Wireless Assisted GPS: Personal Location for GSM and GSM Evolution

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January 11, 2001

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Agenda

- Wireless Assisted GPS (WAG)
  - Definition
  - How it operates
- GSM Standards-Based Messaging Requirements
- WAG Performance

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- Wireless Assisted GPS (WAG)
  - Definition
  - How it operates

WAG Definition

Wireless

Information is obtained from the wireless infrastructure, wireless handset, or via wireless messages from a Location Server. This information is called assistance information, and it is used by the WAG receiver

Assisted

The assistance information received, or derived from, the wireless network is used to “aid” the WAG receiver by providing data that would normally be derived by time-consuming demodulation of GPS satellite signals – demodulation is difficult and sometimes impossible in certain common wireless environments

GPS

A proven system for world-wide positioning and navigation used for personal, commercial, business, and government applications. Commercial implementations have been in place for close to 10 years, though the system has been in place over 20 years.

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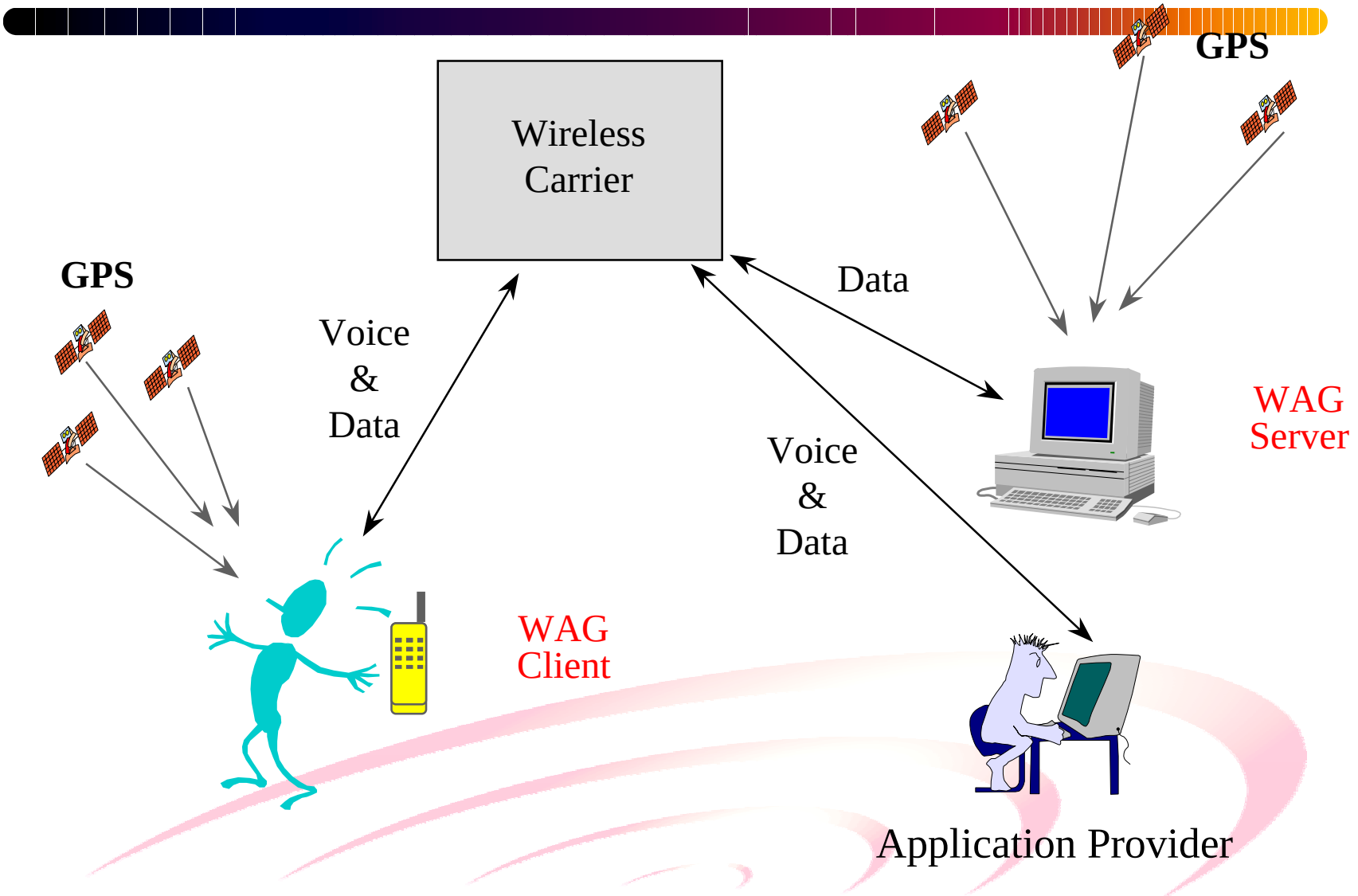
WAG Architecture



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What's So Good About WAG?

