NY State

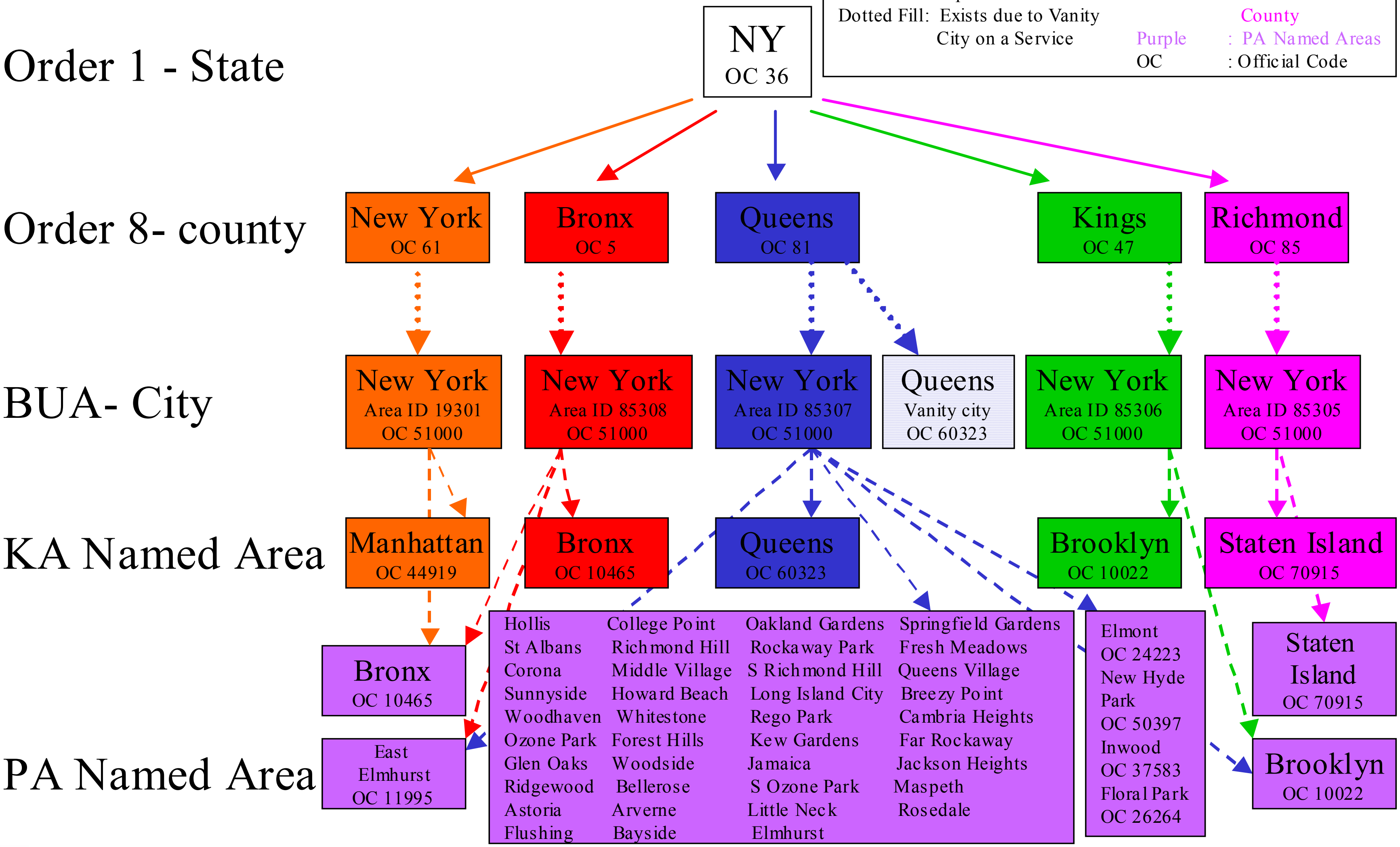
⋯▶ :1007 Relationship

– –▶ :1018 Relationship

Solid Fill :RE points to the feature

Dotted Fill: Exists due to Vanity City on a Service

Orange	: NY County
Red	: Bronx County
Blue	: Queens County
Green	: Kings County
Pink	: Richmond County
Purple	: PA Named Areas
OC	: Official Code



Order 1 - State

NY
OC 36

Order 8- county

New York
OC 61

Bronx
OC 5

Queens
OC 81

Kings
OC 47

Richmond
OC 85

BUA- City

New York
Area ID 19301
OC 51000

New York
Area ID 85308
OC 51000

New York
Area ID 85307
OC 51000

Queens
Vanity city
OC 60323

New York
Area ID 85306
OC 51000

New York
Area ID 85305
OC 51000

KA Named Area

Manhattan
OC 44919

Bronx
OC 10465

Queens
OC 60323

Brooklyn
OC 10022

Staten Island
OC 70915

PA Named Area

Bronx
OC 10465

East
Elmhurst
OC 11995

Hollis
St Albans
Corona
Sunnyside
Woodhaven
Ozone Park
Glen Oaks
Ridgewood
Astoria
Flushing

College Point
Richmond Hill
Middle Village
Howard Beach
Whitestone
Forest Hills
Woodside
Bellerose
Arverne
Bayside

Oakland Gardens
Rockaway Park
S Richmond Hill
Long Island City
Rego Park
Kew Gardens
Jamaica
S Ozone Park
Little Neck
Elmhurst

Springfield Gardens
Fresh Meadows
Queens Village
Breezy Point
Cambria Heights
Far Rockaway
Jackson Heights
Maspeth
Rosedale

Elmont
OC 24223
New Hyde
Park
OC 50397
Inwood
OC 37583
Floral Park
OC 26264

Staten
Island
OC 70915

Brooklyn
OC 10022

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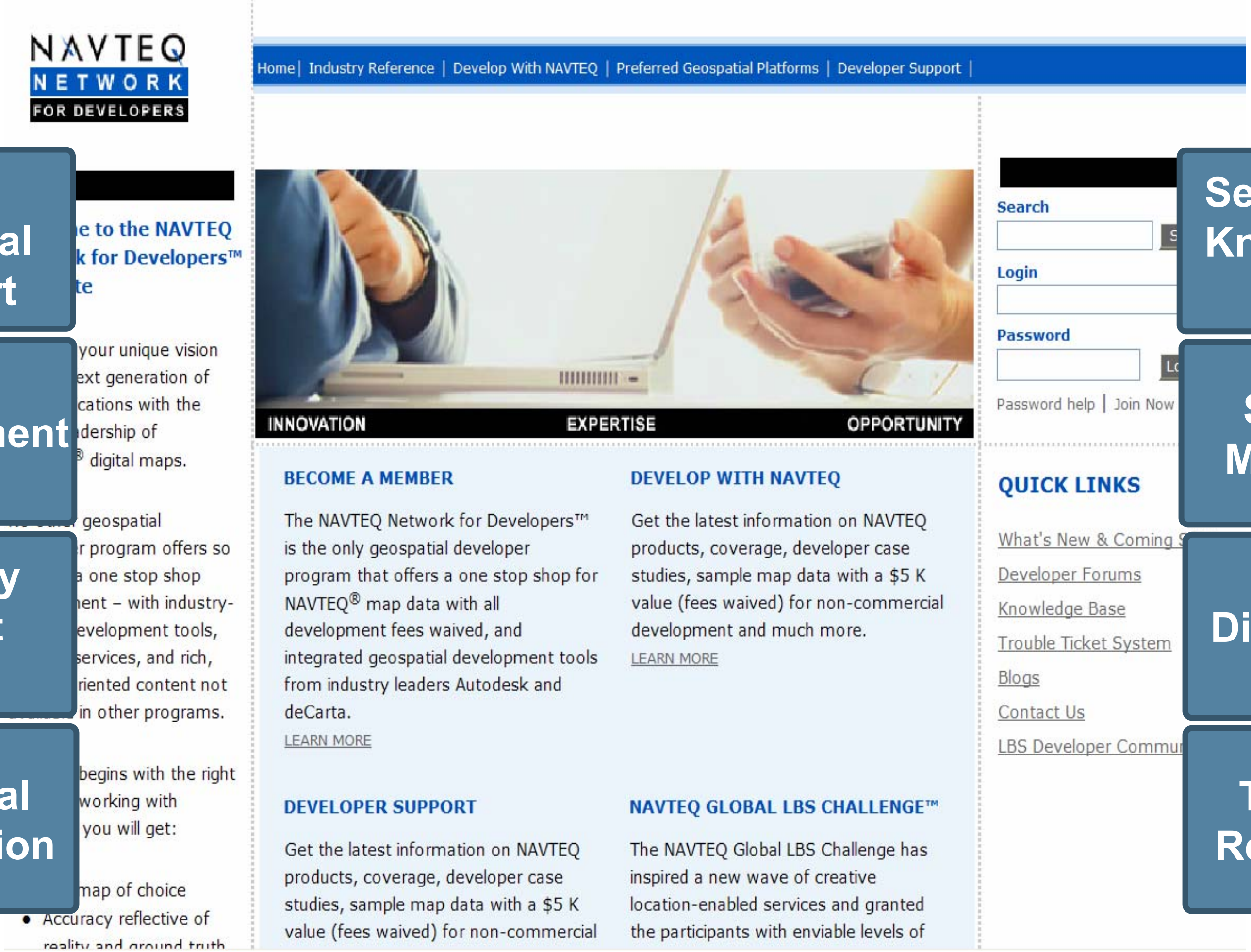
Explore the Resource



NAVTEQ NETWORK FOR DEVELOPERS

Home | Industry Reference | Develop With NAVTEQ | Preferred Geospatial Platforms | Developer Support |

e to the NAVTEQ k for Developers™ te

your unique vision ext generation of cations with the dership of ® digital maps.

geospatial r program offers so a one stop shop nent – with industry- evelopment tools, services, and rich, riented content not in other programs.

begins with the right working with you will get:

map of choice

- Accuracy reflective of reality and ground truth

INNOVATION EXPERTISE OPPORTUNITY

BECOME A MEMBER

The NAVTEQ Network for Developers™ is the only geospatial developer program that offers a one stop shop for NAVTEQ® map data with all development fees waived, and integrated geospatial development tools from industry leaders Autodesk and deCarta.

LEARN MORE

DEVELOP WITH NAVTEQ

Get the latest information on NAVTEQ products, coverage, developer case studies, sample map data with a $5 K value (fees waived) for non-commercial development and much more.

LEARN MORE

DEVELOPER SUPPORT

Get the latest information on NAVTEQ products, coverage, developer case studies, sample map data with a $5 K value (fees waived) for non-commercial

NAVTEQ GLOBAL LBS CHALLENGE™

The NAVTEQ Global LBS Challenge has inspired a new wave of creative location-enabled services and granted the participants with enviable levels of

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Developer Forums

Knowledge Base

Trouble Ticket System

Blogs

Contact Us

LBS Developer Commu

Free Technical Support

Free Development Tools

Industry Expert Blogs

Technical Information

Searchable Knowledge Base

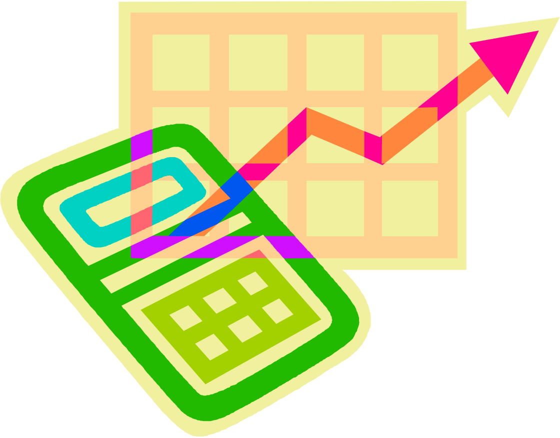
Sample Map Data

Active Discussion Forum

Training Resources

Foster a Healthy Ecosystem

- **Holistic Developer Offering**
  - Access to desirable partners, channels, and support
  - Free NAVTEQ® sample map data (for development and demo) with support
  - Knowledge base: forums, tech docs, etc.
  - Program communications and activities

