Location Based Services

Application Server
&
Spatial Analysis

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Location Based Services

- Services designed for personal use.
  - Developed by mobile operators
  - Deployed on handheld devices.
- Services designed for usage in vehicles.
  - Developed by automobile manufactures.
  - Deployed often as OEM equipment in the vehicle.
Location Based Services

Services designed for use in vehicles

- Have large existing customer base
- Suppliers are the existing components suppliers to the Auto manufacturers:
  - Hardware:
    - Bosh (blaupunkt)
    - VDO
    - Application and Service (called “telematics”):
      - OnStar
      - T-Traffic (Tegaron) (now a subsidiary of T-Mobile)

Vehicle Mobile Location Services Value Chain
Location Based Services
Services designed for personal use

- Customer base is owned by Mobile operator, or media companies:
  - Yahoo!
  - AOL
  - Can be a subsidiary or investment of the mobile operator.

- Services are provided directly by the mobile portal (unlike automotive which is provided by the manufacturer)
Location Based Services

Solution Components architecture

- Comprised of different technologies integrated by an **Application Server** which provides the framework for the solution.

Solution components:
- Mobile Location Based Server Application Deployment Environment
- Mobile Operator Network
- Mobile Client Devices

Example of an architecture for a Mobile Location Solution
Location Based Services
Server Applications Deployment Environment

- **Application Server:**
  - Location Server
  - System Management (SNMP)
  - Provisioning
  - User Database (LDAP)
  - Authentication and Security
  - Personalization / Profiling
  - Commerce
  - Billing
  - Reporting

Location Based Services
Solution Components architecture

- **Location Server**
  - Spatial analysis
  - Map database
  - Mobile positioning server (interfaces with the mobile operator network for computing of a position)
Location Based Services
Solution Components architecture

Application Server may interface with the mobile operator network using HTTP with technologies such as:

- XML
- SOAP
- WAP
- VXXML
- HTML
- cHTML

Location Based Services
Services designed for use in vehicles

Vehicle Mobile Location Services Value Chain
Location Based Services
Vendor review

Autodesk GIS Design Server
- MS Win 2000 solution.
- Integrates multiple map and design data
- Stores information in standard Oracle® format
- Deliver data to the entire organization through browsers
- Non-proprietary.
- Component based

Autodesk MapGuide®
- MapGuide® Author: Integrate GIS and CAD data and to design intelligent maps.
- MapGuide® Server: Delivers maps and their data to both the Autodesk MapGuide Author and the Viewer
- Web mapping platform
- MapGuide Open Source platform available on Windows and Linux.

Other Autodesk solution Components

Autodesk® Map 3D
- built on the AutoCAD® 2006 platform
- Provides geospatial features that mapping and CAD technicians and civil engineers require

Autodesk® Raster Design
- Integrates with all AutoCAD® 2006–based applications to provide advanced vectorization, raster editing, and analysis tools.
- Uses scanned drawings and maps, aerial photos, satellite imagery, and digital elevation models

Autodesk® OnSite Enterprise
- Delivers live, interactive design and mapping information from your company’s central server to Microsoft® Windows® CE based mobile computing devices.

Autodesk® OnSite View
- A way to electronically review, mark up, and measure AutoCAD® DWG and DXF™ drawings, using Windows CE mobile computing devices.

Autodesk® Utility Design
- Design a cost-estimate electric system for electric utility configurations. Adds accuracy, and shortens development.

*More information available at: http://www.autodesk.com/gis*
Location Based Services
Services designed for use in vehicles
Vendor review

- A leading provider of telematics services in the United States.
- In-vehicle safety, security, and information services use GPS satellite and cellular technology to link the vehicle and driver to the OnStar Center.
- Advisors offer real-time, personalized help 24/7.

Location Based Services
Services designed for use in vehicles
Vendor review

- World leader in premium-quality digital map data. You'll find NAVTEQ data onboard most in-vehicle navigation systems.
- Navigation and map coverage in 52 countries.
- POI
- Traffic
- Map voice data
Location Based Services
Vendor review

- Worldwide provider of total location-based solutions for in-vehicle, Internet and wireless platforms.
- Uses premier spatial software platform, patented automated user notification technology and industry partners.
- Help its customers provide complete, real-time, highly scalable solutions for navigation, mobile safety, security and convenience.