- Very rapid acquisition--100 to 1000 times faster than conventional GPS.
  - Extremely fast positioning in almost all conditions
  - Operation in difficult environments (blocked signals, fading, etc.)
- Very sensitive for given acquisition time
  - Can withstand >20 dB signal attenuation due to building blockage, etc.
  - Works indoors
- Excellent accuracy/reliability through cooperation between MS client and server

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(Continued) What's So Good About WAG?

- A single server supports roaming across different networks and different geographies
- Other than one Server, no special infrastructure equipment is needed
- Accuracy of WAG supports emergency services and enables a much larger number of location service applications
- Cost of implementation decreases over time as handset integration increases
- WAG can be combined with other terrestrial radio-location methodologies

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How WAG Works

- **WAG receiver obtains aiding data from the server and/or extracts key information from the wireless network**
- **Using this aiding data, WAG receiver processes small amounts of GPS satellite signals**
- ***Then…***

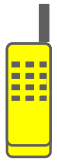
MS-Assisted: **Sends data to Server for position calculation**

MS-Based: **Calculates position in the handset**

WAG splits the workload into a very efficient, quick, and accurate client/server structure

Client/Server Structure

Client



Server

1 →

- Location request command
- Approximate location (BS address)

- SV ephemeris/almanac
- Doppler corrections

- Signal processing

← 2

- Satellites in view
- Doppler frequency corrections for SVs in view or other data depending on mode of operation

3 →

- MS calculates position or sends GPS time stamped pseudoranges to Server, depending on mode of operation

- DGPS, multipath, etc.
- Final position calculation

↓

To mapping or tracking application

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- GSM Standards-Based Messaging Requirements

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GSM LCS Methodologies

- Two Mobile Station Location Methodologies
  - MS-Assisted = Location Computation in Network
  - MS-Based = Location Computation in MS
- Two Location Transaction Modes
  - Broadcast mode
    - Periodic Short Message Service Cell Broadcast (SMSCB) on Broadcast Control Channel (BCCH)
  - Point-to-Point messaging mode (request/response)
    - Standalone Dedicated Control Channel (SDCCH) in idle mode
    - Fast Associated Control Channel (FACCH) in dedicated mode
    - Slow Associated Control Channel (SACCH) in dedicated mode

GSM Point-to-Point Mode

- GPS Assistance Data Element provides several information elements
  - Reference Time (optional)
    - GPS Time Assistance information (optional)
      - Nominal size - 3 bytes per satellite
      - Produces ~3dB sensitivity improvement
      - Allows LMU-independent GPS time dissemination
  - Reference Location (optional)
  - DGPS Corrections (optional)
  - Navigation Message Bits (optional)
  - Acquisition Assistance (optional)

GSM Broadcast Mode

- Broadcast SMSCB messages with four data elements
  - Reference Time (mandatory)
    - GSM Time (optional)
    - GPS Time (mandatory)
  - Reference Location (mandatory)
  - Differential (DGPS) Corrections (optional)
  - Navigation Message Bits (optional)
    - Produces ~3 dB additional sensitivity improvement
    - Allows LMU-independent GPS time dissemination capability
    - Incremental means for Navigation Model update
      - Reduces requirements for point-to-point messages

GSM Scenario 1: Broadcast Mode

- Handset listens to broadcast messages to
  - Receive navigation message bits for GPS SVs (satellites) in view
  - Acquire one or more GPS SVs
  - Determine/maintain GPS time
    - Software-based method utilizing navigation message bits
  - Incrementally update Navigation Model
- Ready for location requests from user or network

