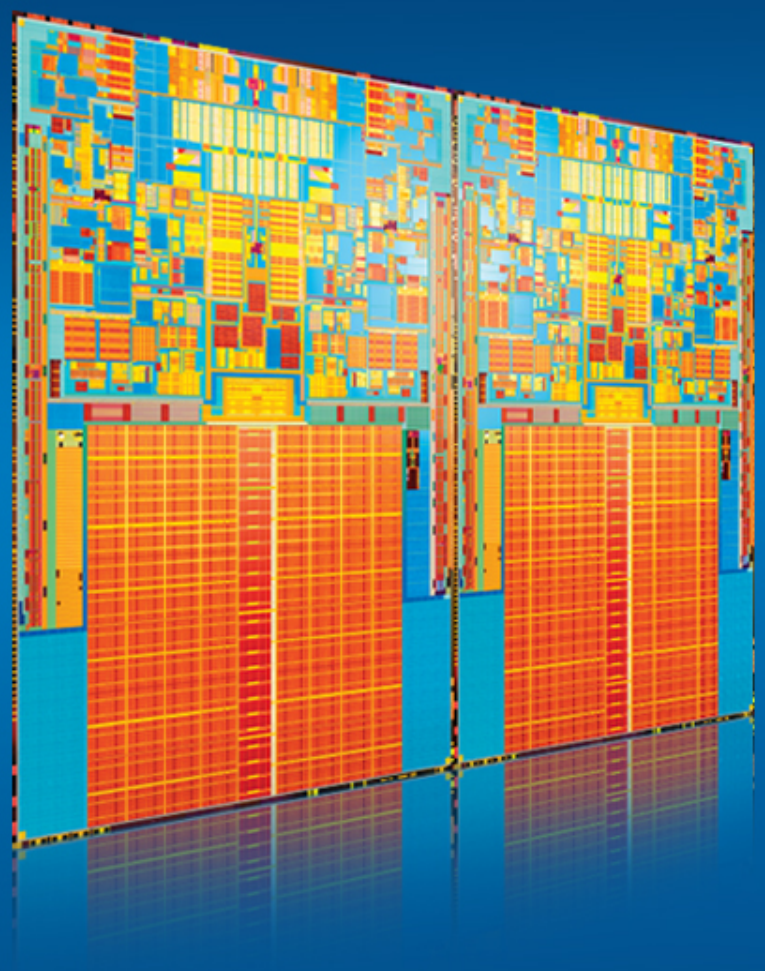

Mobile WiMAX:
Emergence of Mobile Internet

OMA Workshop: Feb 2010

Dr. Pouya Taaghol
Intel Mobile Wireless Group

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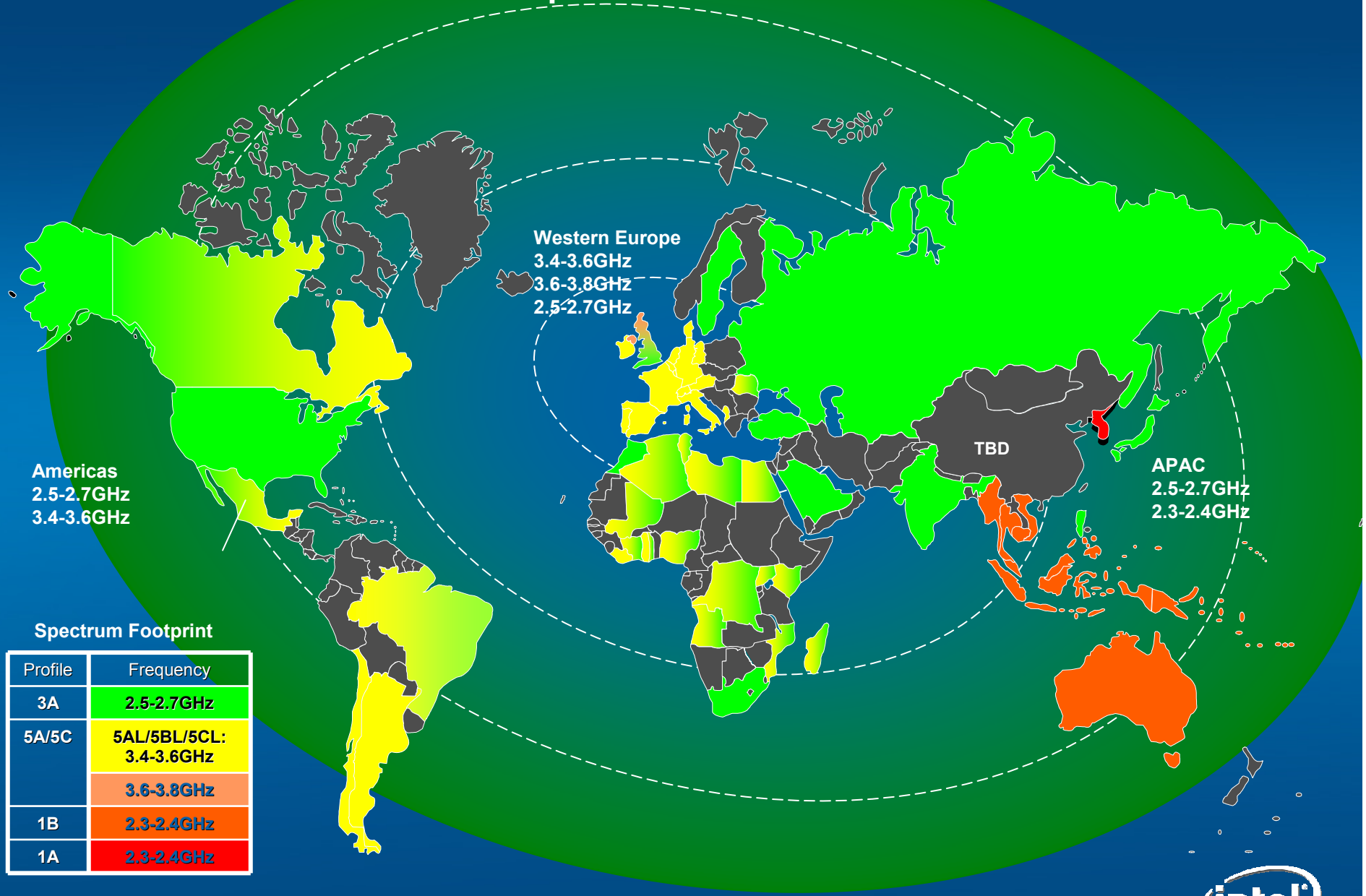
- Performance of wireless systems is highly dependent on the operating environment, device and network implementation. The competitive results are based on a given set of assumptions and methodology. Data has been simulated and is provided for informational purposes only. Data was derived using simulations. Any difference in system hardware or software design or deployment scenario and channel models may affect actual performance. The performance numbers are best used as guidelines on relative performance of the different technologies.