Drill Down Server™ (DDS)
- Platform for LBS
- Accesses maps and spatial data
- Application can be delivered to Web browsers, PDAs, Pocket PCs, and vehicle telematics units.
- Provide information about Traffic

Universal Telematics Server™ (UTS)
- Automated web and telephony service platform
- Can be customized and branded to customer needs: Enterprise systems, GPS, Wireless, Hardware.

Rich Map Engine™ (RME)
- Accesses base map data using Telcontar’s Geo/Spatial Search Keys.
- Map Rendering
- Routing
- Positioning
- Dynamic customization
- Ideal for applications requiring client-side functionality.
- Used to develop apps on embedded systems as well as pocket PCs.
Location Based Services
Vendor review

- Has been acquired on Sep 13th 2004 by

- Location platform industry-leading fast Kivera location engine™
- Route planning
- Map generation
- Flexible platform that includes customizable applications
- Private label, branded interface
- Enterprise-strength scalability
- Fast, accurate mapping and routing at 400,000 geocodes per CPU per hour.
- Optimized for static and real-time geocoding, reverse geocoding, point-to-point (phone location, address, point of interest, latitude/longitude) driving directions, map displays, and proximity searches

The Application Server
The Application Server

- Enables expandability
- Protection of business logic. (no need to redesign if a component needs to be replaced)

Location Based Services

- Infrastructure based on industry standards will help insulate any one piece from problems of the other.
  - LIF (Location Interoperability Forum)
  - GML (Geography Markup Language)
  - Open GIS Consortium
What is an Application Server?

- Server side framework for deployment of business logic
- Comprised of at least 3 layers:
  - Business logic
    - Implements business intelligence, rules and logic
  - Presentation
    - Methods for delivering the content of the application server
  - Data Access
    - Integration of services to components in the business logic

Why is an Application Server Important?

- Intellectual Protection
  - Reversed engineering is prevented by hiding the business processes and algorithms behind the presentation layer in the application server
- Reuse
  - Reuse of the business logic is possible. New interfaces can be easily incorporated. In larger projects separation of the business logic from the presentation layer is crucial, to avoid maintaining repeated coding which is a result of combining layers
Why is an Application Server Important?

**Manageability**
- Managing a system based on thin client application is easier, as most of the "work" is done by the server, only minimal upgrade is needed on the client side.

**Network Security**
- Using secure protocols such as SSL in the presentation layer provides industry standard well known security.

Why is an Application Server Important?

**Performance**
- High CPU requirements of technologies used in components such as spatial analysis are more cost effective if performed on a server side whether then on the mobile client's side.
The Application Server

Integrating distributed enterprise application can be done in several ways.
Typically involves a high speed network software bus, operated by a transaction server (such as BEA Tuxedo).
A simplified example can be done by Java 2 Enterprise Edition (J2EE)

J2EE Application Server

Why Java on the Server?

- Good 3rd Generation Language
  - Simpler than C++
  - Can solve large problems
  - Programming can be much faster than C++

- Good 4th Generation Language
  - Easy to extend to reusable, high level business abstractions.
  - Object Oriented (as apposed to 4th generation scripting languages)

- Widespread
  - Large developer community
  - Portability, multi-platform (OS) environment

- Robust
  - No direct access to memory
  - Automatic garbage collection, reduces memory leaks.
  - Reduces time to market
J2EE Application Server

Why Java on the Server?

Strong Network Support
- Very strong support
- Business object can be passed by value
- Change an object representation without breaking remote application
- Load functionality with standard byte code
- Distributed garbage collection.

Component Oriented Computing
- Component oriented model, allows data independent of business logic, and business logic independent of presentation logic

Fast
- Performance has improved compared to native compiled 3rd generation languages. Only a small portion of the processing time is spent on the business logic. The rest is in the network and the DBMS.

What is a J2EE Application Server?

The J2EE specification states a set of minimum characteristics a J2EE application server must exhibit, delivered to your mobile location services infrastructure before you even begin to build.
What is a J2EE Application Server?

The J2EE specification minimum characteristics a J2EE application server must exhibit

- Consistency
- Adoption
- Openness
- Specification

What is a J2EE Application Server?