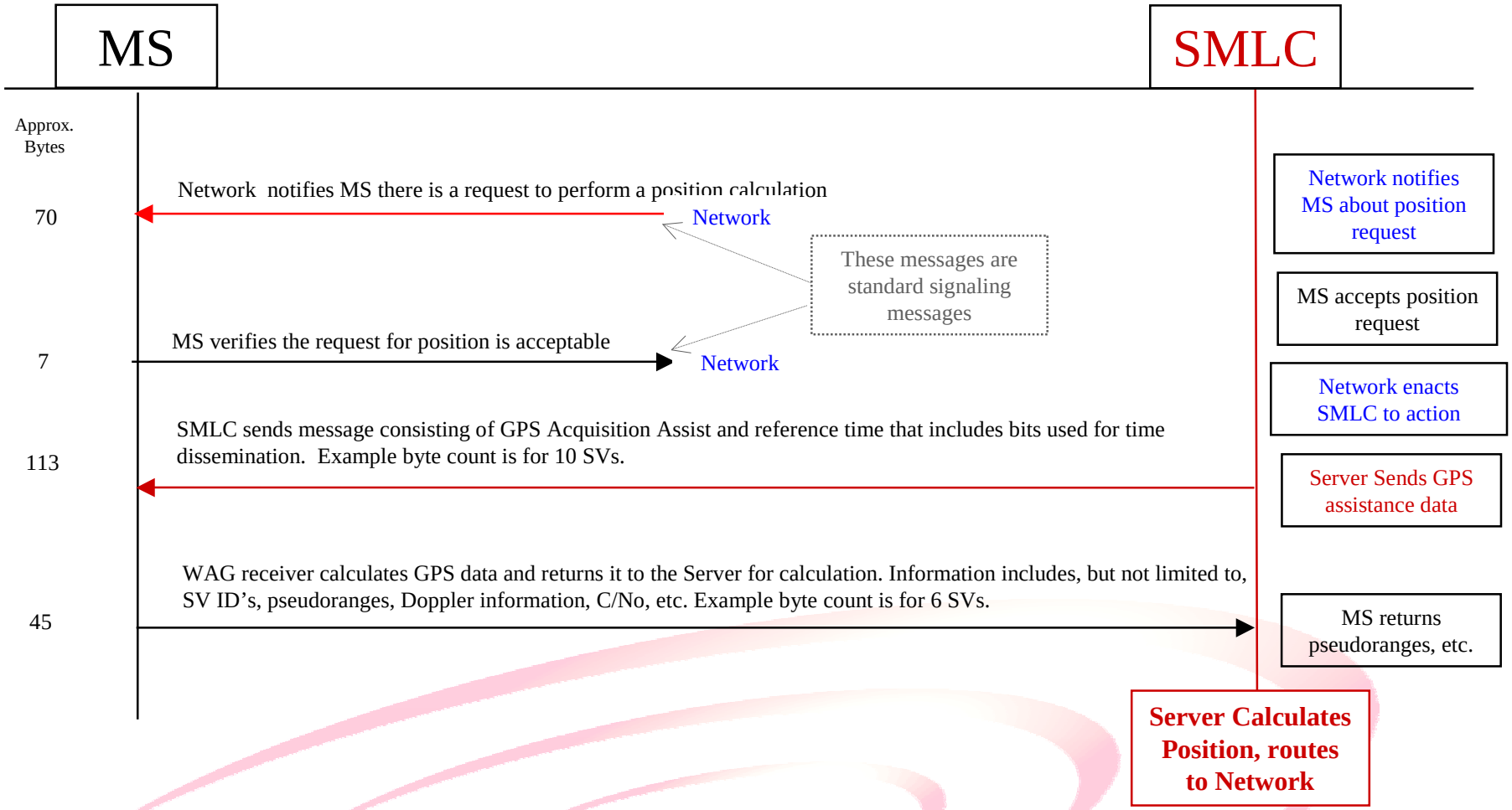
Supports MS-based or MS-assisted solutions

