Location Based Services and The Future of Wireless Communications

Mobility Solutions

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Lucent Technologies
Bell Labs Innovations

Outline

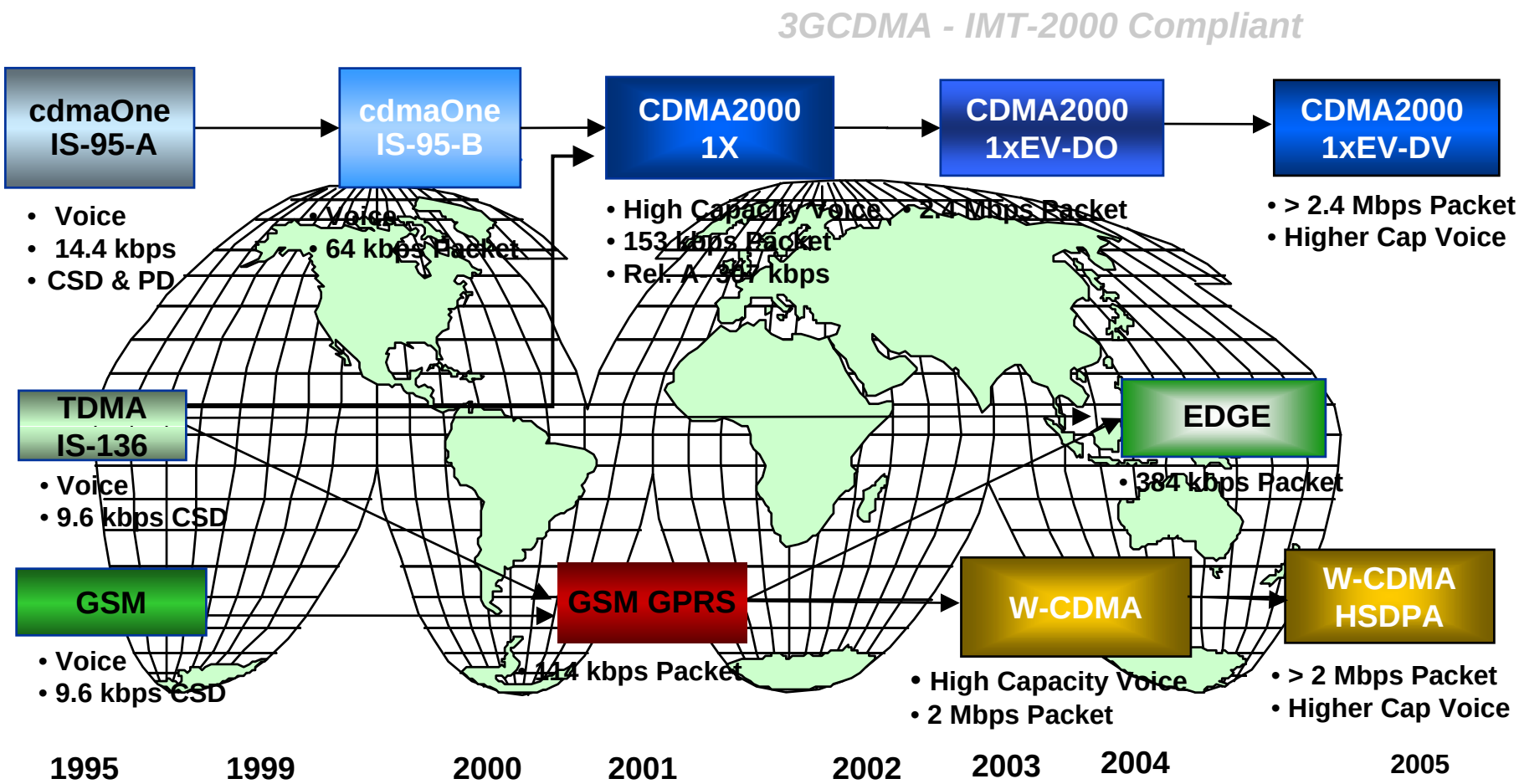
- Mobile industry evolution and trend
- Points of convergence
- Drivers for location based services (LBS)
- LBS architectures
- Mobile location technologies overview
- LBS opportunities
- Conclusion

Source: Bell Labs 75 Anniversary Web Page

Mobile Industry Evolution And Trend

- Telecommunication is coming out of the ***Storm!***
- Telecommunication mega trend: convergence
  - Wireless/Internet: Mobile Internet
  - WLAN/WWAN: WiFi/3G handoff, indoor micro-cells
  - Voice/Data: VoIP
- Points of convergence: IP and mobile handsets
- Mobile technology has evolved from analog to digital
  - 1G->2G->3G
  - 3G is picking up and 4G is in the work
  - Tremendous bandwidth growth
  - Enable new services (value-added services)
- (High) data services are growing at a rapid rate, but low cost voice remains important
  - ARPU for voice coming down due to competition and saturation
  - Value-added services important for new revenue
  - Many data services require high speed and large bandwidth

Global Wireless Evolution

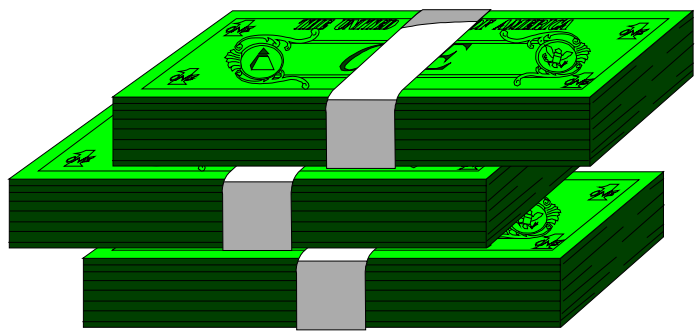


GSM: Global System for Mobile Communications
CDMA: Code Division Multiple Access
TDMA: Time Division Multiple Access
GPRS: General Packet Radio System
W-CDMA: Wideband CDMA

HSDPA: High Speed Downlink Packet Access
EDGE: Enhanced Data rates for GSM Evolution
EV: EVolved
DV: Data and Voice
DO: Data Optimized

Why Are We Interested in LBS?

- Big opportunity: Many surveys show multibillion dollars market
- FCC E911 requirements provide an initial stimulus
- Service providers wants LBS to improve revenue
- LBS capability is a platform enhancement that
  - enables vertical applications
  - facilitates network performance/optimization features (synergistic with intelligent antenna technology)
  - is a key feature in 3G systems



Some Location Based Applications

- End-User Applications
  - Wireless E-911
  - 511 traveling services
  - Emergency roadside assistance/ stolen vehicle recovery
  - Personal locator service/ personal security
  - Location assisted concierge services & yellow pages, nearest POI
  - Traffic warning
  - Enhanced call routing
  - On line navigation and directions services
  - Fleet management (AVL - automatic vehicle location)
  - Government personnel tracking/personal security
  - Offender tracking (house arrest)
- Service-Operator Applications
  - Location sensitive billing
  - Cellular fraudulent user arrest/prosecution
  - Wireless system performance optimization
  - Cellular inter-system border negotiation

End-to-End LBS Solution

Component	*Product or Technology*
LCS enabled wireless network	**Network elements with LCS features**
New chip sets	**VLSI includes AGPS**
Mobile Station or PDA	**New hardware with AGPS chip set, GPS antenna**
Client platform Software	**New protocol stacks, LCS API**
Client to Server interface	**Handling LCS messages**
SMLC/PDE/AGPS server	**Software to support various location determination algorithms**
GMLC/MPC	**Gateway software to LCS features**
GPS satellite reference service network	**Reference stations and access points using DGPS receivers and IP network**
Internet services gateway	**Gateway between Internet and wireless network, combing services**
Applications and contents	**Include both client and server applications**

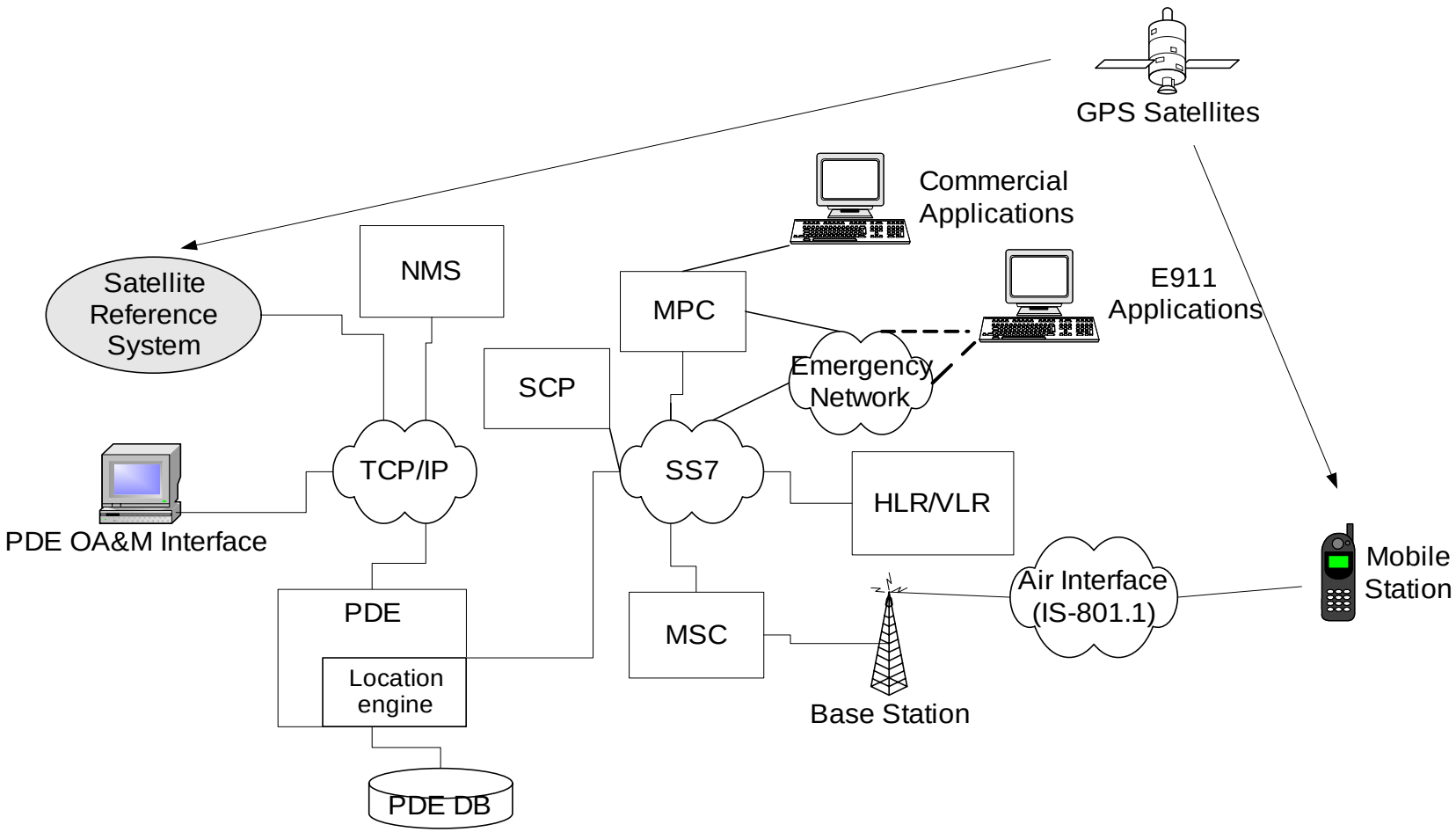
Wireless Geolocation Standards

- IS 801: air interface message standard for CDMA systems
- Jstd-036: network standard for E911 service
- IS 881 (PN4747): wireless network element interoperability standard for enhanced location services
- IS 843 (PN 4818): WIN based enhanced location service standard
- 3GPP LCS standards
  - TS25.305 (RAN2) - Stage 2 functional specification of location service in UTRAN
  - TS25.331 (RAN2) - RRC protocol specification
  - TS25.215 (RAN1) - Physical layer - measurements (FDD)
  - TS25.133 (RAN4) - Requirements for support of radio resource management (FDD)
  - TS25.171 (SA1) - Functional stage 2 description of location services in UMTS