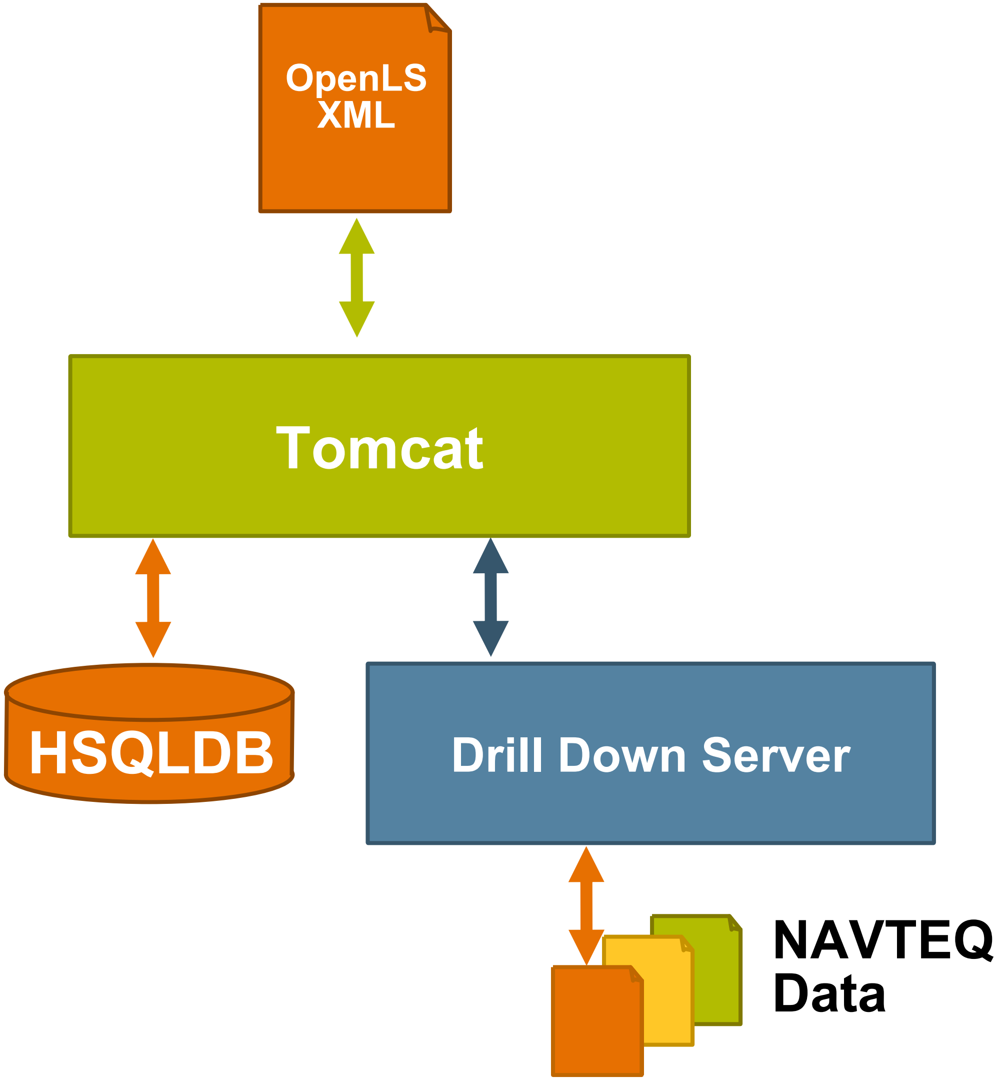


- **Accelerating Partner Success**
  - Access to pre-qualified developers for recruitment
  - Free NAVTEQ sample maps and support for partner's developers
  - Developer work-flow tools and utilities
  - Co-Marketing opportunities via NAVTEQ partner programs

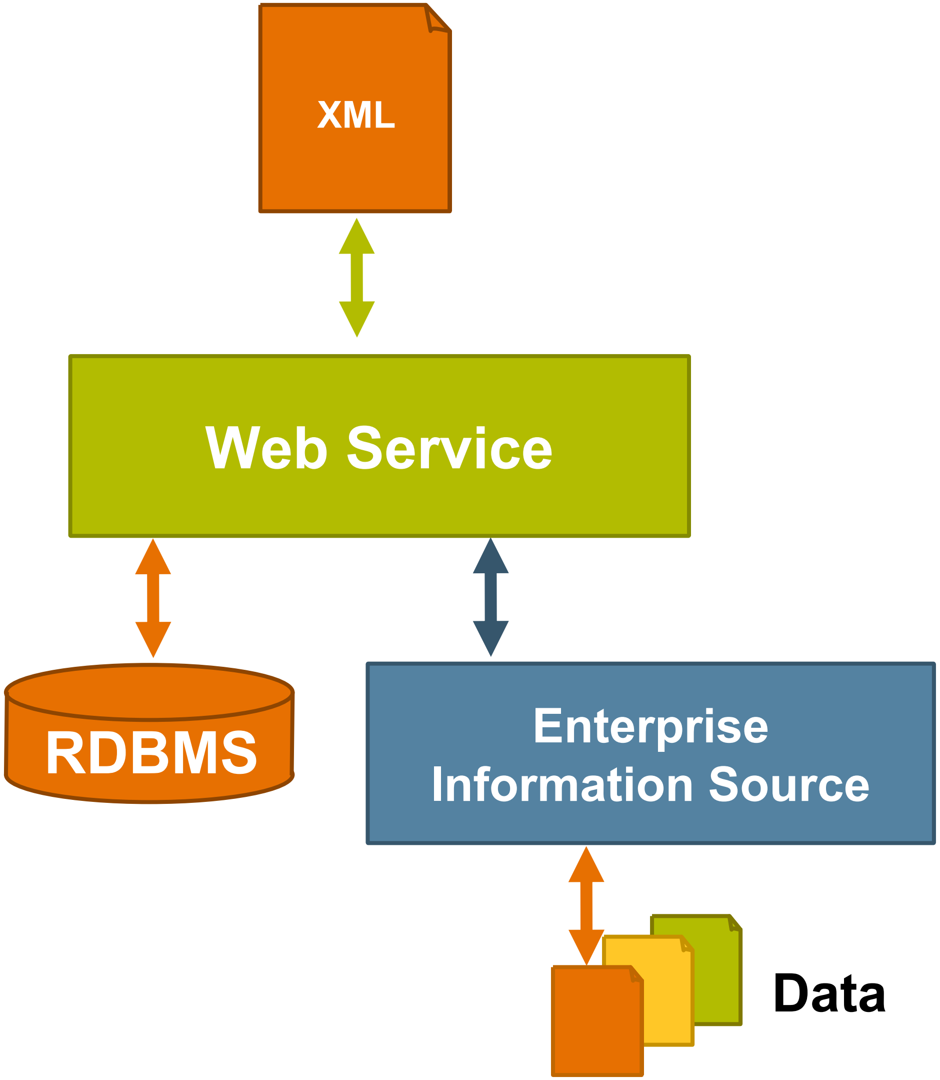
Agenda

- Location Is Everywhere
- Single Specification and Data Model
- Use Case: Zone in GDF
- Developer Support
- **Use Case With Java Platform: deCarta**

Server Architecture



Generic Architecture



Use Case Objectives

- Introduce basic geospatial functions
- Overcome JavaScript™ technology programming challenges in location
- Share experiences in developing deCarta's software stack
  - Widely applicable to Web Services developers
  - Sample code and best practices for building Web 2.0 servers

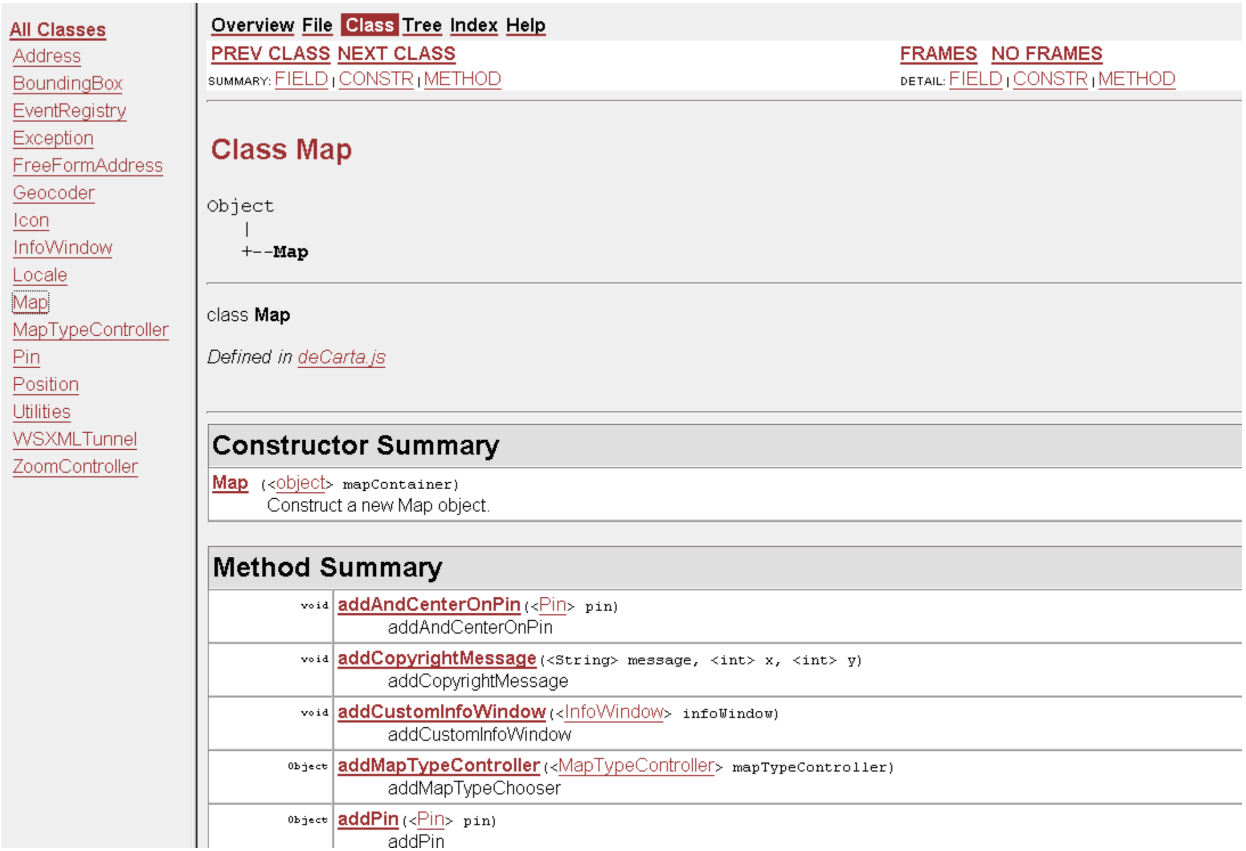
Basic Geospatial Functions

- Geocoding
  - Turning a street address into a Lat/Long
  - Cleaning up/normalizing user-entered address
- Reverse Geocoding
  - Turning a Lat/Long into a street address
- Map Display
  - Tiled draggable maps have replaced static maps
- Routing
  - Server must calculate route
  - Client must display route on tiles

Understanding the JavaScript Technology Landscape

- JavaScript Map APIs pioneered Object-Oriented JavaScript Technology
- Object-Oriented JavaScript technology will appear familiar to Java platform developers
- Asynchronous callback-based programming
  - Familiar model to Swing or SWT programming
  - “onZoomEnd”, “onDragEnd”

Object-Oriented JavaScript Technology



All Classes

- Address
- BoundingBox
- EventRegistry
- Exception
- FreeFormAddress
- Geocoder
- Icon
- InfoWindow
- Locale
- Map
- MapTypeController
- Pin
- Position
- Utilities
- WSXMLTunnel
- ZoomController

Overview File **Class** Tree Index Help

PREV CLASS NEXT CLASS FRAMES NO FRAMES

SUMMARY: FIELD | CONSTR | METHOD DETAIL: FIELD | CONSTR | METHOD

Class Map

```
Object
   |
   +--Map
```

class **Map**

Defined in deCarta.js

Constructor Summary

Map (<object> mapContainer)
Construct a new Map object.