GSM Scenario 2: Point-to-Point Mode

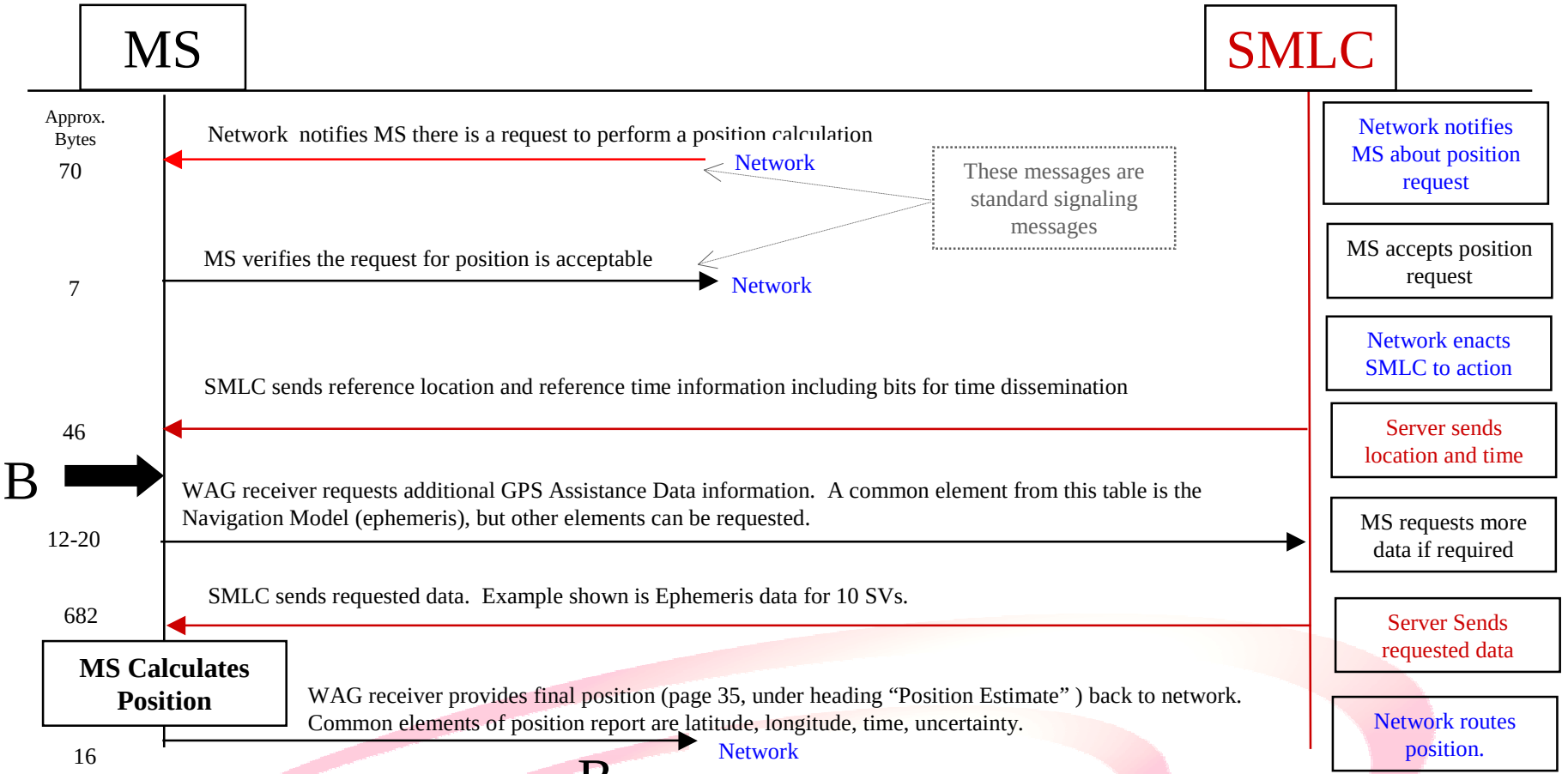
- Handset is powered on
- Scenario 1 operation commenced
- Location request initiated by user or network
- Resident GPS assistance data evaluated
- If data insufficient, point-to-point mode entered
- Required assistance data requested/received
- Required location request performed
- Transition back to Scenario 1

Supports MS-based or MS-assisted solutions

MS-Assisted Sample GSM Call Flow



MS-Based Sample GSM Call Flow



B At this point, if the WAG receiver can calculate a position with this data, then it does so (eg. may have ephemeris data from a previous calculation, or from an assistance broadcast). Otherwise it requests whatever additional information is needed.

