

# Pervasive Connectivity – The Role of Wireless Networks

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# Dr. Mehmet Unsoy

- For the last 1 year, serving as Advisor and Consultant to 4 large U.S. based VCs (with \$5.5 Billion in portfolio), for their investments in the wireless industry;
- On the Advisory Board of or consultant to 12 wireless related technology companies, across the wireless value chain, in the U.S., Canada and Europe
- Formerly Vice President, Chief Wireless Architect / CTO for BT / BT Wireless / mmO2, for about 3 years, responsible for the end-to-end technology and architectural evolution of mmO2's mobile operators in the U.K., Germany, Holland, and Ireland, with total 19 million subs.
- Director of Wireless Internet for Nortel; Developed Nortel's GPRS, 3G, wireless Internet and wireless IP business
- Director of Product Marketing for Nortel in Asia/Pacific; Grew data network sales in A/P five fold over 3 years
- Director of Product Development for Bell Northern Research; Led large development teams for data networking (IP, ATM, ISDN) products
- Close to 30 years of data, IP & wireless networking experience, as an executive in product development, product marketing and network operator roles
- Extensive international experience with assignments in Canada, USA, Europe & Asia/Pacific
- Significant experience in data networking standardization
- Ph.D. from University of Waterloo, Canada, on routing & congestion control in Arpanet
- BSEE (Computer Science) from METU, Ankara, Turkey, in 1973

# Outline

- **Pervasive Connectivity and Wireless Networks**
- **Wireless Networks Evolution & Challenges**
- **Wireless Devices Evolution & Challenges**
- **Wireless Services Evolution & Challenges**
- **Conclusions**

# What is Pervasive Connectivity?

- **Types of service: Connectivity with various communication means and services, starting with voice communication**
- **Location: Connectivity from anywhere to anywhere**
- **Time: Connectivity at anytime and for any duration**
- **Parties: People to people, people to machine, and machine to machine**
- **Service continuity: Seamless hand-off of service between various access networks**
- **QoS: Offering the most appropriate QoS (bandwidth, error rate, latency) for the service and the access network**
- **On-line and Off-line: Maintenance of service, where appropriate, during intermittent connectivity**

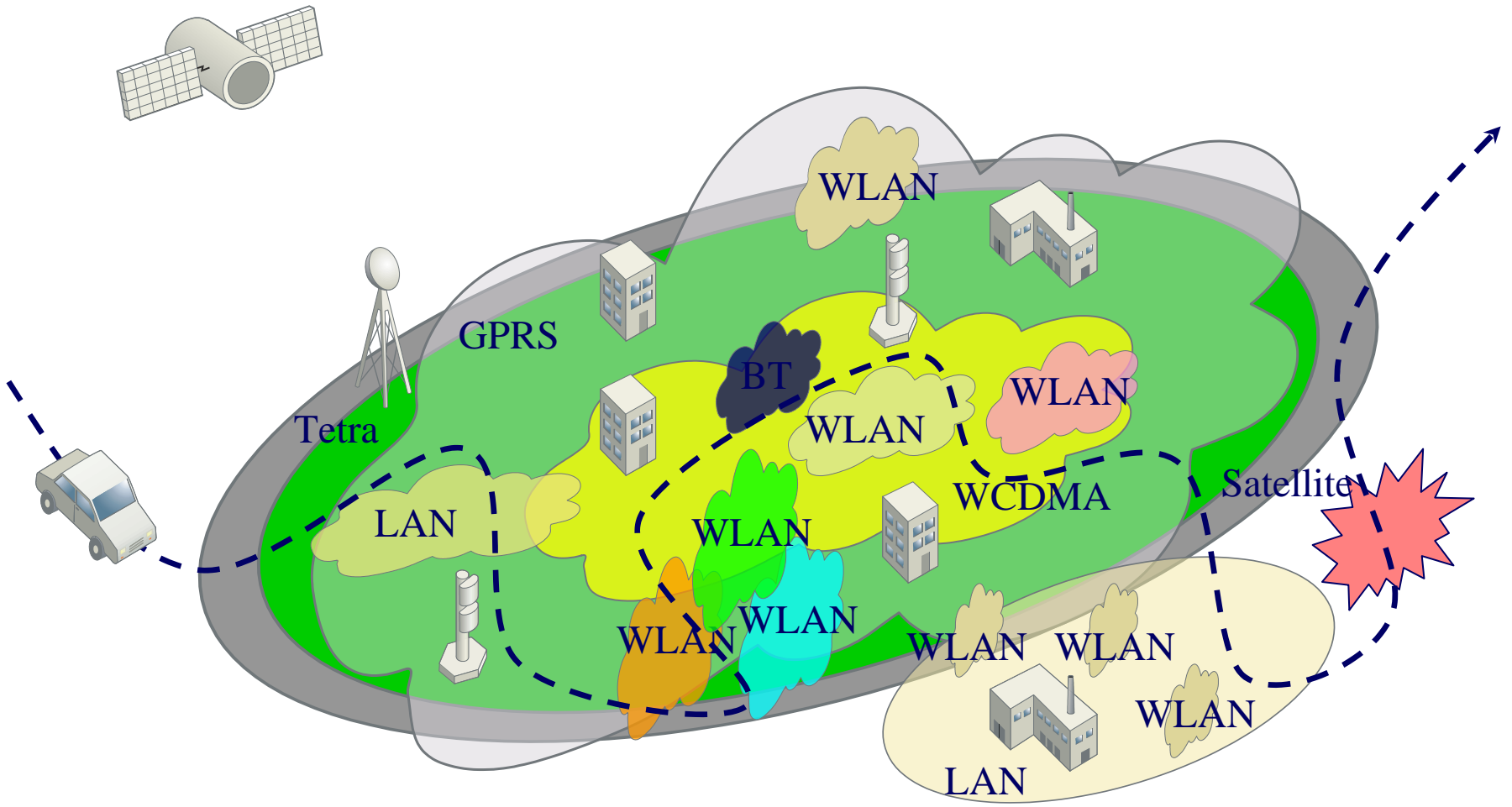
# Service Centric vs. Connection Centric

- **Connection focus**
  - DSL, WLAN, GPRS, UMTS, etc
  - Fat pipe; data rate focus mentality
- **Service focus**
  - How to maintain sessions; graceful transition; session persistence
  - Adaptable applications to varying network conditions and types
- **Offline Service / Computing / Session**
  - Proactive caching the application / data required ahead of time
  - Offline application / service environment
  - Synchronization

# Immediate Implications / Opportunities

- **Communication Networks: Wireless, WLAN, PAN, etc**
  - Support roaming, handoff and seamless handoff
  - Allow users the choice of which network to connect to based on a policy / preference
- **Devices**
  - Enable offline computing, applications, services
  - Synchronize when connected
  - Allow handoffs
- **Applications**
  - Adaptive applications to varying network conditions and types
- **Market segments for pervasive connectivity**
  - Enterprise: most important in short term
  - Consumers: most important in the long term

# Several Access Networks



# Pervasive Connectivity - Broader Set of Requirements

- **More wireless networks**
  - Better coverage; higher capacity, better quality
  - Infrastructure for wide range of services and applications
- **Wide range of wireless devices**
  - Different price ranges, functionalities, more powerful, with less power consumption, with built-in simplicity & intuitiveness
- **Compelling set of new services / applications**
- **New technologies for**
  - Roaming
  - Handoff
  - Mobile IP and Mobile IPv6
  - Synchronization, e.g. SynchML
  - Session persistence
  - Offline computing, e.g. device platforms, OS, app development environments

# U.S. Wireless Market Trends

- **Subscriber growth is continuing, but slowing down; however, MOU and data revenues are on the rise**
  - **150 Million subs in the U.S. with almost 50% penetration**
- **Coverage is improving, with almost 150,000 cell sites; CAPEX growth is around 21%**
- **About 50 Million wireless data users in the U.S., will grow to 120 M by 2006**
  - **100 Million wireless data capable handsets in the U.S.**
  - **\$700 Million wireless data revenues in 1H03 (70% growth year/year)**
  - **1.5 Billion SMS sent in June 03 (50% growth year/year)**
  - **25 Million camera phones sold (vs. only 20 Million digital cameras) in 1H 03**
- **1XRTT and GPRS is widely available, and both Cingular and AWS are fully committed to 100% EDGE deployment**
  - **AWS announcement at Comdex, almost nation-wide EDGE service launch, after \$300M investment**
- **Wi-Fi hot spot deployment continuing by all carriers / service providers; wireless & wireline carriers will be the dominant Wi-Fi service providers**
  - **T-Mobile USA 3000 hotspots, installing 50/day**

# 3G and EDGE in Europe

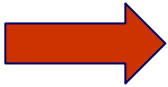
- **3G deployment in Europe had started sometime ago, and over a dozen networks already offer 3G services,**
- **Number of networks offering 3G services will exceed 20 by year end 2003; major drivers are a combination of regulatory (e.g. Germany) and running out of voice capacity (e.g, Italy)**
- **Several networks already announced plans for EDGE; more networks have been trialing Nokia EDGE equipment**
- **However, EDGE deployment will be delayed in Europe due to unavailability of handsets,**
- **Also, EDGE will be deployed in Europe as a complement to 3G, on a case by case basis**
- **This would require handsets that are multi-mode (WCDMA, GPRS and EDGE)**
- **Expect 25-30% penetration of WCDMA + EDGE in Europe by 2007 (about 150 Million Subs)**