Agenda

- Mobile WiMAX Market Status
- Mobile WiMAX Overview
- Mobile WiMAX Technology Roadmap
- Evolution of Services

WiMAX Market Status

Worldwide WiMAX Spectrum Allocation and Kilmer Peak



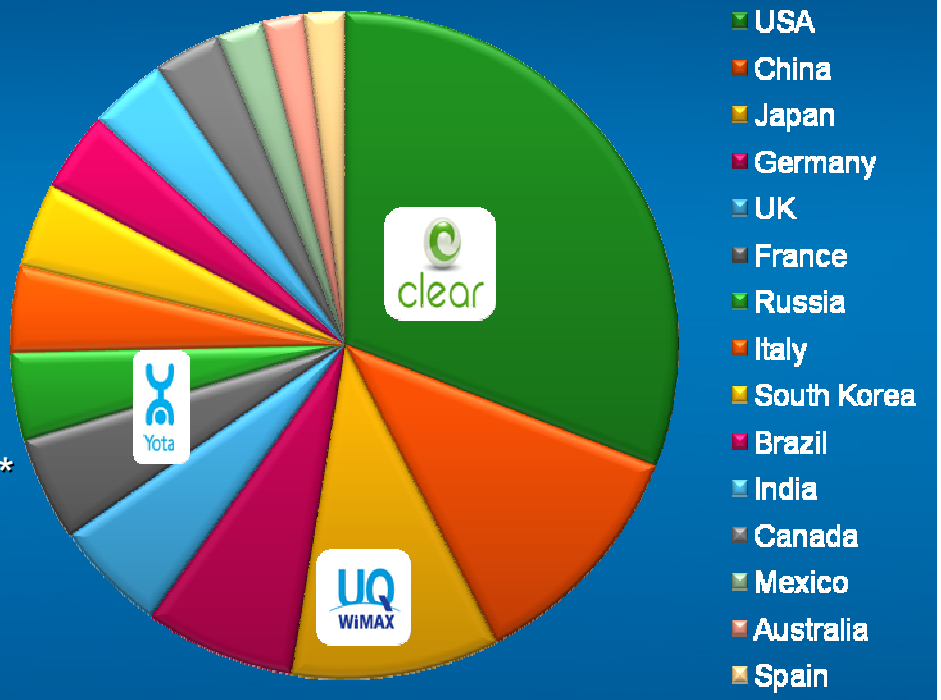
Spectrum Footprint

Profile	Frequency
3A	2.5-2.7GHz
5A/5C	5AL/5BL/5CL: 3.4-3.6GHz
	3.6-3.8GHz
1B	2.3-2.4GHz
1A	2.3-2.4GHz

[1]Applies to TDD Spectra

Embedded WiMAX Notebooks/Netbooks

- Top 15 represent 71% of total[1]
- All countries have 2.3/2.5 or 3.5GHz
- 11 IA OEMS supporting WiMAX today
- Clear / US: 35+ models from 5 OEMs*
- UQ / Japan: 7 OEMs shipping today*
- Russia: 43+ models available from 6 OEMs*
- 100 notebook + netbook models*



ASUS EPSON FUJITSU lenovo NEC Panasonic SONY
acer Clarion DELL hp msi ONKYO SAMSUNG SHARP TOSHIBA

* Certified for operator networks and/or shipping as of Jan 2010.

[1] Source: Computer Industry Almanac, Jan '09

WiMAX Pricing Around the World

CLEARWIRE, US
Home Internet as low as $25/mo
Mobile Internet as low as $35/mo
Combo Packages as low as $55/mo

Yota, Russia
USB/Embedded Note/netbooks - $30/mo
4G Max GSM/WiMAX Phone - $17/mo
Yota Day Pass - $1.70/day

UQ Communications, Japan
UQ Flat Rate - $48/mo
No Contract. Free Wi-Fi Access
Additional devices $2/mo each

P1 Networks, Malaysia
Mobile Internet as low as $20/mo
Home Internet as low as $14/mo
"Office" Plans as low as $47/mo

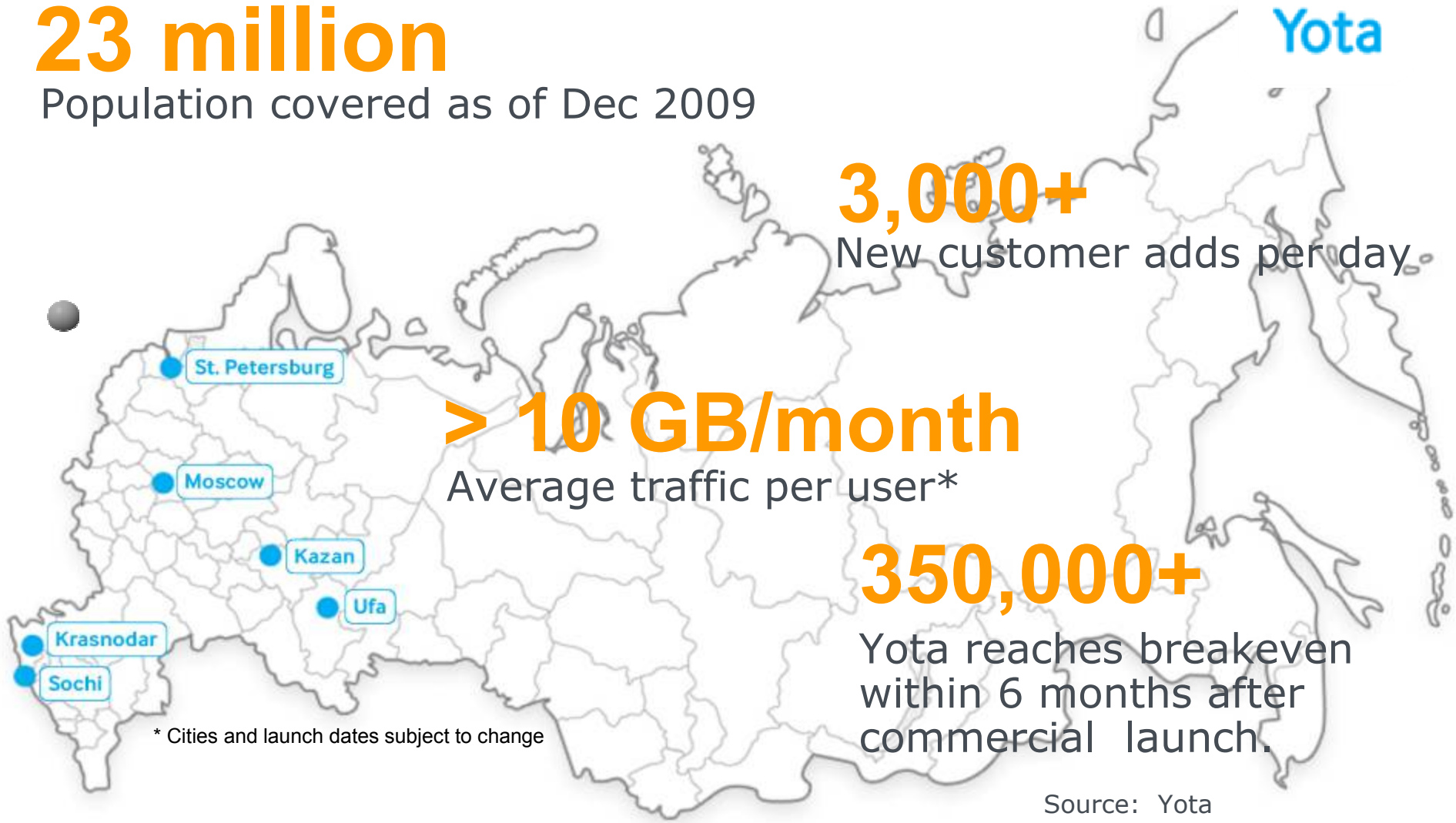
KT, South Korea
WIBRO plans as low as $10/mo
Pre-paid plan at $1/hour
Pre-paid plan at $3/day