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- WAG Performance

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WAG Performance Expectations

- High Performance
  - High Sensitivity (inside, urban canyons, etc.)
  - Rapid First Fix (<8 seconds from cold start)
  - Accuracy suitable for location services (5-50m)

- Roaming
  - Across geographies
  - Maintain accuracies

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Performance Validation Across the World

Field Proven Globally on All Major Wireless Standards

Denver, Colorado (analog/CDMA)
outdoor, open: 4 m accuracy

San Francisco, California (analog/GSM/CDMA)
25 m inside urban parking garage:
45 m accuracy

Tampa, Florida (CDMA)
1st story, 2-story house: 20 m accuracy

Tokyo, Japan (PHS/PDC)
dense urban: 18 m accuracy

Madrid, Spain (GSM)
dense urban: 37 m accuracy

Washington, D.C. (analog)
urban alley: 50 m accuracy

Performance Validation in Europe

SnapTrack GSM Test Group Independently Audited Performance

Carrier Members

Vodafone Airtouch (UK)
Bell South (US)
BT Cellnet (UK)
Esat Digifone (Ireland)
France Telecom Mobiles (France)
Omnitel Pronto Italia (Italy)
T Mobil (Germany)
Telecel (Portugal)
Telefonica (Spain)
Signalsoft

Infrastructure/MFG Members

CMG
Nortel
Siemens

Note: Only Publicly disclosed members shown.

- **Phase I trial, hosted by Telefonica, completed October, 1999**
- **Phase II trial, hosted by France Telecom Mobiles, completed in July, 2000**
- **Tracking and information services applications**
- **Prototype SnapTrack enabled terminals**
- **Roaming and services transparency**
- **SMS and circuit-switched data transport**

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European Field Test Results

Hyde Park of London, UK
Outdoor: 8.89m accuracy
Yield: 100%

Shaftsbury Hotel, London, UK
Urban Outdoor: 29.76m accuracy
Yield: 100%

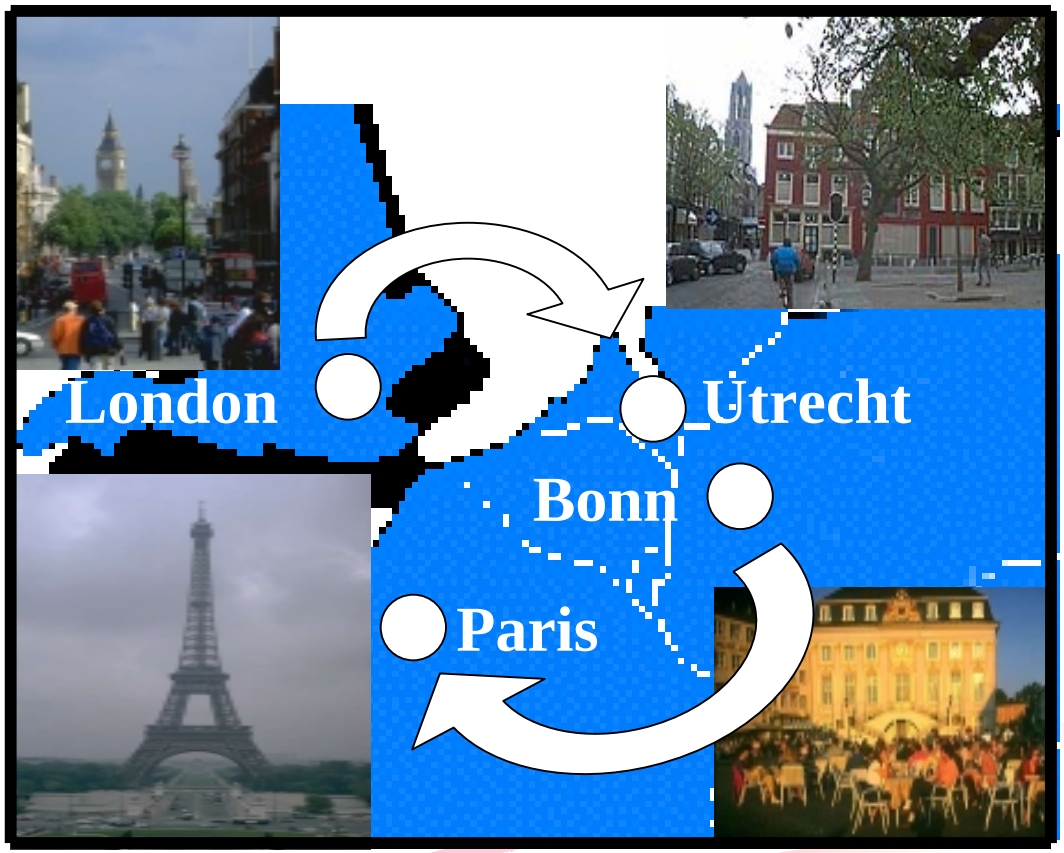
San Isidro Church, Madrid, Spair
Dense Urban: 37.6m accuracy
Yield: 99.5%