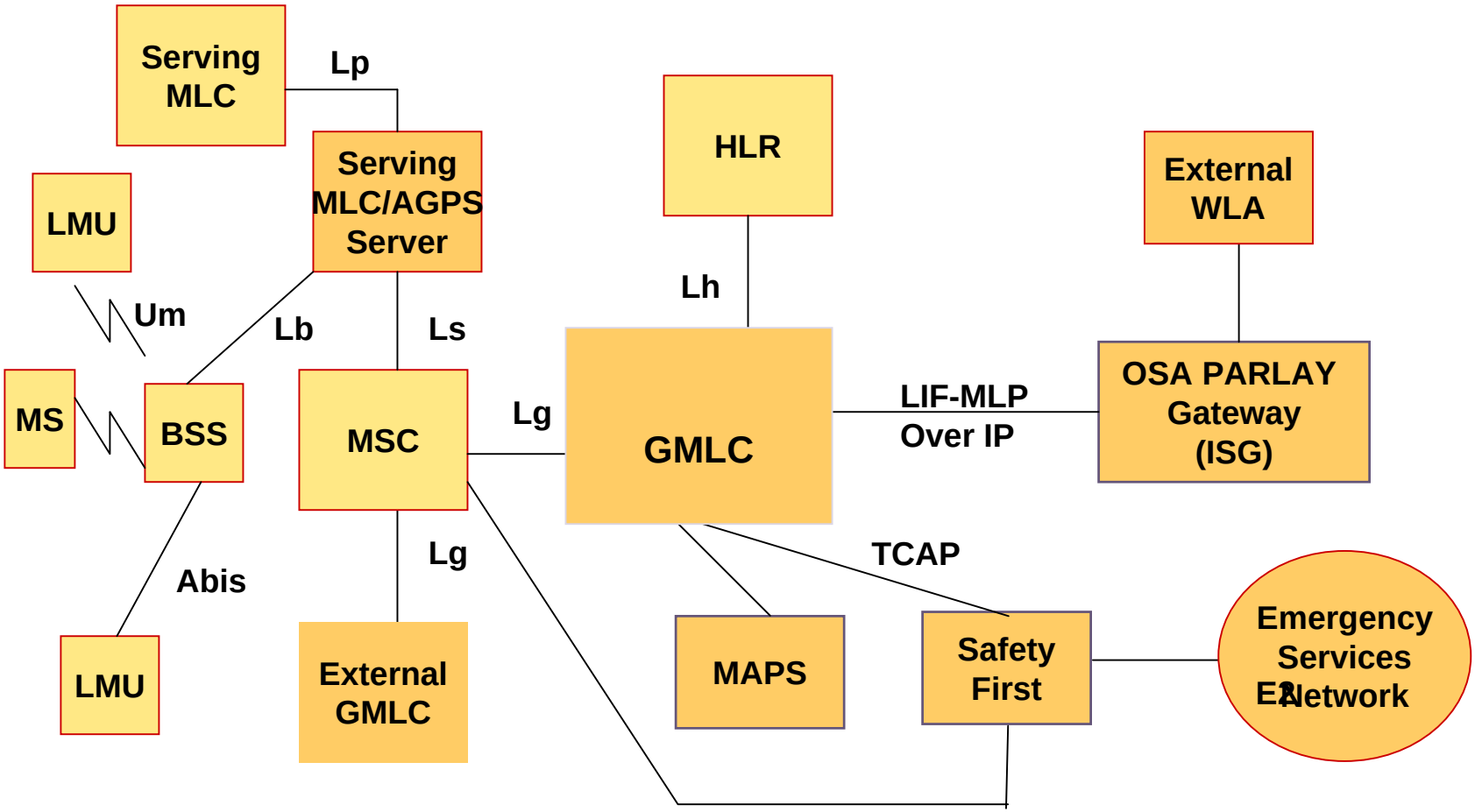
Ad hoc industry groups:

- OMA
  - LIF
  - MLP
- GSM Association PRD SE.23
- AGPS Forum

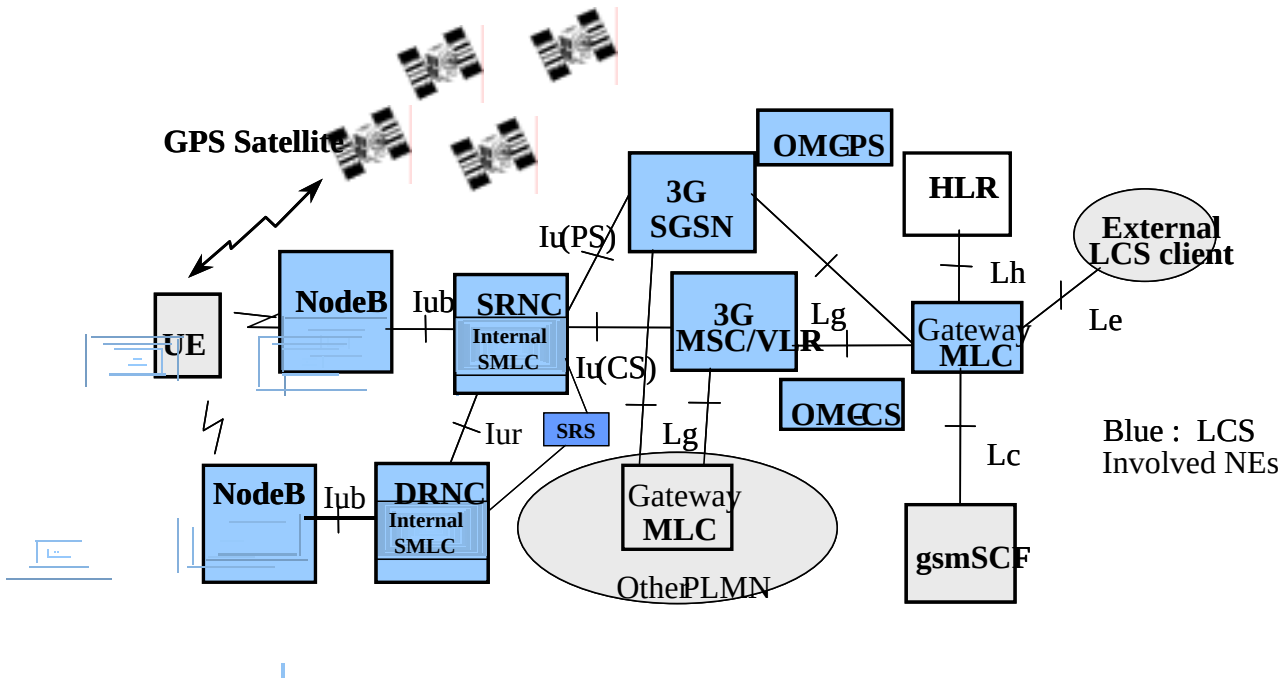
CDMA 2G Wireless LBS Architecture



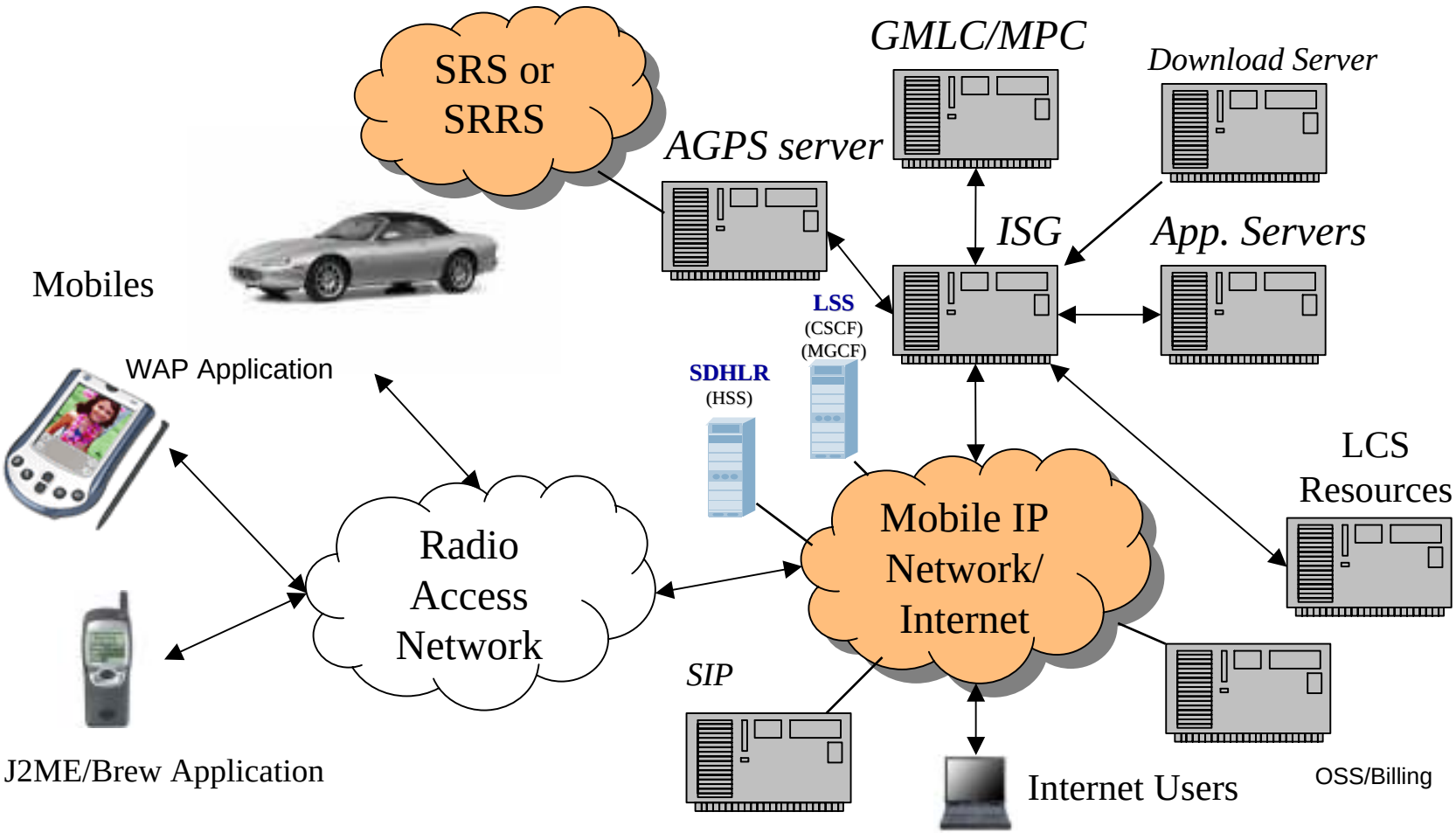
GSM LBS Architecture with OSA



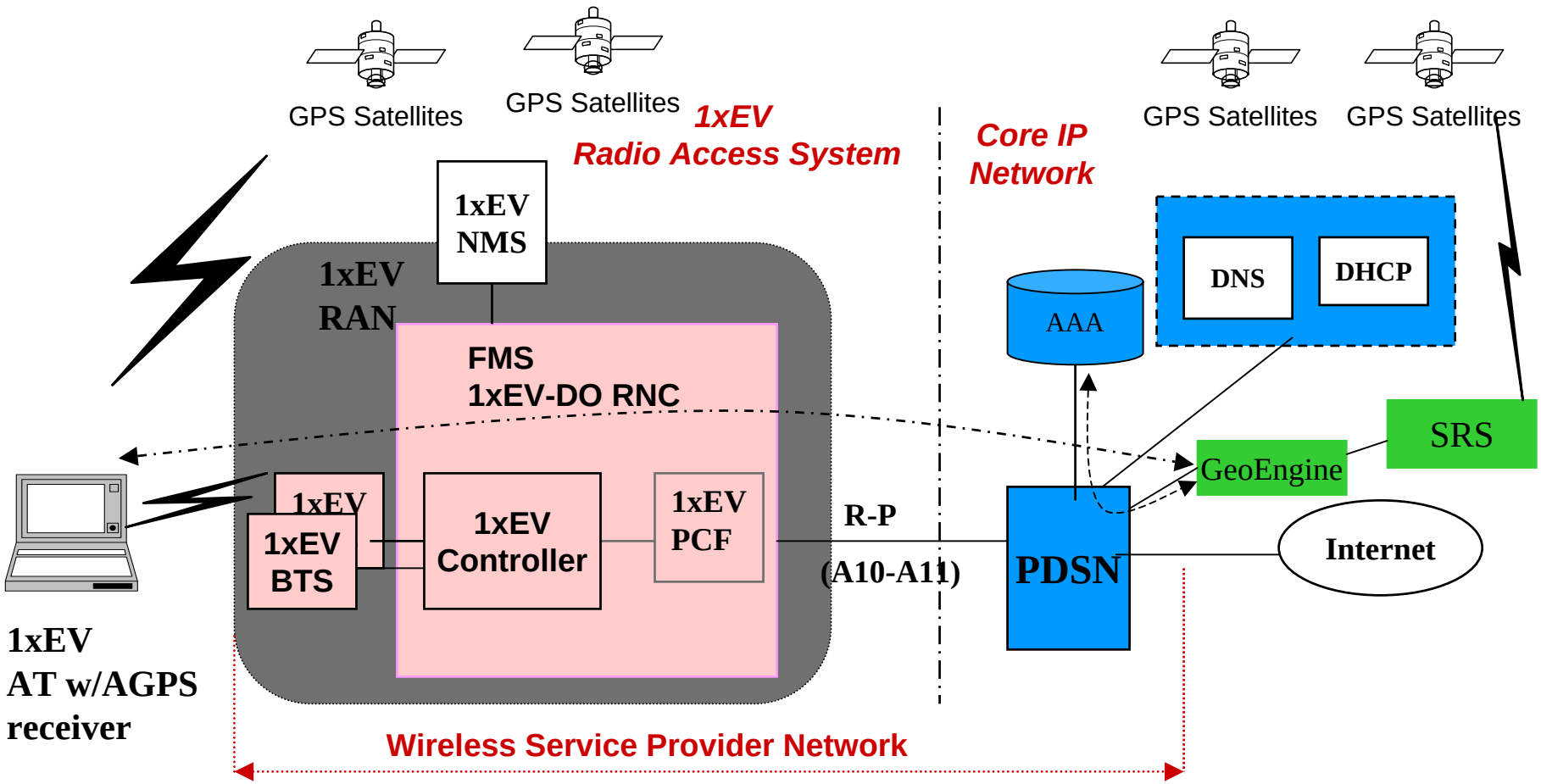
UMTS LCS Architecture



New IP Based LBS Architecture



IP Based LBS Architecture For 1xEV-DO



AT - Access Terminal
RAN - Radio Access Network
RNC – Radio Network Controller
NMS - Network Management System
PCF - Packet Control Function

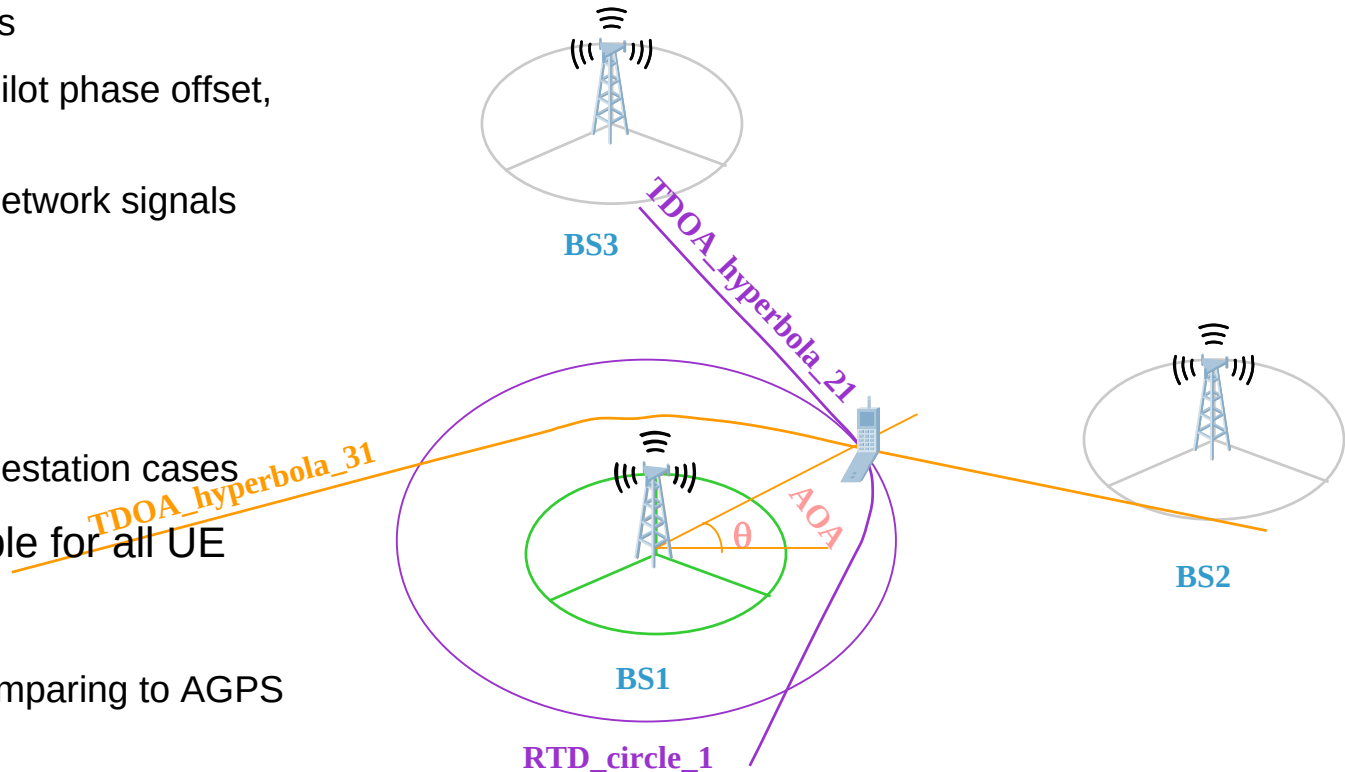
PDSN - Packet Data Service Node
AAA - Authentication, Authorization and Accounting
DNS - Domain Name Server
DHCP - Dynamic Host Configuration Protocol
SRS – Satellite Reference Service
GeoEngine – Lucent AGPS server

Wireless LBS Technologies Overview

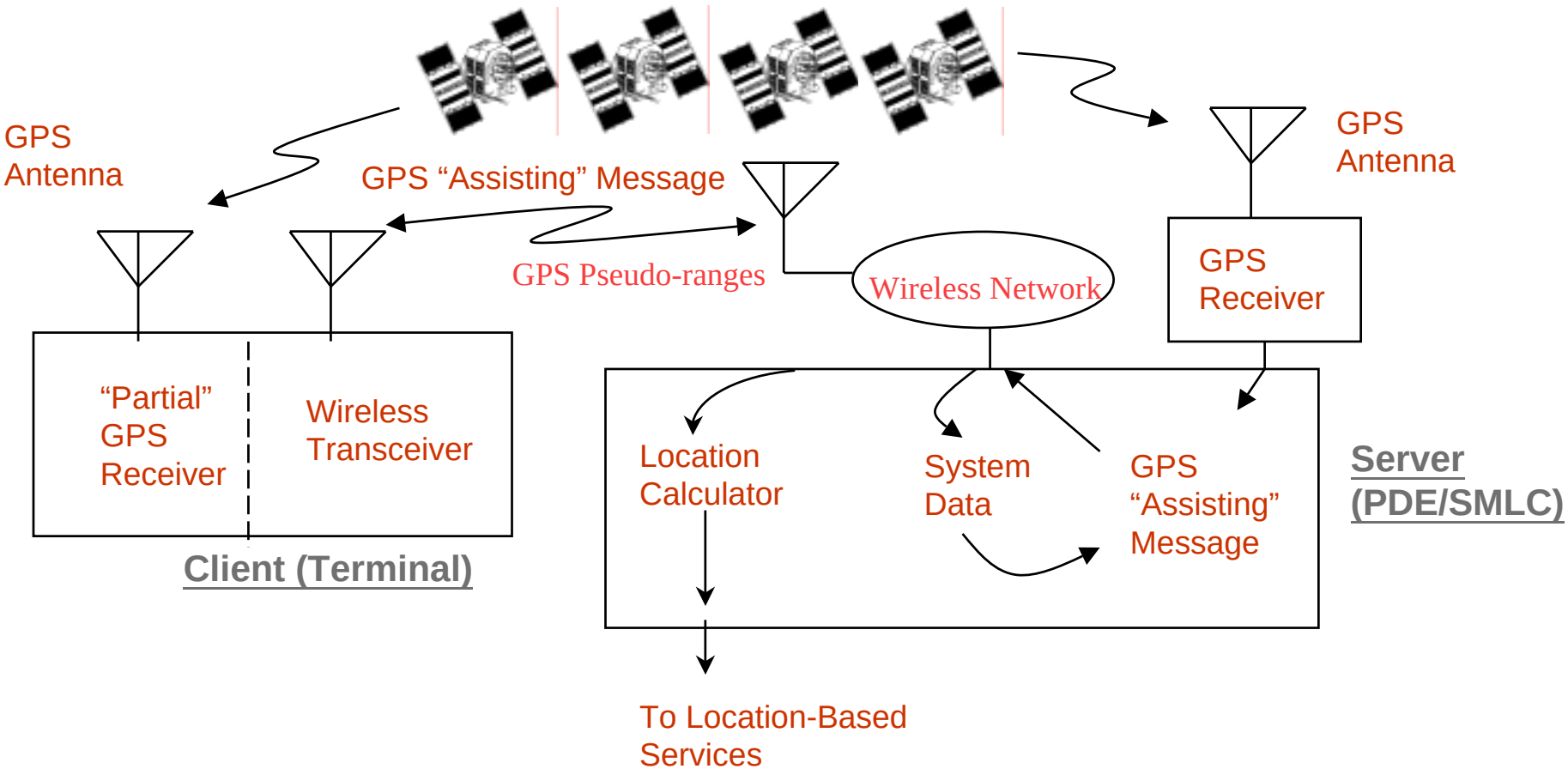
- Basic algorithms
  - TDOA
  - TOA
  - AOA
  - Pattern match (finger printing)
- Methods used in wireless industry
  - Cell ID: low accuracy
  - Enhanced Cell ID (Cell ID + RTD + sector antenna AOA): low accuracy
  - EFLT in CDMA: handles legacy handsets, medium accuracy
  - AFLT (EOTD, OTDOA) : requires new handsets, medium accuracy
  - GPS : high accuracy outdoor, not work indoor or shadow environment, slow cold start
  - AGPS: high accuracy
  - Hybrid AGPS: best perform

AFLT/EFLT Method

- Use forward link signals
- handset reports back pilot phase offset, and power strength
- Integration with more network signals
  - RTD
  - Handet delay
  - AOA
- Handle less than 3 basestation cases
- Advantage: available for all UE
- Disadvantage:
  - Lack accuracy comparing to AGPS



Assisted GPS (AGPS)

