Session II

위치기반서비스를 위한 기반 기술 및 고도화 기술

위치기반서비스에서의 무선 측위 기술
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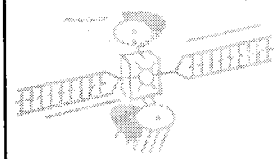

위치기반서비스에서의 무선 측위 기술

- Network Assisted GPS 의 개념 및 기반 기술

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Contents

- LBS Applications
- Location Technologies
- A-GPS
- Current Issues

LBS Applications

- Emergency services:
  - E-911, roadside assist
- Carrier-based:
  - Zone-based billing, Network management
- Vertical and corporate:
  - Asset and Personnel Management
- Productivity (Concierge Service)
  - Yellow pages, traffic avoidance, navigation, weather
  - Service location (food, hotel, gas), Delivery, Taxi
- Entertainment
  - Celebrity tracking, chat, BBS, fortune telling, hunt and seek, treasure hunts, movie seat availability, and so on

LBS Applications

FCC E911 Revisions

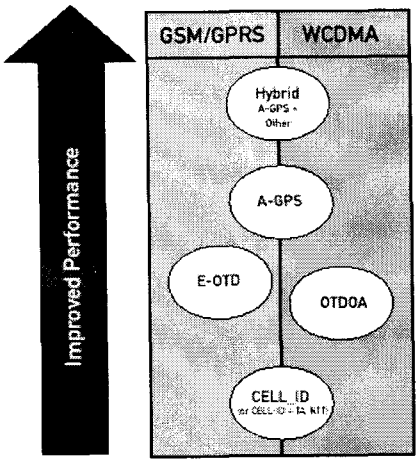
- For handset-based technology:
  - Within 50m for 67% of the calls
  - Within 150m for 95% of the calls
- For network-based technology:
  - Within 100m for 67% of the calls
  - Within 300m for 95% of the calls

※ Test Methodology

- Qualcomm, Recommended Minimum Performance Specification for IS-801-1 Spread Spectrum Mobile Stations

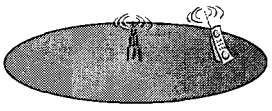
Location Technologies

- Cell-ID
  (Cell site IDentification)
- E-OTD
  (Enhanced Observed Time Difference)
- OTDOA
  (Observed Time Difference Of Arrival)
- A-GPS
  (Assisted GPS)
- Hybrid
  (A-GPS + other technologies)

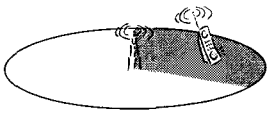


Location Technologies

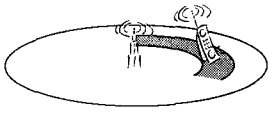
Cell ID + Time Advance



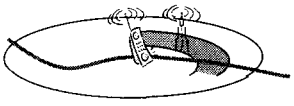
Cell Site only



Cell Site with sector



Cell Site with sector
and Timing Advance



Cell Site with sector,
Timing Advance and
Supplementary information

Location Technologies

Cell ID + Time Advance

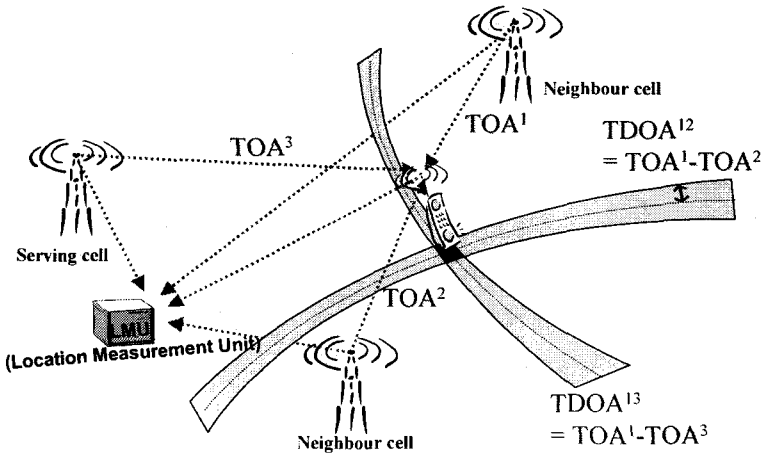
Technology	Rural	Suburban	Urban	Indoor
Cell ID	Range 1-35km Typically ~15km Extreme 100km	Range 1-10km Typically 5km	Macro cells: Range 500m-5km Typically 2km Micro cells Range 50m-500m Typically 200m	If Pico Cells are deployed then Typically 10m-50m
Cell ID + TA	No major improvements in accuracy. However, is a good check against connecting to cell which is not the nearest.			