CLEARWIRE, SPAIN
Mobile Internet as low as €29.90/mo
No usage caps
No contract necessary

Yota: Breakeven in Record Time

23 million

Population covered as of Dec 2009



3,000+

New customer adds per day

> 10 GB/month

Average traffic per user*

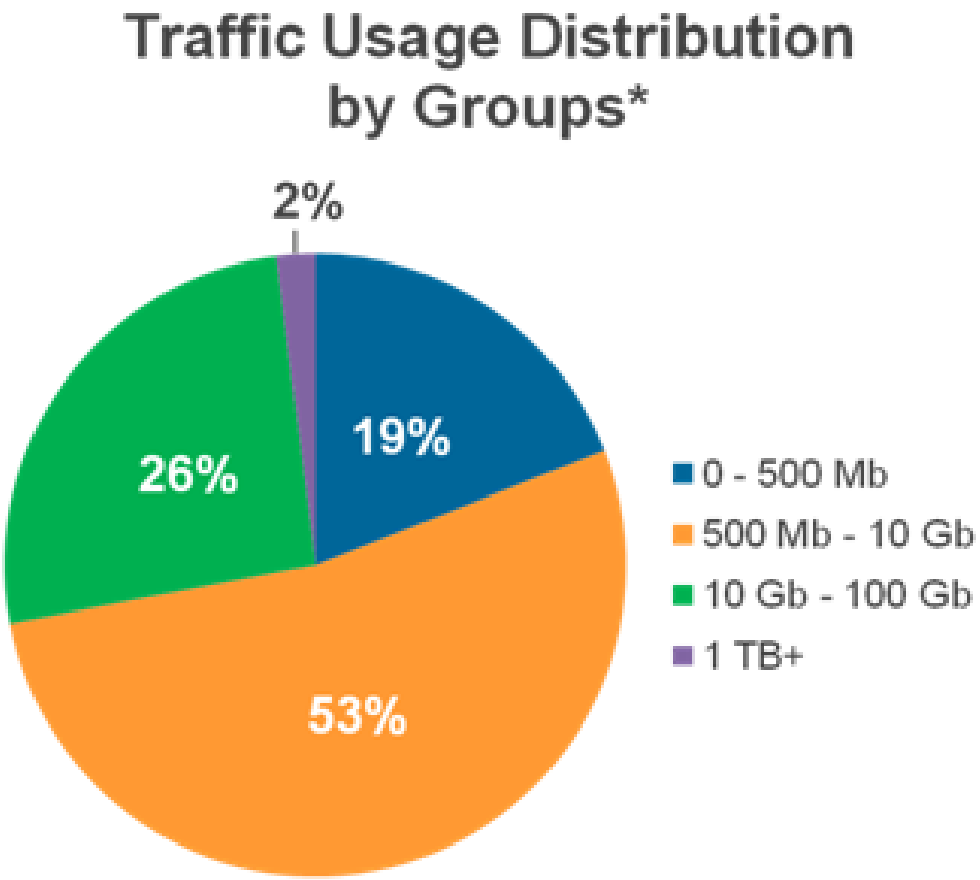
350,000+

Yota reaches breakeven within 6 months after commercial launch.

* Cities and launch dates subject to change

Source: Yota

Proof is in the Usage: Yota



*July, 2009 Data

- Average traffic per user (excluding idle and heavy/abusive) – **10.3 GB/Mo!**
- **Almost 20% higher** than average ADSL/cable broadband usage in Moscow and Saint Petersburg
- **100 times more** than average GPRS/EDGE/3G usage in Russia