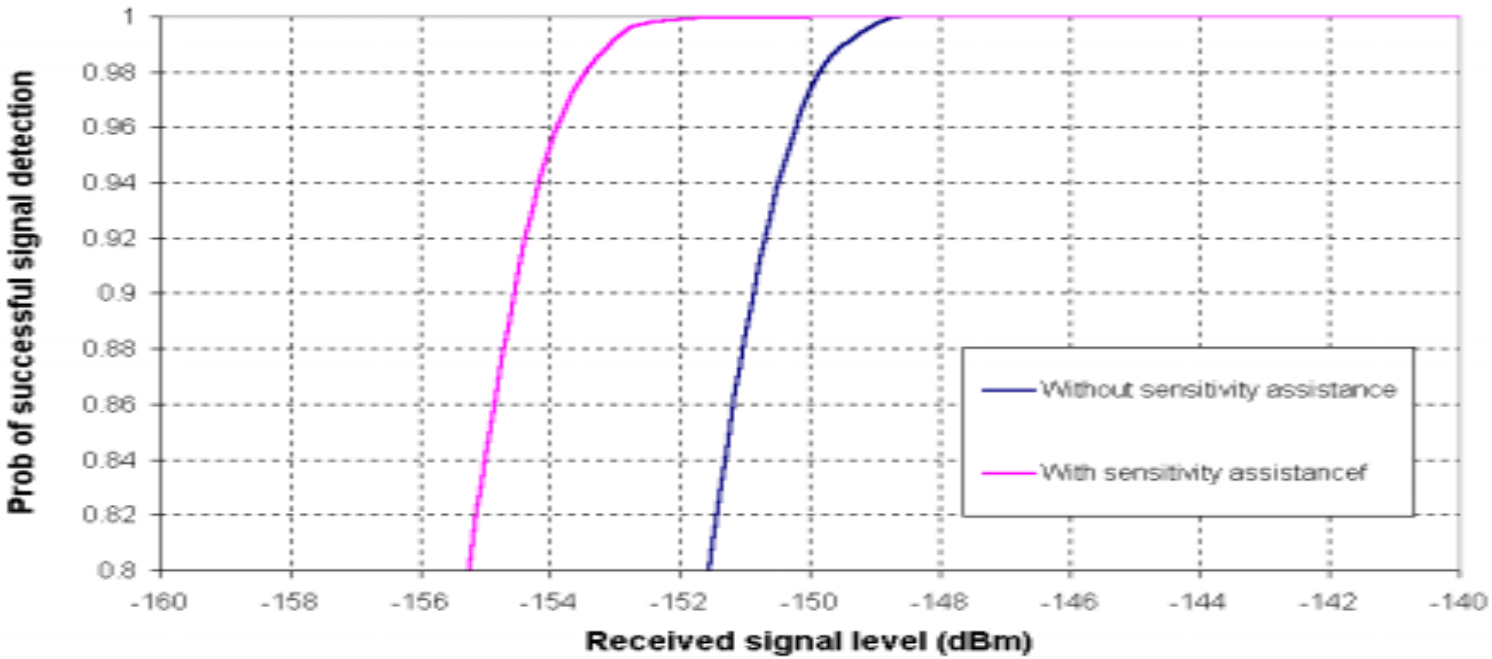


Advantages Of AGPS Over GPS

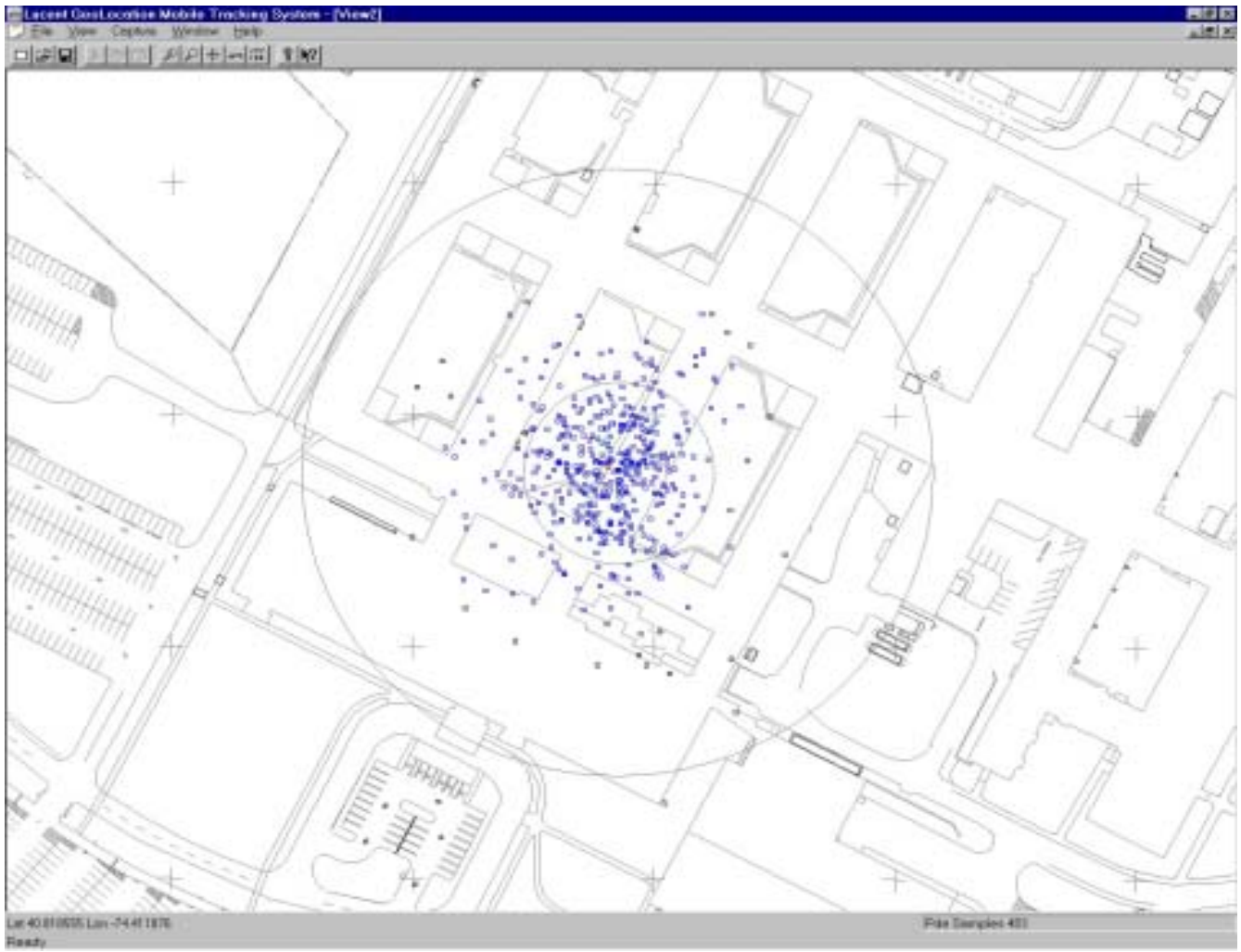
- Higher gain and sensitivity
  - 20 db over regular GPS
  - Works indoor and shadowed environments
- Fast acquisition time
- DGPS accuracy outdoor
- Lower battery drain in handset
- Lower cost in handset

Unique to Lucent: Modulation Wipe-off doubles sensitivity

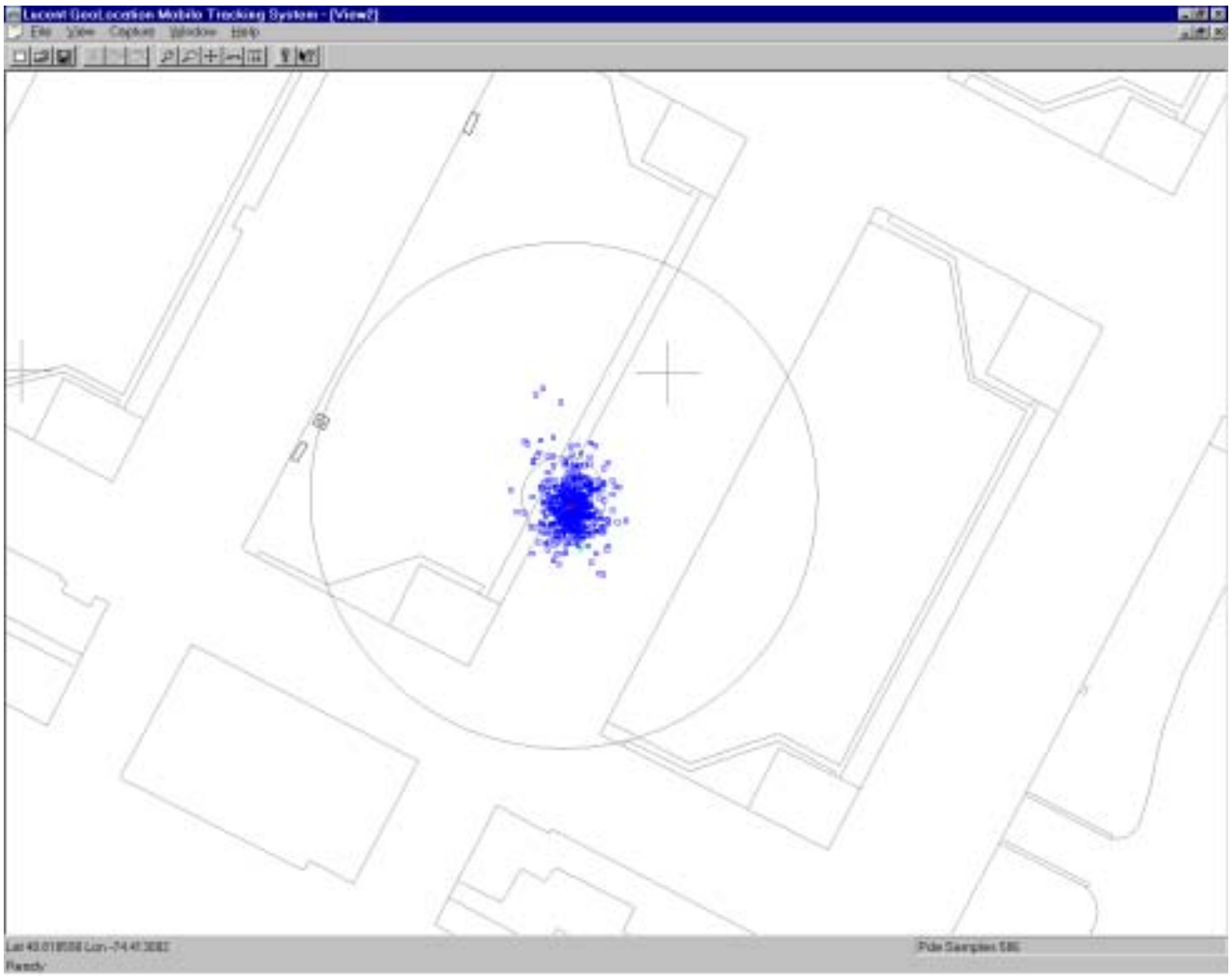
- **Modulation wipe-off enables long, coherent integration which doubles sensitivity (by 3-4) dB leading to deeper coverage indoors**



Lucent AGPS Technology Prototype Lab Test Indoor

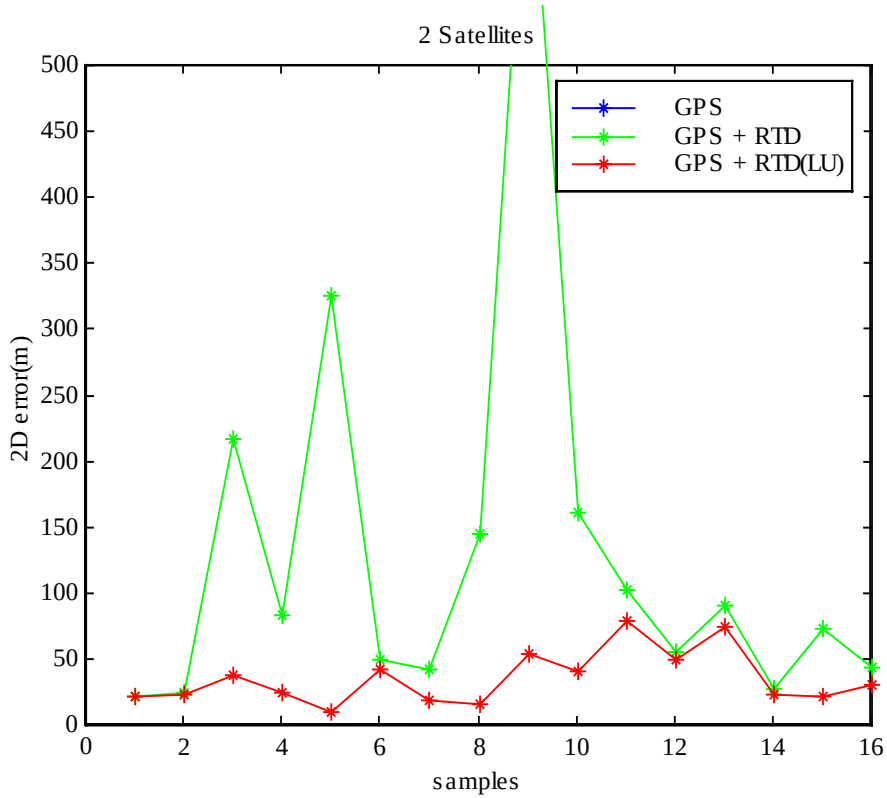


Lucent AGPS Technology Prototype Lab Test Outdoor



Unique to Lucent: "Hybrid" approach eliminates Gaps when only 2 satellites visible