Location Technologies

E-OTD (OTDOA)

1) Measure Time Of Arrival (TOA) at Handset

2) Make Time Difference Of Arrival (TDOA) equation at LMU



Location Technologies

E-OTD (OTDOA)

- TOA measurements are made at the handset
  - $TOA = T_H + T_P + T_T + T_E$

T_H	Handset clock reference
T_P	Propagation Delay from BTS to Handset
T_T	Transmission time of signal from BTS
T_E	Errors in measurement (noise, interference, multipath, receiver chain delays, etc...)

- Results from two Base Transceiver Systems (BTSs) are combined to give a TDOA equation
  - $TDOA = TOA^1 - TOA^2$
    $= (T_H^1 - T_H^2) + (T_P^1 - T_P^2) + (T_T^1 - T_T^2) + (T_E^1 - T_E^2)$

Location Technologies

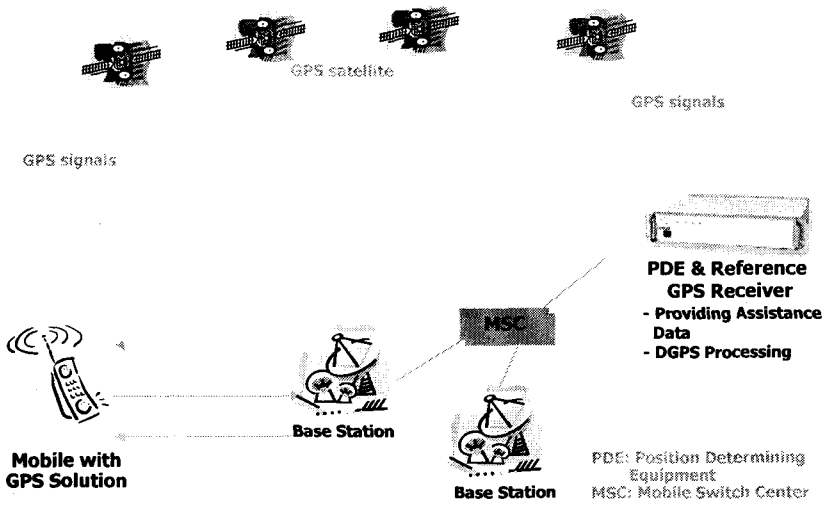
E-OTD (OTDOA)

- Advantages of E-OTD:
  - Minor modification to handset functionality
  - Good positioning performance in high BTS density areas
  - Good indoor coverage
  - Comparing to TOA, E-OTD LMUs are much simpler and can be deployed at 1 per 3-5 BTSs.

- Disadvantages of E-OTD:
  - High impact on Network Infrastructure - cost, deployment, planning, maintenance.
  - Uncertain performance in Universal Mobile Telecommunications System (UMTS)
  - Poor performance in low density BTS areas

Location Technologies

A-GPS Concept



Location Technologies

A-GPS Key Issues

- The location solution should be produced wherever a cellular phone can operate (and possibly some places where they can't).
  - Issue regarding the sensitivity required to detect indoor GPS signals
- The location solution should be provided in a reasonable time, generally accepted as being less than 5 seconds.
  - Issue regarding the achievable time to first fix
- The location solution must not affect the cost (area of circuitry, number of components) or the power consumption of the phone.
  - A minimal overhead is the key to satisfactory integration with the phone.

Location Technologies

A-GPS Types

Handset Based A-GPS

- Full functionality GPS receiver in handset
- Assistance data is reproduction of satellite data
- Distributed processing, so higher potential maximum LCS subscribers supported

Handset Assisted A-GPS

- Reduced functionality GPS receiver in handset
- Assistance data sent is minimum required for receiver to acquire satellite pseudo-ranges
- Lower signaling load, but can also work with Handset Based A-GPS assistance data

Location Technologies

A-GPS Properties

Advantages of A-GPS:

- Low impact on Network Infrastructure
- Excellent outdoor performance
- Good evolution path to UMTS

Disadvantages of A-GPS:

- Major modification to handset functionality
- Improved yet variable indoor coverage

Location Technologies

Summary of Requirements

REQUIREMENT	CELL-ID	E-OTD	OTDOA	A-GPS	HYBRID
Yield	Excellent	Average	Poor	Very Good	Excellent
Consistency	Poor	Average	Average	Very Good	Very Good
Accuracy	Poor 100m-20km 2-dimensions	Average 100m-500m 2-dimensions	Average 100m-500m 2-dimensions	Excellent 5m-50m 3-dimensions	Excellent 5m-50m 3-dimensions
TTFF	Excellent 1s	Very Good 5s	Very Good 5s	Very Good 5-10s	Very Good 5-10s
Handset	Excellent	Good	Good	Average	Average
Roaming	Excellent	Poor	Poor	Excellent	Excellent
Efficiency	Excellent	Average	Average	Very Good	Very Good
Expansion	Excellent	Poor	Poor	Excellent	Excellent
Compatibility	Excellent	Poor	Poor	Excellent	Excellent
Overall Cost	Excellent	Poor	Poor	Very Good	Very Good
Summary	**Average**	**Average**	**Poor**	**Very Good**	**Excellent**