Place de Pantheon, Paris, France
Urban Outdoor: 37.84m accuracy
Yield: 100%

Hotel Astra Opera, Paris, France
Indoor: 39.93m accuracy
Yield: 68.7%

Restaurant Chevaux de Marly,
Paris, France
Indoor: 31.52m accuracy
Yield: 98.1%

Roaming Validation



- Seamless Roaming
  - Ability to roam to another network and retain location capabilities from home network
  - MSC/ VLR data used for initial position
  - SMS transport, pre-standards demonstration
  - Negligible impact on system performance.
- In this test, a single server in one location supported roaming in four countries

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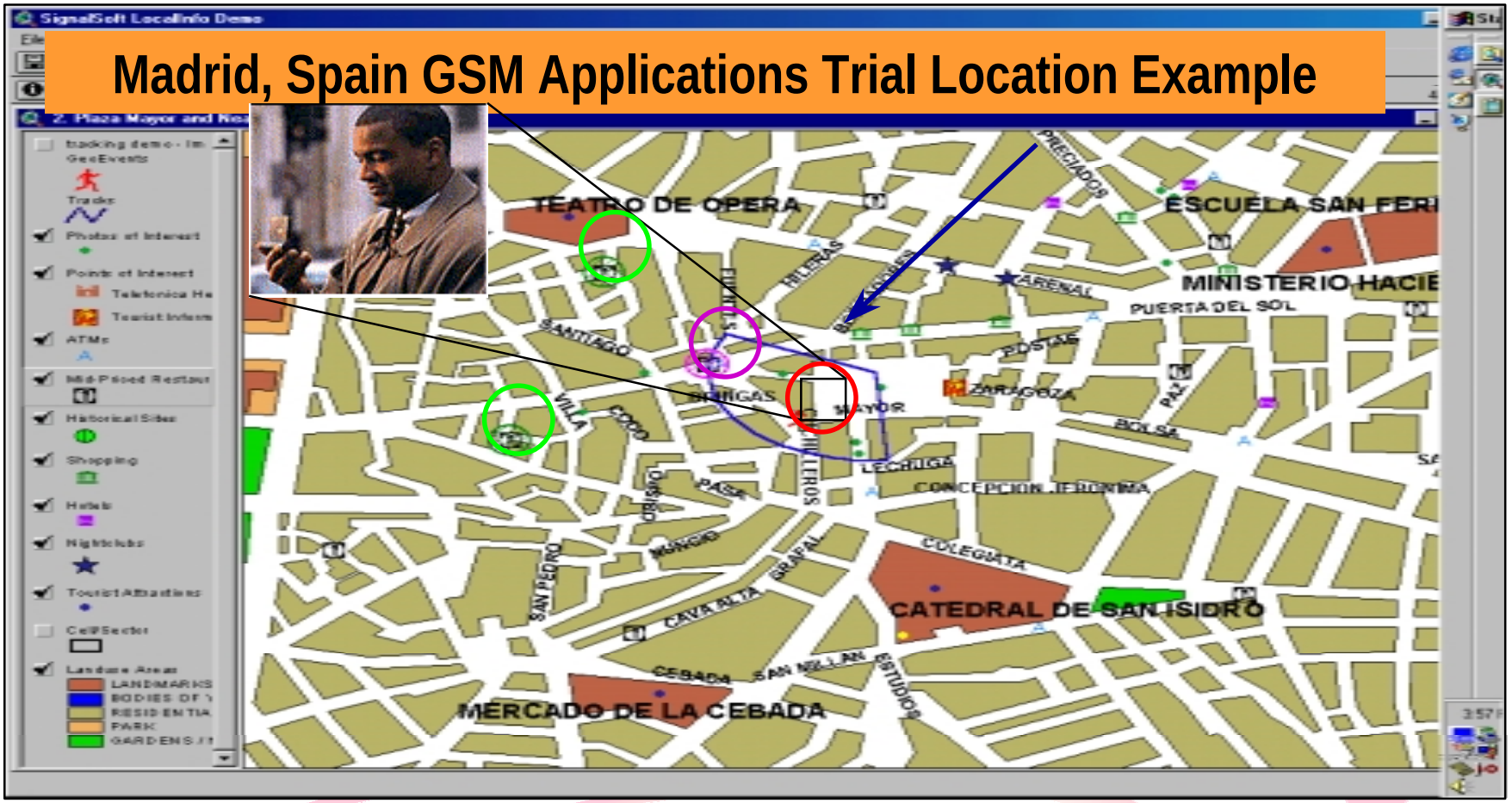
STGTG Applications Example: SignalSoft Local.Info