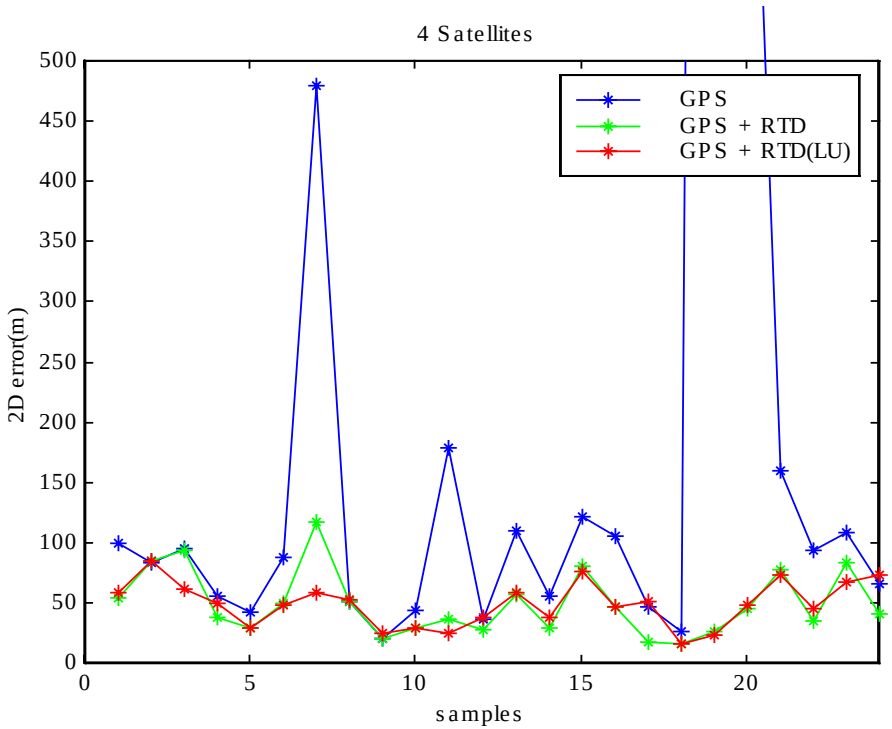
- Even with network assistance, it frequently happens that only 2 or fewer GPS satellites are visible indoors; in these cases:
  - The LU approach using hybrid data, can find a solution
    - GPS-only solutions will FAIL to achieve a fix
  - Using our proprietary algorithm in the PDE, the solution achieves good accuracy.



NOTE: data shown are

Unique to Lucent: "Hybrid" approach eliminates inherent gaps even when enough satellites are visible

- Gaps are likely even when 4 satellites are visible
- When enough satellites can be seen indoors, all assisted GPS approaches get a fix but the quality varies widely
  - Without network data
    - Accuracy can be very poor
    - Poor satellite alignment and multipath sometimes preclude ANY solution



Opportunities in End-to-End LBS Solution

Component	*Product or Technology*
LCS enabled wireless network	**Network elements with LCS features**
New chip sets	**VLSI includes AGPS**
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LBS Opportunities

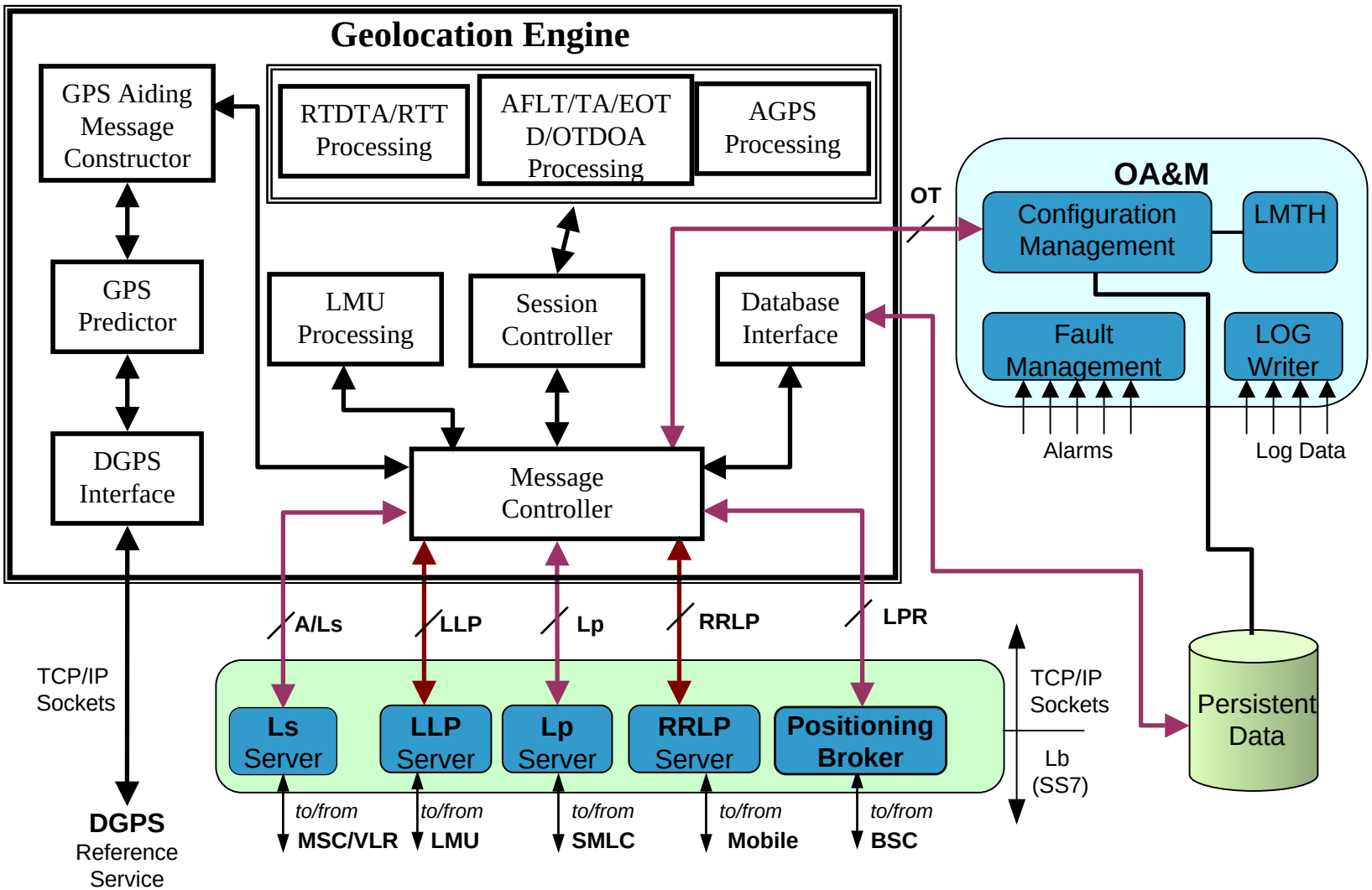
- Server applications
  - Application software that run on a server to provide LBS
- Handset applications
  - Application software that run on a handset to provide LBS
- New handset platform
  - New hardware (e.g., AGPS), software, and protocol stacks to support LBS application software
- Gateways
  - Internet gateway to combine other services with LBS
  - Mobile location gateway to provide LBS supports
- End to end solution and integration

Conclusion

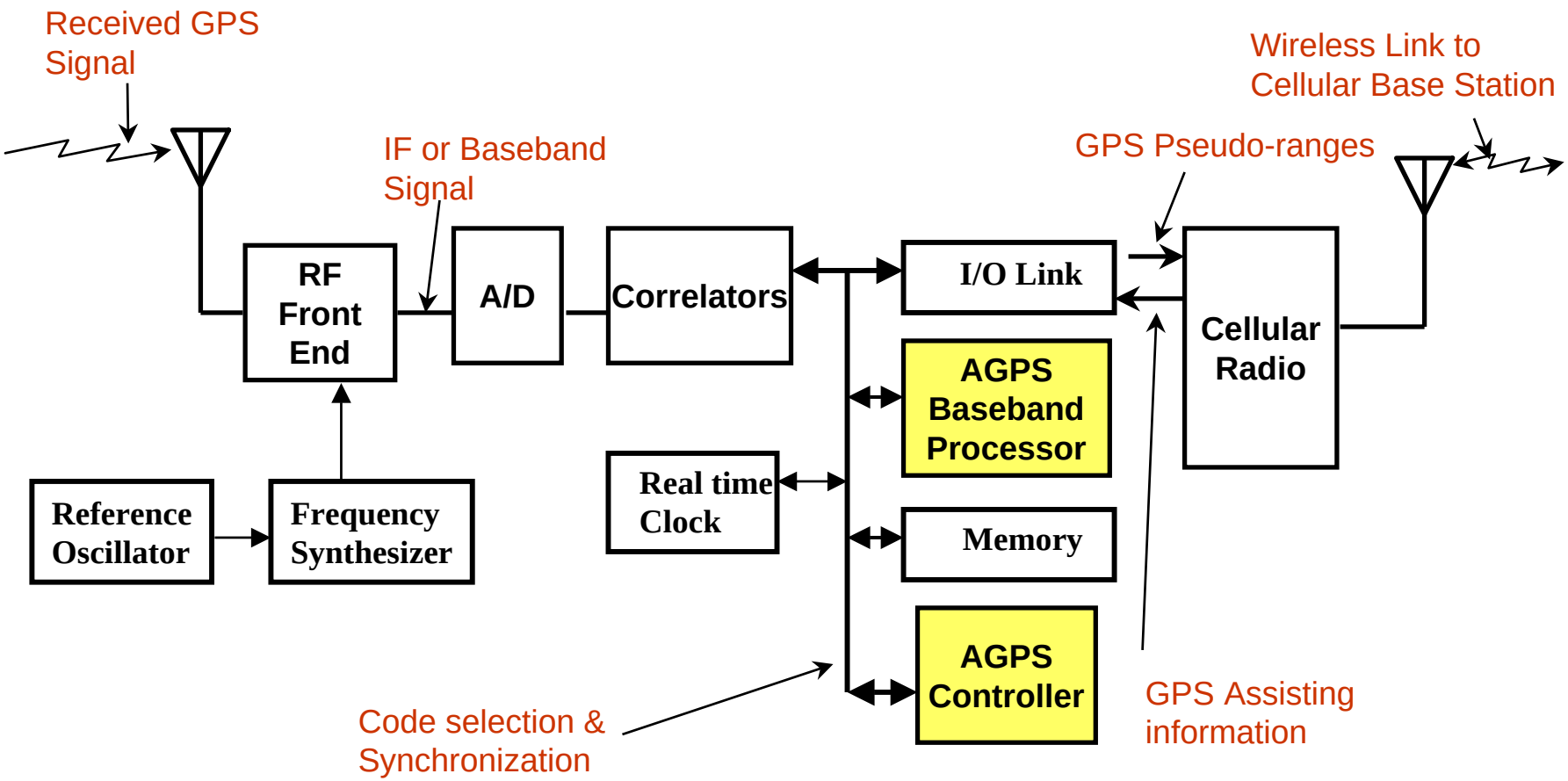
- Telecommunication industry is merging with other industries and no longer only for “communication”
- Voice services are under competitive pressure
- Data services will have high growth rate
- Value added services will be necessary for service providers to compete
- LBS is a value added service that starts to take off
- Many opportunities exist for the industry