Method Summary

void	**addAndCenterOnPin**(<Pin> pin) addAndCenterOnPin
void	**addCopyrightMessage**(<String> message, <int> x, <int> y) addCopyrightMessage
void	**addCustomInfoWindow**(<InfoWindow> infoWindow) addCustomInfoWindow
Object	**addMapTypeController**(<MapTypeController> mapTypeController) addMapTypeChooser
Object	**addPin**(<Pin> pin) addPin

Geocoding Process

1. Send freeform address to server
2. Server responds, invoking callback
3. Two arrays passed into application callback:
    1. `positions`: an array of possible locations for the address
    2. `addrCandidates`: an array of addresses, from the map database, corresponding to the positions
4. Application should use the highest quality match:
    1. positions[0], addrCandidates[0]

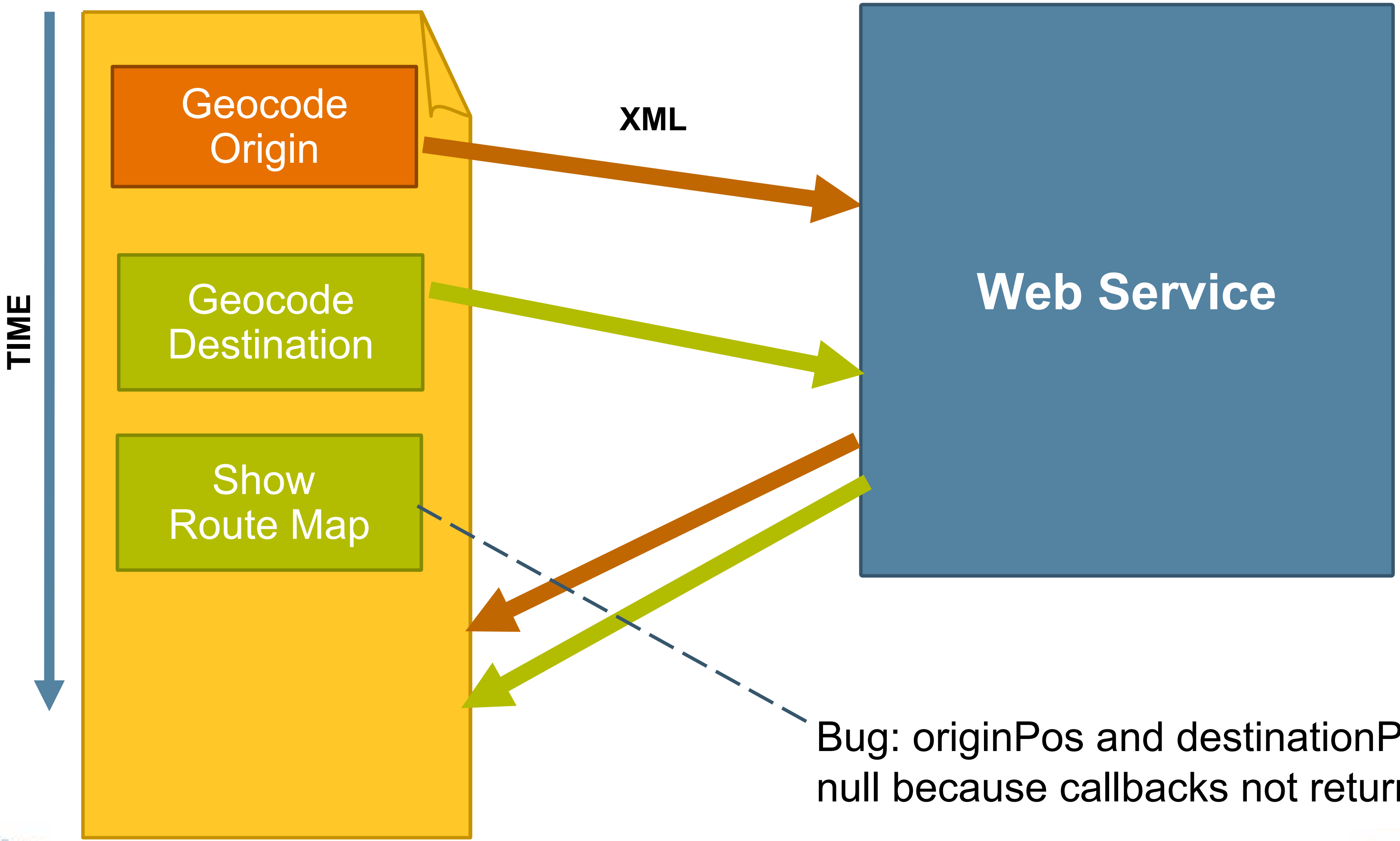
Anonymous Function Callbacks

```
var ffa = new FreeFormAddress(“4 N 2nd Street 95113");
var geo = new Geocoder();

//positions is array of candidate locations
//addrCandidates is array of possible address matches
geo.geocode(ffa, function(positions, addrCandidates) {
  if(positions.length==0) alert("unable to geocode");
  else alert(“Best address match: ”+addrCandidates[0]);
});
```

Pitfalls of Asynchronous JavaScript Technology

```
var map = new Map(document.getElementById("map"));
var originAddr = new FreeFormAddress(“San Jose CA");
var destinationAddr = new FreeFormAddress(“94105");
var geo = new Geocoder();
var originPos = null;
Var destinationPos = null;

geo.geocode(originAddr, function(positions, addrCandidates) {
     originPos = positions[0]; //first position match
});
geo.geocode(destinationAddr, function(positions,
addrCandidates) {
     destinationPos = positions[0] //first position match
});
//the following is a bug! No guarantee originPos
//or destinationPos is set.
map.routeMap(new Array(originPos,destinationPos));//show map
```

What’s the Bug in Previous Example?

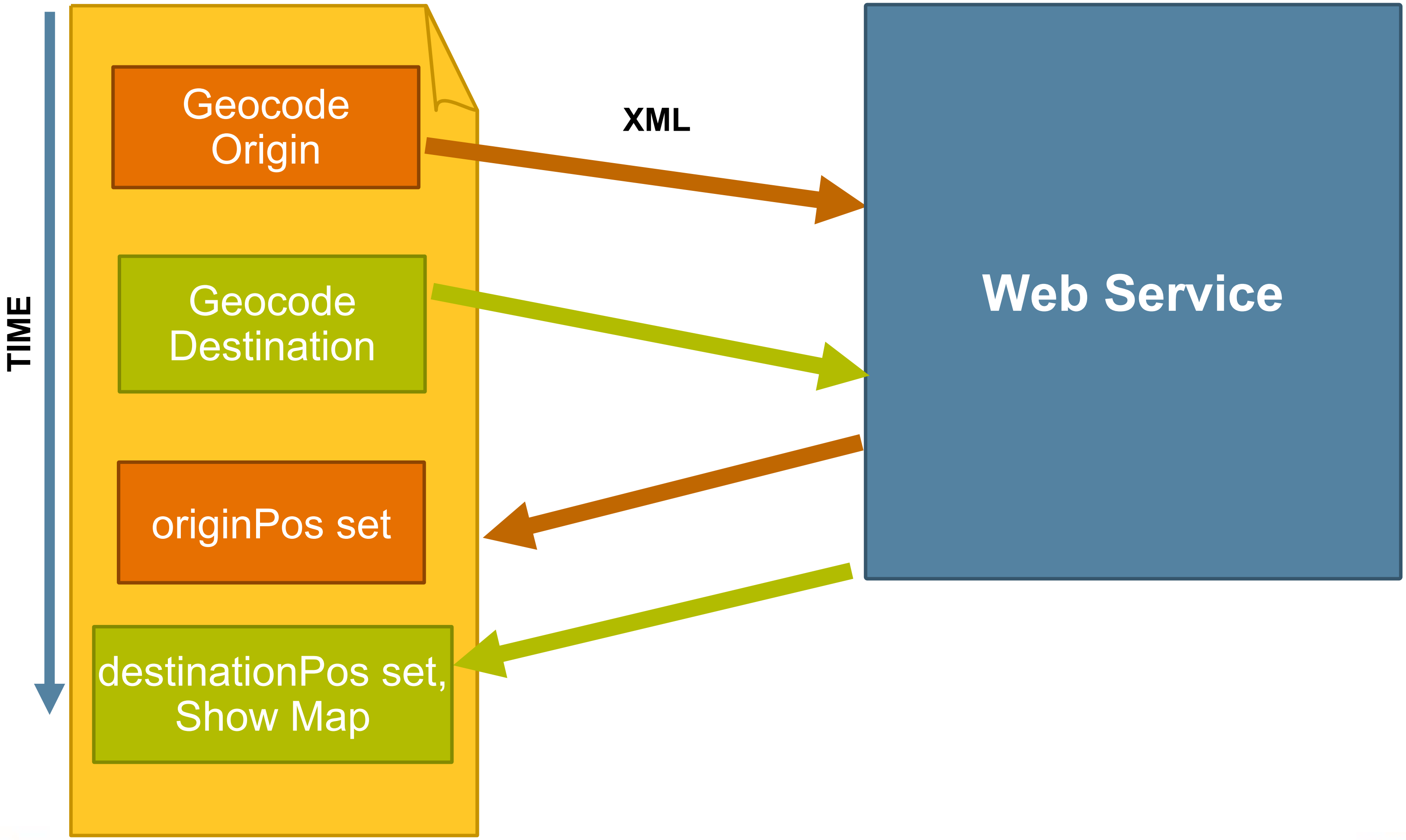


Bug: originPos and destinationPos are null because callbacks not returned yet

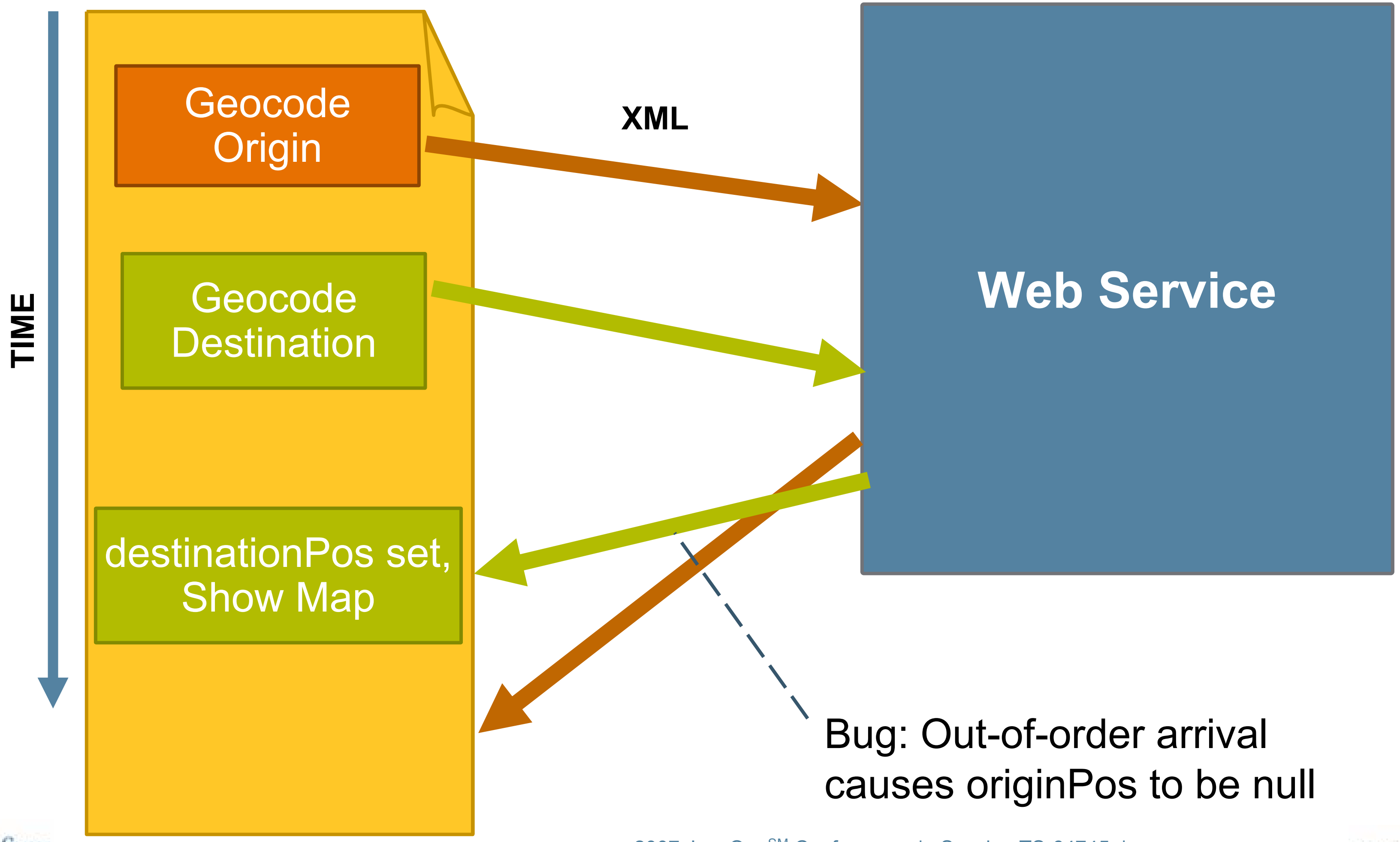
Correcting the Routing Function (First Pass)

```
var map = new Map(document.getElementById("map"));
var originAddr = new FreeFormAddress(“San Jose CA");
var destinationAddr = new FreeFormAddress(“94105");
var geo = new Geocoder();
var originPos = null;
Var destinationPos = null;

geo.geocode(originAddr, function(positions,addrCandidates ) {
     originPos = positions[0]; //first position match
});

geo.geocode(destinationAddr, function(positions, addrCandidates)
{
     destinationPos = positions[0]; //first position match
     map.routeMap(new Array(originPos,destinationPos));
});
```