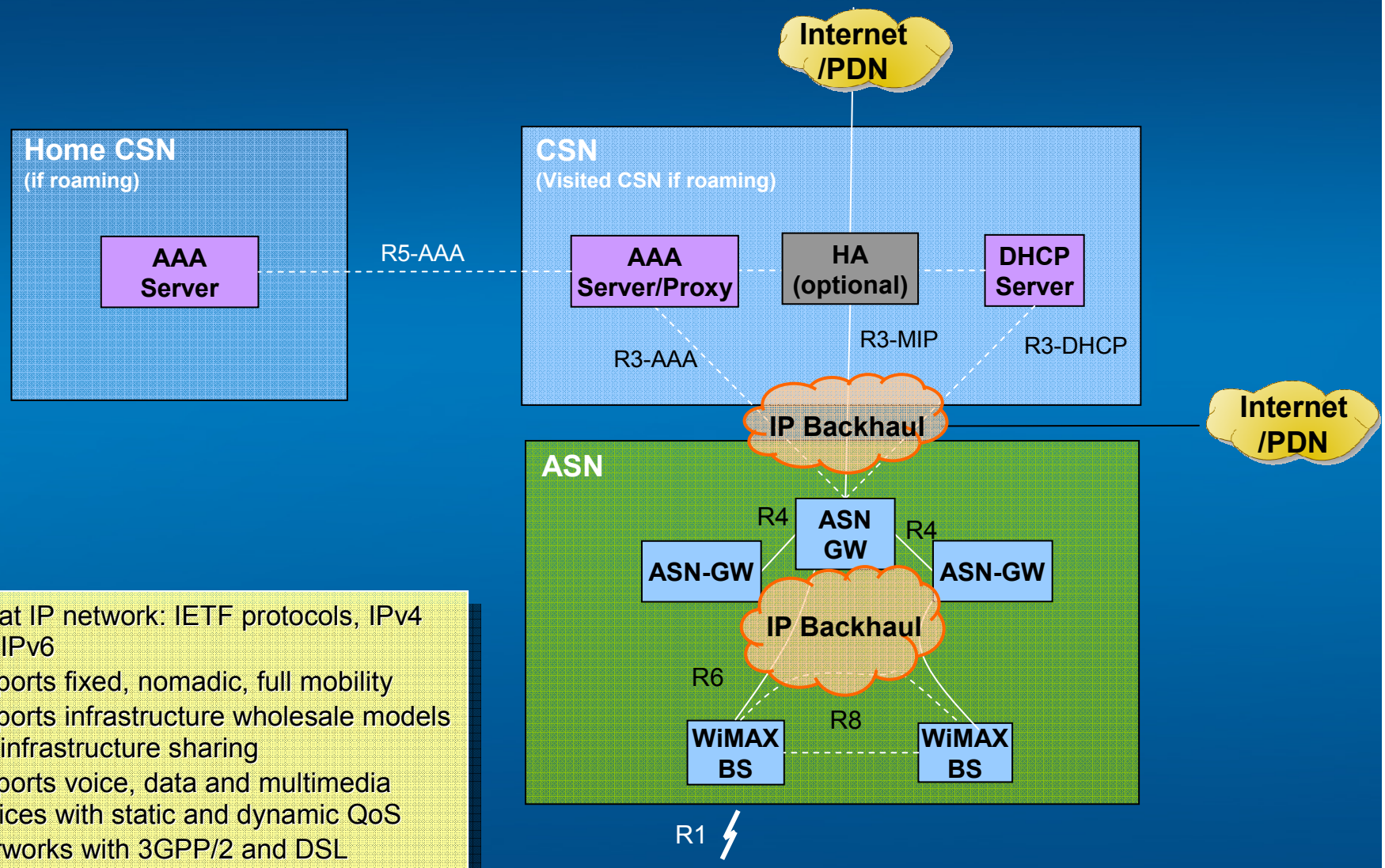
Open IPR Structure and OPA

An Open Patent Alliance (OPA) has been formed to stimulate innovation and attract new entrants into the WiMAX ecosystem by providing a simple, predictable and fair intellectual property rights framework that facilitates the widespread implementation and adoption of the WiMAX standard

OPA Forms PATENT POOL
Includes Cisco, Intel, Samsung, Huawei, GCT, UQ, Alvarion and others
Patent pools significantly reduce both litigation costs and the transaction costs of negotiating licensing agreements.
A patent pool is far more likely to represent the generally acceptable royalty rate for a particular technology vis - à - vis bilateral licensing arrangements, and therefore establishes a good market reference point