Backup Slides

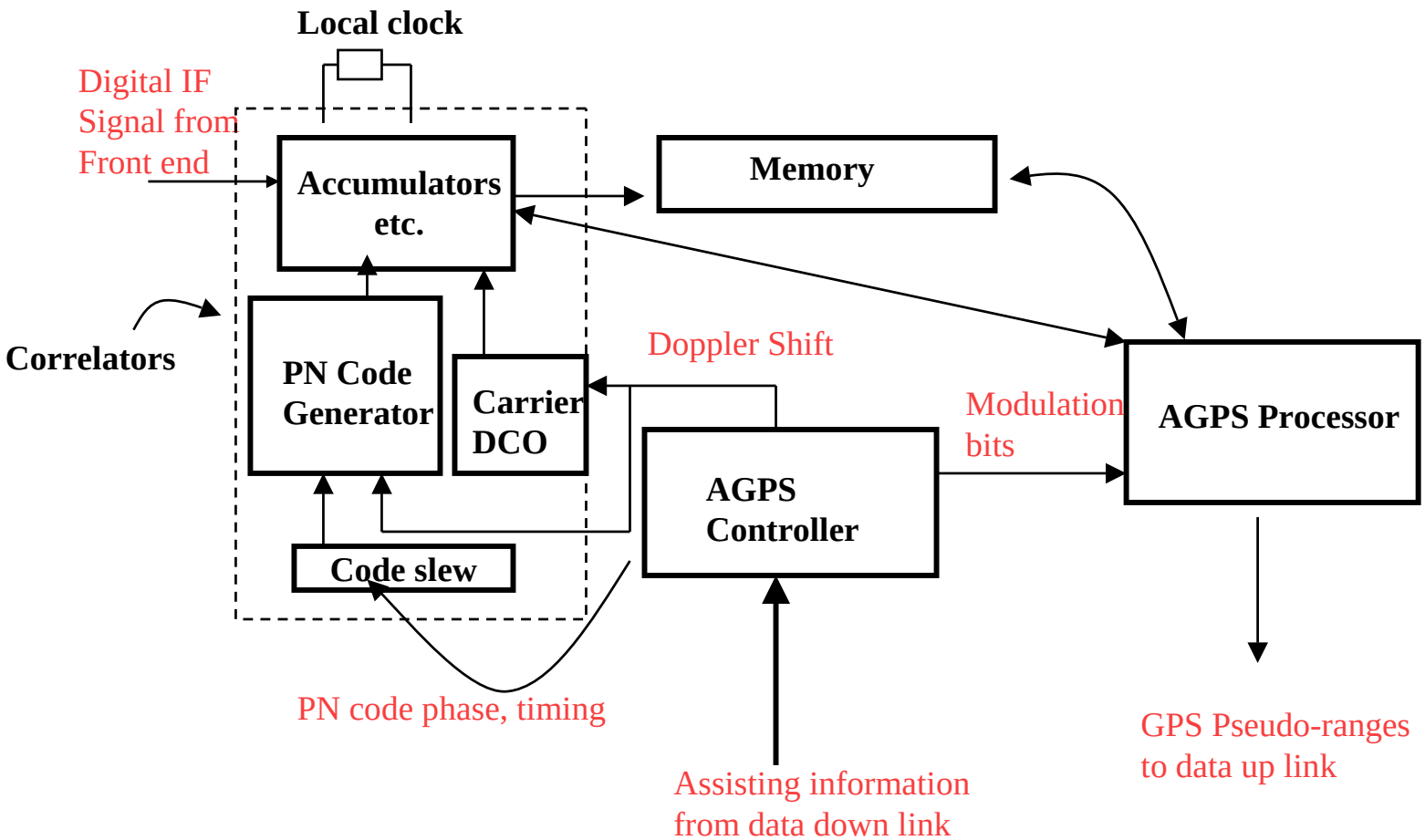
CDMA/PDE And BSC/RNC Integrated SMLC (With All Lucent Software) - Software Architecture Overview