Expected Outcome



There Is Still a Bug



TIME

Geocode Origin

Geocode Destination

destinationPos set, Show Map

XML

Web Service

Bug: Out-of-order arrival causes originPos to be null

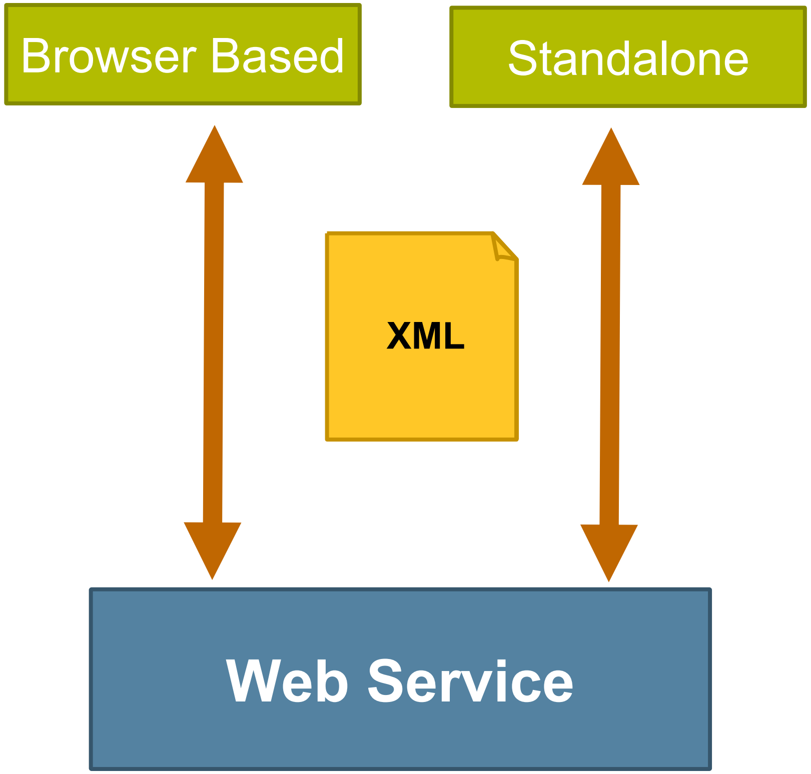
Correcting the Routing Function

```
var map = new Map(document.getElementById("map"));
var originAddr = new FreeFormAddress(“San Jose CA");
var destinationAddr = new FreeFormAddress(“94105");
var geo = new Geocoder();
var originPos = null;
Var destinationPos = null;

geo.geocode(originAddr, function(positions, addrCandidates) {
     originPos = positions[0];
     if(null != destinationPos)
        map.routeMap(new Array(originPos,destinationPos));
});
geo.geocode(destinationAddr, function(positions, addrCandidates)
{
     destinationPos = positions[0];
     if(null != originPos)
        map.routeMap(new Array(originPos,destinationPos));
});
```

Looking Underneath the Hood

- Client-server communication protocols
- Server-side implementation details
- Architectural/deployment considerations

Client-Server Communication



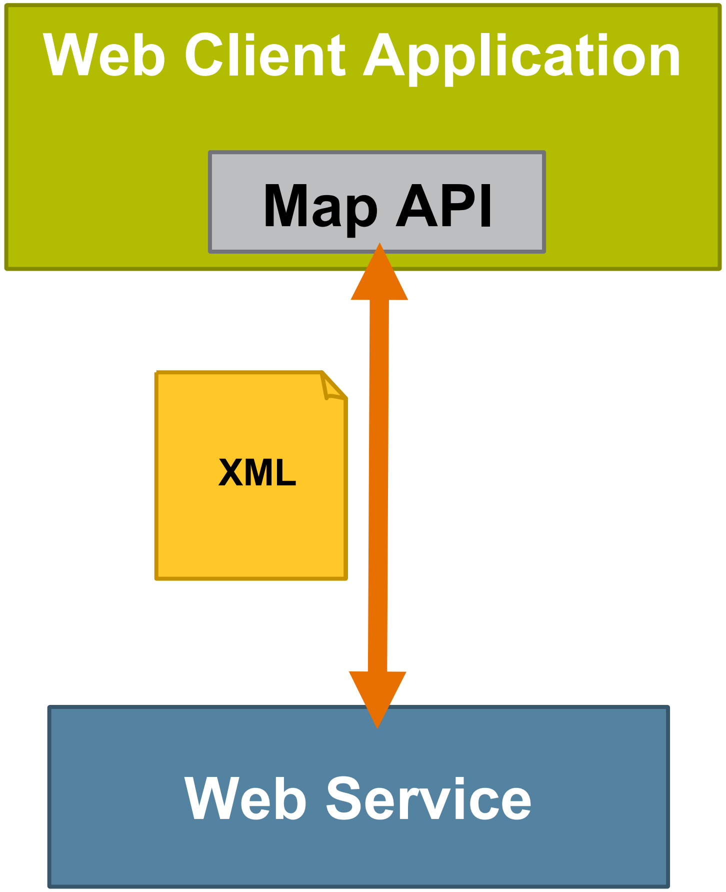
OpenGeospatialConsortium (OGC) Open Location Services

```
<XLS xmlns=http://www.opengis.net/xls xmlns:gml=“http://www.opengis.net/gml” >
    <RequestHeader clientPassword=“x" sessionID="999" clientName=“y"/>
    <Request requestID="1” version="1.0">
        <PortrayMapRequest>
            <Output height="400" width="400">
                <CenterContext SRS="WGS-84">
                    <CenterPoint>
                        <gml:pos>41.002 -72.002</gml:pos>
                    </CenterPoint>
                    <Radius unit="KM">0.3</Radius>
                </CenterContext>
            </Output>
        </PortrayMapRequest>
    </Request>
</XLS>
```

Standards Alphabet Soup

- OGC Open Location Services (OpenLS)
  - XML for Location Services (XLS)
- OGC Web Feature Server (WFS)
- OGC Web Map Server (WMS)
- OGC Web Coverage Server (WCS)
- OGC Geography Markup Language (GML)
- GeoRSS
- Keyhole Markup Language (KML)

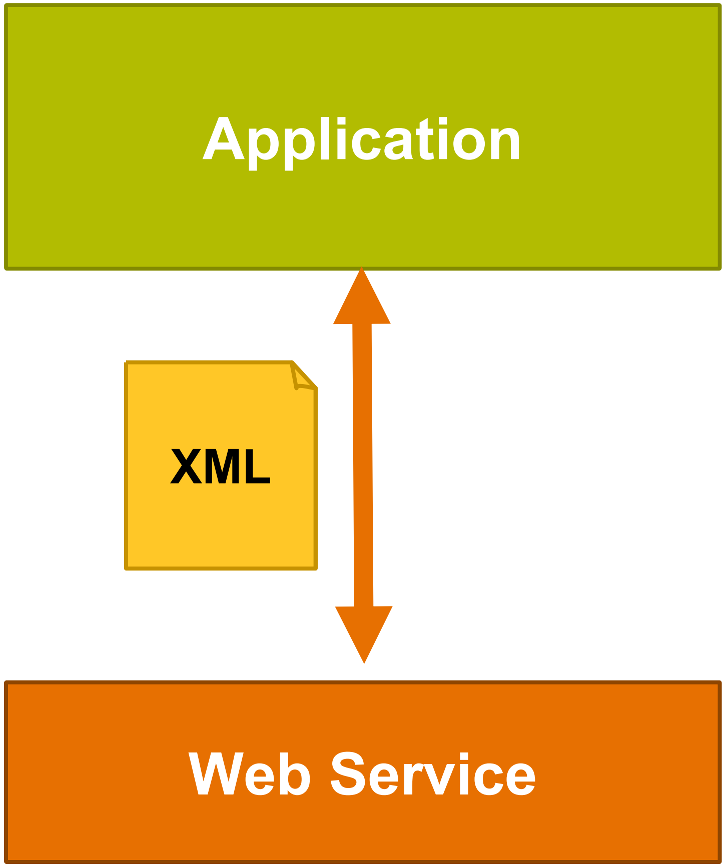
JavaScript Technology API Provides Insulation From Geospatial Protocols/Standards



What if Your App Isn’t JavaScript Technology Based?

- Java 2 Platform, Standard Edition (J2SE™ platform) APIs are available for deCarta Drill Down Server
- Other vendors offer different APIs for .Net, etc.
- Reality: There will always be some platform/ language where no API is available
  - Must communicate directly with server using XML
  - Interesting discussion in geospatial community on JSON vs. XML

Application Directly Produces and Consumes XML



Standards Are Great… So Many to Choose From

- Consider the following when evaluating a product that implements a geospatial XML:
  - How many schemas compose the standard?
  - How stable are the schemas
  - Are vendor extensions available/necessary?

Implementing Direct XML Communication

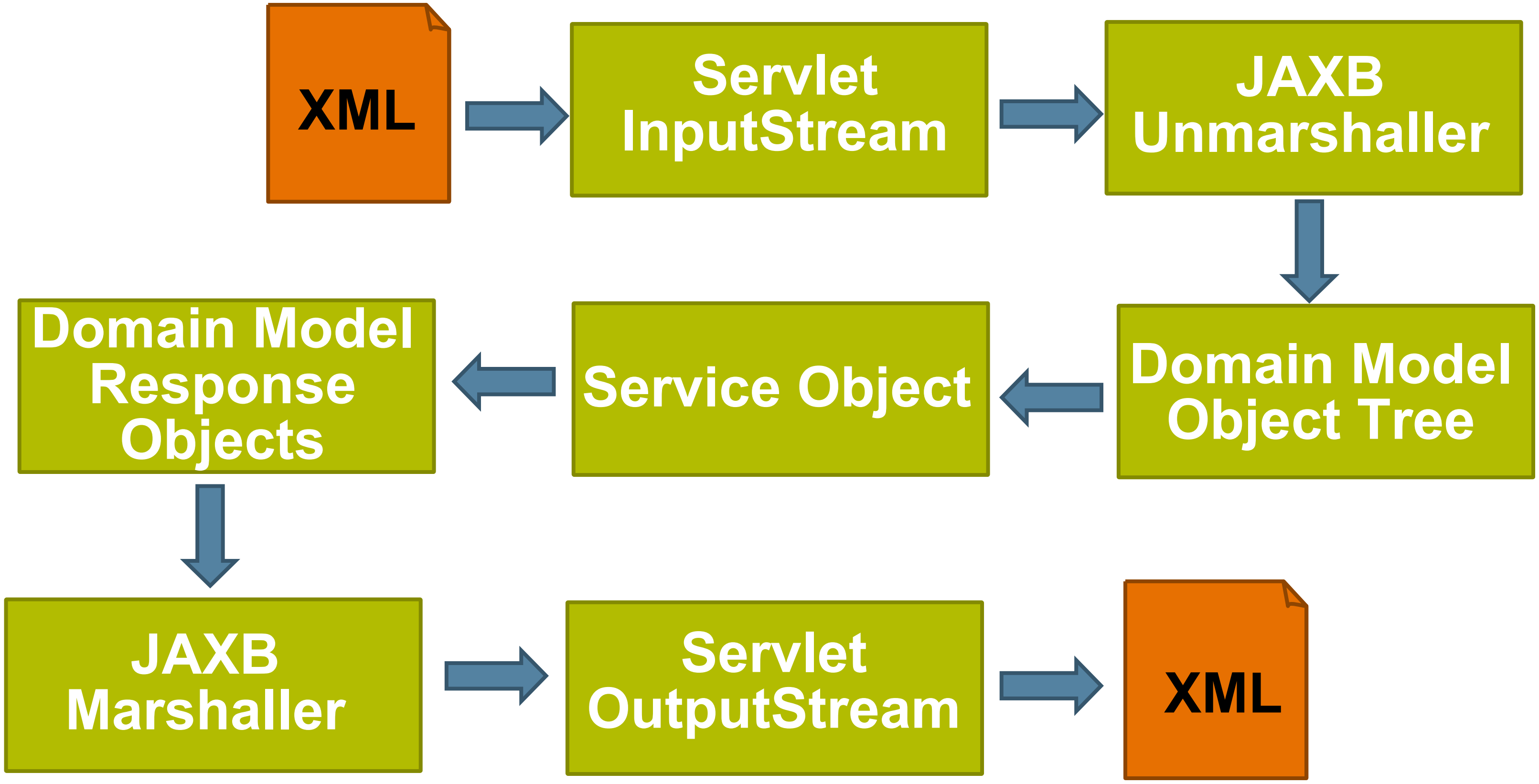
- How to tackle a geospatial XML vocabulary where:
  - There are multiple schemas
  - Multiple namespaces
  - A potentially overwhelming number of data types