# Wireless Growth in China & in India

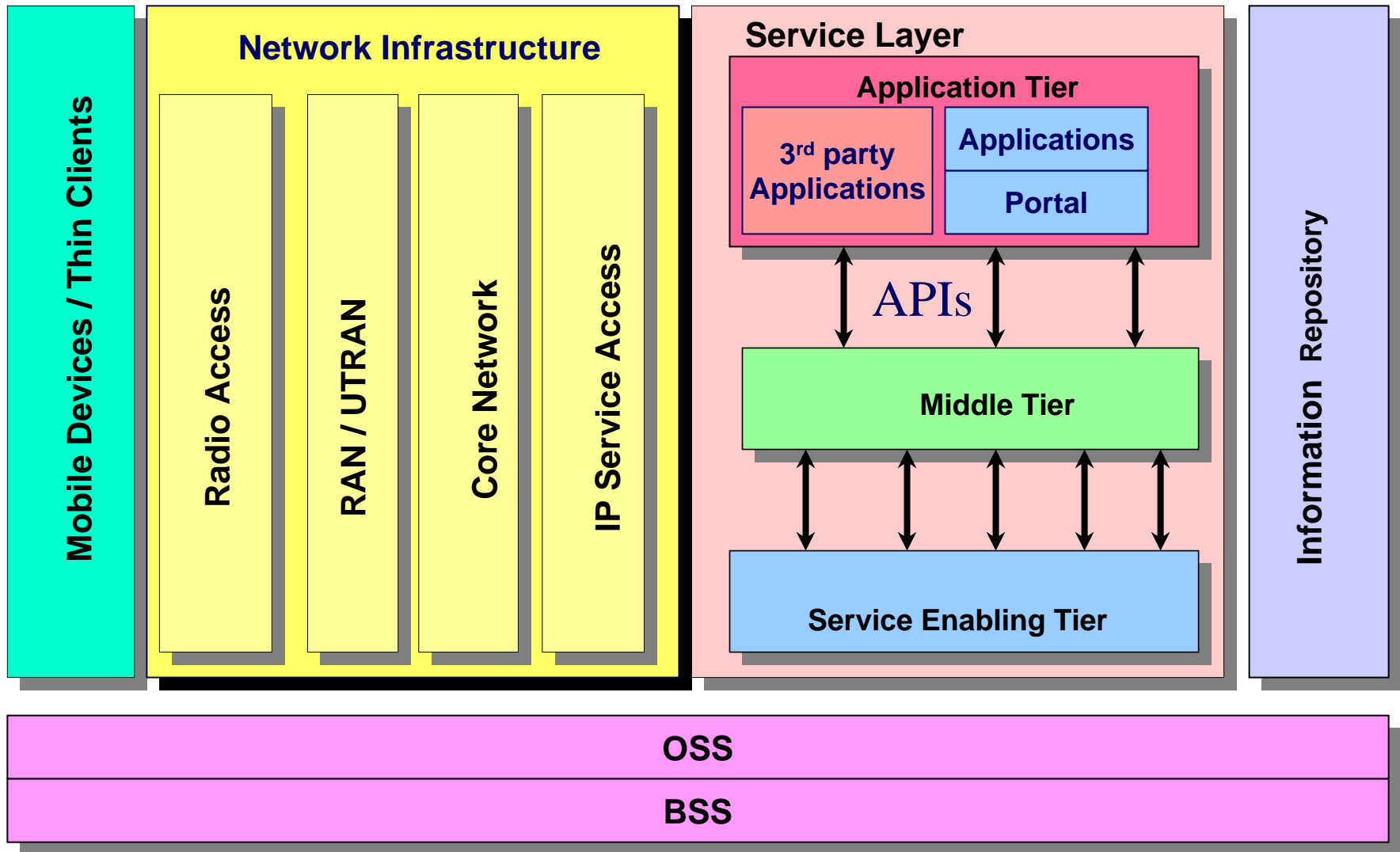
- **China is already the largest wireless market with over 240 Million (about 13M CDMA, rest GSM) subscribers, expected to reach 450 Million by 2006**
- **Significant focus on messaging and value added services in China; total wireless revenues expected in China by 2006 is \$88 Billion**
- **3G licenses to be issued in 2004, for 4 operators, China Mobile, Unicom, China Telecom and China Netcom**
- **Significant presence of GSM (evolving to WCDMA), some presence of CDMA (evolving to CDMA 2000) and a new standard (TD-SCDMA), more efficient and cost effective for China**
- **More new handsets in China than new PCs in the World this year!!**
- **Other Asian market will also experience significant growth rates, e.g. in India, 15 Million subs expected to grow to 31 Million by 2004.**
- **Japan still most mature wireless market, for advanced mobile applications; but Korea is close, with very interesting business models**

# Outline

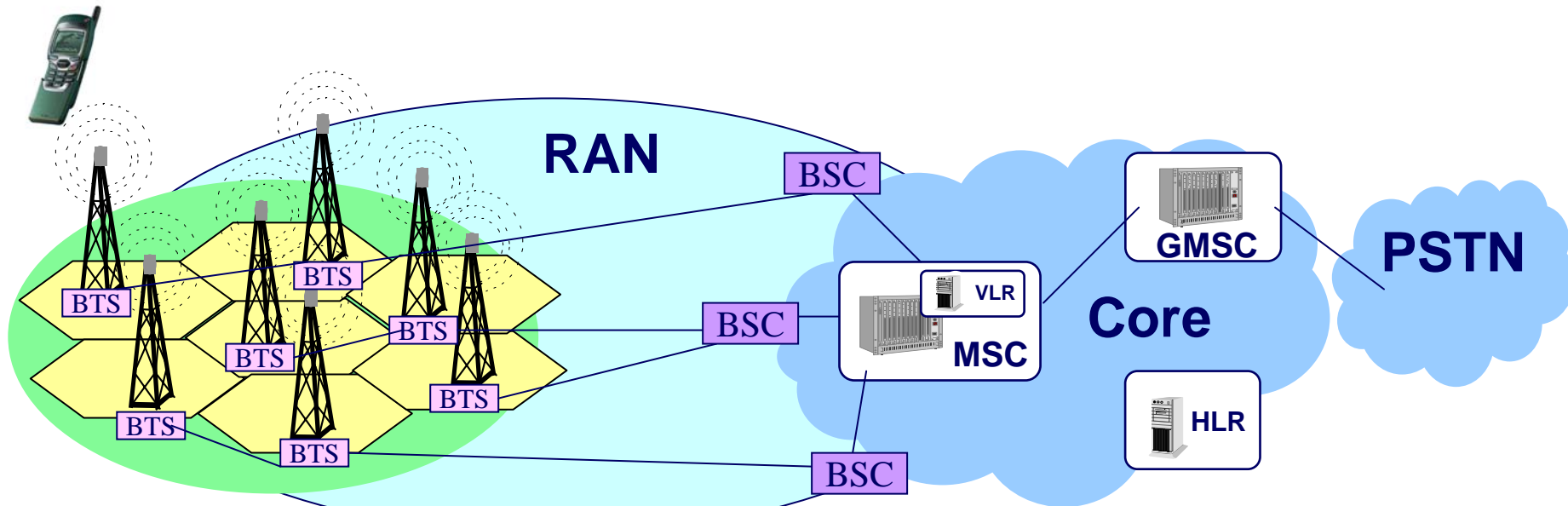
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# End-to-End Architecture for Wireless Networks



# Components of Wireless Infrastructure



## Cellular Radio Network

- Includes sites, antennas, transmitters, power, etc
- Main focus on quality and coverage over the air interface
- Macro, Micro, Pico cells
- Indoor & Outdoor units
- 10's of thousands of sites
- Significant CAPEX cost; 50-60% of total CAPEX

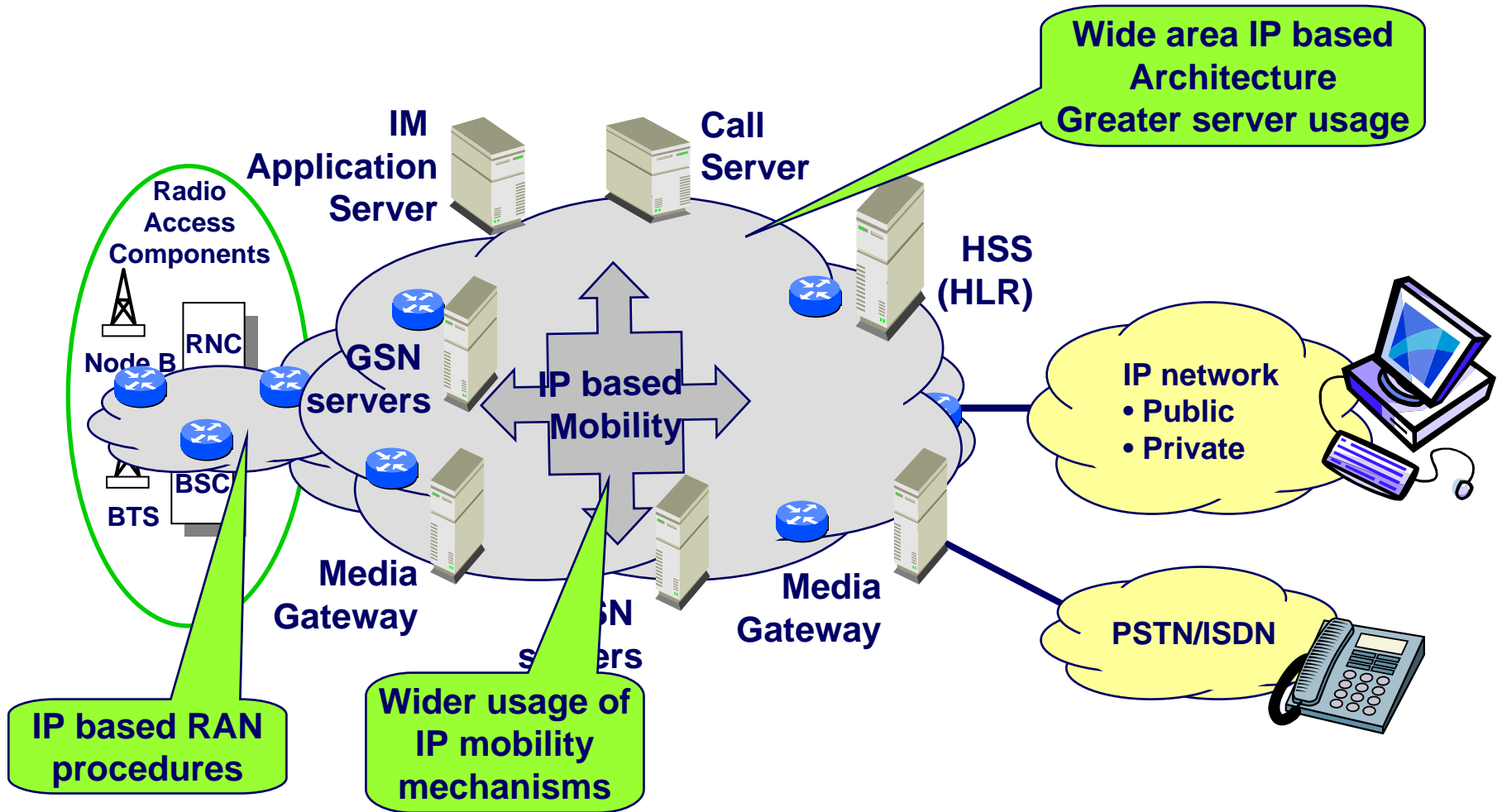
## Radio Access Network

- Includes Base stations, Base station controllers, and the transmission facilities
- Main focus on cost efficient transport
- 10's of thousands of T1s/E1s
- Some CAPEX, but huge OPEX implications; 30% of total OPEX

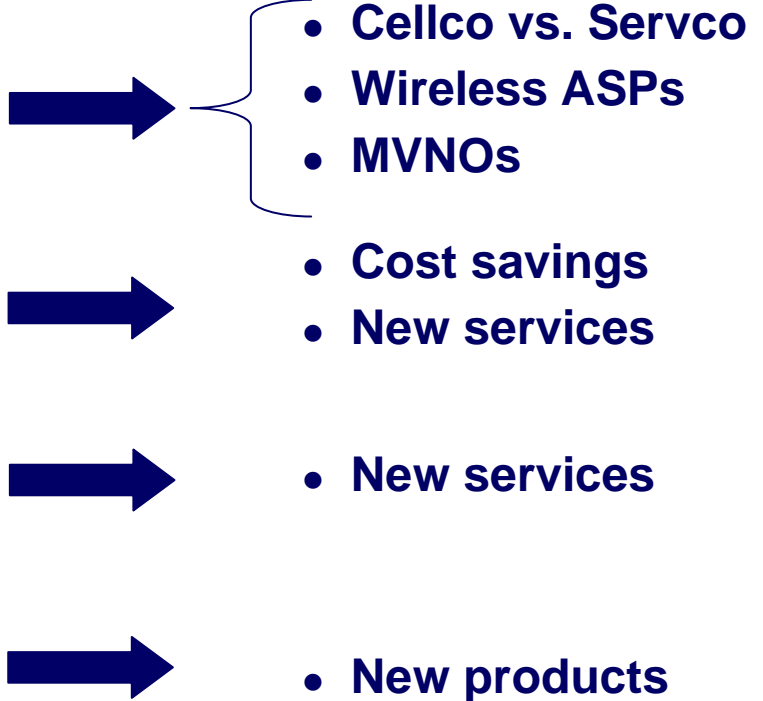
## Core Network

- Includes Mobile Switches, Gateways, HLR etc
- Main focus on basic services, connections, and transport
- 10's of switching sites
- Mostly CAPEX implications, 10-15% of total