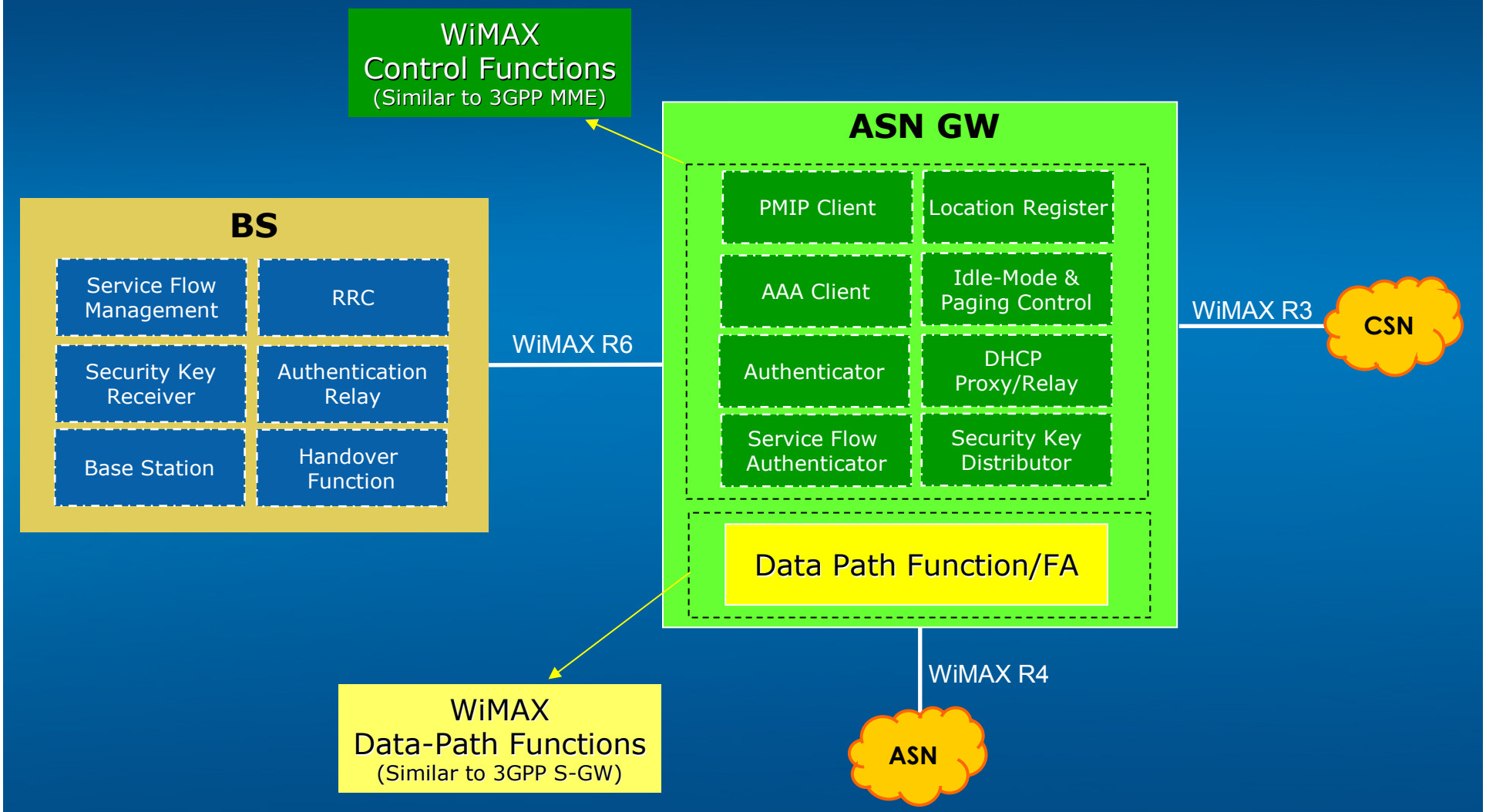
Mobile WiMAX Architecture

Mobile WiMAX Network Architecture

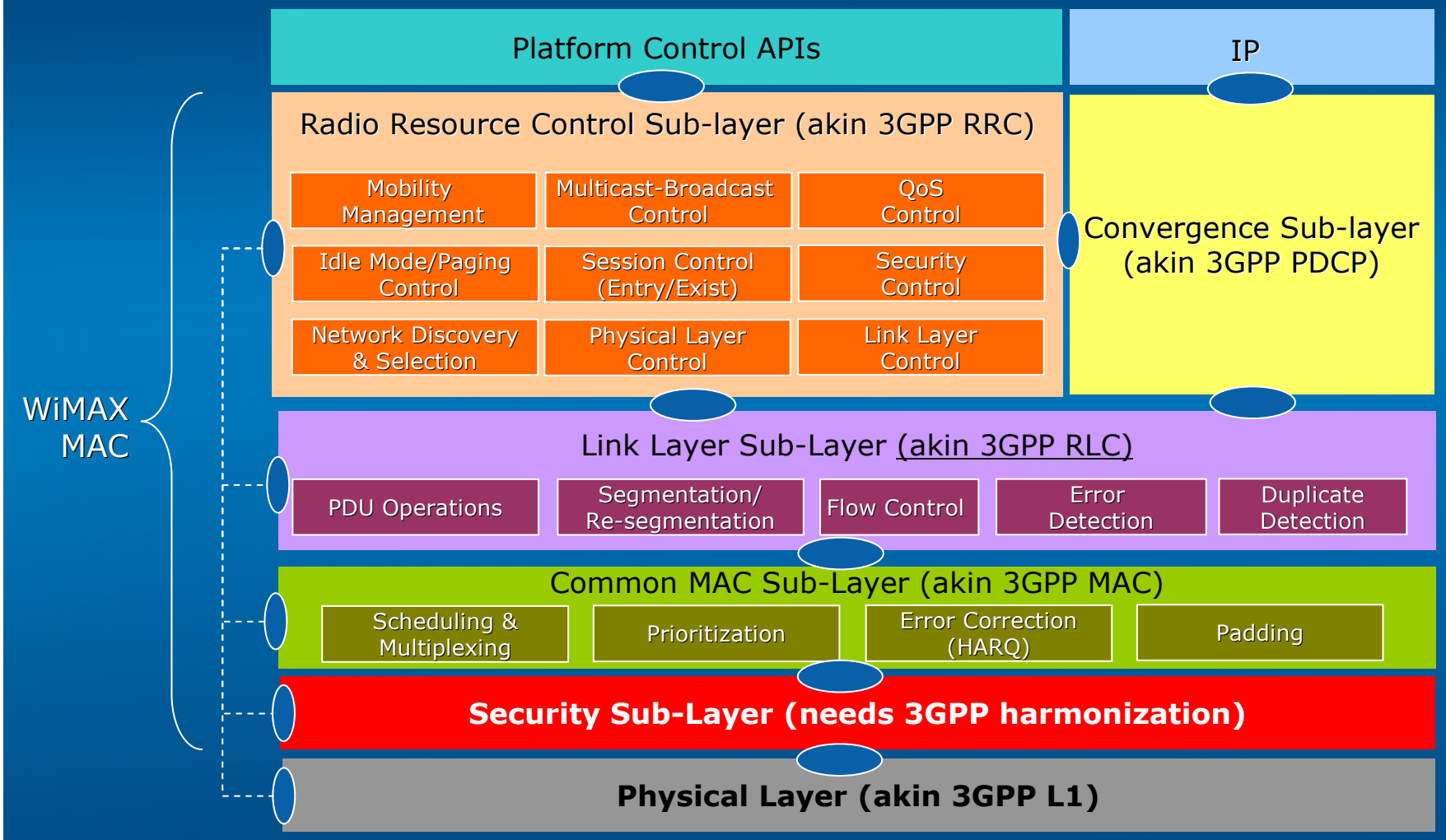


- All flat IP network: IETF protocols, IPv4 and IPv6
- Supports fixed, nomadic, full mobility
- Supports infrastructure wholesale models and infrastructure sharing
- Supports voice, data and multimedia services with static and dynamic QoS
- Interworks with 3GPP/2 and DSL