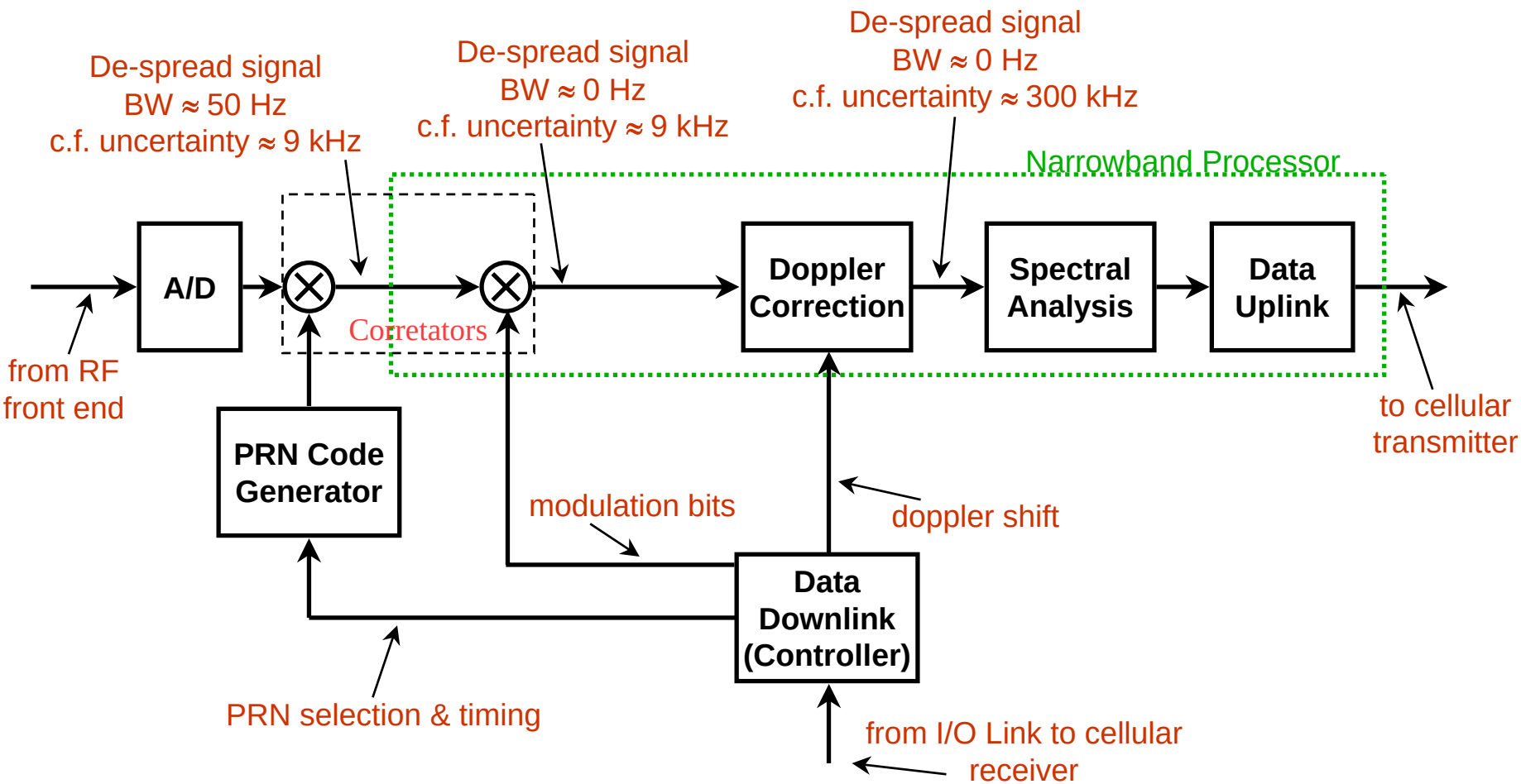
Assisted GPS Receiver In Handset



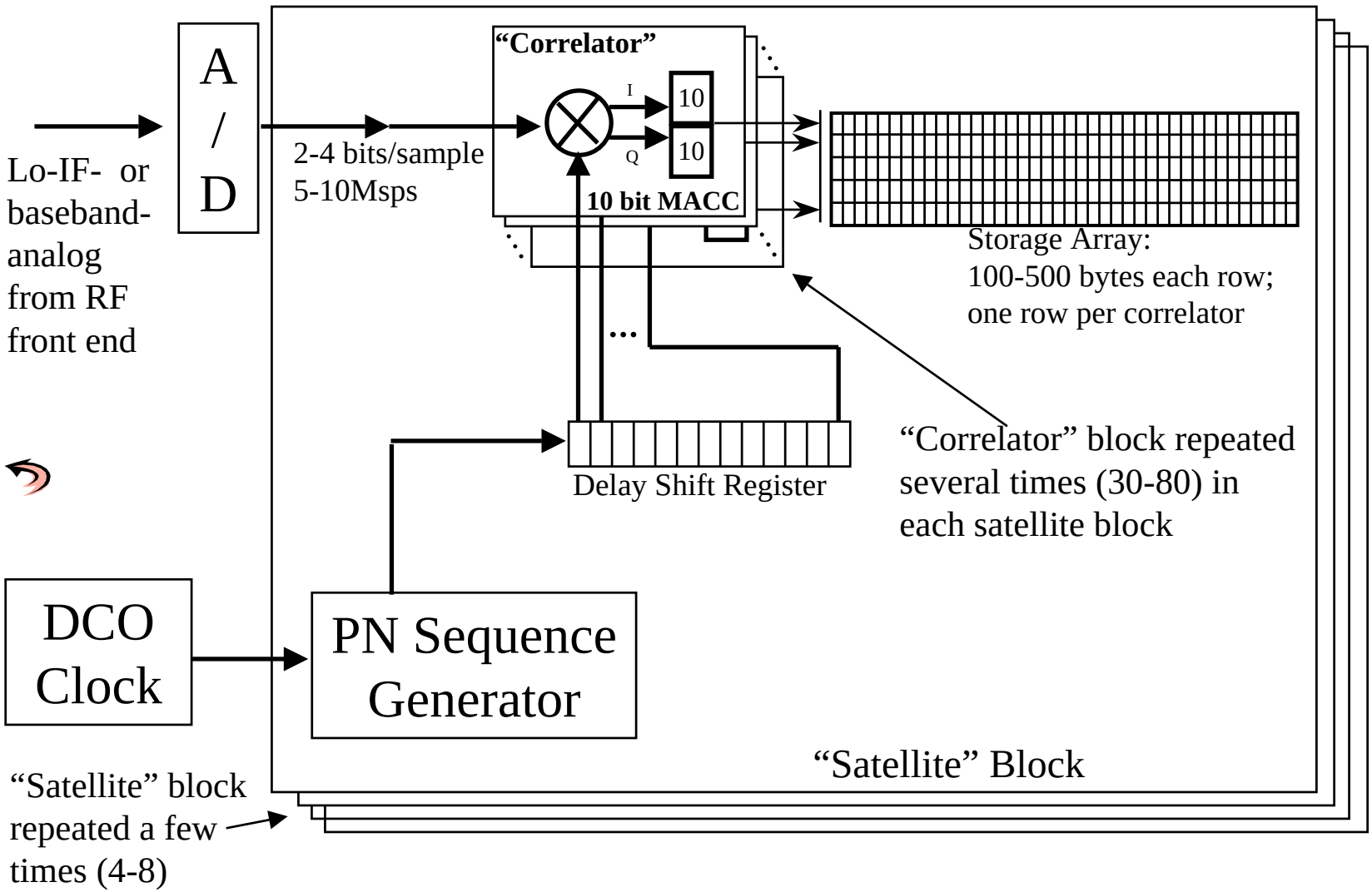
AGPS Signal Processing



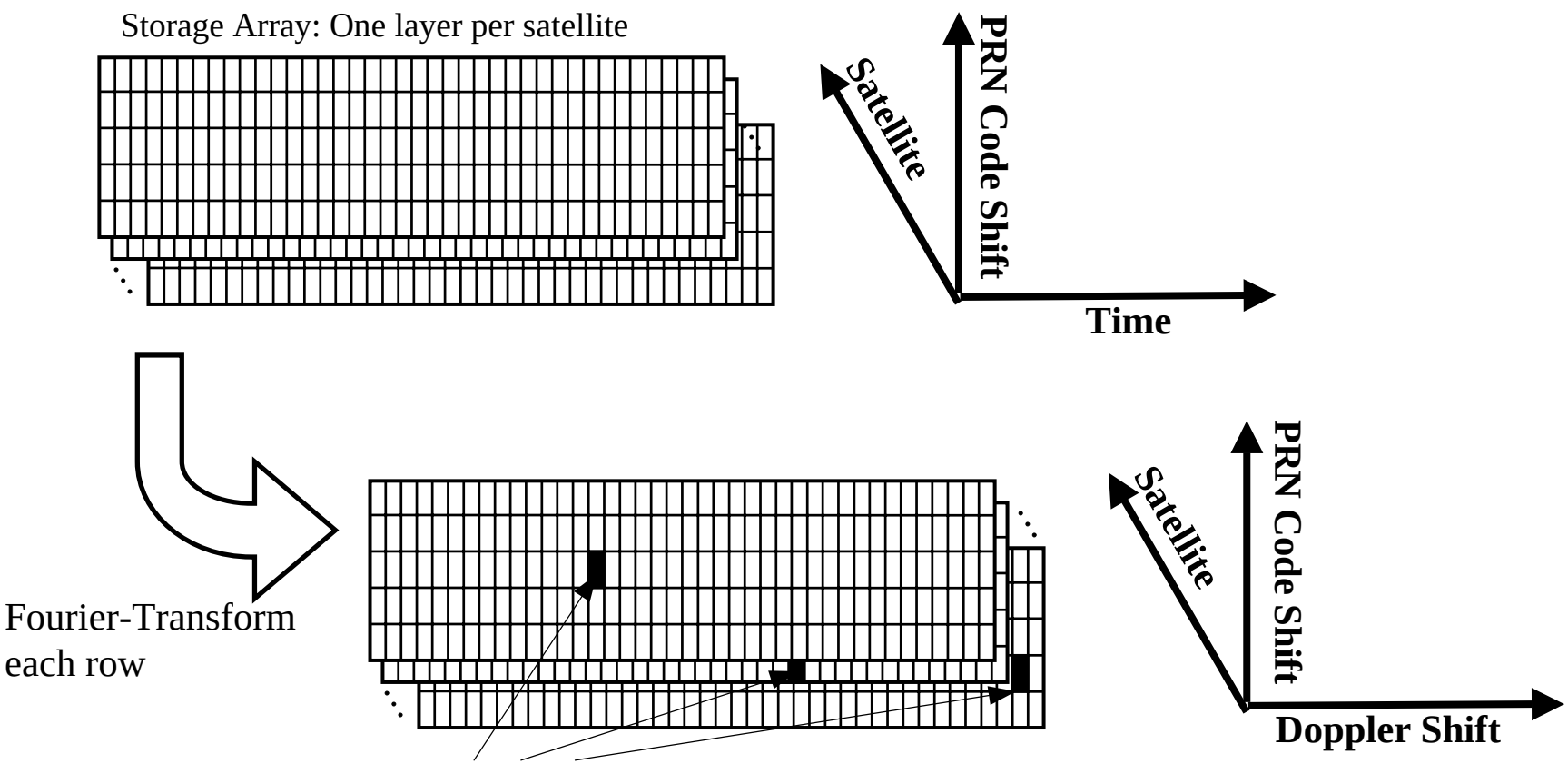
Signal Processing in Narrowband Processor



Baseband Signal Processing - Hardware



Baseband Signal Processing - Software



One cell in each layer contains the satellite signal, the others contains noise.

Some Examples of Handsets











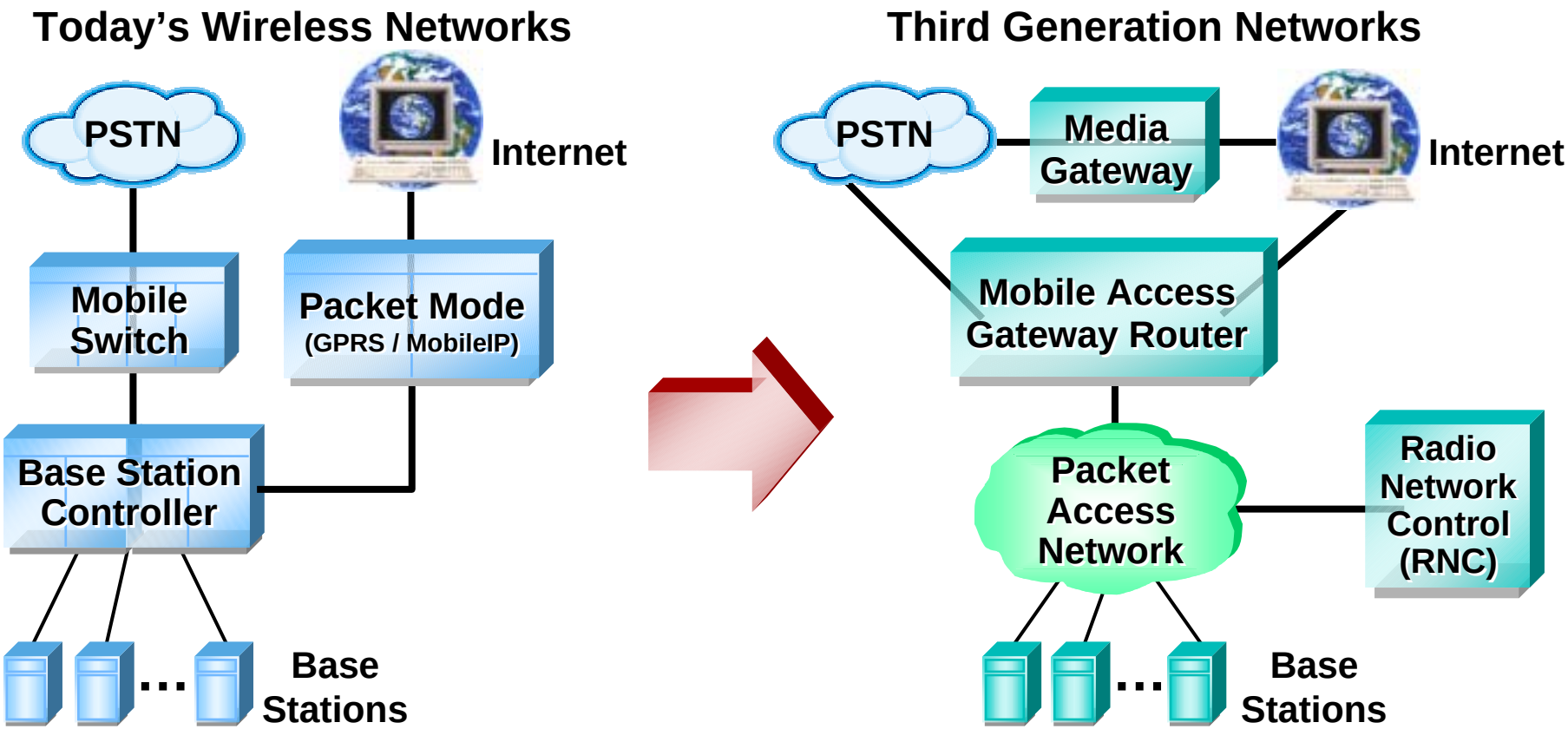









IP as Point of Convergence: Network Architecture 2G to 3G

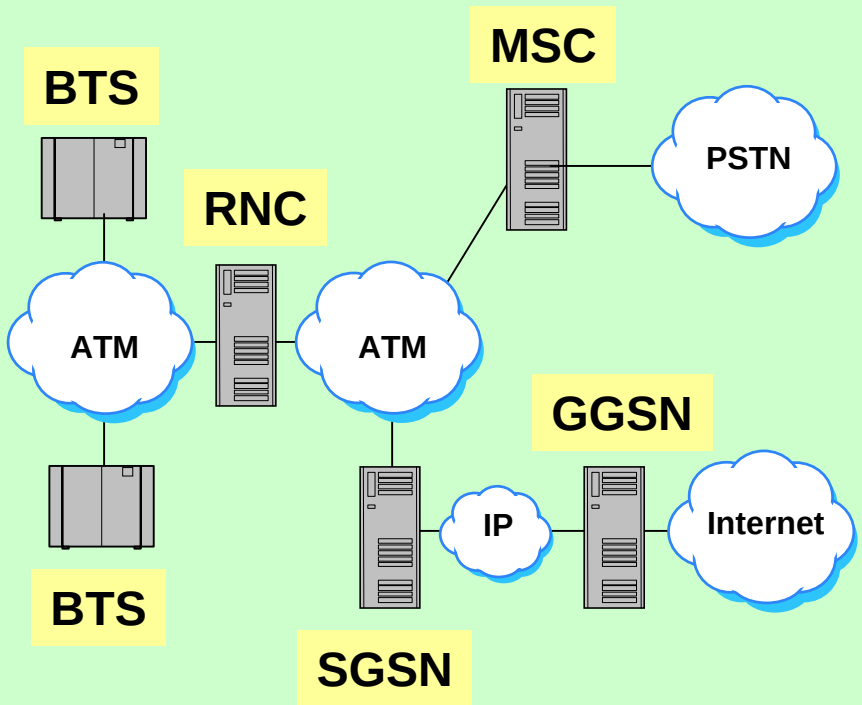


Capability Implications (2G ⇨ 3G)

- **Air Interface:** Increased voice capacity & data rates (9.6 kbps ⇨ Mbps)
- **Transport/Switching:** Circuit switched ⇨ Packet routed
- **Interconnect:** Voice to PSTN, Data to Internet ⇨ Voice & Data to Internet

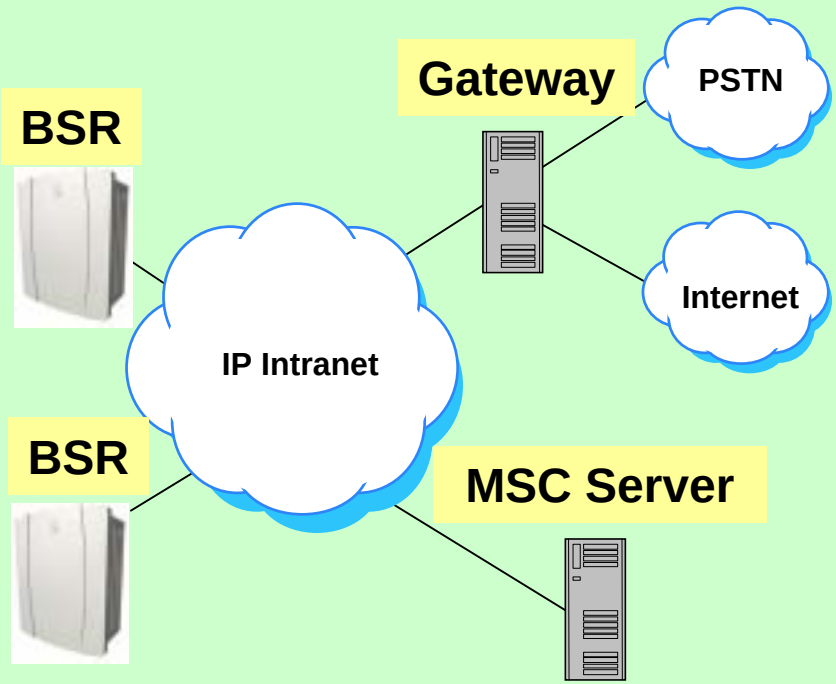
IP as Point of Convergence: 3G Architecture Comparison

Internet on Mobile



- Internet added to a mobile network
- Legacy 2G architecture, all intelligence in the RNC and core elements
- Optimised for circuit-switched traffic
- Circuit/packet switching and ATM transport

IP Mobile Internet (BSR)



- Mobility added to the Internet
- Optimised for IP data traffic and services
- Intelligence at the edge of the network
- Inefficiencies of R99 removed, end-to-end latency reduced by 50%
- IP switching and transport

Handset As A Convergence Point

- Multiple modes to work with multiple air interface standards, including WWAN and WLAN
- Multiple functionalities to meet demands on communications, information services, multimedia streaming, VoIP, LBS, gaming, entertainment, and computing
- Integrate multiple technologies: AGPS/GPS, Bluetooth, MP3, MPEG, J2ME, camera, sensors, voice control, MIMO for different applications
- Various form factors include color screen, HiFi sound, keyboard, and fashion statement
- High degree of integration, low power consumption, low cost solution are needed
- Impose challenging design issues on handsets and chipsets
- Collaboration between handset vendors and infrastructure vendors is also needed, for example, IOT for compliance and interoperability

High Speed Data for Enterprises

The Lucent HSDe demonstrates:

- The benefits for real Enterprise users of Mobile 3G high speed data capability
- Seamless convergence with WiFi technologies addressing security, authentication, network selection, seamless billing, and seamless roaming.
- Mobile Network Operator value added services can enable to deliver:
  - Compelling and easy to use tools for the end user
  - Revenue for the MNO.
- Seamless and transparent multi network roaming in a user friendly way.

High Speed Data for Enterprises

- Enterprise applications that create demand for 3G:
  - video conferencing
  - email
  - Citrix
  - Siebel Sales tools
  - security, etc.