XML-to-Object Binding for Non-Browser Apps

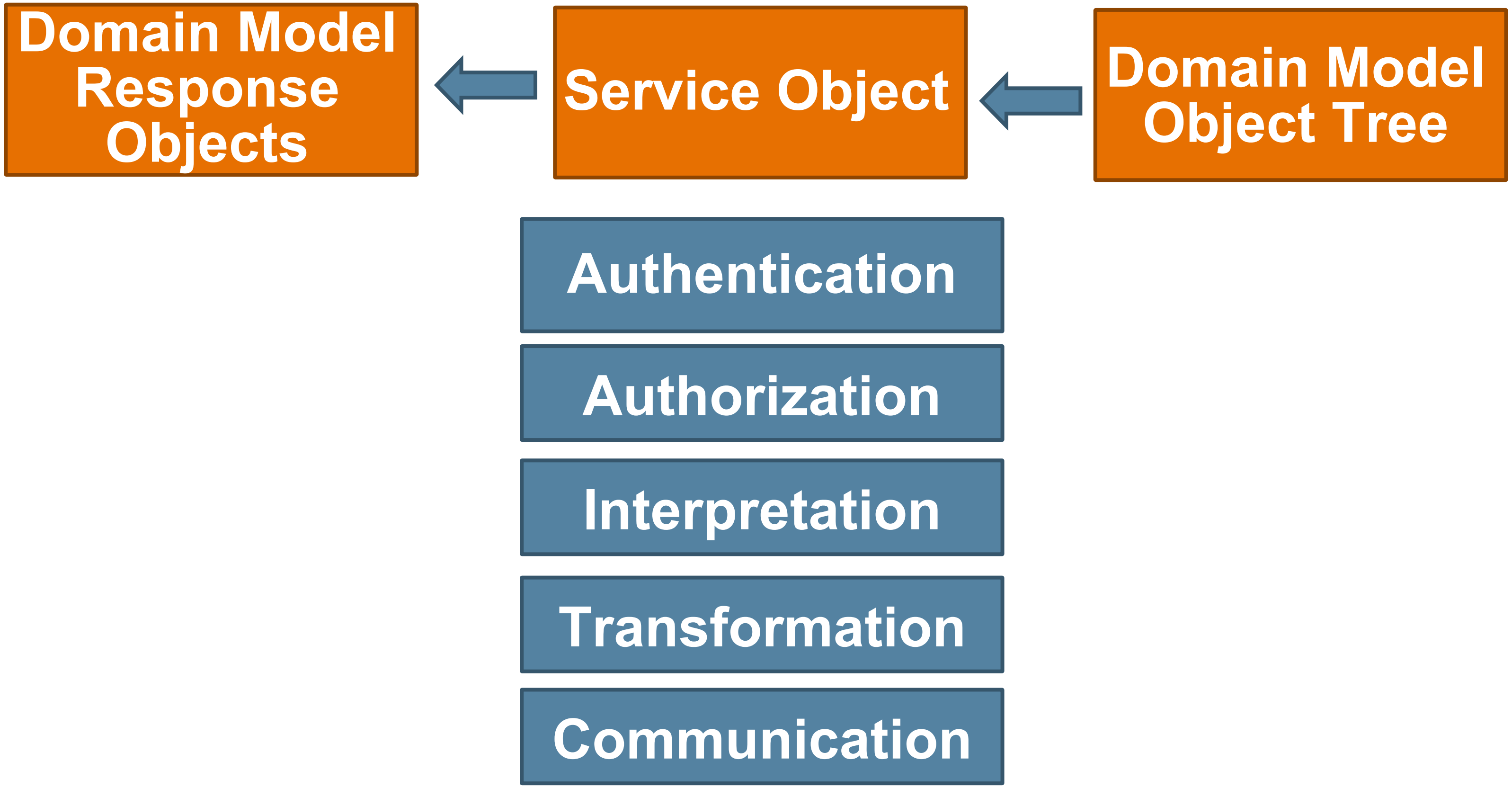
- Java Architecture for XML binding (JAXB)
  - xjc compiler reads schemas and emits Java source files

```
  <target name="jaxb"> <!-- run Java-to-XML binding
  compiler-->
  <java fork="yes" classname="com.sun.tools.xjc.Driver">
     <arg line="-extension -d ${src} -p
  com.telcontar.openls.xml
        ${schema}/LocationUtilityService.xsd
        ${schema}/RouteService.xsd
        ${schema}/DirectoryService.xsd
        ${schema}/PresentationService.xsd/>
        <classpath>
              <fileset dir="${lib}">
               <include name="**/*.jar" />
              </fileset>
           </classpath>
   </java>
<target>
```

XML-Over-HTTP Serverside Processing Pipeline



Service Invocation



Domain Model Response Objects

Service Object

Domain Model Object Tree

Authentication

Authorization

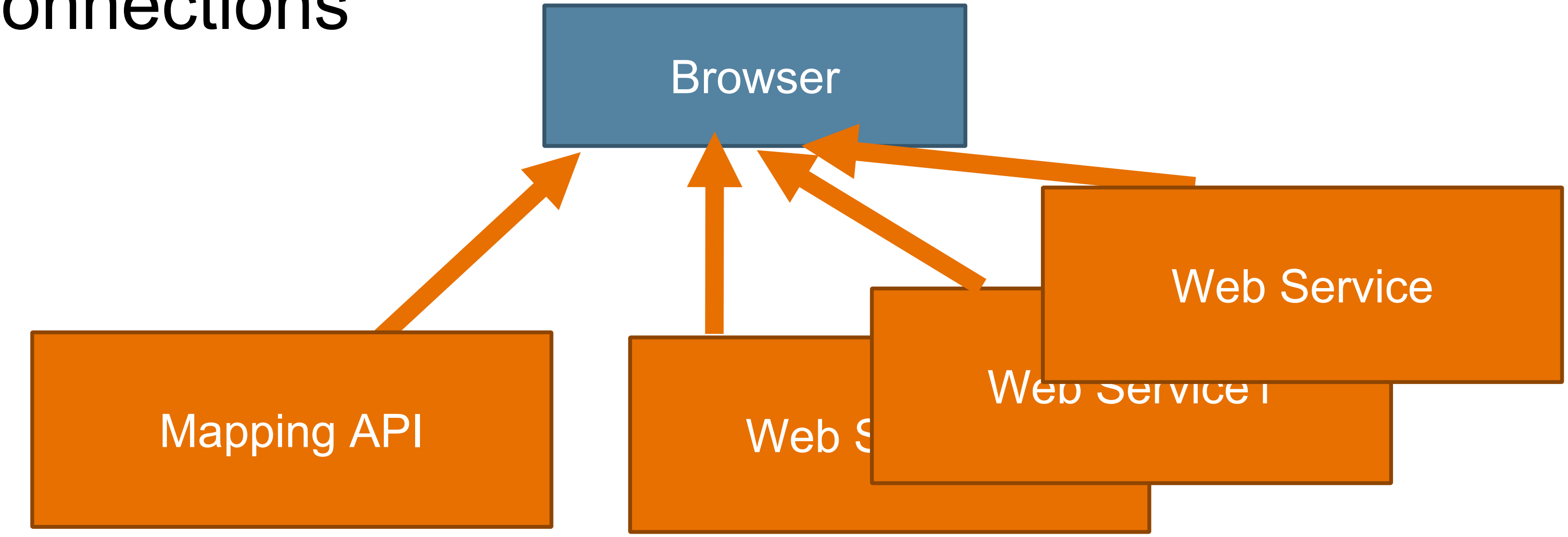
Interpretation

Transformation

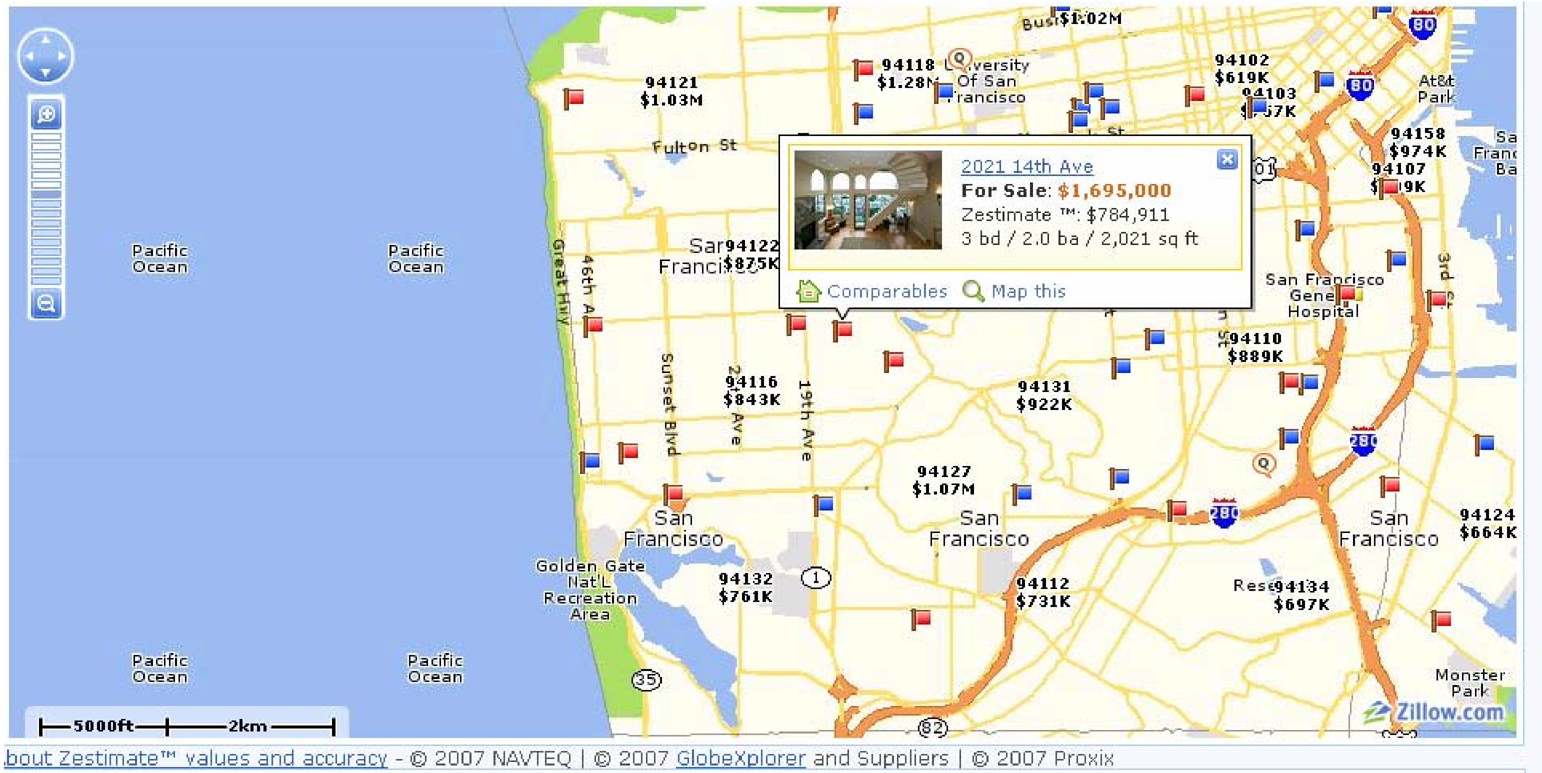
Communication

Map Mashups

- Connect to multiple sources of geospatial information
- Client makes concurrent asynchronous connections