- The caller, inside the black box, is using a Wireless Assisted GPS™equipped mobile
- The restaurant closest to the caller is in magenta.The blue arc represents cell/sector location

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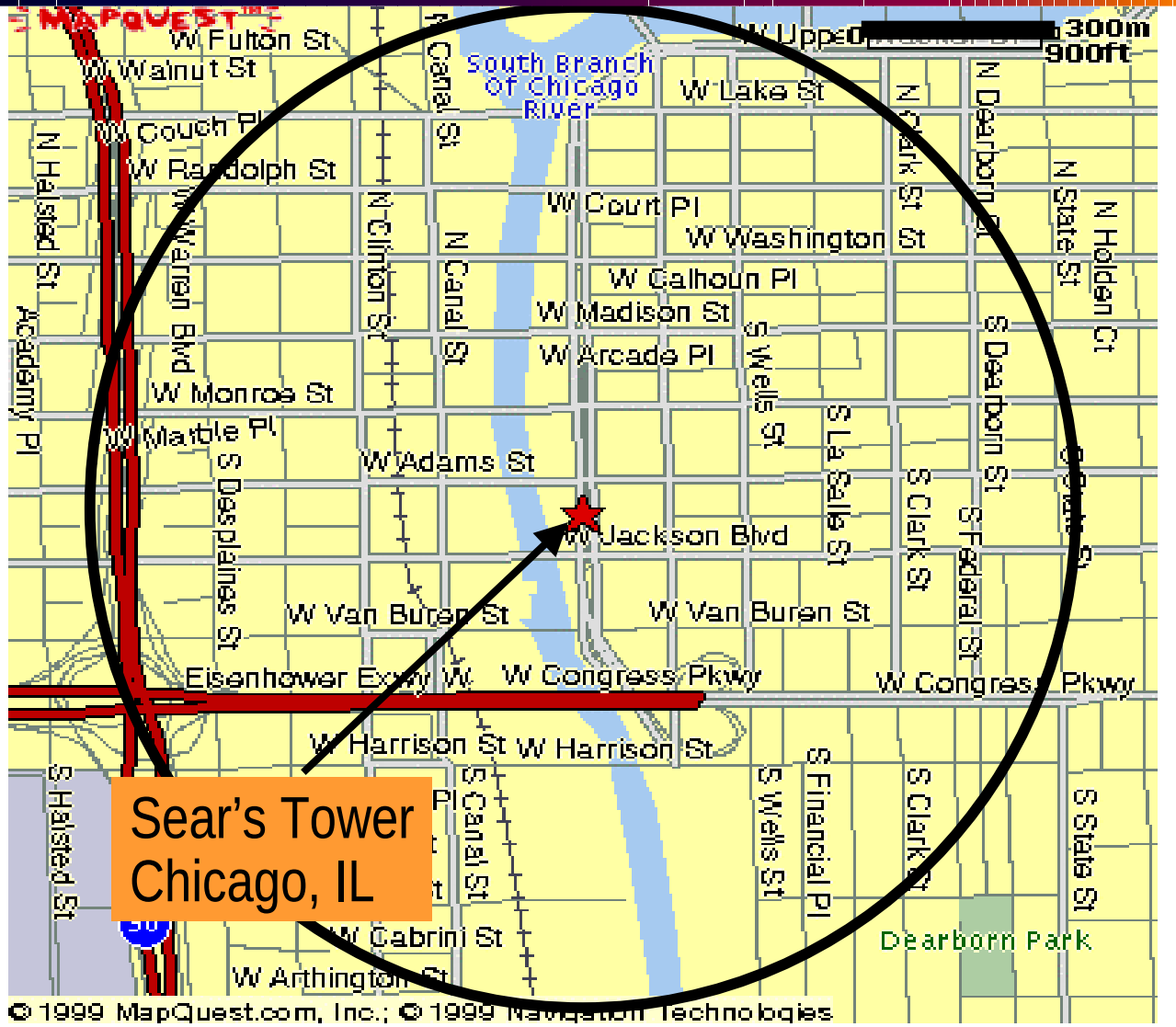
800m Accuracy