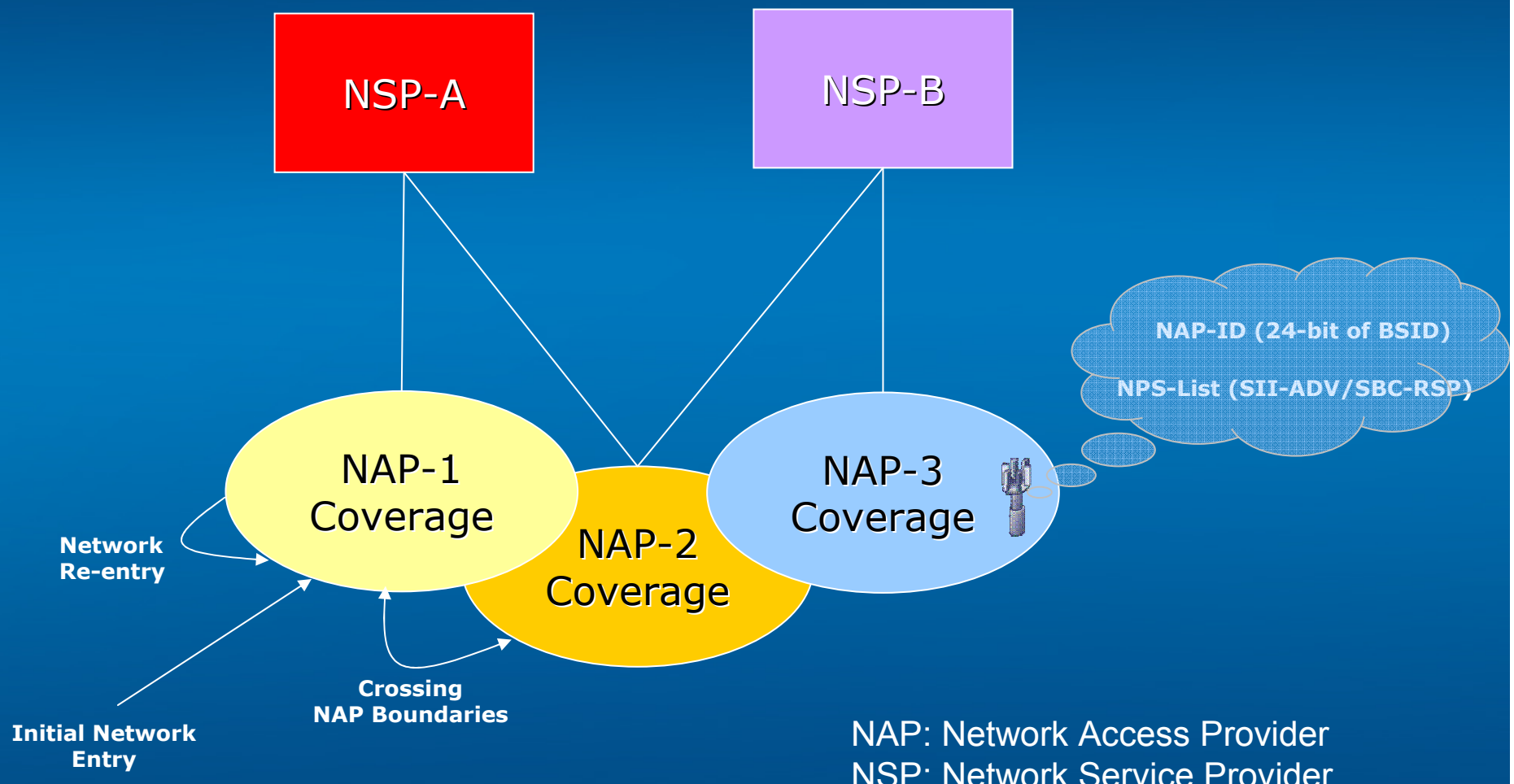
ASN Functional Decomposition



Dissection of WiMAX Protocol Stack

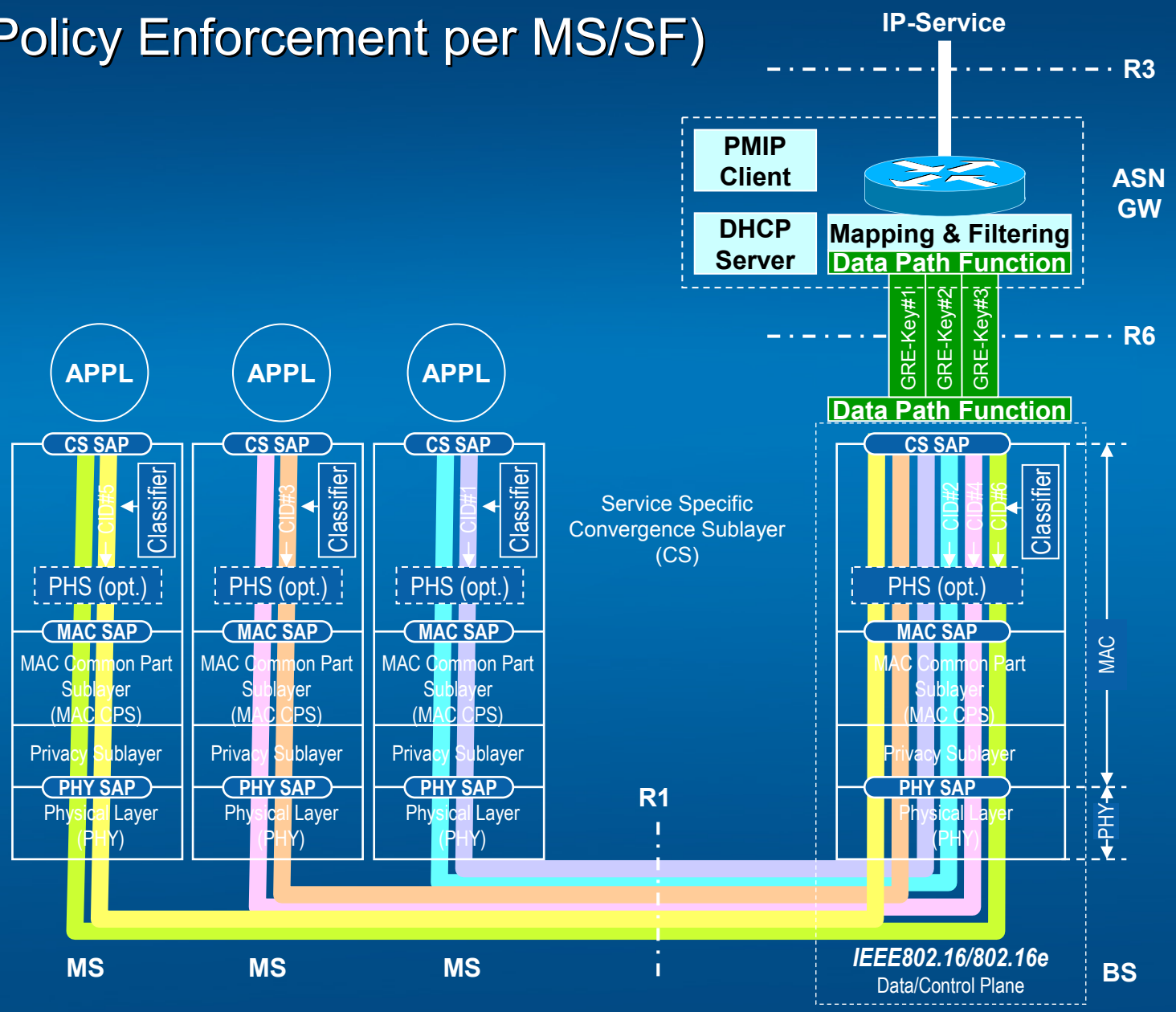


Built-in Infrastructure Sharing

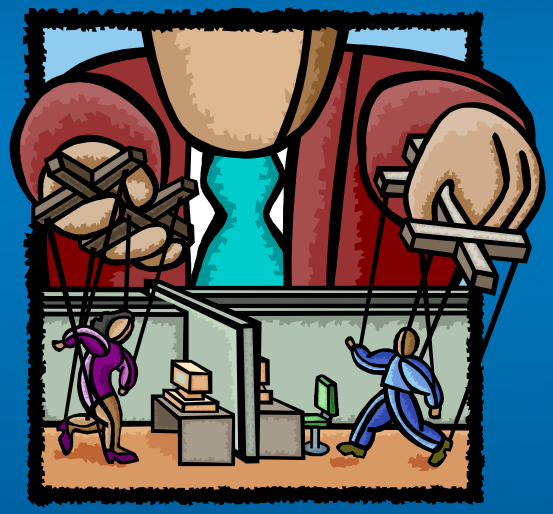


NAP: Network Access Provider
NSP: Network Service Provider

WiMAX Service Flows
(QoS/Policy Enforcement per MS/SF)