Location Technologies

Summary of Trends

TREND	CELL-ID	E-OTD, OTDOA	A-GPS
Performance Trends	• Cell-ID accuracy varies dramatically and is often very poor • Provides good coverage	• Provides improved accuracy compared to Cell-ID, but is subject to errors from linear BTS configurations and multipath • Has coverage problems where there are limited base stations (tends to be in rural areas)	• Provides optimum accuracy compared to the other location technologies • Has coverage problems deep inside large buildings (tends to be in heavy urban areas)
Implementation Trends	• Easy to implement • Requires no handset changes • Can be supported without major infrastructure changes • Requires BTS almanac development and maintenance • Easy to roam wide areas or other networks, but areas of sparse coverage create severe accuracy degradation	• Difficult to implement • E-OTD requires changes to the handset • Requires the addition of LMUs for asynchronous networks • Requires BTS almanac development and maintenance • Possible BTS easement issues • Does not easily support roaming in wide areas or into other networks	• Easy to implement in the infrastructure • Requires handset changes • Requires no major infrastructure changes • Operates on both synchronized and asynchronous networks • Easy to roam wide areas and into other networks

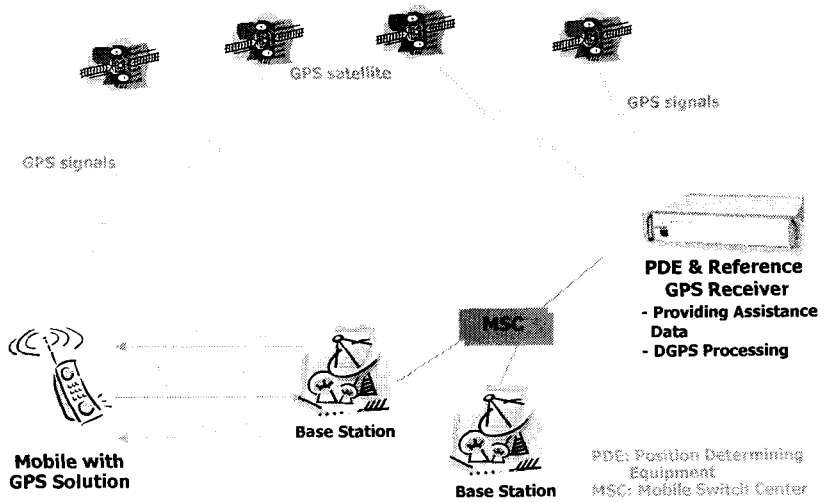
Location Technologies

Summary of Trends

TREND	CELL-ID	E-OTD, OTDOA	A-GPS
Standards Support	• Works across all air interface standards including GSM, GPRS, WCDMA	• E-OTD = GSM only • OTDOA = WCDMA only	• Works across all air interface standards including GSM, GPRS, WCDMA
Overall Cost Evaluation	• Low initial cost since Cell-ID is generally available in the network as long as the Cell-ID LS has access to BTS location and ID for BTS communicating to the handset • Cost to maintain is low • Cost to expand is low as long as expansion is into compatible network • Poor ROI	• Initial rollout cost is high – must add extensive equipment to provide subscriber coverage (approx 1 LMU per every 1.5 BTSs) • Cost to maintain is high since must maintain large network of LMUs • Cost to expand is high since must add LMUs as add new BTS to expand coverage • Poor ROI	• Initial cost is driven by the cost of the handset, related to the number of subscribers that need location • Handset costdelta is related to semiconductor costs and will go down with time. There is minimal infrastructure cost for the initial rollout and for expansion • Cost to maintain A-GPS is negligible • Good ROI