Map Mashups



2021 14th Ave

For Sale: **$1,695,000**

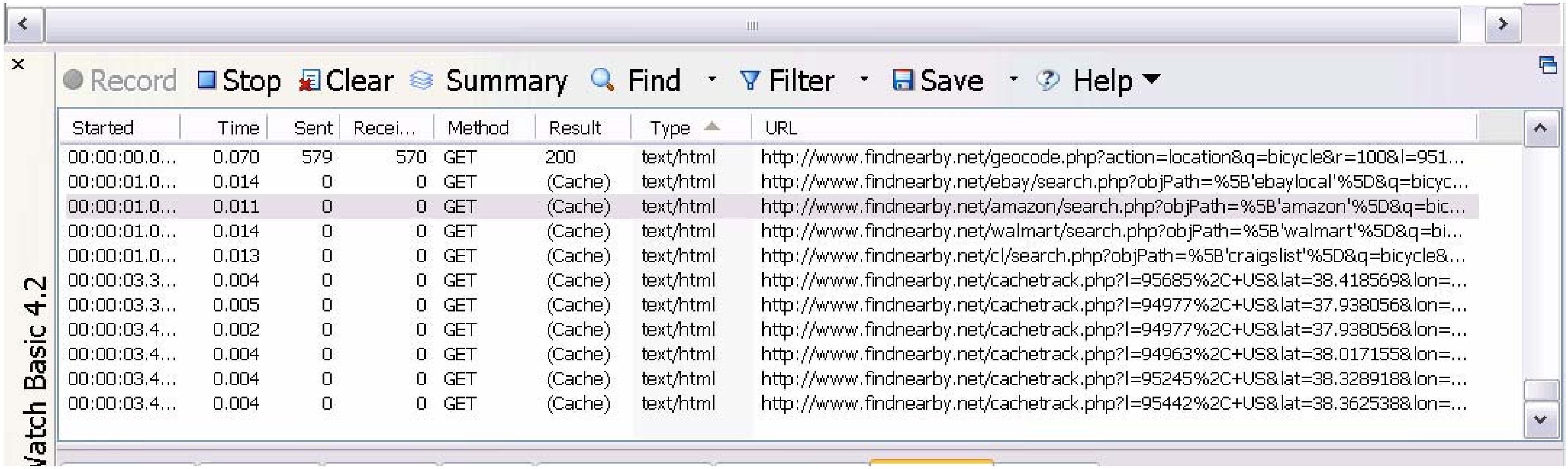
Zestimate ™: $784,911

3 bd / 2.0 ba / 2,021 sq ft

bout Zestimate™ values and accuracy - © 2007 NAVTEQ | © 2007 GlobeXplorer and Suppliers | © 2007 Proxix

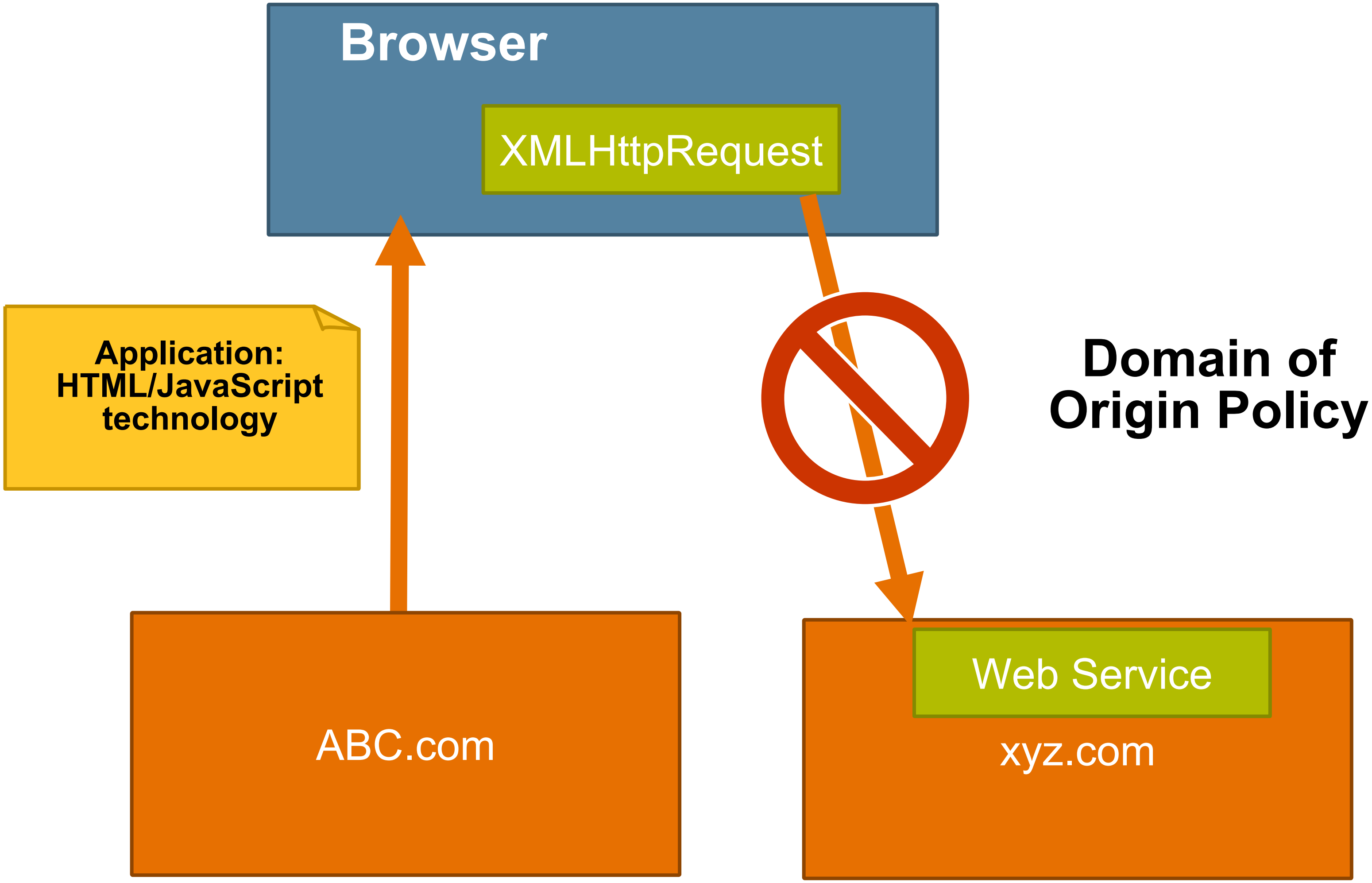
Is It a Real Mashup?

- Use HttpWatch browser plug-in to snoop findnearby.net
- All search queries are proxied through findnearby.net
- Why?



Started	Time	Sent	Recei...	Method	Result	Type	URL
00:00:00.0...	0.070	579	570	GET	200	text/html	http://www.findnearby.net/geocode.php?action=location&q=bicycle&r=100&l=951...
00:00:01.0...	0.014	0	0	GET	(Cache)	text/html	http://www.findnearby.net/ebay/search.php?objPath=%5B'ebaylocal'%5D&q=bicyc...
00:00:01.0...	0.011	0	0	GET	(Cache)	text/html	http://www.findnearby.net/amazon/search.php?objPath=%5B'amazon'%5D&q=bic...
00:00:01.0...	0.014	0	0	GET	(Cache)	text/html	http://www.findnearby.net/walmart/search.php?objPath=%5B'walmart'%5D&q=bi...
00:00:01.0...	0.013	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cl/search.php?objPath=%5B'craigslist'%5D&q=bicycle&...
00:00:03.3...	0.004	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=95685%2C+US&lat=38.418569&lon=...
00:00:03.3...	0.005	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=94977%2C+US&lat=37.938056&lon=...
00:00:03.4...	0.002	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=94977%2C+US&lat=37.938056&lon=...
00:00:03.4...	0.004	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=94963%2C+US&lat=38.017155&lon=...
00:00:03.4...	0.004	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=95245%2C+US&lat=38.328918&lon=...
00:00:03.4...	0.004	0	0	GET	(Cache)	text/html	http://www.findnearby.net/cachetrack.php?l=95442%2C+US&lat=38.362538&lon=...