Easy to Develop and can deploy distributed Java Applications

- Structure and environment to facilitate building well-formed applications
- Systems infrastructure and management tools for deploying an enterprise application
What is a J2EE Application Server?

- Scales to Permit Thousands of Cooperative Servers to Be Accessed by Tens of Thousands of Clients. Provides:
  - Fully multithreaded
  - Sparingly consumes network and other resources
  - No architectural bottlenecks to prevent linear scaling

What is a J2EE Application Server?

- Provides an Integrated Management Environment for:
  - Comprehensive View of Application Resources
  - Network Resources
  - System Resources
  - Diagnostic Information
What is a J2EE Application Server?

- Provides Secure Communications, Including SSL, Access Control Lists, HTTP, and IIOP Tunneling to Communicate Across Firewalls

J2EE Application Server Architecture

- Divided into at least 3 layers:
  - Presentation
  - Business logic
  - Data access

- Can include interfaces for:
  - Systems management
  - Reporting
Because EJBs are based on a component model, they operate within a specific environment and its interactions are governed according to a specific set of rules. There are three types of EJBs:

- **Session beans**: Implement a client/server conversation and are typically found managing business process or workflow.
- **Entity beans**: Represent persistent business objects such as `CustomerAccountInformation`.
- **Message-driven beans**: Allow clients to asynchronously invoke server-side business logic.

In a mobile location services application, session beans might include the following:

- **PositionUser**: Attempts to update the user's current position.
- **Notifier**: Sends SMS message.
- **GenerateRoute**: Calculates a route between two locations.
- **CheckoutCounter**: Responsible for totaling all the items a user put in a user's shopping cart, processing payment, and sending a message to an inventory system to ship the items to the user's address.
J2EE Application Server Architecture
Enterprise JavaBeans (EJBs)

- Entity beans might include the following:
  - Account: Customer's account information
  - Inventory: List of items available for purchase

Scalable J2EE Web Application
Network Architecture

- The technique below provides many advantages over other J2EE application architectures, in which the application server executes both presentation and business logic.
Spatial Analysis

Spatial operations include:

- Geocoding (the process of looking up a position from an address)
- Reverse Geocoding (the process of looking up an address from a position)
- Routing (calculating a route between two positions)
- Map rendering (translating an area of map database into a vector or raster map)
- POI Searches
- Real-Time Map Attribute Editor
Example Spatial Analysis Server

A set of software libraries performs search and data retrieval operations on a compiled map database.

Operations defined earlier require specialized business logic and access the digital map database using the access libraries.

An interface is provided to integrate the spatial analysis server into your location server infrastructure.

Selecting a standards based interface for spatial operations, such as GML, provides maximum extensibility for your system.
Unlike traditional GIS products, spatial analysis software for mobile location services is focused on:

- Speed of data retrieval
- Supports a high volume of concurrent requests

There are 3 primary database structures used in spatial analysis server software:

- Hybrid database
- Pure relational database
- Pure object-oriented database.
Spatial Analysis

Hybrid database
- The underlying assumption is that you cannot optimize both the spatial data storage and the attribute data storage simultaneously.
- Spatial data such as coordinates and topological data is stored using a standard file-based approach.
- Attribute data is stored in relational database tables.
- Data and Attributes are linked via a unique identifier.

Spatial Analysis

Relational database
- Stores both the spatial data and the attribute data in relational tables, linking them with a standard relational join.
- Poorer system performance
  - Spatial data that is close together is not necessarily stored close together in the database.
Spatial Analysis

- **Object-Oriented Database Model**
  - Attempts to deliver speed without sacrificing flexibility
  - Data is organized around the spatial entities
    - These databases define data as a series of objects that have similar criteria (object classes).
    - Relationships between objects and classes are explicitly defined.
  - **Drawbacks:**
    - No standard query language for object-oriented databases
    - Object-oriented databases take substantially more skill and time to design than other databases

Digital Maps

- **What Is a Digital Map?**
  - A digital map attempts to capture the underlying geographical phenomena and make it available for dynamic retrieval, spatial analysis, and representation by sophisticated software systems.
Digital Maps

Digital maps can represent information in 2 basic ways:

1. The geographic world is composed of entities that can be positioned on the map by a geometric coordinate system and described by attributes and properties.
   • This approach typically uses a vector data model, where entities are defined using points, lines, and polygons.
   • Spatial analysis required in mobile location services (e.g., routing through a linked network topology; i.e., roads) is well served by the entity model.
   • Is the most common map data model used by spatial analysis software vendors.