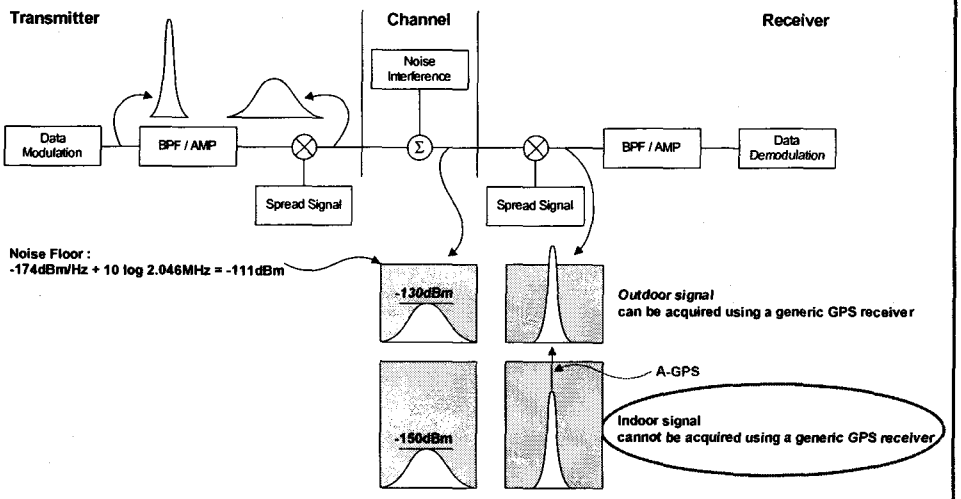
A-GPS

Concept



A-GPS

GPS Signal Flow



A-GPS

RF Sensitivity Enhancement

Strengthening RF Sensitivity

Coherent Integration

$$\left(\sum_{k=1}^{M} I_k\right)$$

- Bit stream & time(1pps) inforamation are required for coherent integration.
- Long term integration is not proper.

Non-coherent Integration

$$\sum_{k=1}^{M} \sqrt{I_k^2 + Q_k^2}$$

- Squaring loss is caused by non-coherent integraion.

Coherent/Non-coherent Integration
(20 msec./50 times)
(Bit stream & Time(1pps))

A-GPS

Assistance Information

Objective

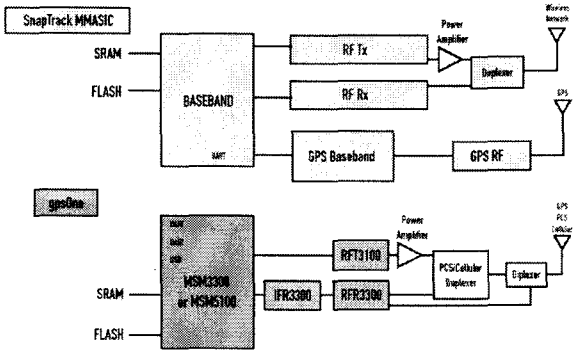
- Fast Time to Fist Fix of Mobile GPS RCVR
- RF Sensitivity Enhancement: -130dBm → < -152dBm

Type

- Acquisition Assistance
  - Doppler and Coarse Range
  - RTD (Round Trip Delay)
- Location Assistance
  - BS Location
  - Satellite Position
- Sensitivity Assistance
  - Navigation Message Bits

A-GPS

Qualcomm & SnapTrack (1)

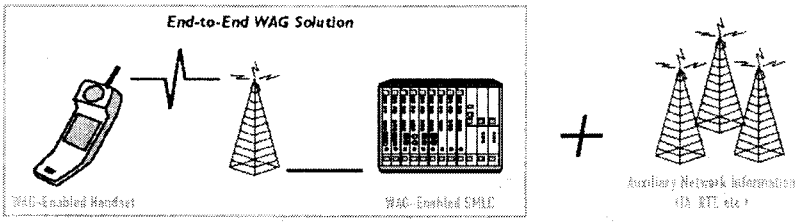


gpsOne and SnapTrack MMASIC

A-GPS

Qualcomm & SnapTrack (2)

Hybrid Wireless Assisted GPS(WAG) Solution

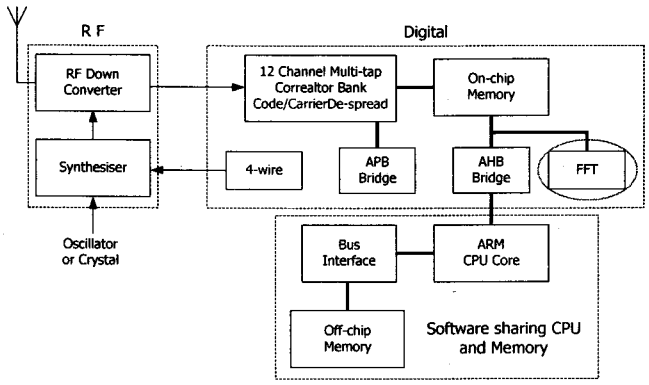


Providing the various positioning modes

- **Smart Mode: Self Positioning**
- **Thin Mode: Remote Positioning**
- **Autonomous Mode**

A-GPS

Parthus (1)



NavStream™ 3000 Architecture

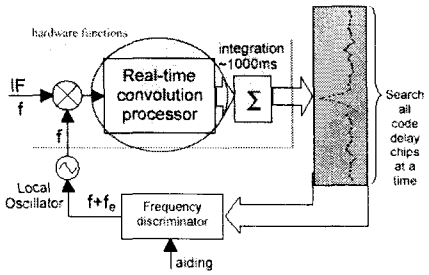
A-GPS

Parthus (2)