# All-IP Mobile Network Architecture



# Paradigm Shifts by All-IP Networks

- **Business Paradigm shifts**
    - Peer-to-peer SIP for signaling
  - **Technical Paradigm Shifts**
    - Separation of signaling and bearer channels
    - Multimedia services – combination of voice and data on an end-to-end basis
    - Mobility enabled, MPLS enabled, IPv6 based routing environment for wireless core networks
- 
- The diagram illustrates the flow from paradigm shifts to their outcomes. On the left, there are two main categories: Business Paradigm shifts and Technical Paradigm Shifts. On the right, there are four bullet points representing outcomes. A large blue arrow points from the Business Paradigm shifts to the first three outcomes: Cellco vs. Servco, Wireless ASPs, and MVNOs. A smaller blue arrow points from the Technical Paradigm Shifts to the last three outcomes: Cost savings, New services, and New products.
- **Cellco vs. Servco**
  - **Wireless ASPs**
  - **MVNOs**
  - **Cost savings**
  - **New services**
  - **New services**
  - **New products**

# In-Building Wireless

- **Wireless subscribers demand ubiquitous coverage, outdoors as well as in-building**
- **Significant amount of subscriber dissatisfaction as well as churn is due to poor coverage**
- **Some statistics**
  - **33% of all voice calls originate or terminate on wireless networks (CTIA)**
  - **78% of all wireless calls originate from inside a building (Agilent Technologies)**
  - **30% of all wireless traffic is completely indoors (both origination and termination are indoors), and expected to double by 2007 (Foxcom)**



# In-Building Technology Options




- **Passive Systems**

- Coax cable from base unit to antennas,
- “leaky cable” solutions for tunnels
- Require amplifiers due to high attenuations
- Lowest equipment cost; but very high installation / labor cost
- Cost-effective for smaller systems (e.g. 50K sq.ft.) and/or low labor rate markets (e.g. Asia)





- **Active Systems – several choices**

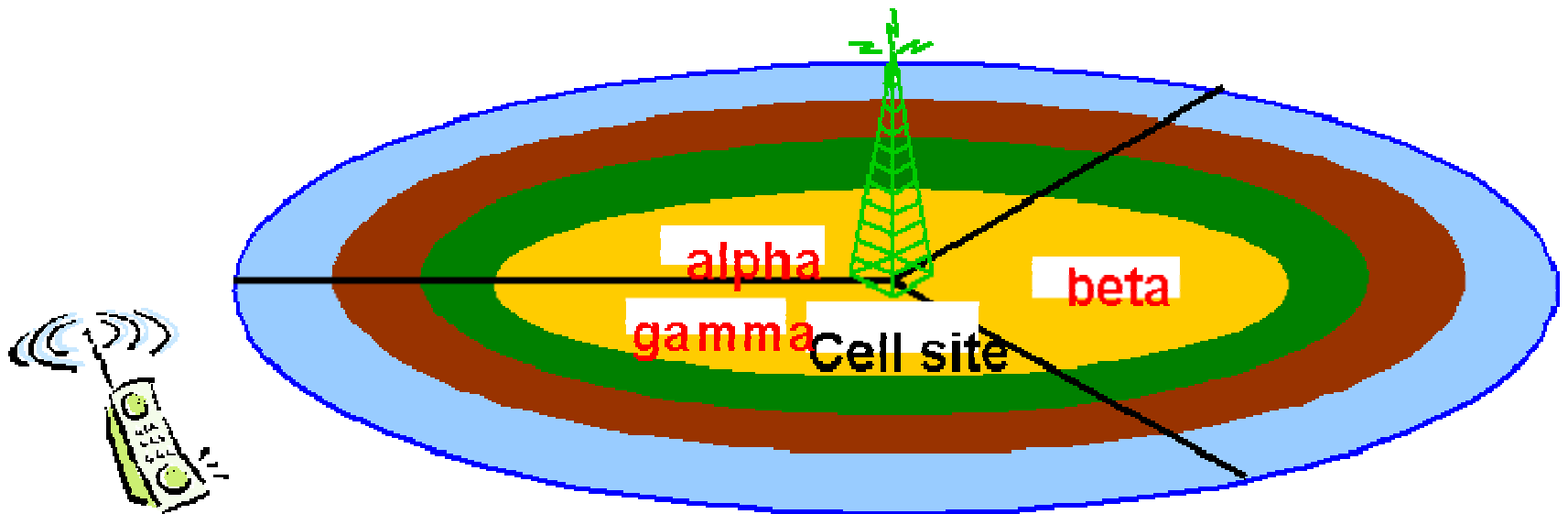
- Hybrid Multi-Mode Fiber and Coax systems
- Multi-Mode Fiber only systems
- Multi-Mode Fiber with CAT5 wiring with active electronics
- Single Mode Fiber – much less attenuation, used for backbones, Point-to-Point, popular in Japan

# Why Existing In-Building Technologies not Cost Effective

- **For large projects, such as airports, or buildings larger than 250 K sq.ft., it is primarily finding the right business model,**
  - less of a technology issue
- **For projects smaller than 250 K sq.ft., cost of engineering, customization, installation & maintenance become a dominating cost**
  - Every building is treated differently and custom solutions are provided
  - Cost of engineering, primarily RF engineering is high and going to be higher,
  - Much higher ration of h/w equipment and h/w people compare to s/w products and s/w people (e.g. Foxcom may have 9 to 1 ratio for h/w vs. s/w staff)
- **Going forward**
  - Coax cost 
  - Labor cost 
  - Electronics cost 

# 3G / UMTS Site Density


-  - Voice Coverage
-  - 64 kbps Coverage
-  - 128 kbps Coverage
-  - 384 kbps Coverage



# 3G / UMTS Site Density

<b>Radii / Number of users</b>	<b>Rural – Km</b>	<b>Suburban – Km</b>	<b>Urban – Macrocell – meter</b>	<b>Urban – Microcell – meter</b>	<b>Urban – Picocell - meter</b>
<b>Speech</b>	<b>8.16 / 43.0</b>	<b>1.61 / 43.0</b>	<b>360 / 43.0</b>	<b>140 / 82.6</b>	<b>103 / 81.9</b>
<b>64 Kbps</b>	<b>5.83 / 7.1</b>	<b>1.15 / 7.1</b>	<b>250 / 7.1</b>	<b>120 / 15.4</b>	<b>88 / 15.7</b>
<b>128 Kbps</b>	<b>4.96 / 3.9</b>	<b>0.98 / 3.9</b>	<b>220 / 3.9</b>	<b>110 / 8.8</b>	<b>72 / 9.2</b>
<b>384 Kbps</b>	<b>3.85 / 1.5</b>	<b>0.76 / 1.5</b>	<b>170 / 1.5</b>	<b>80 / 2.5</b>	<b>52 / 2.6</b>

# Rhein – Ruhr Area Study

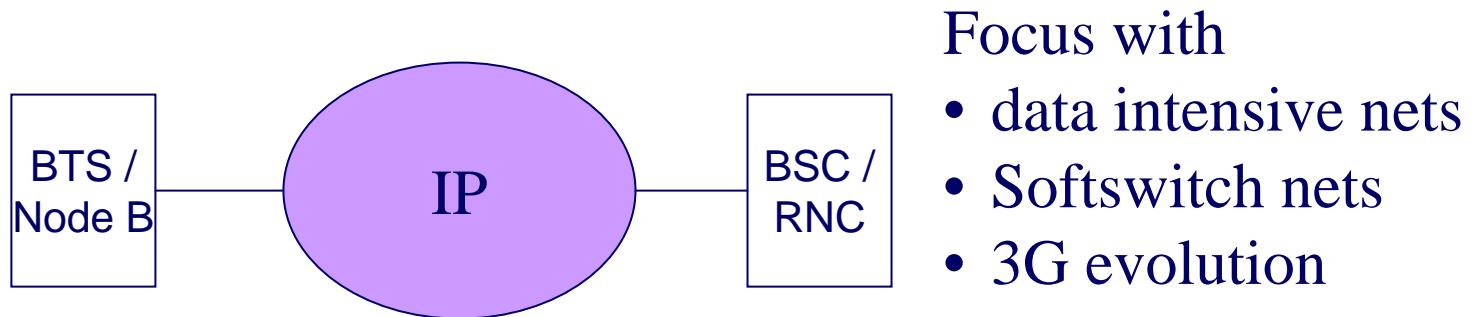
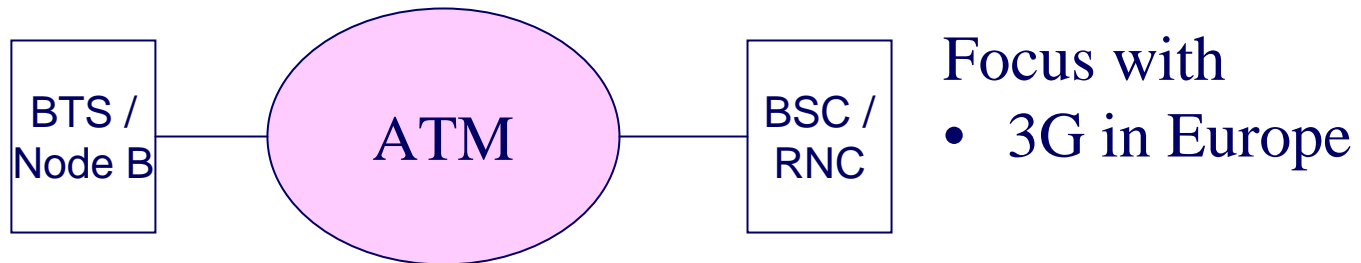
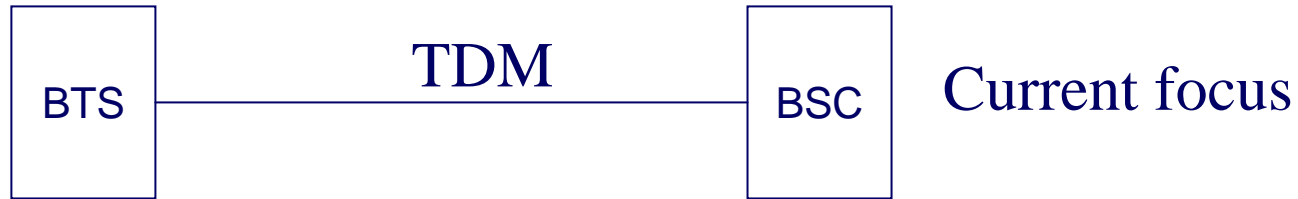
- 17500 sq Km area with 12 million population
  - Single Operator, 20 % market share, 80% wireless penetration
  - 11,000 pico cells
  - 8,500 micro cells,
  - 2,000 macro cells
  - 150 rural cells
  - 26,500 Mbps capacity
  - About 100 RNCs
    - Each with about 265 Mbps capacity (min 2 STM-1's)
  - Assume 3 out of 5 operators will deploy 3G / EDGE, and no infrastructure sharing
    - About 60,000 mostly new cell sites just in Rhein-Ruhr area
- 
- About 21,000 cell sites

# Market Size Estimates for Europe \*

<b>Europe UMTS / EDGE penetration levels</b>	<b>10%</b>	<b>20%</b>	<b>30%</b>	<b>50%</b>
<b>Number of Cell sites (pico / micro / macro)</b>	<b>336,000</b>	<b>672,000</b>	<b>1 Million</b>	<b>1.7 Million</b>
<b>Number of RNCs</b>	<b>1,500</b>	<b>3,000</b>	<b>4,500</b>	<b>7,500</b>
<b>Traffic Volumes / Capacities</b>	<b>397,500 Mbps</b>	<b>795,000 Mbps</b>	<b>1,192,500 Mbps</b>	<b>1,987,500 Mbps</b>
<b>Number of 2<sup>nd</sup> Stage Hubs</b>	<b>7,500</b>	<b>15,000</b>	<b>22,500</b>	<b>37,500</b>