Mass Market VAS And Solutions

- **Collaboration Services and Solution Examples: Community Group Services**

  IP Multimedia Subsystem (IMS)
  will support

  – Full Duplex VoIP SIP to PSTN calls:

  – Real time Video SIP Calls:
  Real time Web Sharing

- **Network Intelligence**:

  – MiLife ISG (Intelligent Services Gateway)

  – Lucent Assisted GPS solution: to support LBS

- **Converged Messaging Solutions**:

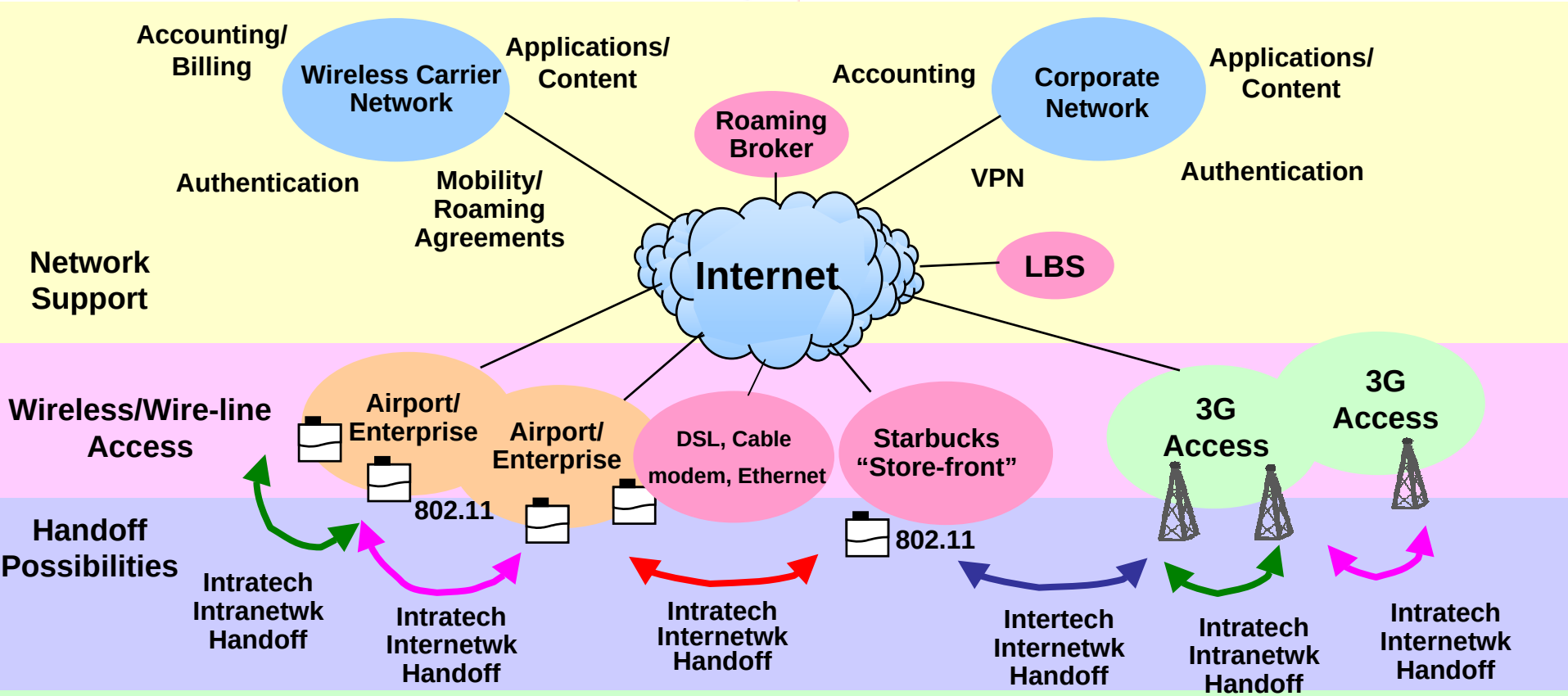
  – AnyPath and WebVoiceMail – mobile converged messaging.

  – AnyPath and Ecrio Short Voice Service (PDA via 3G handset)

- **eMRS Multimedia Portal Personal Video Greeting**

- **SurePay Pre-Pay Platform**

Complete Service Picture



Subscriber Service

Uninterrupted Applications: Streaming, Email, Corporate VPN, Web, LBS

One Bill from Wireless Carrier/ Bundled Data Package

Seamless Mobility/Roaming for Subscriber

Terminal Possibilities

Dual Interface

Built-in 802.11

Built-in 802.11 3G data card

Combined Air Card

Universal Handset ??

Global Summary

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total subscriptions (000)	480,106	732,730	952,624	1,106,814	1,261,963	1,413,736	1,565,610	1,710,180	1,845,525	1,970,671	2,084,276	2,183,299
Growth (%)		52.62	30.01	16.19	14.02	12.03	10.74	9.23	7.91	6.78	5.76	4.75
Population (000)*	5,959,923	6,028,285	6,109,802	6,276,432	6,364,000	6,440,939	6,529,706	6,612,424	6,685,889	6,766,144	6,839,806	6,917,713
Penetration	8.06	12.15	15.59	17.63	19.83	21.95	23.98	25.86	27.60	29.13	30.47	31.56
ARPU month (US$)	41.86	36.08	33.13	32.22	31.87	31.97	32.13	32.13	32.20	32.66	33.59	34.59
ARPU year (US$)	502.30	432.98	397.58	386.66	382.49	383.66	385.62	385.53	386.40	391.98 4	03.11	415.11
Total revenues (US$ mil.)	241,160	317,254	378,745	427,962	482,693	542,395	603,730	659,327	713,117	772,454	840,197	906,306
Growth (%)		31.55	19.38	12.99	12.79	12.37	11.31	9.21	8.16	8.32	8.77	7.87
Revenues (US$ mil.)												
Voice	**236,231**	**304,033**	**356,248**	**400,388**	**439,905**	**477,413**	**515,097**	**543,314**	**568,948**	**595,295**	**624,836**	**649,427**
Data	**4,928**	**14,952**	**26,448**	**37,744**	**51,629**	**71,011**	**93,333**	**119,452**	**146,522**	**179,999**	**218,560**	**260,551**
Revenue share (%)												
Voice	**97.96**	**95.31**	**93.09**	**91.39**	**89.50**	**87.05**	**84.66**	**81.98**	**79.52**	**76.78**	**74.09**	**71.37**
Data	**2.04**	**4.69**	**6.91**	**8.61**	**10.50**	**12.95**	**15.34**	**18.02**	**20.48**	**23.22**	**25.91**	**28.63**
Tech subs (000)												
Analogue (eg AMPS) subs	81,329	63,253	53,761	41,075	29,412	24,788	19,491	11,265	5,587	338	233	150
Digital (GSM, CDMA, TDMA, PDC) subs	398,778	669,353	894,675	1,041,787	1,160,738	1,237,479	1,271,734	1,250,466	1,168,007	1,038,649	898,329	920,104
2.5G subs	0	123	4,162	22,876	60,510	119,834	204,695	316,831	453,025	599,953	725,711	716,073
3G subs	0	0	25	1,077	11,303	31,634	69,690	131,618	218,907	331,730	460,003	546,971
Tech shares (%)												
Analogue (eg AMPS) subs	16.94	8.63	5.64	3.71	2.33	1.75	1.24	0.66	0.30	0.02	0.01	0.01
Digital (GSM, CDMA, TDMA, PDC) subs	83.06	91.35	93.92	94.12	91.98	87.53	81.23	73.12	63.29	52.71	43.10	42.14
2.5G subs	0.00	0.02	0.44	2.07	4.79	8.48	13.07	18.53	24.55	30.44	34.82	32.80
3G subs	0.00	0.00	0.00	0.10	0.90	2.24	4.45	7.70	11.86	16.83	22.07	25.05
Prepaid												
total prepaid subs (000)	128,009	280,443	428,441	538,349	647,337	758,436	870,858	977,446	1,078,099	1,173,227	1,259,651	1,334,967
prepaid as % of total subs	27	38	45	49	51	54	56	57	58	60	60	61

Source: Baskerville Strategic Research

	Penetration (%) 2001		Penetration (%) 2010	
1	Israel	96.04	Israel	93.93
2	Italy	86.14	Italy	92.00
3	Portugal	84.07	Hong Kong	89.95
4	Hong Kong	83.42	Finland	88.87
5	Taiwan	82.87	Sweden	88.29
6	Finland	82.56	Taiwan	86.91
7	Sweden	80.92	UK	84.92
8	UK	76.62	Netherlands	84.91
9	Netherlands	73.69	Singapore	84.82
10	Spain	69.43	Portugal	84.67
11	Czech Republic	67.68	Germany	84.54
12	Singapore	65.44	Czech Republic	84.43
13	Germany	65.13	Australia	82.98
14	Australia	62.17	Japan	81.64
15	France	62.13	Spain	79.87
16	South Korea	60.90	France	79.44
17	Japan	52.99	US	76.90
18	Hungary	49.16	South Korea	74.81
19	US	44.20	Hungary	72.10
20	Canada	33.84	Poland	60.93
21	Malaysia	32.66	Canada	58.12
22	Turkey	29.71	Turkey	50.24
23	Poland	26.18	Malaysia	46.95
24	South Africa	24.62	Philippines	42.88
25	Argentina	17.88	South Africa	42.78
26	Brazil	16.63	China	42.13
27	Philippines	13.10	Brazil	39.32
28	China	11.39	Argentina	31.62
29	Indonesia	3.08	Indonesia	11.56
30	India	0.53	India	5.77

Notes: Countries are only those profiled in the report. Figures refer to period Jan-02-Dec-10

Source: Baskerville

Rank	Country	Growth(%)	Rank	Country	Growth(%)
1	India	1124	16	Singapore	34
2	Indonesia	323	17	France	33
3	China	297	18	Germany	33
4	Philippines	284	19	South Korea	28
5	Brazil	151	20	Czech Republic	22
6	Poland	133	21	Spain	19
7	Argentina	95	22	Hong Kong	17
8	Canada	79	23	Netherlands	16
9	US	78	24	Portugal	13
10	South Africa	73	25	Taiwan	13
11	Turkey	70	26	Sweden	12
12	Malaysia	61	27	UK	11
13	Japan	56	28	Finland	9
14	Australia	54	29	Israel	8
15	Hungary	51	30	Italy	7

Notes: Countries are only those profiled in the report. Figures refer to period Jan-02-Dec-10
Source: Baskerville

Consumer Reaction to Value-Added Services

- The value-added services appeal to consumers at levels that are similar to the interest in the Basic Service.
- Services with higher mass appeal potential are “Mobile Phone Replaces Fixed Line Phone”, “Finding Places On The Move” followed by the “Voice Control” and “Personal Organiser” services.

Source: Ipsos-Vantis

Affinity for Services*

- Independent of their current mobile phone usage and the party who pays the bill, consumers show strong affinity for the Finding Places On The Move and Mobile Phone Replaces Fixed Line Phone services, suggesting strong likelihood for these two services to appeal to a wide range of consumers.

- Others services do not have as much potential to have broad appeal but are likely to gain the interest of more defined groups of consumers. Business Users are more likely to show interest in some of the more practical services.

Mean Rating (6-Pt. Scale)

		Mobile Phone Usage		Party Who Pays Mobile Phone Bill	
	Total	Personal Only (A)	Any Business (B)	Self Payers (C)	Company Only/ Company Shared (D)
(N)	(434)	(263)	(171)	(358)	(76)
Finding Places On The Move	4.3	4.1	4.5$_A$	4.2	4.5$_C$
Mobile Phone Replaces Fixed Line Phone	4.3	4.2	4.4	4.3	4.4
Voice Control	3.8	3.5	4.1$_A$	3.7	4.3$_C$
Personal Organizer	3.7	3.4	4.0$_A$	3.6	4.2$_C$
Video Clip Messaging	3.3	3.1	3.5$_A$	3.2	3.7$_C$
News, Sports And Leisure Clips On Demand	2.9	2.9	3.1	2.9	3.1
Video Clip Alerts For Sports, News And Leisure	2.9	2.8	3.1	2.8	3.3$_C$
Remote Access To Company Network	2.8	2.3	3.6$_A$	2.5	4.1$_C$
Gaming	2.4	2.4	2.3	2.4	2.4
Gambling	1.9	1.9	1.9	1.9	2.0

Q. How much do you think you would like or dislike this service? (1 = "Not Like At All" and 6 = "Like Extremely Well")

* Prior to pricing of services.

Source: Ipsos-Vantis