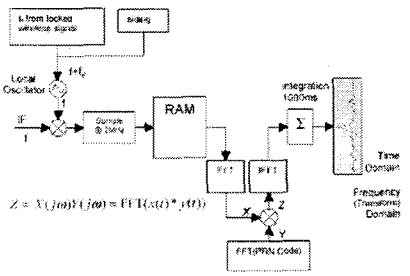
- NavStream™ 3000 Solution
  - One Channel Hardware Platform
  - 32-tap Matched Filter & 64-point FFT
  - Providing the Host Embedded Software

A-GPS

Global Locate (1)



Baseband IC Structure (Now)



Baseband IC Structure (Future)

A-GPS

Global Locate (2)

- Providing the Baseband IC and PDE Solution
  - Multiple Correlator Structure: 16,368 correlators
  - Providing the Host Embedded Software

A-GPS

Performance Comparison

	Qualcomm (SnapTrack)	Parthus	Global Locate
RF Sensitivity	-152dBm	-150dBm	< -150 dBm
Time to First Fix	3 sec.	2 sec. (good signal) 3.5 sec. (poor signal)	250 msec.(typ.)
Position Accuracy	3 ~ 5 m (Smart) 3~ 10 m (Thin) 15 ~ 20 m (Autonomous)	15 ~ 20 m	15 ~ 20 m

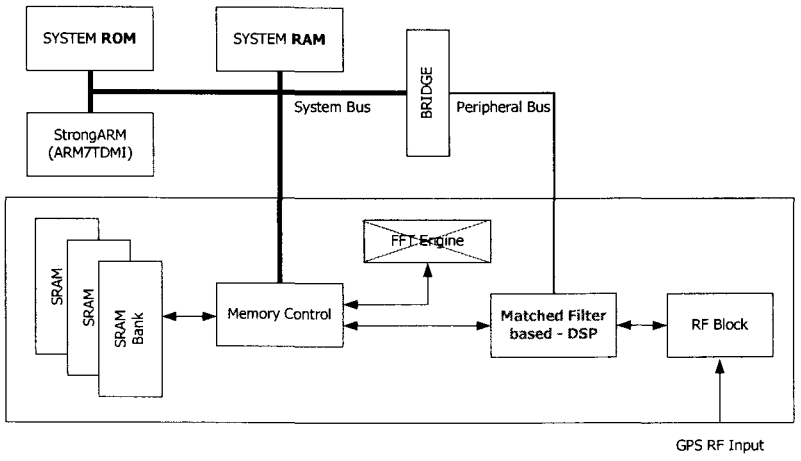
A-GPS

Feature Comparison

	Qualcomm (SnapTrack)	Parthus	Global Locate
Tracking Loop	Loopless Tracking	Continuous Tracking	Closed Loop
Aiding Information	Time, Freq., RTD	Time, Ephemeris, Position	SV orbit data
Bit Recovery	No Demodulation	Data Demodulation	Data Demodulation
Support Protocols	All (Air Interface Independent)	ISO-801 CDMA, ETSI GSM	All (Support All Cellular/PCS)
Hardware Feature	Massively Parallel Matched Filter (Equivalent of 8184 Correlator)	FFT(8~64 point) Search Windows (24,576)	Multiple Correlator(16,000) Convolution Processor

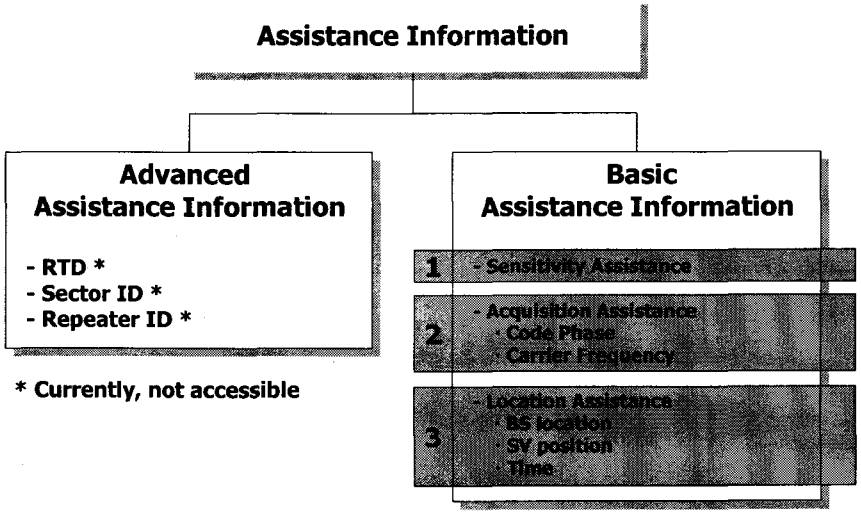
A-GPS

A domestic solution : Navicom



A-GPS

A domestic solution : Navicom



A-GPS

A domestic solution : Navicom

- **Self-determining Mode**
  - **Bit stream and time(1pps) information are not necessary.**
  - **The squaring loss is reduced.**

※ Code phase full search
※ Ephemeris aiding
⇔ Frequency search space: 20Hz → 500Hz
⇔ Fast Mean Acquisition Time

- Highly Optimized KOREA Hybrid NAG Solution
  - RTD is a useful information but RTD via repeater increases the position error and the probability of false alarm.
  - The Navicom hybrid NAG solution checks the quality of RTD.