OTA Device Provisioning and Management



WiMAX Certification Program

Sample WiMAX Enabled Device/Module Ready For Testing

WiMAX FORUM

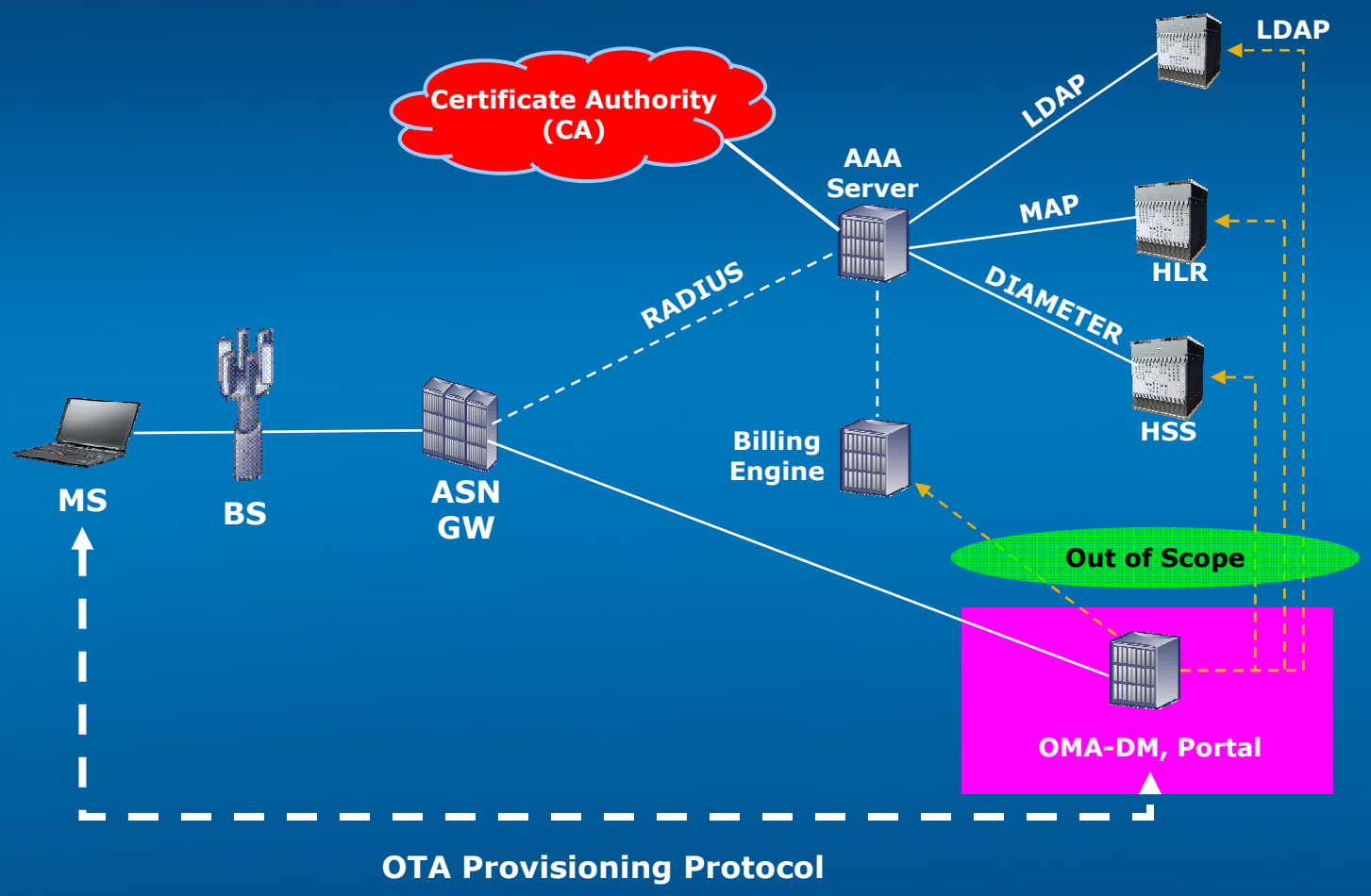
Certification Program

Successfully Tested Mobile Device

Mass Product Shipping

WiMAX certification program guarantees IOT
No further testing needed by operator
Device auth verifies device authenticity and WiMAX compliance

Provisioning System Architecture



New session hot-lining used for isolating non-provisioned devices

WiMAX OTA Device Provisioning using OMA-DM

(Retail Model)

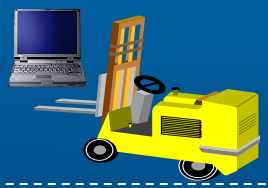
User Buys a Certified WiMAX Device for Retail Store

User selects a WiMAX operator from list of available signals

Device Authentication

Subscription Plan Offers

User selects a subscription plan



Device gets OTA provisioned

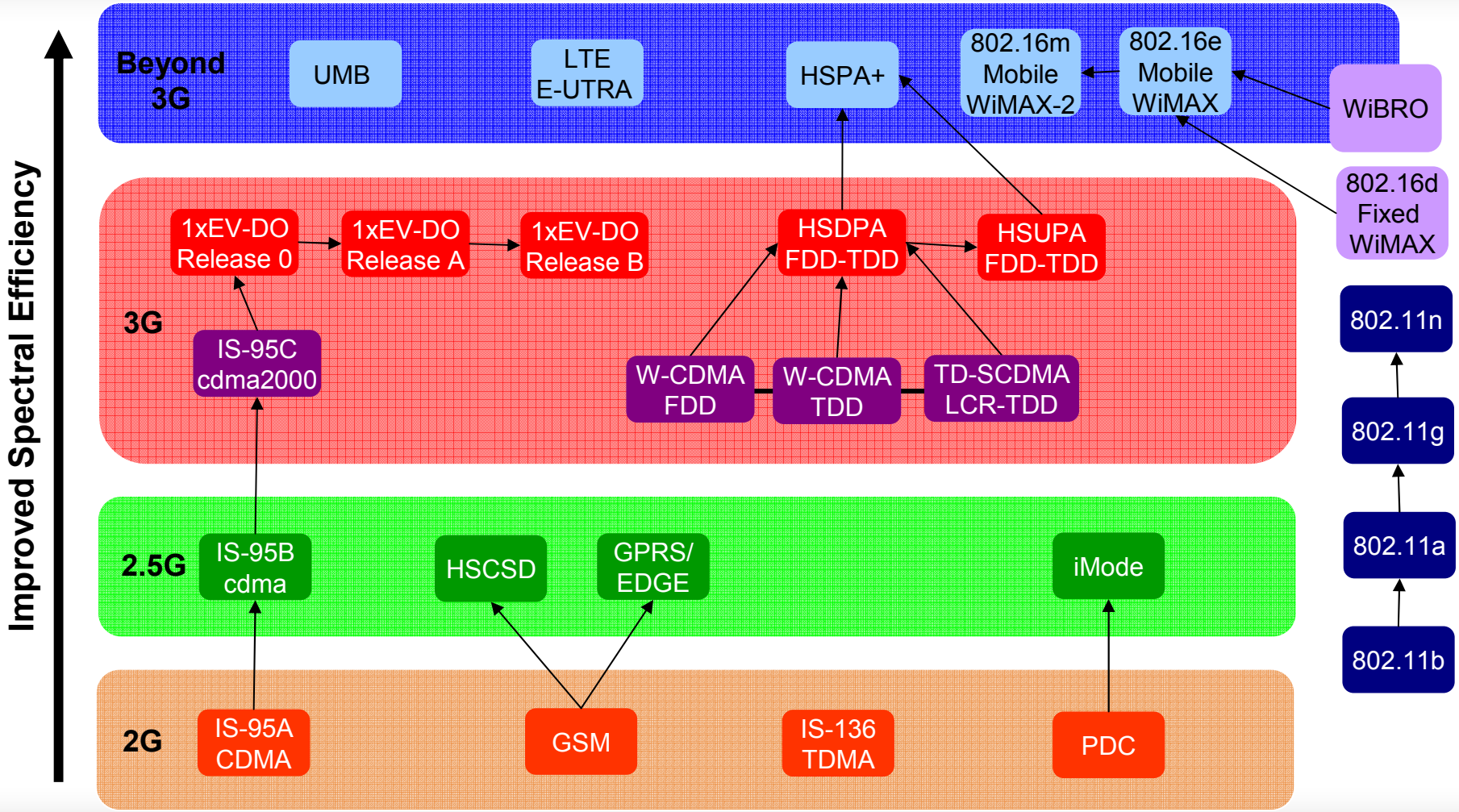
WiMAX OTA provisioning allows open retail model without compromise.
Seamless and fast signup to WiMAX services using OMA-DM

Backward Compatibility

Backward Compatibility

- Definition: Ways to make new and legacy technologies share radio and/or core network resources
- Backward compatibility at air-interface level:
  - Allows new RAN to co-exists with the old one at the same frequency channel
- Backward compatibility at core network level:
  - Allows new RAN to share the same core network elements (e.g. gateways) with the legacy RAN

Evolution of Air-Interface Technologies



Performance Comparison

	Downlink spectral efficiency in b/s/Hz/sector		Uplink spectral efficiency in b/s/Hz/sector		VoIP capacity in active calls (10 MHz)	
	Low mobility	Mixed mobility	Low mobility	Mixed mobility	Low mobility	Mixed mobility
WiMAX 1.0	1.39	1.24	0.72	0.65	155	140
WiMAX 1.5	1.6	1.45	0.94	0.83	195	175
LTE	1.63	1.41	0.86	0.75	215	185
WiMAX 2.0(*)	2.85	2.6	1.45	1.3	300	270