Accessing Third-Party Content/APIs



Browser

XMLHttpRequest

Application:
HTML/JavaScript
technology

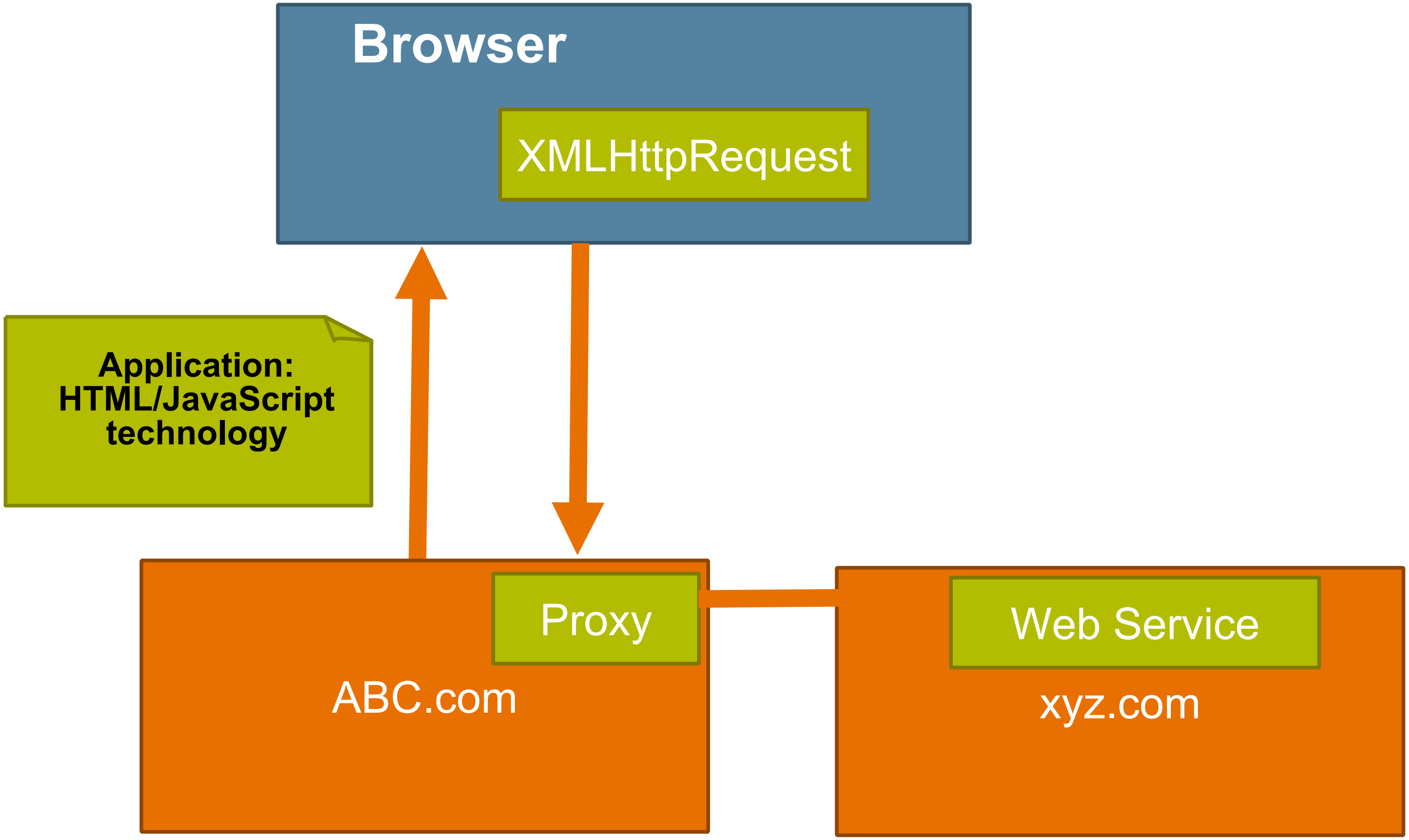
Domain of
Origin Policy

ABC.com

Web Service

xyz.com

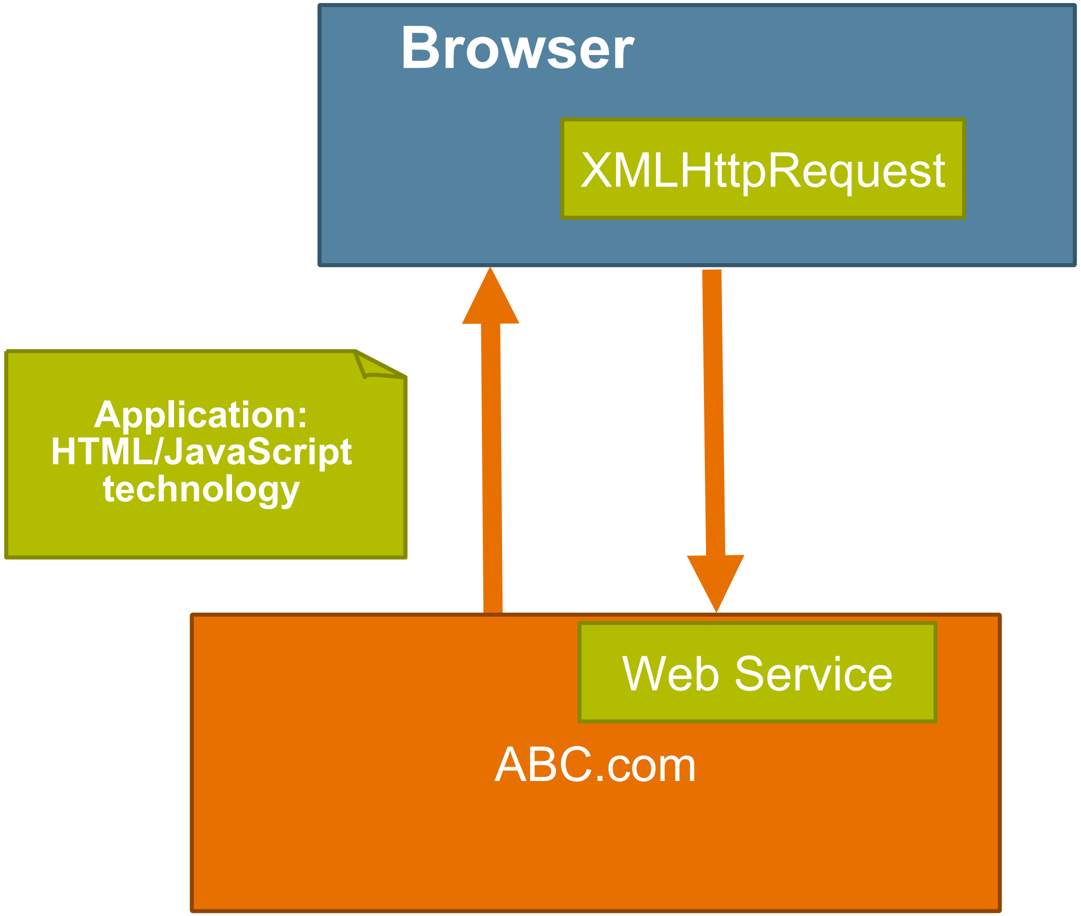
Workaround 1:
Proxy Around Domain of Origin Policy



Disadvantages of Proxy

- “Triangle routing” is inefficient
- Customer has to deploy a proxy
- Customer has to serve JavaScript technology API
  - Versioning/maintenance
  - Bug fixes/patches
- Customers cannot easily try out the JavaScript technology
  - Scripts are supposed to be easy to access and run, not hard!

Workaround 2: Customer Hosts Web Service



Advantages of Self-Hosted

- Security/reliability meets needs of “enterprise”
- No triangle routing
- Gives customer control over hardware/ software/data environment

Disadvantages of Self-Hosted

- Forces large-scale/expensive model onto customer
- Software versioning still an issue

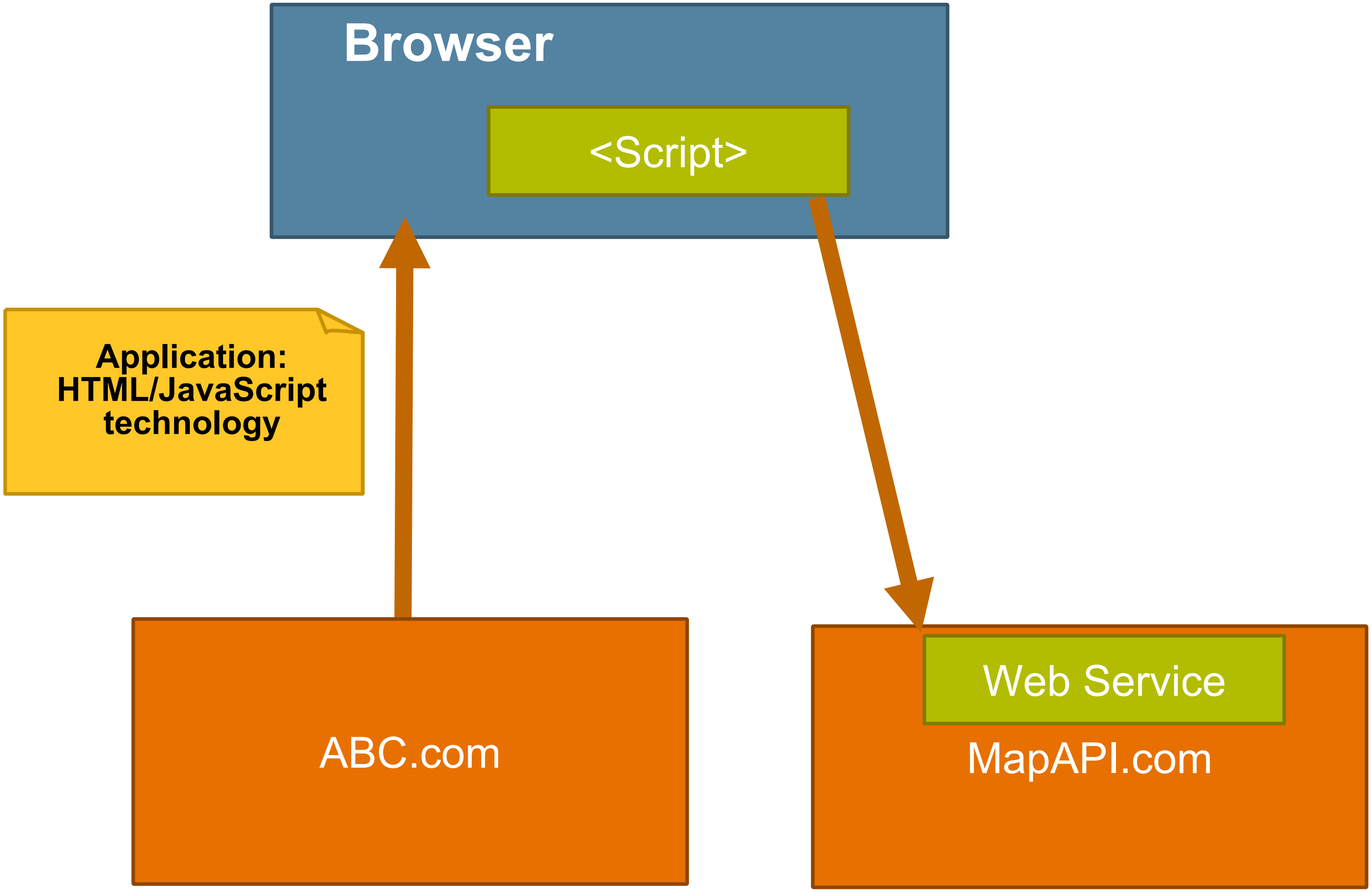
Next Topic: Scriptlets, a.k.a. Dynamic Script Tags

- Asynchronous access
- Can be mashed up on anyone’s application
- Can be integrated with a JavaScript Technology API

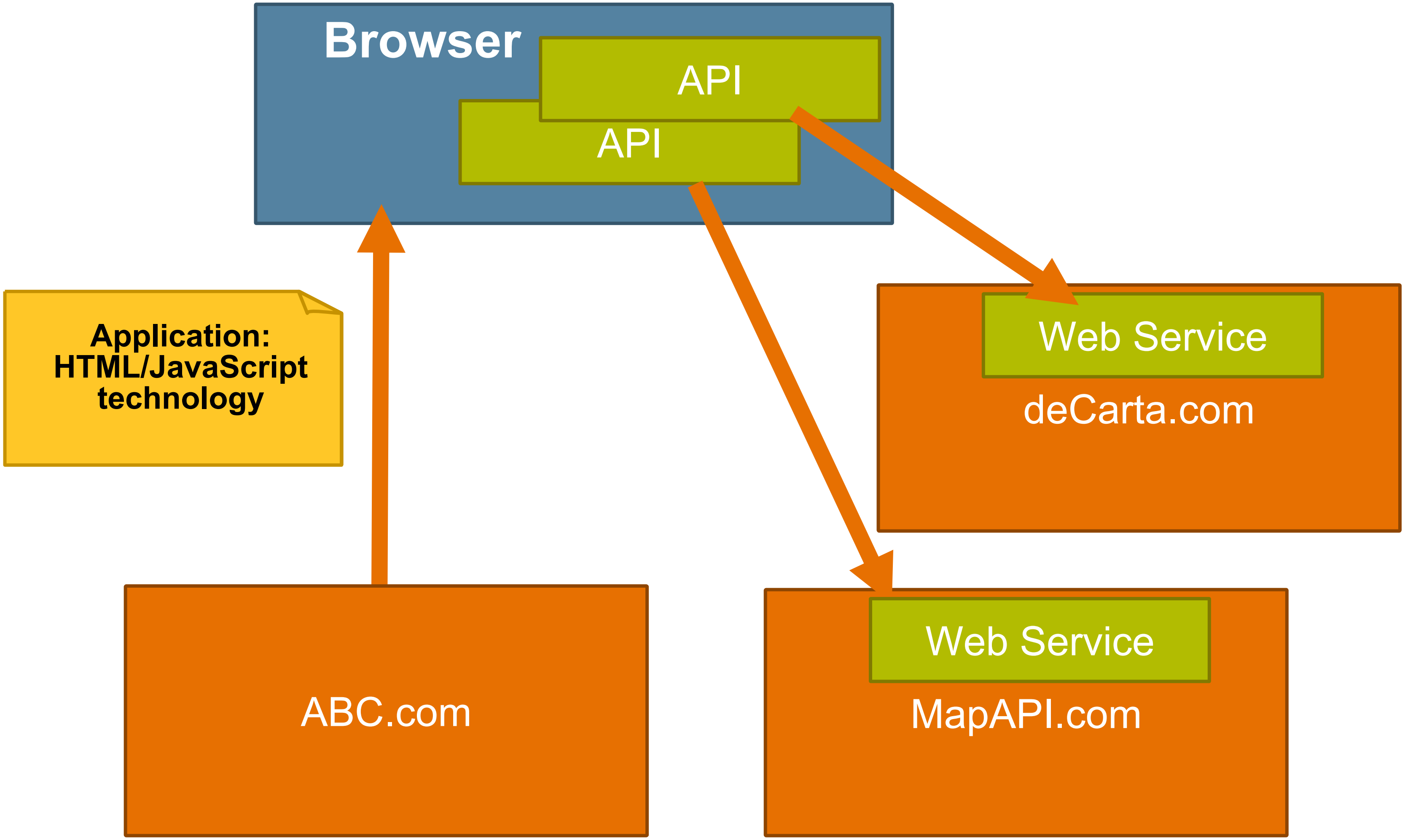
Dynamic Script Tag

- Script src not subject to Domain of Origin
- API methods internally invoked as <Script> tags
  - <Script> added to DOM on-the-fly
  - src attribute set on the fly
- Parameters passed in script src URL
- <script src="http://MapAPI.com/map?center=42.0,-128.0"/>
- Valid JavaScript technology returned
- callme({"URL":"http://MapAPI.com/2345124.gif"})

Dynamic <Script> Tags



Dynamic <Script> Tags Inside APIs



Dynamic Script Tag Callbacks

- Script URL must include callback to *your* application
- <script src="http://MapAPI.com/map?center=42.0,-128.0&callback=callme"/>
- Server returns dynamically created JavaScript technology that calls your callback when evaluated
- callme({"URL":"http://MapAPI.com/2345124.gif"})

JSON

- JavaScript Object Notation
- Parameters passed into callback are
  - JSON Object {}
  - JSON array []
- Example JSON Object with key:value pair

{“URL”:“http://MapAPI.com/2345124.gif”}

- JSON.org has complete set of productions for JSON

Issues With Dynamic Script Tags

- Length of allowable URL is limited on different browsers
- 2,083 chars can be too small to accommodate many requests

Browser	**Maximum URL length**
Internet Explorer	**2,083** chars
Firefox	65,536 chars
Safari	80,000
Opera	190,000