※ Probability of receiving RTD via repeater
※ Possibility of separating RTD via repeater from receiving RTD

A-GPS

A domestic solution : Navicom

Operation Modes

- **Snapshot Method (Indoor or Outdoor)**
  - **Periodic or on request: Low-power Scheme**

Snap Shot	Calculation	IDLE	Snap Shot	Calculation	IDLE

  - **Continuous**

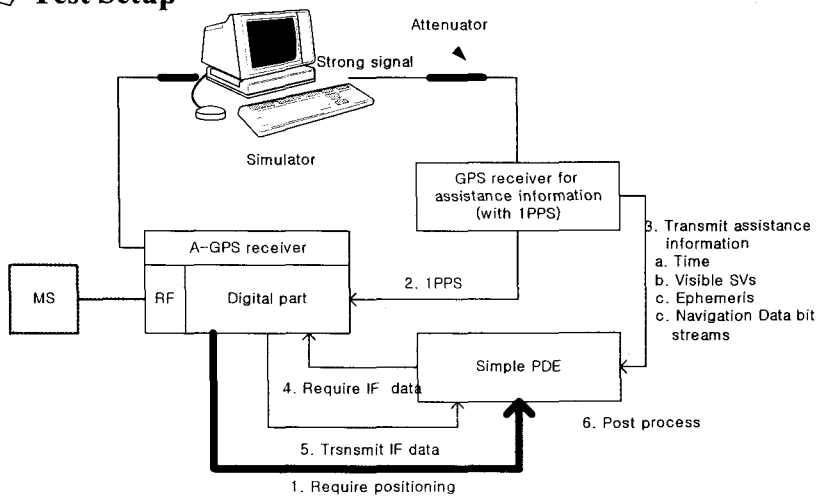
Snap Shot	Calculation	Snap Shot	Calculation	Snap Shot	Calculation
Calculation	Snap Shot	Calculation	Snap Shot	Calculation	Snap Shot

- **DSP Architecture of Typical GPS RCVR**
  - **Generic serial correlator structure**
  - **Outdoor operation**

A-GPS

A domestic solution : Navicom

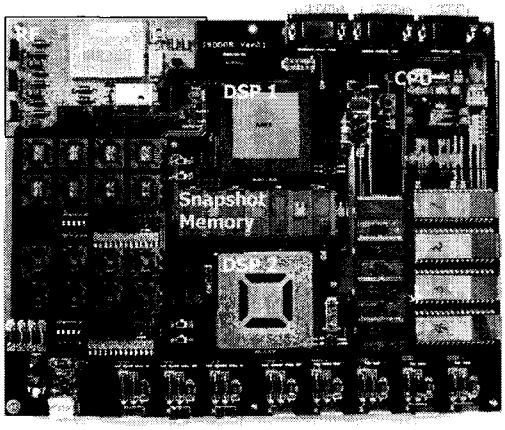
Test Setup



A-GPS

A domestic solution : Navicom

Prototype of A-GPS Receiver



A-GPS

A domestic solution : Navicom

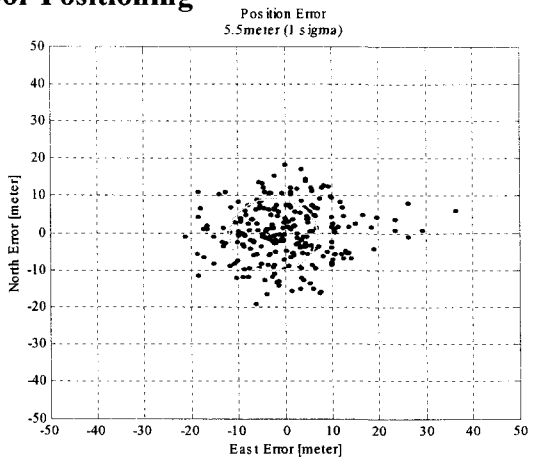
Performance Summary

- **RF Sensitivity**
  - 100% of Calls: -155.6 dBm
  - 89% of Calls: -156.6 dBm
  - 64% of Calls: -157.6 dBm
    - ※ Antenna Gain : 20±3 dB;
    - ※ Noise Figure: ≤ 3 dB
- **Positioning Accuracy**
  - -154.6 dBm: 50.0m@67%, 93.7m@95%
  - -155.6 dBm: 65.6m@67%, 259.9m@95%