\* Assume Rhein – Rohr area is about 1/50 of European market

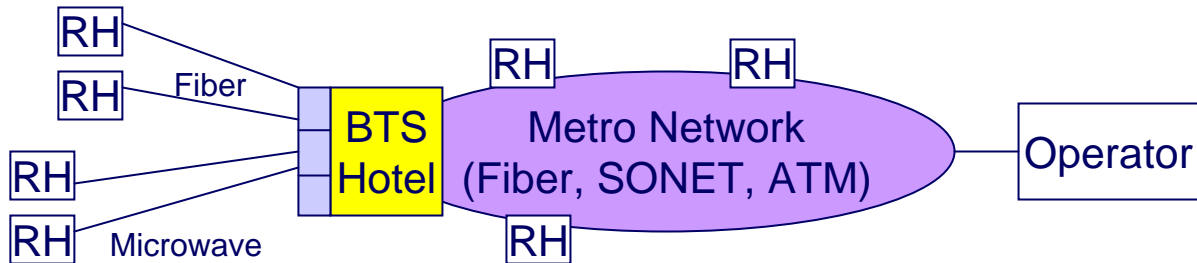
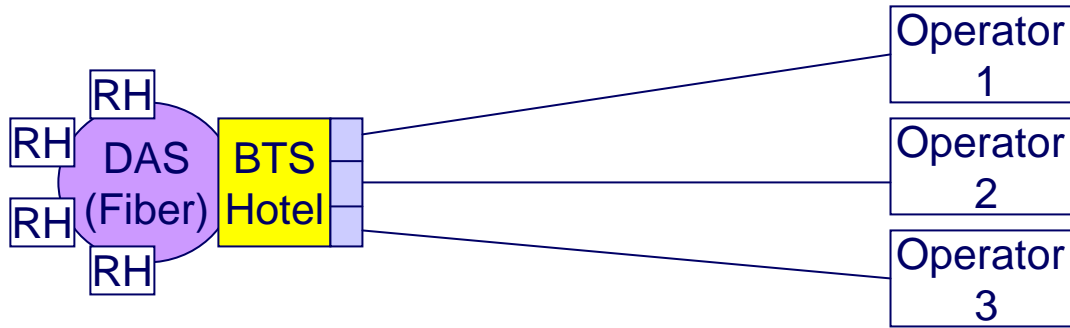
# Wireless Backhaul Evolution



# Distributed RF – An Industry Trend

- **Carriers are asking for distributed RF solutions**
  - 2002 Cingular RFI
  - MMO2
  - AT&T currently in trials
  - Verizon and Nextel completed trials in 1Q03
  - Asia has embraced the technology
- **OEM's are searching for ways to satisfy need**
  - Powerwave introduces WCDMA distributed amp
  - Samsung DAS under development
- **OEM's begin to partner with outside companies for new products**
  - Airvana and Nortel/Ericsson
  - Cisco and Motorola
- **Distributed RF named as one of the top-10 hot technologies by industry telecom magazine**

# Wireless New Backhaul Opportunities



Other opportunities to explore in this new paradigm:

- Centralized radio resource management opportunity
  - Dynamic load sharing between radio heads
  - Data compression opportunities
  - Synchronization and location positioning requirements
-

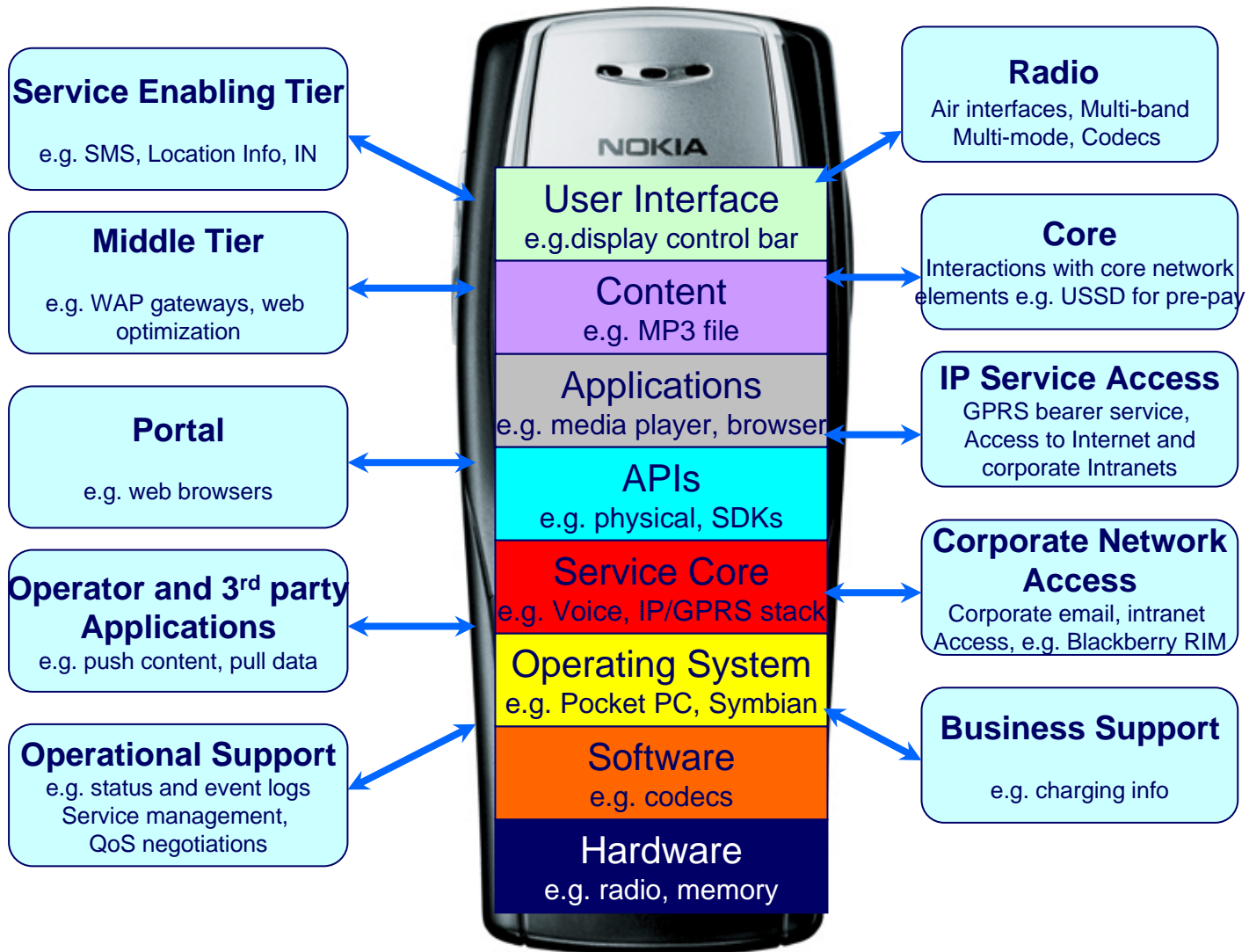
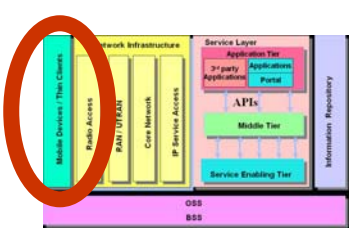
# Coverage and Capacity Growth Driven Challenges / Opportunities

- Capacity demand is driven by increased number of subscribers and new wireless services which demand higher data rates
- Coverage growth demand is in the U.S., Latin America, China, India, etc
- Need solutions related to
  - Radio Networks (.e.g. macro, micro,pico cells),
  - Backhaul (e.g. fiber, microwave/ BWA, ATM/IP hubs),
  - Radio engineering,
  - In-building wireless solutions,
  - Engineering tools,
  - Infrastructure build-outs, in-building coverage solutions, etc
- Significant impact on CAPEX and OPEX
- Several new innovation opportunities in this space

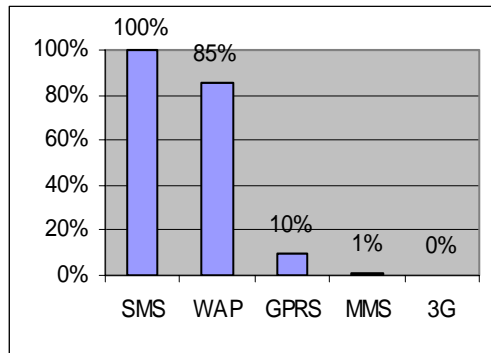
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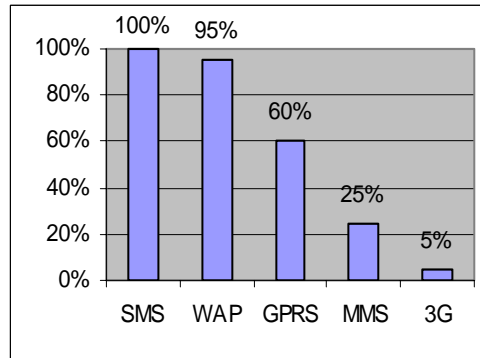
# Mobile Device Architecture