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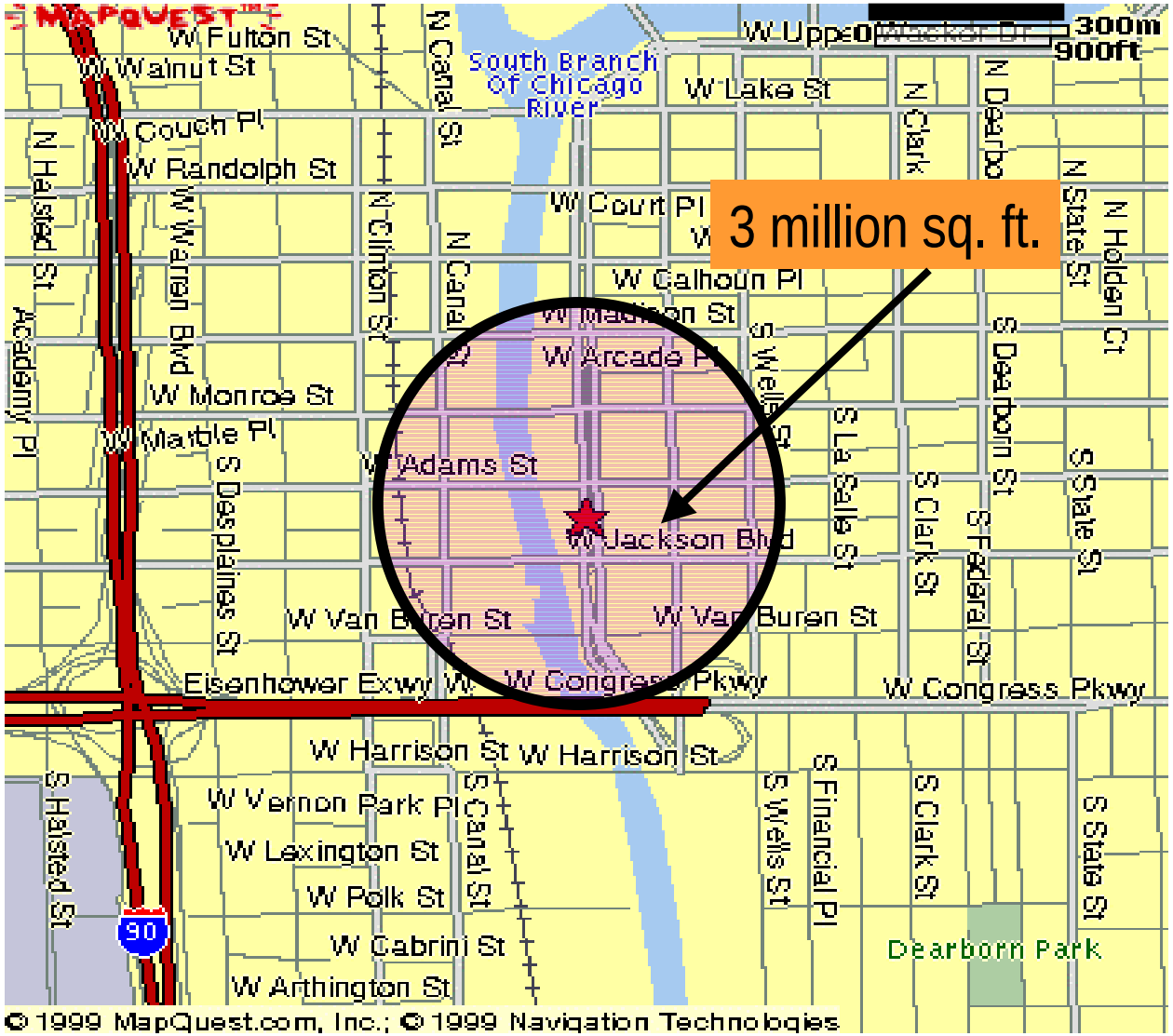
300m Accuracy



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50m Accuracy