A-GPS

A domestic solution : Navicom

Outdoor Positioning



5.5m@67%

Network Assisted GPS

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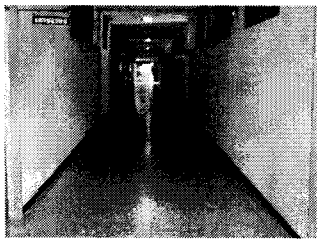
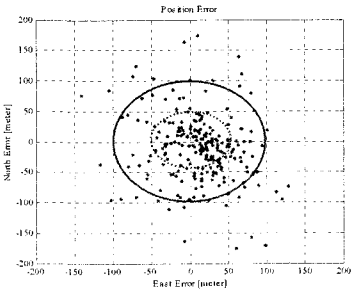
A-GPS

A domestic solution : Navicom

Indoor Positioning (1)





50.0m@67%
93.7m@95%

Network Assisted GPS

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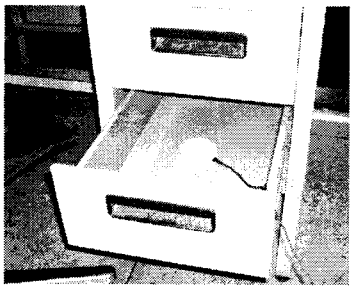
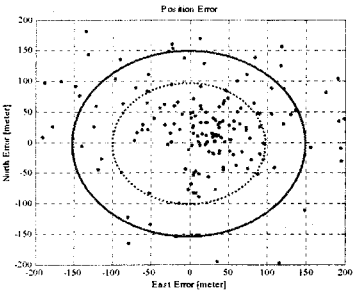
A-GPS

A domestic solution : Navicom

Indoor Positioning (2)





100m@67%
150m@95%

A-GPS

A domestic solution : Navicom

Performance Comparison

	Qualcomm (SnapTrack)	Navicom
RF Sensitivity	-152dBm	< -152dBm (-156dBm)
Time to First Fix	3 sec.	15 sec.*
Position Accuracy	3 ~ 5 m (Smart) 3~ 10 m (Thin) 15 ~ 20 m (Autonomous)	15 ~ 20 m #

* Below 3 sec using multiple MF structure
\# Using advanced assistance information

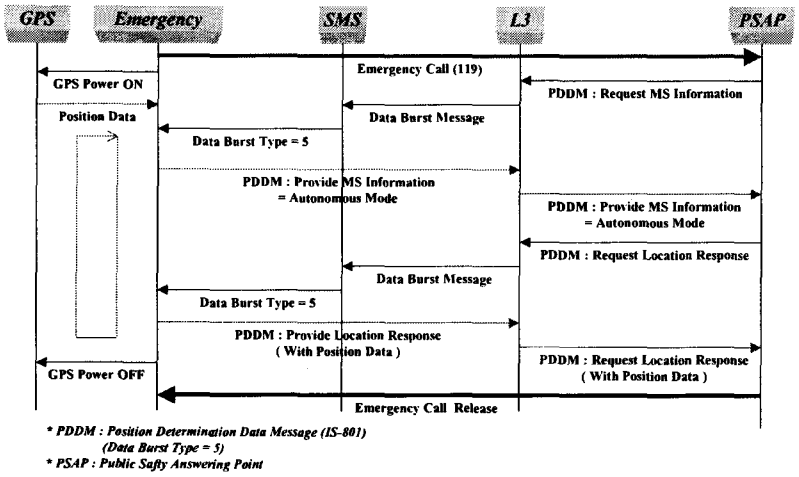
Current Issues

- Repeater
  - RTD information quality
- Continuous Operation
- Multipath

Supplementary

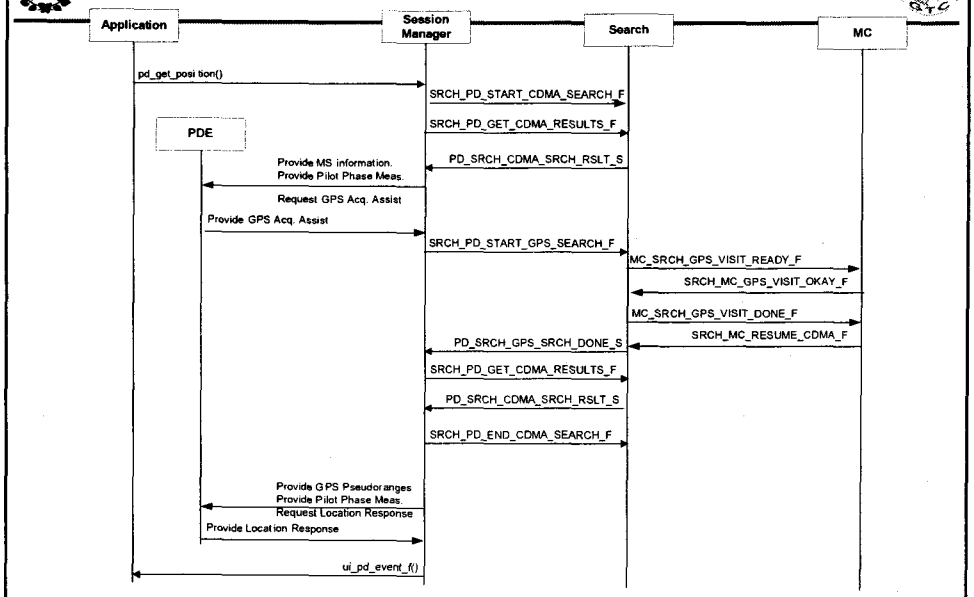
- Emergency Call Flow
- Call Flow Diagram
- PDDM Exchange Procedure
- E911 Initial Position
- E911 Updated Position