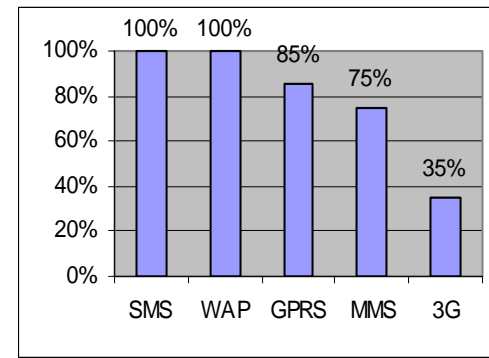
# MMS Handset Penetration



**2002**



**2004**



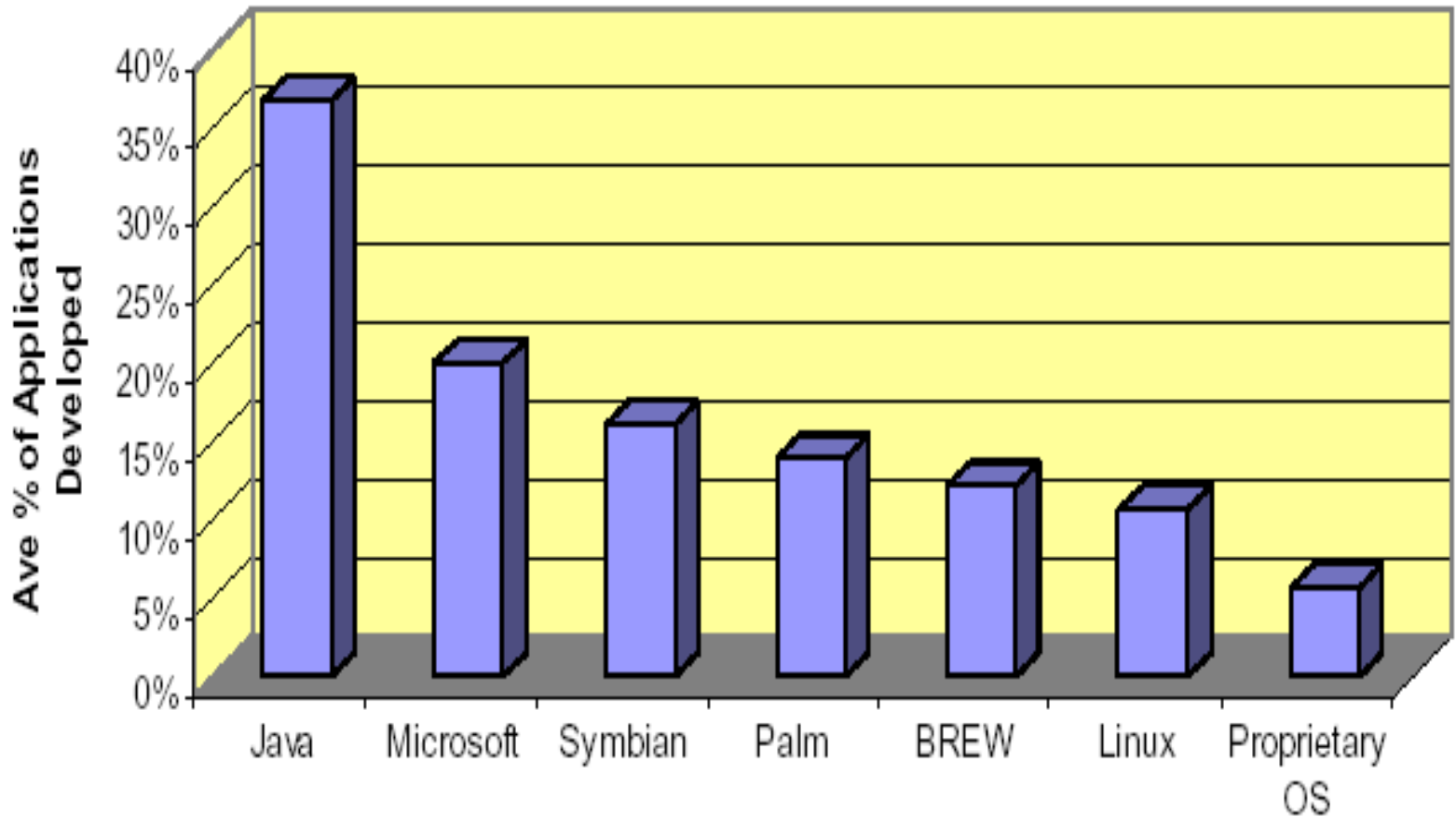
**2006**

- **37 Million MMS handsets with cameras (8% of total) in 2003,**
  - About 30 different models of MMS handsets already available;
  - 50 new models of color MMS handsets being launched in 2003
  - some around \$100 subsidized and \$200 without subsidy
  - more camera phones than digital cameras in 2003!!
- **MMS handset penetration is expected to reach 25% by 2004 and 75% by 2006, according to Ericsson**
- **Ovum predicts 50% MMS handset penetration by 2005; and also 30% of all person-to-person messaging be MMS**
- **Orange group forecasts 40% of their users will be using MMS by 2005**



# Java: The Preferred Technology Enabler

Proportion of Wireless Applications to be developed on wireless platforms



# 2<sup>nd</sup> Billion Handsets

- **Global wireless population has reached 1.25 Billion; but where will be next 1 Billion handset growth come from?**
  - Developing countries: China, India, Latin America
  - Developing Demographics: Older and Younger consumers, e.g. 60+ and 6-12 yr olds)
  - More enterprise usage
  - More Machine-to-Machine communications



- **Implications and Opportunities**

- Simpler, cheaper handsets
- Applications that appeal to new age groups,
- Versatility, flexibility, usability improvements on handsets
- Advanced recognition technologies
- Telemetry devices



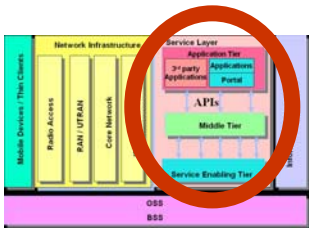
# Challenges / Opportunities at Mobile Devices

- OS battles still continuing; Java, Brew, Symbian, Microsoft, etc
- Smarter handsets, with lots of processing power, better power management, etc
- Near term opportunities in Client-server solutions for
  - Device management,
  - Data synchronization, etc
- Longer term solutions in improving “ease of use” and delivering “delightful user interface”
  - Natural speech recognition,
  - Hand-writing recognition, etc
- Technologies to improve device security such as
  - Biometrics, such as finger-print, voice-print recognitions

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# All Wireless Operators are Building Service Layers

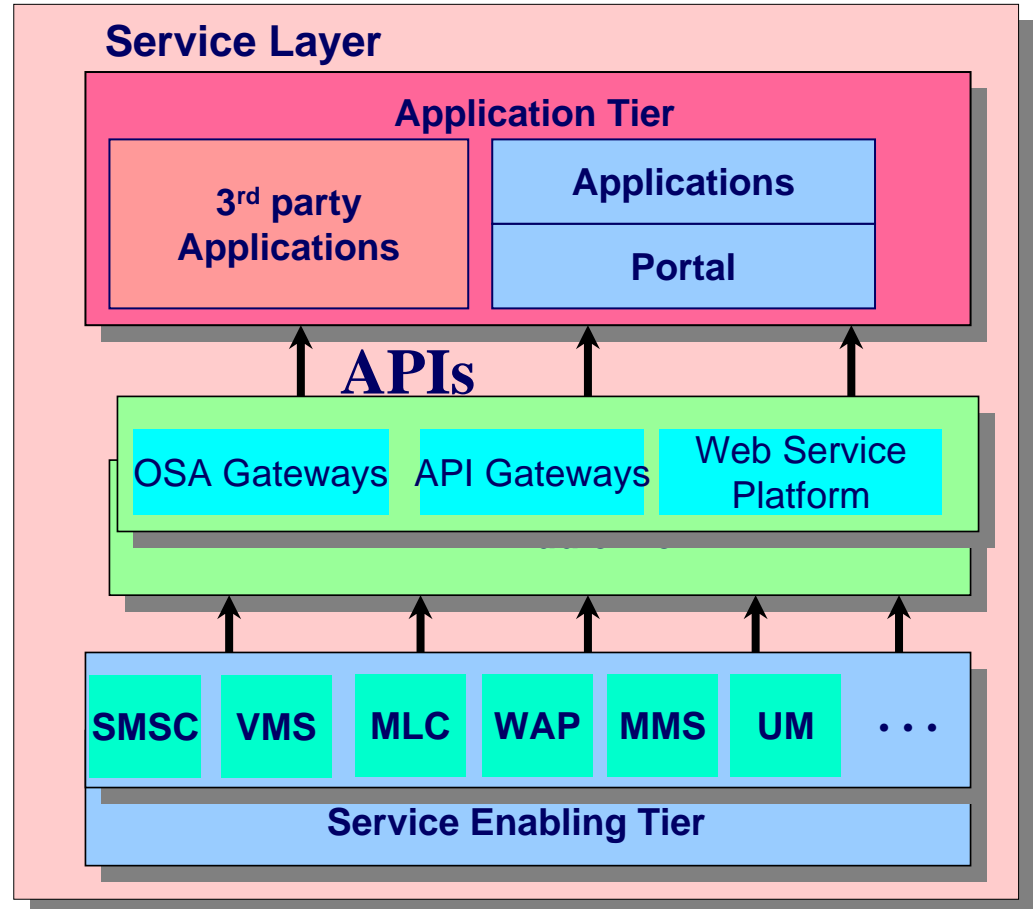
## Objectives:

- To go up the value chain
- Enable high-margin revenues
- Build on early successes, e.g. SMS

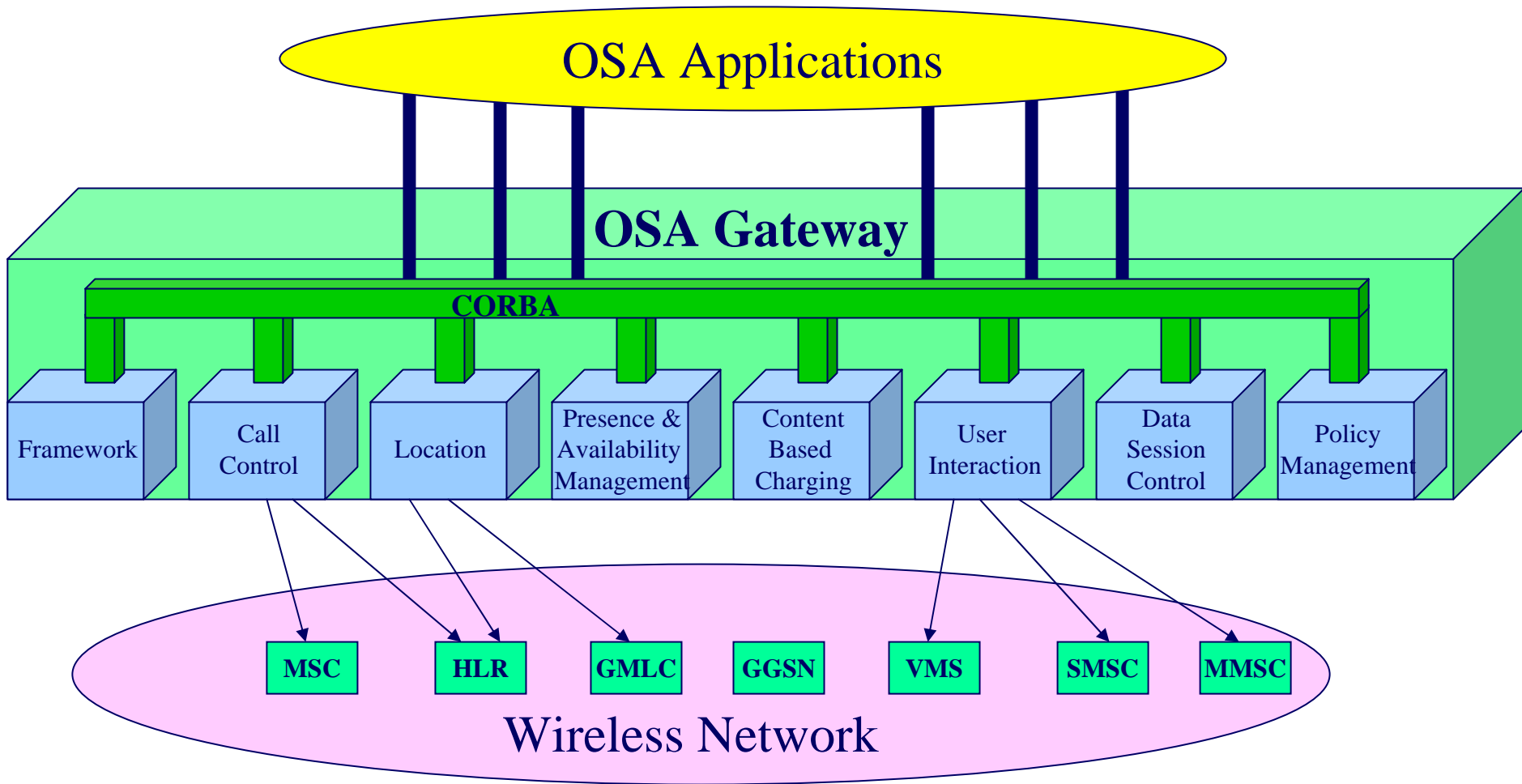
## 3<sup>rd</sup> Party apps very critical