Vector Representation of Entity Data Model with Attributes for each polygon
Digital Maps

Digital maps can represent information in 2 basic ways:

2. Specific attributes (e.g., elevation) vary continuously in the map as a mathematical function.
   - Because using simple differentiable numerical function to represent large geographical areas can be difficult, it is common to divide the geographical space into discrete spatial units. The result is known as a tessellation, and can be composed of square cells if a raster model is used.
Digital Maps

Raster Tessellation in a Continuous Variation Data Model, One Layer for Each Attribute

Digital Maps

How Are Digital Maps Created and Maintained?

- Gathering Source Information
- Collecting Data From the Field
- Developing Products
How Are Digital Maps Created and Maintained?

**Gathering Source Information**
- Continually update relationships with local vendors and government agencies to collect map source materials from public and private suppliers
- Aerial-rectified photos
- Differential GPS field surveys

This allows the map data vendor to extend digital maps with information like new roads, postal codes, and address ranges.

**Collecting Data From the Field**
- Drive the roads to compare reality with the digital data and collect new features and attributes for the map.
- Additional info such as new signage information, turn restrictions, road geometry, tunnels, bridges, vehicle restrictions, and address ranges.

This information is delivered to a production unit, who will make the necessary improvements to the core map database.
Developing Products

Map data conversion from source format into various product formats optimized for specific applications such as:

- MultiNet GDF, Multinet Shapefile
- MapInfo
- MapBase
- MapAccess
- Spatial Data Engine (SDE)
- Oracle Spatial
- KIWI
- geocoding-specific formats, or lighter formats such as those for mobile location services.

Geographical Data Types

In the vector data model, geographic data is stored in discrete points, lines, and polygons.

Points, lines, and polygons are respectively zero-, one-, and two-dimensional static representations of real-world phenomena in terms of simple x, y coordinates.
Geographical Data Types

Points

- Refer to objects that have location and attribute information not large enough to be represented as areas.
- Points have no dimensions.
- Representation as a Point or a polygon depends on the level of abstraction and scale of the map.
- Examples of points:
  - Points of interest (POIs)
  - Parcel centroids such as postal codes or addresses.
Geographical Data Types

**Nodes**
- Are a special type of point that represent a junction or the endpoint of a line.
- Same as points in all other respects
- Provide information that includes connectivity between lines and information about adjacent polygons and enclosed islands

Geographical Data Types

**Line Primitive**
Geographical Data Types

Polygons

- A set of connected lines that form a closed mathematical figure.

- Can have any number of points and can be any shape or size

- Ways to represent a polygon include the set of x, y coordinates that form its boundary or the area contained by the boundary.

- Polygons can have holes, contain other polygons, and be directly adjacent to other polygons
Geographical Data Types

- Linked Attributes
  - Each geographic primitive has attached information that describes it. In mobile location services, the most important attributes relate to the road network, such as:
    - Speed
    - Street names
    - Turn restrictions
    - Connectivity.

Geographical Data Types

- Computer Storage of Geographic Data Structures
  - Points will have an (x, y) coordinate
  - A simple line with only two nodes will have two (x, y) coordinates,
  - An arc will have n number of (x, y) coordinates,
  - A polygon could have either n number of lines or n number of points.
Geographical Data Types

- Computer Storage of Geographic Data Structures
  - To achieve sufficient precision, it is necessary to use a 32-bit or 64-bit real data type for each value in the coordinate pair.
  - A point would require 8 or 16 bytes of storage, a line requires a minimum of 16 bytes of storage, and a polygon requires a minimum of 24 bytes.
  - A map databases can contain many millions of spatial entities and each can have linked attributes - A map database can become very large.

Geocoding

- The ability to look up an address on a map
  - Many problem are due to the fact that:
    - Address schemes differ significantly by geographic region
    - Differences may require highly complex rule systems to analyze the address and good map data to make geocoding effective.
Geocoding

The process of associating an address with geographic features.

- The geographic features are often represented by a line, such as a street center line database.
- Typically, each segment of the street center line has attributes such as high and low address range (or left and right address range), street name(s), the city, postal code, and many others.