Emergency Call Flow

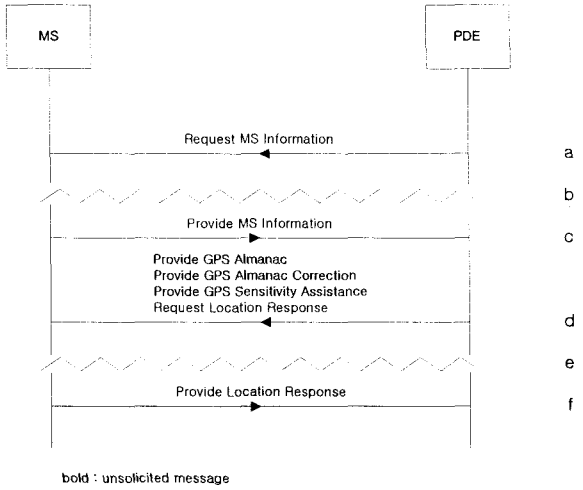


* *PDDM : Position Determination Data Message (IS-801)*
(Data Burst Type = 5)
* *PSAP : Public Safty Answering Point*

Call Flow Diagram



PDDM Exchange Procedure (1)



bold : unsolicited message

Network Assisted GPS

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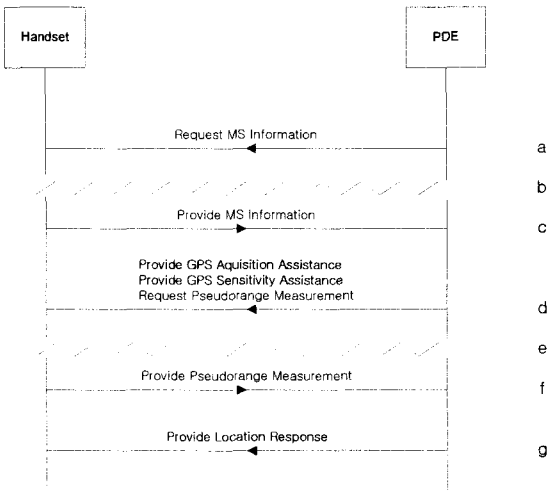
PDDM Exchange Procedure (2)



bold : unsolicited message

Network Assisted GPS

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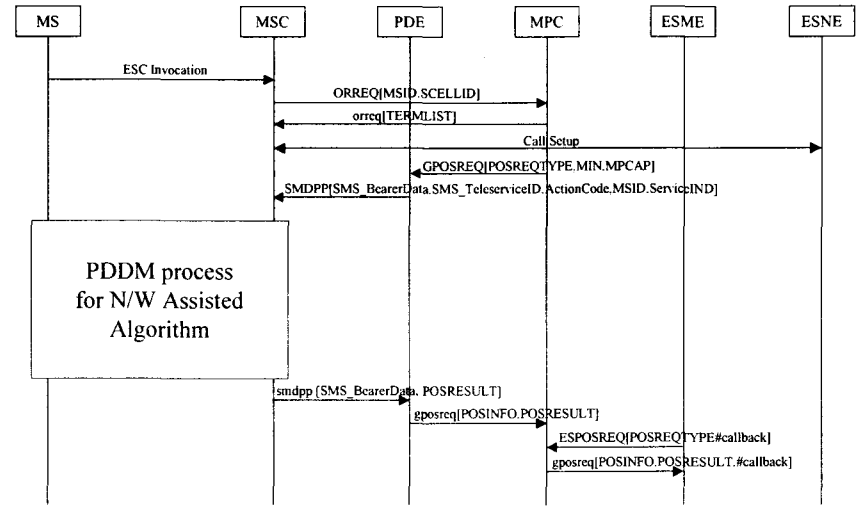
E911 Initial Position



E911 Updated Position