- 90+% future apps
- APIs very important

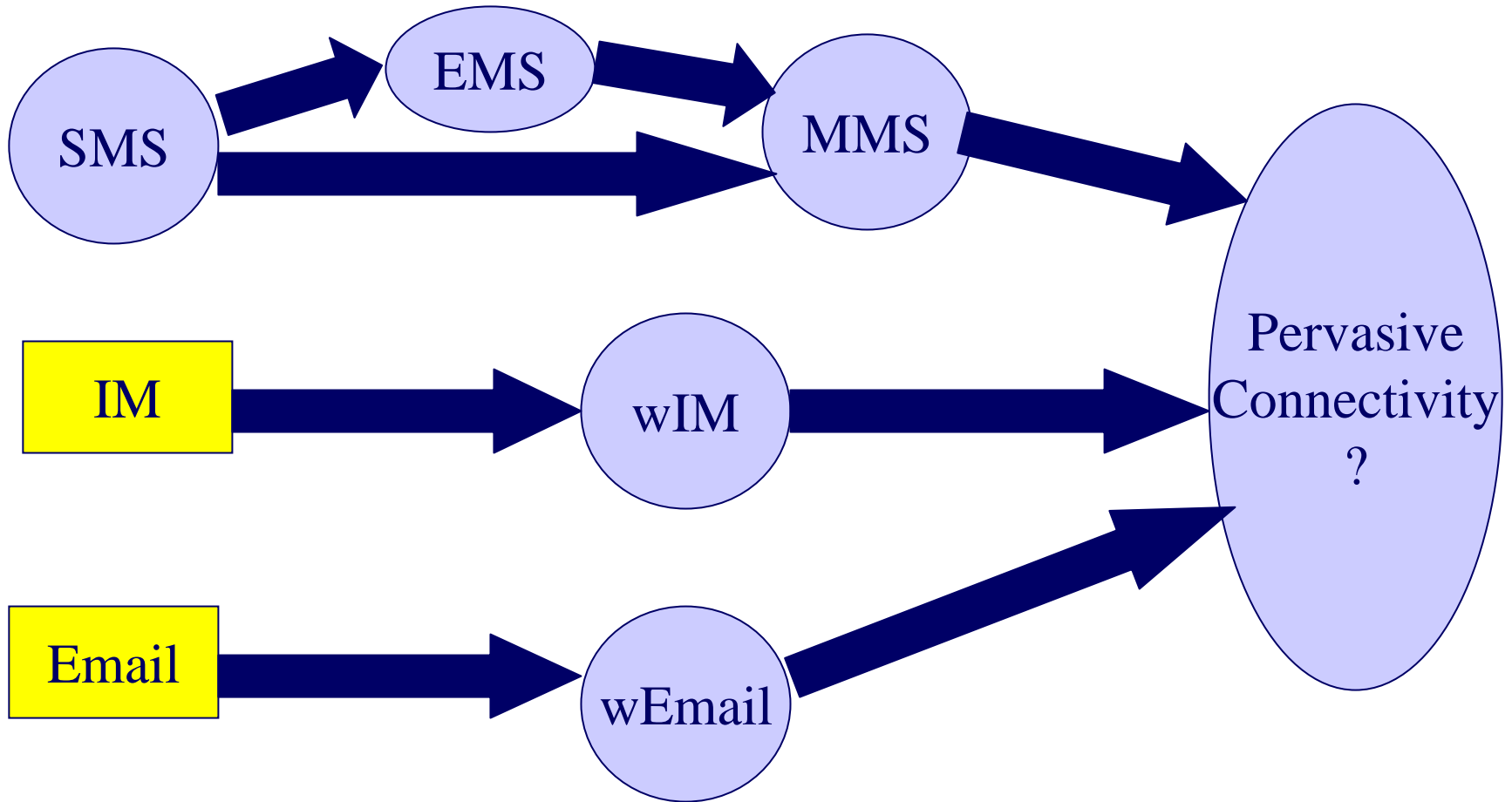
SIP will revolutionize the service layer



# Overview of OSA



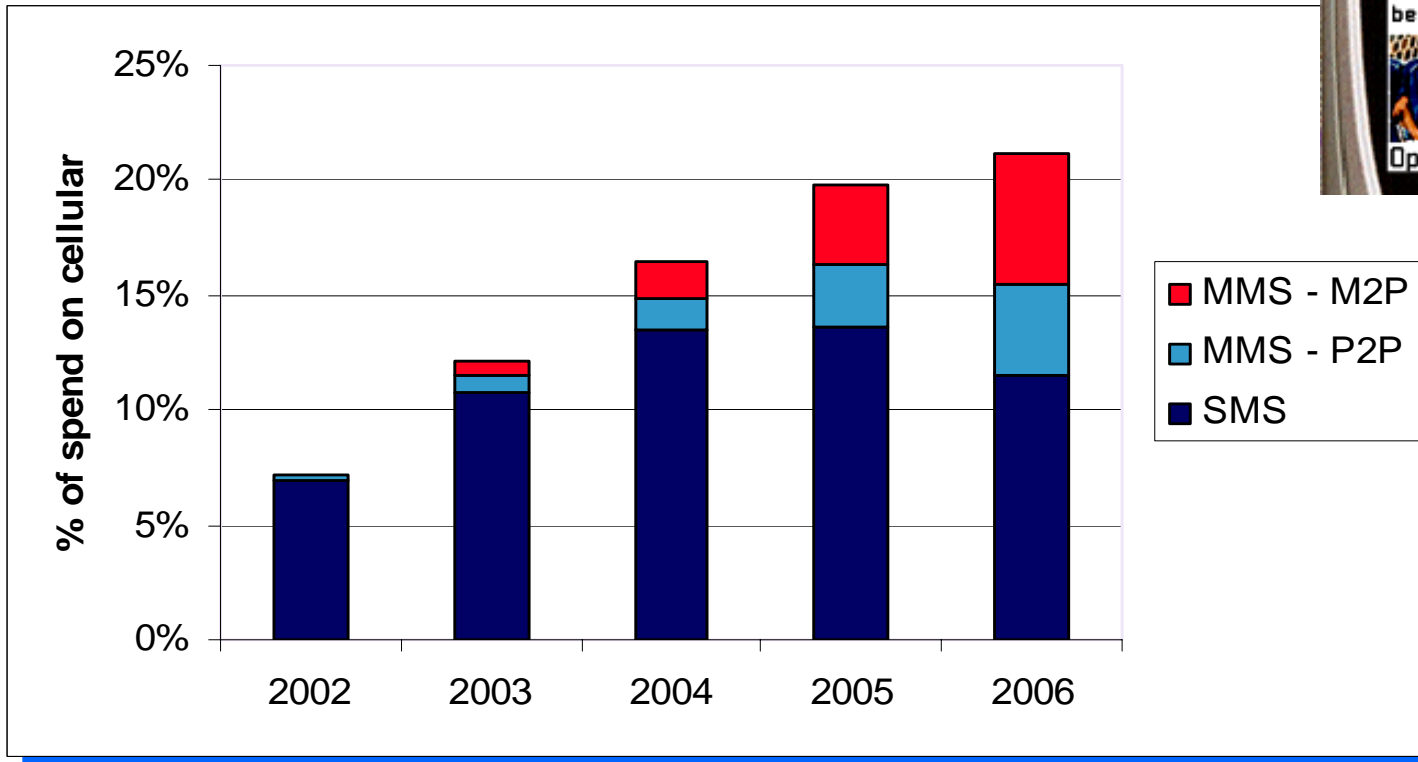
# Wireless Messaging Evolution



# Wireless Messaging

- **Wireless messaging traffic, both for consumer and corporate market will continue to rise**
- **SMS, MMS, wireless IM and wireless Email will all play significant roles**
- **Specific new innovation opportunities are in**
  - **Delivering multimedia solutions with MMS (the whole MMS ecosystem)**
  - **Offering solutions agnostic of which type of messaging is used to deliver the message**
  - **Ability to leverage presence, location information, personalization for all or any of the messaging solutions**
  - **Optimization of the messaging solutions for some key vertical markets, corporate (e.g. financial) or consumer (e.g. 6-12 yr. old youth)**
  - **Solving problems related security, privacy, DRM, and ease of use**

# MMS Opportunity – % of ARPU



Source: Ovum 2002

**No instant success – but good potential**

# IM Standards and Wireless IM

- **ICQ and AOL have their proprietary protocols.**
- **Two competing IETF standards:**
  - SIP based SIMPLE for instant messaging and presence, and
  - XMPP, which is XML based presence and instant messaging, supported by Jabber.
- **Wireless Village (WV) effort to achieve a wireless IM standard**
  - Formed by Ericsson, Motorola, and Nokia; more handset focus
  - Now rolled into Open Mobile Alliance (OMA) organization's IMPS standard
- **There is no clear-cut winner and interoperability is not possible without standard.**
- **However,**
  - AOL promised to support SIMPLE.
  - MSN messenger has SIMPLE built in Windows XP.
- **One possible scenario is**
  - SIMPLE for setting up connections.
  - Jabber for transporting data, but
  - Wireless Village (WV) support on handsets?

# Wireless Operators' IM Strategies

- **Wireless operators are currently pursuing one of three different schemes:**
- **IMPS Gateway approach**
  - **Vodafone Messenger service**
  - **Use of OMA / Wireless Village IMPS protocol**
  - **Creates Operators own IM community**
  - **Followap is the supplier for Vodafone, throughout Europe**
- **Direct relationship with AOL/MSN/Yahoo**
  - **O2 has launched service with AOL,**
  - **Simplest approach for operators, may require AOL, MSN or Yahoo client on handsets**
  - **Almost all U.S. operators have done the same**
  - **Wireless IM service over either SMS or GPRS**
- **Jabber approach**
  - **Orange has been working on a solution to use Jabber clients in handsets and a Jabber server to connect to all Internet IM hosts**

# Increasingly More IP based Mobile Multimedia Traffic

- **MMS**
  - P2P, C2P
  - Images (jpeg's), video clips, etc

- **Content downloads**
  - Music, video clips, games, etc
- **Streaming**
  - Music, video, TV broadcast