Street address range example
Geocoding

How does it work?

Four-step process:
1. Address is inputted to the geocoding system
2. Address is then analyzed, parsed, and placed into a standard format
3. A Soundex search is done for the city and street name and an address range search is done for any matches found in the soundex search.
4. A scoring system is used to rank the possible matches

-- continued

If a match is found, the geographic coordinate (e.g., projected latitude and longitude) is returned.

If multiple matches are found, they are returned ranked by the scoring system so the user can select the best match.

If no matches are found, the geocoding system logs an error and returns an error message.
Geocoding

**Address Input**

- Geocoding systems need a way to receive the address from the user.
- This might include a Java constructor, an XML document over HTTP, or a proprietary protocol.
- Advanced systems allow a near free-form address input, such as one text input for address and street name and another text input for city, region, and postal code.

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**Address Input - continued**

- The mobile location services application developer does not have to do the complex parsing and error correction (left to the geocoder).
- The user inputs the address the same intuitive way he or she might address a letter.
- Less sophisticated systems require a text input for each element. The more discrete inputs required, the more unsophisticated the geocoder.
Geocoding

Address Standardization

- Once the geocoding engine has received the address, it attempts to parse it and standardize it.

- If the geocoder is region specific (e.g., only designed to work with U.S. map data) the standardization is simpler.

- Address interpretation might appear as follows:

Geocoding

Address Standardization example:

- Address list before parsing and standardization:
  - 1000 Main Street, Suite 100
  - 555 California Avenue
  - 500 South 300 West
  - 1121 3rd Street
  - 501 Avenue G
  - 15 Jefferson Apt# 1

Address list after parsing and standardization:

<table>
<thead>
<tr>
<th>Address1</th>
<th>Name1</th>
<th>Suffix</th>
<th>Direction</th>
<th>Address2</th>
<th>Name2</th>
</tr>
</thead>
<tbody>
<tr>
<td>00001000</td>
<td>MAIN</td>
<td>STREET</td>
<td></td>
<td>00001000</td>
<td></td>
</tr>
<tr>
<td>00000555</td>
<td>CALIFORNIA</td>
<td>AVENUE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000500</td>
<td>300</td>
<td>WEST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00001121</td>
<td>3rd</td>
<td>STREET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000501</td>
<td>G</td>
<td>AVENUE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000015</td>
<td>JEFFERSON</td>
<td></td>
<td></td>
<td>0000001</td>
<td></td>
</tr>
</tbody>
</table>
Geocoding

Perform Soundex and Address Range Search

- Geocoding engine attempts to find a match in the map database

- If an exact match is not available, the system might do a soundex search to find street names that are similar so the user may choose the best match

Soundex index is based on the way a word sounds rather than the way a word is spelled.

Each entry in the index is a combination of one letter and three numbers.

The letter is the first letter of the original word. The three numbers are the number encoding for the letters of the word.
Geocoding

- Perform Soundex and Address Range Search
  - Soundex Coding Guide
    1. B, F, P, V
    2. C, G, J, K, Q, S, X, Z
    3. D, T
    4. L
    5. M, N
    6. R
    - The letters A, E, I, O, U, H, W, and Y are ignored. Double letters are treated as a single letter. Side by side letters that have the same soundex value are treated as a single letter. Words with a prefix are coded both with and without the prefix.

- Soundex Encoding Examples
  - SMITH
    - S-530 (S, 5 for the M, 3 for the T, 0 added)
  - SMYTH
    - S-530 (S, 5 for the M, 3 for the T, 0 added)
  - WASHINGTON
    - W-252 (W, 2 for the W, 5 for the N, 2 for the G)
  - JACKSON
    - J-250 (J, 2 for C, K ignored, S ignored, 5 for N, 0 added)
Geocoding

Apply Scoring Rules

- Now that the geocoding engine has a set of potential results, each result is scored according to certain criteria, which might include the following:
  - Whether the street name was an exact match
  - Whether the street type matched (Avenue or Street)
  - Whether the direction matched, if the street had a directional attribute (e.g., north or southwest)
  - Whether the city, zone, or postal code matches

What Makes Geocoding So Difficult?