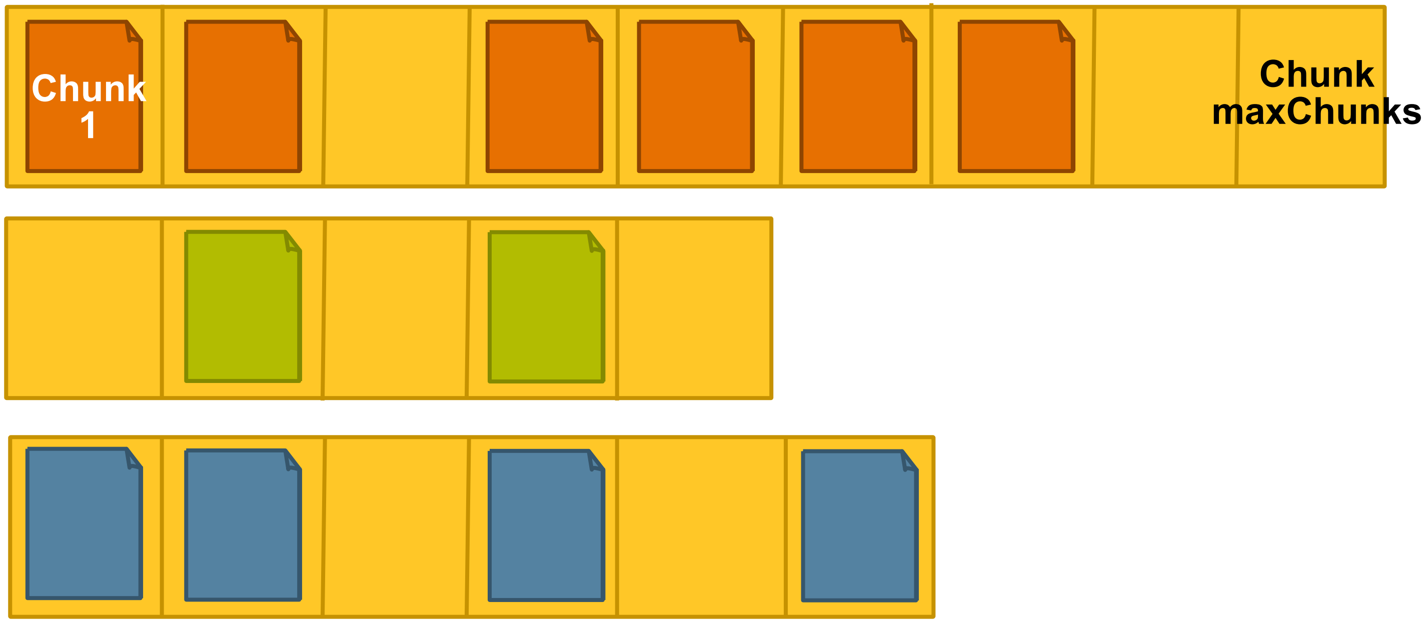
Sending Data in Chunks

- Large request split into numbered chunks
- Each chunk delivered asynchronously to the server via a dynamic <Script> tag
  - <Script> tag added dynamically to the DOM
  - <Script> tag removed when script returns
- Server orders and assembles chunks
  - When final chunk received, request executes on server
  - All non-final chunks return an empty JSON Object

Chunking Data in Dynamic <Script> URLs

- The following URL sends chunk 1 of 3
- http://MapAPI.com://map?
  - callback=callme
  - &requestID=3436233
  - &chunkNum=1
  - &maxChunks=3
  - &data=XXX
- requestID is globally unique across clients
- maxChunks is the total number of chunks that data is split across

Serverside Chunk Assembly

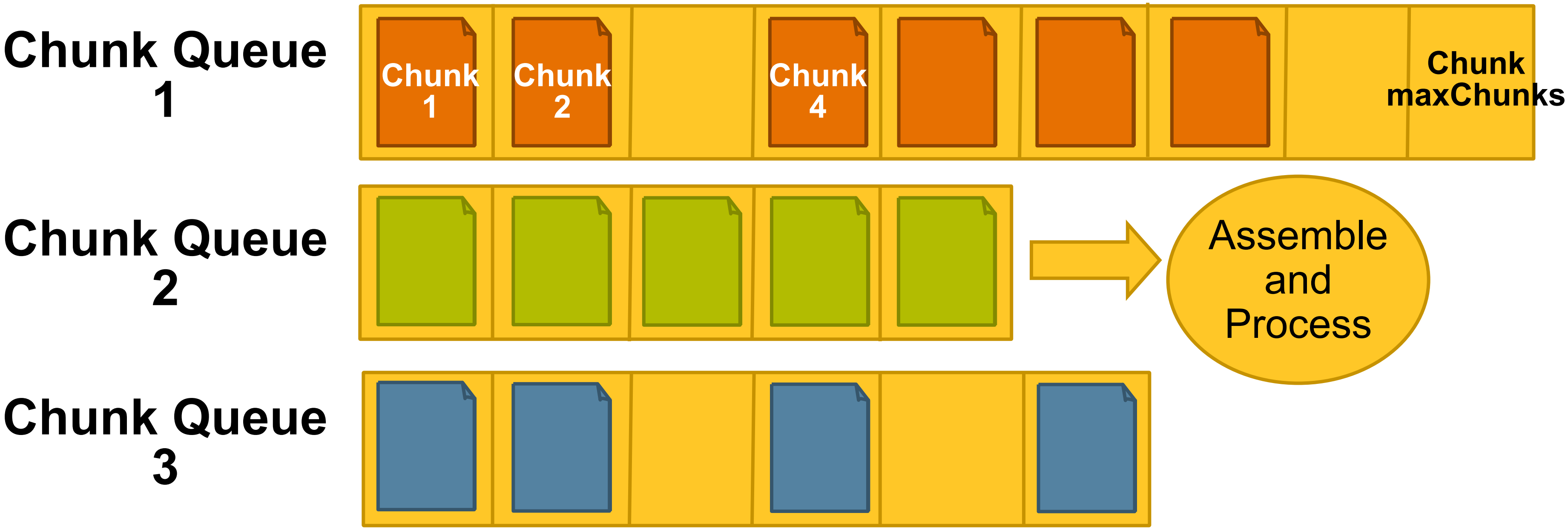


Chunk Queue 1

Chunk Queue 2

Chunk Queue 3

Assemble and Process Full Queue



Zombie Requests

- Client disconnects before all chunks sent
- Leaves zombie queue of allocated memory
- Server continues to wait for more chunks to arrive

Chunk Class Used on Server

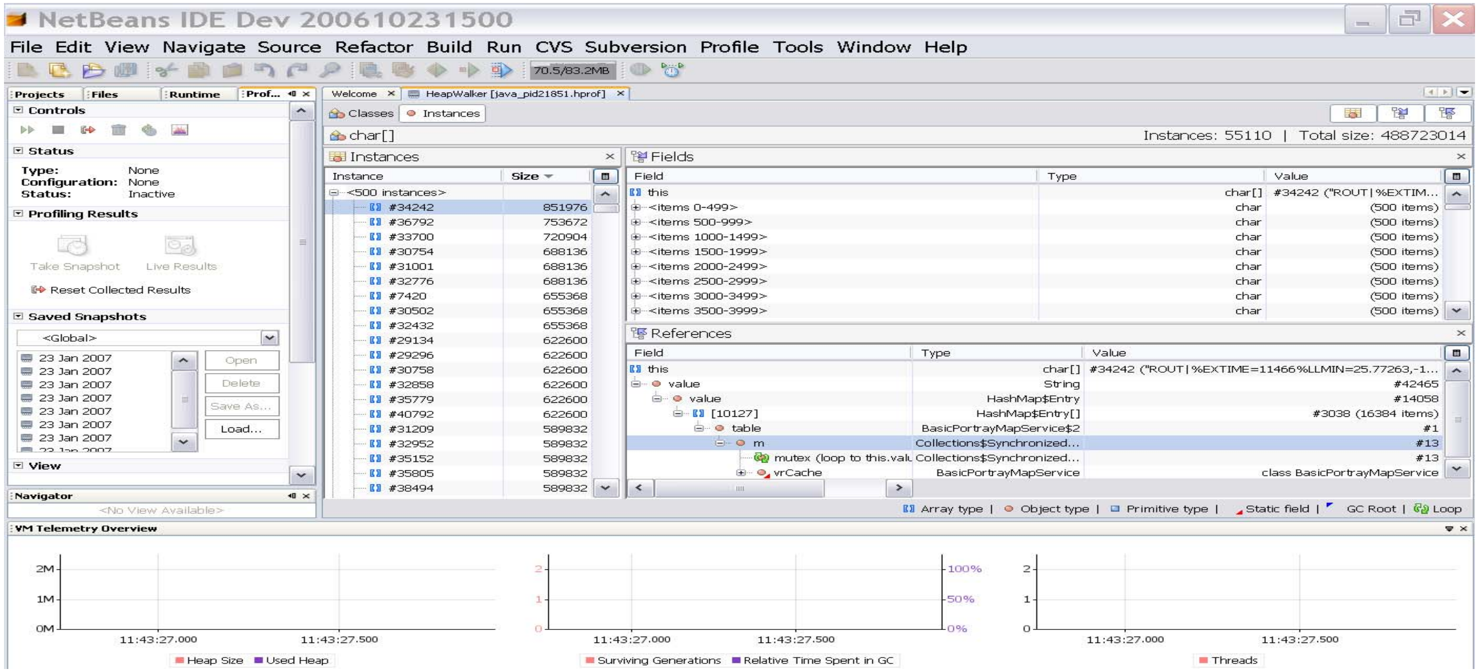
```
public class Chunk implements Comparable{
    Integer order;
    String data;

    public boolean equals(Object o){
        return hashCode() == o.hashCode();
    }

    public int hashCode(){
        return order.hashCode();
    }

    public int compareTo(Object o) {
        return order.compareTo(((Chunk)o).order);
    }
}
```

Assembling Chunks on the Server

```
//this code has a bug, can you find it?
//hint: memory leak!
public Map<String, SortedSet<Chunk>> chunks =
   new LinkedHashMap<String, SortedSet<Chunk>>(){
    protected boolean removeEldest(Map.Entry eldest){
     return size()>1000; //expire zombie chunk queue
    }
   };
```

Finding the Memory Leak

- java -XX:+HeapDumpOnOutOfMemoryError
- NetBeans™ Software HeapWalker


NetBeans IDE Dev 200610231500
File Edit View Navigate Source Refactor Build Run CVS Subversion Profile Tools Window Help
70.5/83.2MB
Projects Files Runtime Prof...
Controls
Profiling Results
Take Snapshot Live Results
Reset Collected Results
Saved Snapshots
<Global>
Open Delete Save As... Load...
View
Navigator
<No View Available>
Welcome
HeapWalker [java_pid21851.hprof]
Classes Instances
Array type | Object type | Primitive type | Static field | GC Root | Loop
VM Telemetry Overview
2M 1M 0M
11:43:27.000 11:43:27.500
Heap Size Used Heap
2 1 0
100% 50% 0%
Surviving Generations Relative Time Spent in GC
Threads

Status

Type: None
Configuration: None
Status: Inactive

23 Jan 2007
23 Jan 2007
23 Jan 2007
23 Jan 2007
23 Jan 2007
23 Jan 2007
23 Jan 2007

char[] Instances: 55110 | Total size: 488723014

Instances

Instance	Size
<500 instances>	
#34242	851976
#36792	753672
#33700	720904
#30754	688136
#31001	688136
#32776	688136
#7420	655368
#30502	655368
#32432	655368
#29134	622600
#29296	622600
#30758	622600
#32858	622600
#35779	622600
#40792	622600
#31209	589832
#32952	589832
#35152	589832
#35805	589832
#38494	589832

Fields

Field	Type	Value
this	char[]	#34242 ("ROUT|%EXTIM...
<items 0-499>	char	(500 items)
<items 500-999>	char	(500 items)
<items 1000-1499>	char	(500 items)
<items 1500-1999>	char	(500 items)
<items 2000-2499>	char	(500 items)
<items 2500-2999>	char	(500 items)
<items 3000-3499>	char	(500 items)
<items 3500-3999>	char	(500 items)

References

Field	Type	Value
this	char[]	#34242 ("ROUT|%EXTIME=11466%LLMIN=25.77263,-1...
value	String	#42465
value	HashMap$Entry	#14058
[10127]	HashMap$Entry[]	#3038 (16384 items)
table	BasicPortrayMapService$2	#1
m	Collections$Synchronized...	#13
mutex (loop to this.valu	Collections$Synchronized...	#13
vrCache	BasicPortrayMapService	class BasicPortrayMapService

Assembling Chunks on the Server (Fixing the Bug)

```
//Typo in method name meant removeEldestEntry
//was not overridden.
//Use @Override to detect problems at compile time
public Map<String, SortedSet<Chunk>> chunks =
   new LinkedHashMap<String, SortedSet<Chunk>>(){
    @Override
    protected boolean removeEldestEntry(Map.Entry eldest){
     return size()>1000; //expire zombie chunk queue
    }
   };
```

Q&A

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