- **Gaming applications**
- **Push-to-Talk**
- **Voice over IP**

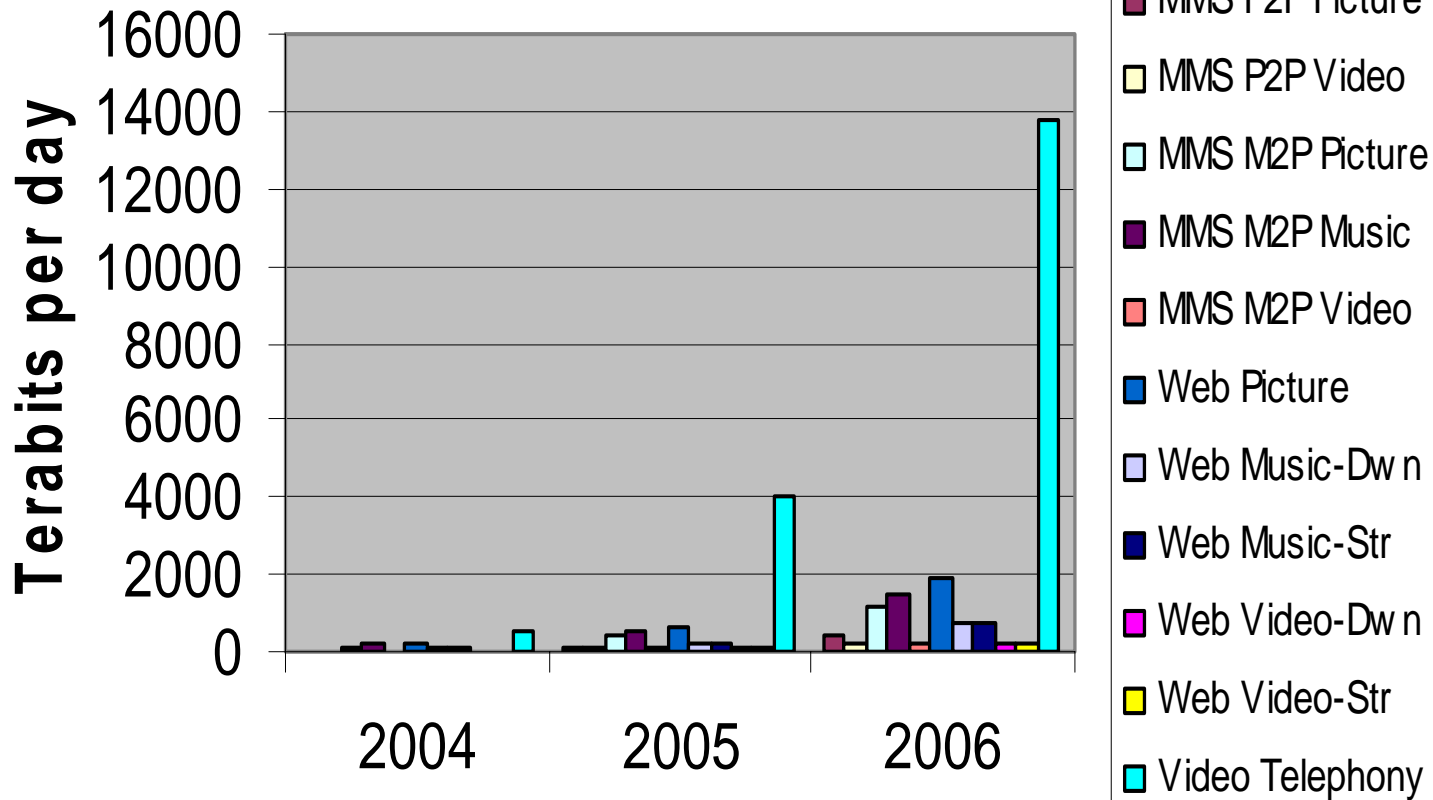
Messaging

Web Access

**More  
IP based  
Mobile  
Multimedia**

# Total Mobile Multimedia Traffic \*

## Total Mobile Multimedia Traffic



\* Based on a private study conducted for a client

# Multimedia Trans-coding

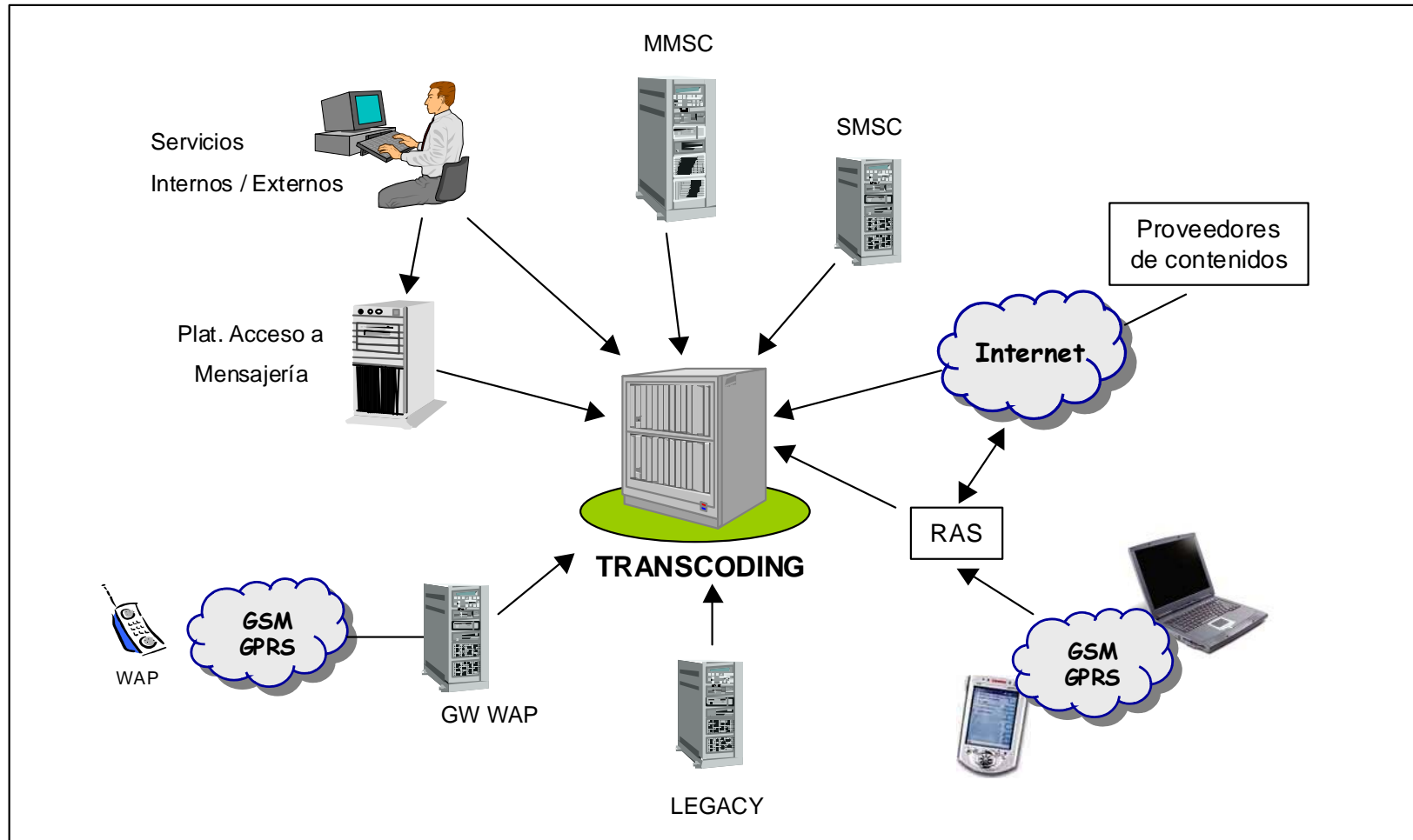
- **Definitions**
  - Adaptation of source media to match the destination device profile
  - Adaptation of rich-content to various media formats, resolutions. Color depths, file sizes etc
    - Resolution reduction
    - Color conversion
    - Rate reduction
    - Detail enhancement

	GIF	JPEG	BMP	TIFF	AMR	AMRPWB	MP3	MIDI	MPEG1	MPEG2	MPEG4	H.323
GIF												
JPEG												
BMP												
TIFF												
AMR												
AMRPWB												
MP3												
MIDI												
MPEG1												
MPEG2												
MPEG4												
H.323												



# Wireless Multimedia Transcoding

## Application Agnostic Deployment

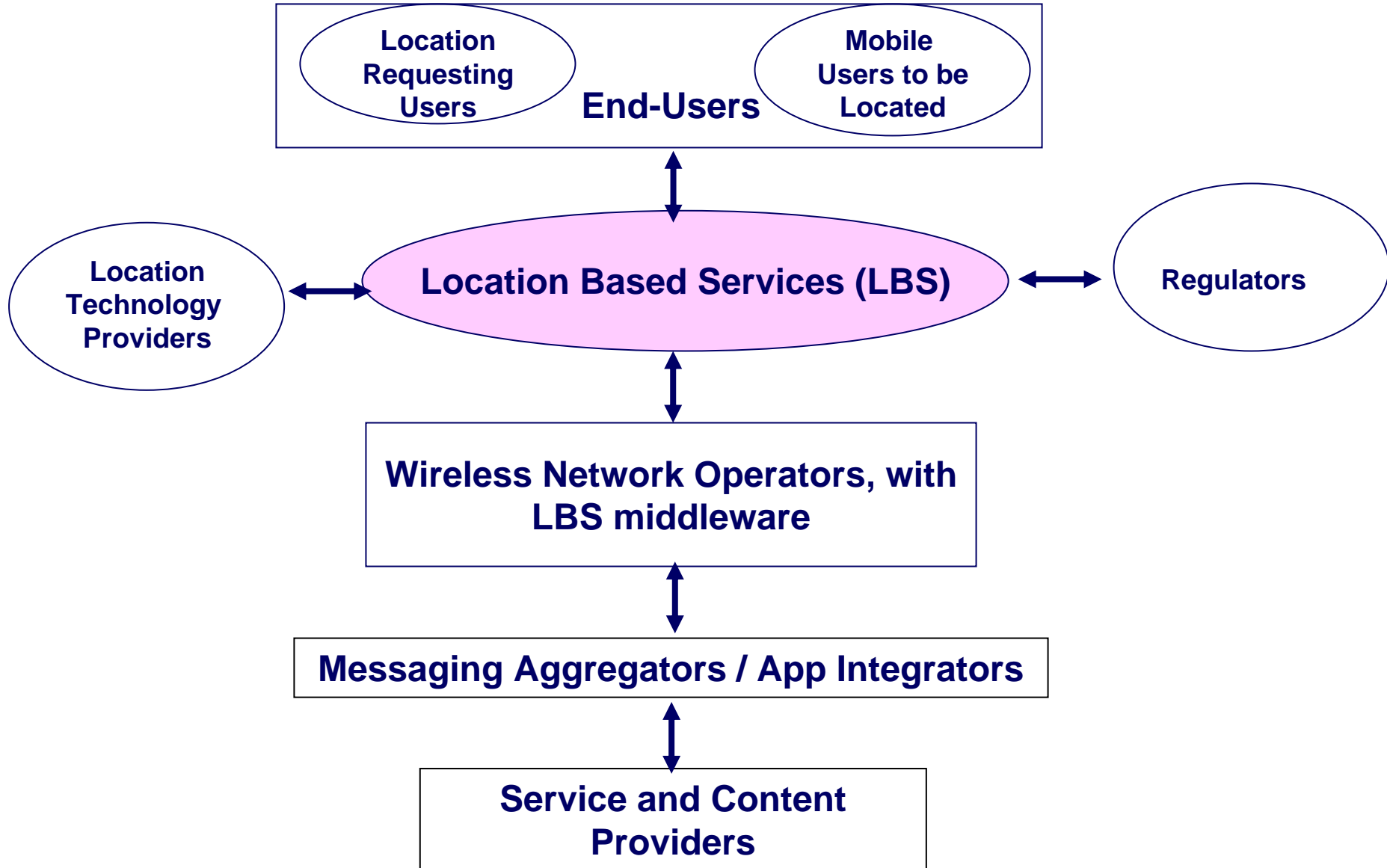


Source: Telefonica's RFI (March 2003)

# Location Positioning Technologies

- **Cell Id**
  - Accuracy around 1 Km
- **Cell Id + Timing Advanced (TA)**
  - Accuracy around 150m in urban areas
- **Time of Arrival (TOA)**
  - Requires LMUs (Location Measurement Units) at BTS sites
  - Accuracy around 100m
- **Angle of Arrival (AOA)**
  - Requires multi-array antennas
  - Accuracy around 125m
- **Enhanced – Observed Time Difference (E-OTD)**
  - Requires LMUs at BTS sites, as well as new software on handsets; location calculated on the handset
  - Accuracy between 50m and 125m
- **Uplink – Time Difference of Arrival (U-TDOA)**
  - Requires LMUs at BTS sites, but no new software on handsets; location calculated by network
  - Accuracy 50m or better; technology promoted by TruePosition
- **Assisted GPS (A-GPS)**
  - Requires handsets with GPS chips; location calculated on the handset
  - Accuracy 50m or better

# Location Based Services - Players



# M-Payment Industry Strategies

As consumers seek **easy, convenient** and secure methods for purchasing digital goods and services, **wireless providers** are perfectly situated to enable and benefit from the growing number of payment scenarios.