- Address Cleanup
  - One of the greatest challenges in providing a high-quality geocoder. Typical problems include the following:
    - Numeric street names - 10 1st Street
    - Addresses with more than one directional - 123 W Main Street East
    - Alphanumeric addresses - 100A Mission Street
    - Fractional addresses - 45½ Bee Street
    - Coordinate addresses (Utah) - 520 East 400 South
    - Addresses with dashes (Hawaii and Queens, NY) - 101-123 Kaanapali Road
    - Street names with numeric components - 1234 10 Mile Road
    - Street names that are directionals - South Street
    - Street names that are suffixes (Brooklyn, NY) - Avenue G
    - Spelled out address numbers - Two Second Street
Geocoding

What Makes Geocoding So Difficult?

- Differing Address Standards
  - Geocoders must be locally adapted, tested, and tuned.
  - Language has a significant impact on how addresses will be input

- Soundex Mismatches
  - Bad matches add processing time and could present the user with unintuitive choices
  - There are many proprietary enhancements that could increase its effectiveness in matching an address
Geocoding

What Makes Geocoding So Difficult?

- Static Map Database and Dynamic Communities
  - Map database releases are typically done two to four times per year
  - New roads and buildings are constantly being constructed.
  - Applications that have a central map database and thin clients have the advantage of being more up to date than systems that require map databases on CD.
  - Offboard navigation systems that use the mobile network to process spatial requests on a remote server are a better option.

Rural Delivery and Post Office Boxes

- Rural delivery and post office boxes present another series of complications for geocoding.
- Depending on the application, the geographical position found might not be useful if the physical location is required.
Geocoding

What Makes Geocoding So Difficult?
- Site Address and Billing Address
  - Ambiguity is possible when a site has both a physical address and a billing address.
  - Certain applications might need the physical address, whereas others require the billing address. A method to distinguish the two is necessary.

Why Is Geocoding Important to Mobile Location Services?
- Significant functionality in mobile location services applications depends on being able to accurately pinpoint and direct users to very specific locations.
- Users save time by relying on the intelligent business logic and the large knowledge bases built into mobile location services systems.
- However, users have very little patience with systems that direct them to the wrong place.
- For location services applications to be successful, it is crucial that map data be current and that a high-quality geocoding product is used (and properly integrated if necessary).
- Equally important is reverse geocoding.
**Geocoding**

Why Is Geocoding Important to Mobile Location Services?

- Success in these basic location service functions is the cornerstone for success in developing higher level applications such as real-time traffic.

**Reverse Geocoding**

- Reverse geocoding is the process of identifying the nearest road segment in a map database given a latitude and longitude pair.

- Once the nearest road segment is available it is possible to process driving or walking direction requests or POI lookups.

- The operation is specific to a given map database. Different map databases of the same area could yield different results.
Reverse Geocoding

Information returned by a successful reverse geocode operation might include:

- How far the nearest road segment is from the point?
- Where the point is in relation to the road segment? (near the beginning of the address range, 15 percent; in the middle of the address range, 50 percent, or near the end of the address range, 85 percent),
- Actual road segment vector data and its associated attributes
Spatial Analysis – Other operations:

**Routing**
- Calculates the optimum path between an origin and destination, subject to certain criteria
- Common routing problems are referred to as shortest path, traveling salesman, multiple traveling salesman, single depot–multiple vehicle, and multiple vehicle–multiple depot route.

**Map Image Generation**
- Raster Map (digital image often in GIF)
- Vector Map (required for an application to properly render the map using Vector Markup Language (VML))

**POI Searches**
- Name Search; Around a Point; Along a route; Globally; Within city, Region, or postal code; Category search; Phone search.

**Real-Time Attribute Editing**
- In the real world, conditions change constantly (Traffic, closed roads, toll changes etc.)
- A method to make interim updates to the map

Links and References

- http://www.apache.com
- http://www.bleo.com
- http://www.bea.com
- http://www.ibm.com
- http://www.earthpoint.com
- http://www.webopedia.com

Commercial Application Servers:
- IBM Websphere Everyplace Server (http://www.ibm.com)
- BEA WebLogic Server (http://www.bea.com)
- Oracle Weblogic (http://www.oracle.com)
- Microsoft Mobile Information Server (http://www.microsoft.com)
- Jakarta Tomcat from Apache (freeware) (http://www.apache.com)
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