## Wireless



## ISP & Broadband

ISP's can create **new revenue streams** by offering users compelling **content and services** to purchase via any fixed or wireless device and then attribute those purchases to a monthly ISP bill.

To **increase profitability** and **reduce churn**, telcos, like wireless operators, are offering customers a variety of goods and services that can be **securely** and **easily** purchased using a bank account, **monthly bill** or **prepaid** account.

## Telcos



**Automotive** **Automotive OEMs** are quickly realizing the revenue and customer loyalty opportunities inherent in both **telematics** and the concept of the “**highway ecosystem**”, and are looking to payment systems to support this “**on-the-go**” type of commerce.

**Financial institutions** are focused on **extending** online banking capabilities and **expanding** the power of debit or credit card offerings with flexible payment systems that can better support e- and m-commerce.

## Financial Services



# Potential M-Payment Solution\*



## Premium SMS

Empowers enterprises to **price SMS messages individually** based on the value of the merchant's content or service offering.

Significantly **reduces the costs** associated with traditional reload scenarios, provides users with **convenient** prepaid account replenishment methods, and helps operators **reduce churn**.



## Prepaid Account Replenishment



## Virtual Payments

Offers enterprises the technology they need to **realize new revenue streams** by building and operating commerce ecosystems where premium content and services are exchanged.

Allows end consumers to pay at physical merchants for hard goods or services using a **non-traditional device** as a credential or anonymous identification repository and electronic payment terminal.



## Proximity Payments

\* Courtesy of iPIN

# M-Commerce and M-Payment

- **Significant market opportunity**
  - Frost Sullivan predicted \$25B global market for m-commerce by 2006, representing 15% OF THE GLOBAL ON-LINE COMMERCE
  - Tower Group predicted 60 Million users of m-payment in Europe and Asia by 2005
- **Wireless operators are natural candidates for offering m-commerce, but especially m-payment services**
- **However, there are several significant challenges / opportunities:**
  - Existing / legacy billing systems
  - New charging and rating schemes
  - Pre-paid system integration
  - Roaming arrangements and implications
  - Security, fraud, non-repudiation and privacy concerns
  - Revenue settlement challenges
  - APIs to partners networks, and
  - Business models

# Opportunities in Wireless Directory Services

- **Wireless directory assistance / directory enquiries market is experiencing a significant growth**
  - **Several market studies put it as multi-billion dollar market**
- **Wireless operators and directory service providers are eager to enlist wireless users and offer directory service**
- **Key barriers have been privacy concerns of the wireless users as well as wireless operators**
- **Technologies / solutions becoming available to overcome these barriers, potentially opening floodgates for wireless directory services**
- **Several key technologies / requirements are:**
  - **Ability to route calls / messages without releasing the wireless user's address**
  - **Whisper technology where the receiving end-user is given a set of choices**
  - **Individual centric listings and updates / moves**

# Challenges / Opportunities with Wi-Fi and Related Topics

- **Services over Public Wi-Fi Hotspots**
  - Service tier, service continuity,
- **VoIP over Wi-Fi**
  - Cost effective voice service, voice hand-off, interworking, etc
- **Wi-Fi Backhaul**
  - Cost efficient back-haul, mesh networks, etc
- **New wireless broadband solutions**
  - Both for licensed and un-licensed bands; 802.16a solutions;
  - Both for developed and developing markets

# WWAN - WLAN Interworking Scenarios

**Scenario 1: Common Billing and Customer Care**

**Scenario 2: 3G system based Access Control and Charging**

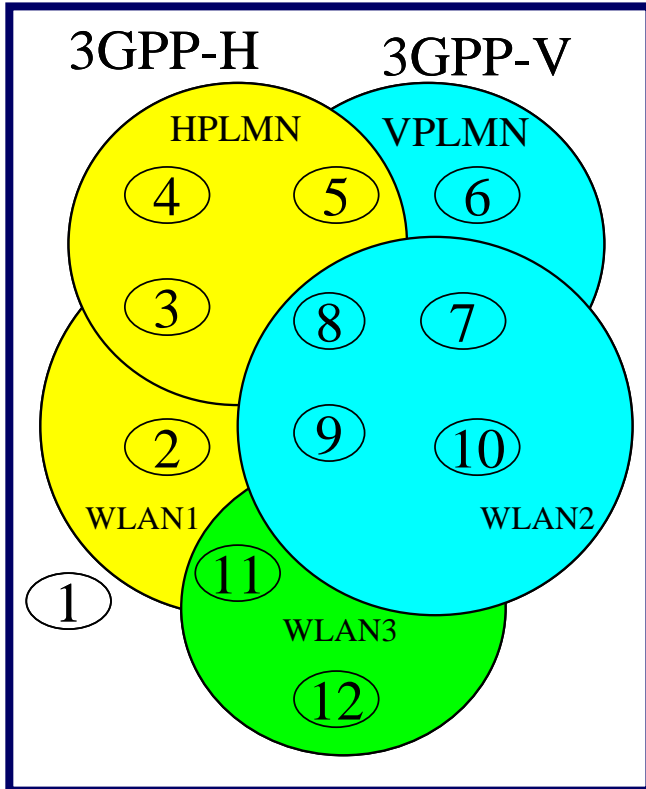
**Scenario 3: Access to 3G system PS based services**

**Scenario 4: Service Continuity**

**Scenario 5: Seamless Services**

**Scenario 6: Access to 3G systems CS based services**

# WWAN-WLAN Interworking User States

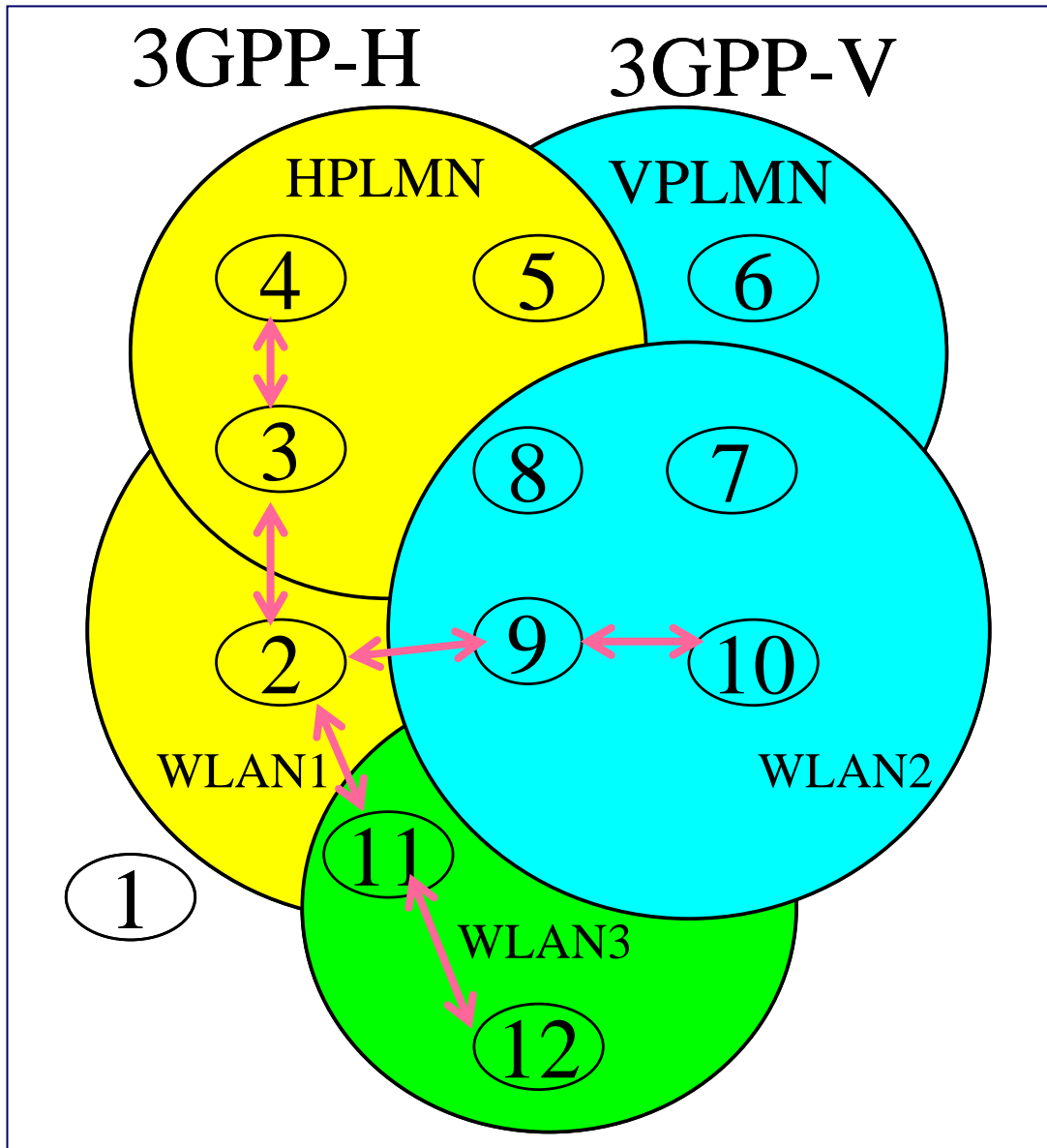


State	Description	WLAN Coverage	3GPP PLMN Coverage
1	Switch on	No coverage	No coverage
2	Single network WLAN1 coverage	Coverage only available from WLAN1(s)	No coverage
3	Overlapping 3GPP & WLAN coverage	Single network coverage	Home network coverage
4	Single network 3GPP-H coverage (HPLMN)	No coverage	Home network coverage
5	Multiple networks 3GPP coverage	No coverage	Coverage from home network and other operator(s)
6	Network(s) 3GPP-V coverage (VPLMN)	No coverage	Coverage from visited network(s) only
7	Overlapping 3GPP & WLAN coverage	Coverage only available from WLAN2(s)	Coverage from visited network only
8	Multiple 3GPP & Multiple WLANs	WLAN1(s) & WLAN2(s) (NOTE 1):	Coverage from Home and Visited Networks
9	Multiple WLAN coverage	Coverage available from WLAN1(s) & WLAN2(s)	No coverage
10	Single WLAN2 network coverage	Coverage only available from WLAN2(s)	No coverage
11	Multiple WLAN coverage	Coverage available from WLAN1 & WLAN3	No coverage
12	WLAN(s) coverage not interworked	Coverage only available from WLAN3(s)	No coverage

NOTE 1 : May also include WLAN 3 (Not Illustrated)

Source: 3GPP TR 22.934

# Challenges: Hand-off Scenarios



# RFID and Low Cost Connections

- **Major wave of opportunities in the near future**
- **Wal-Mart and others will make RFID almost as common as bar codes; however, need to be careful about too much hype!**
- **Immediate opportunities in RFID are in**
  - **some vertical markets,**
  - **developing packaged solutions, based on various RFID gadgets, e.g. auto theft prevention**
- **Requirements for smart devices communicating with each other, and communicating with a server**
  - **None of the current solutions, GSM telemetry, WLAN fits**
  - **Numerous future applications**

# Conclusions

- **Pervasive connectivity is a lot more than few technology developments**
- **It is cost effective coverage, capacity and QoS for networking, for out-doors and in-building**
- **It is cost effective devices that offer the right functionalities, with ease-of-use, personalization, security, etc.**
- **It is wide range of services and applications that can deliver enhanced quality of life, as a result of pervasive connectivity**

**Goal: To Enhance Quality of Life**