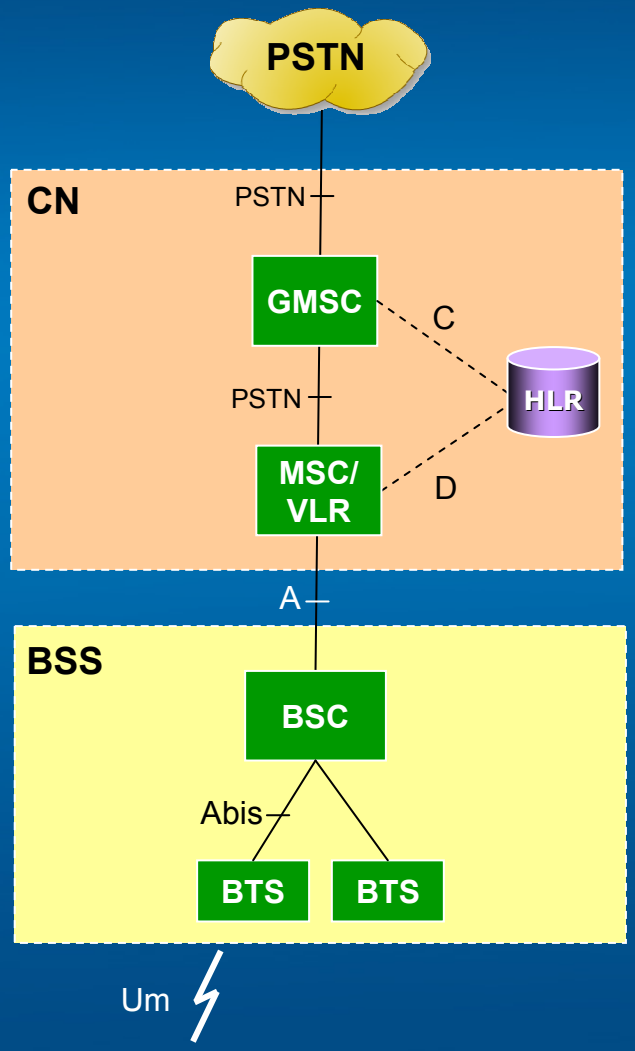
(*) Targets according to 802.16m SRD; targets appear to be achievable through the use of MU-MIMO, FFR, optimized control signaling, lower transmission time intervals

24

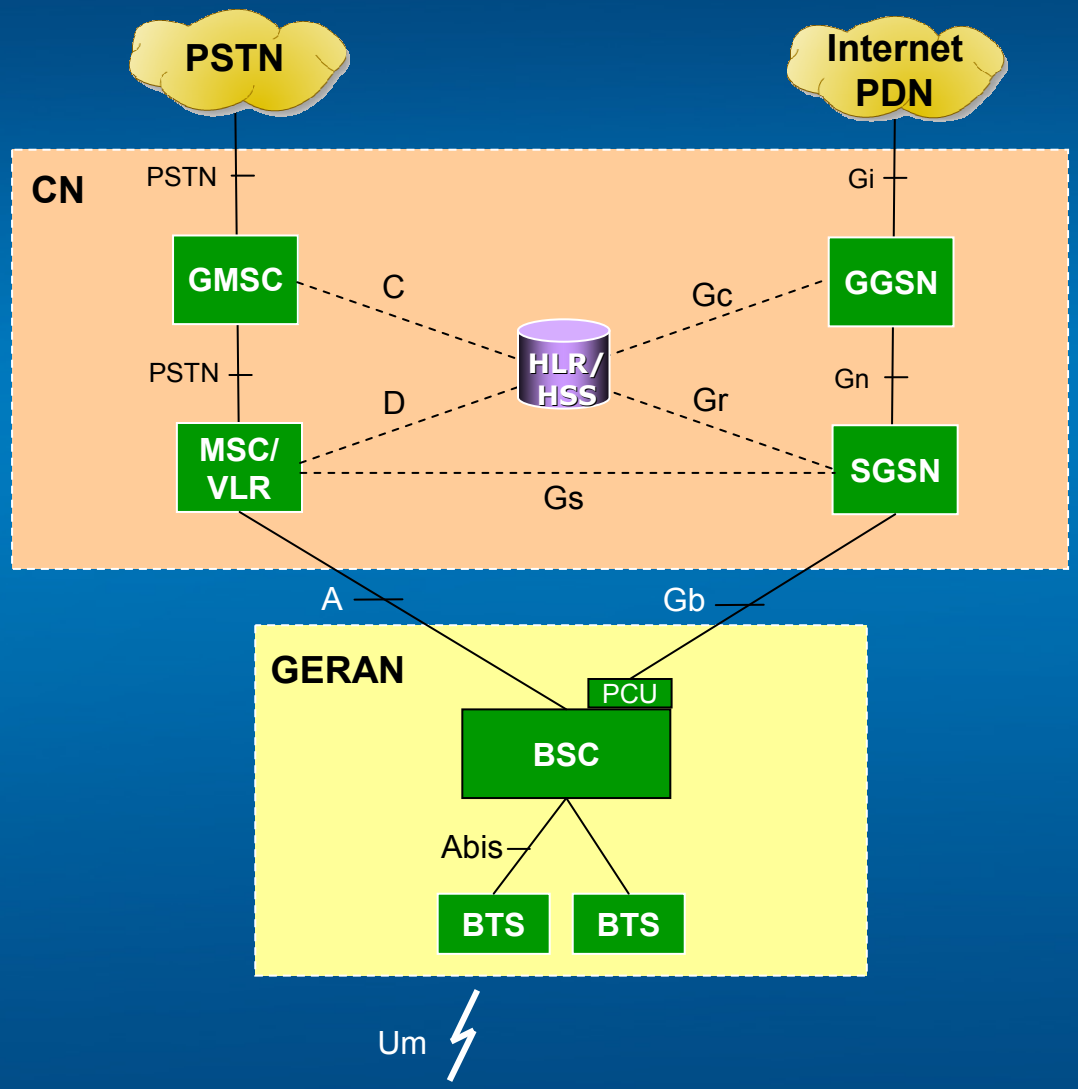
Performance Comparison (cont'd)

Technology	Peak Data Rate		RAN Access Latency	Idle to Active transition time
	Downlink	Uplink		
WiMAX Release 1.0 TDD (2:1 Ratio) 10 MHz	40 Mbps	10 Mbps*	40 ms	100 ms
HSPA (today)	14 Mbps	2 Mbps	50-250 ms	600 ms
HSUPA	14 Mbps	5.8 Mbps	50-250 ms	600 ms
HSPA Evolved (Rel-7) MIMO 2x2	28 Mbps	11.6 Mbps	50-250 ms	600 ms
HSPA Evolved (Rel-8) MIMO+64QAM downlink	42 Mbps	11.6 Mbps	50-250 ms	100 ms
LTE (Rel-8) 2x5MHz	43.2 Mbps	21.6 Mbps	30 ms	100 ms

The Good Old GSM

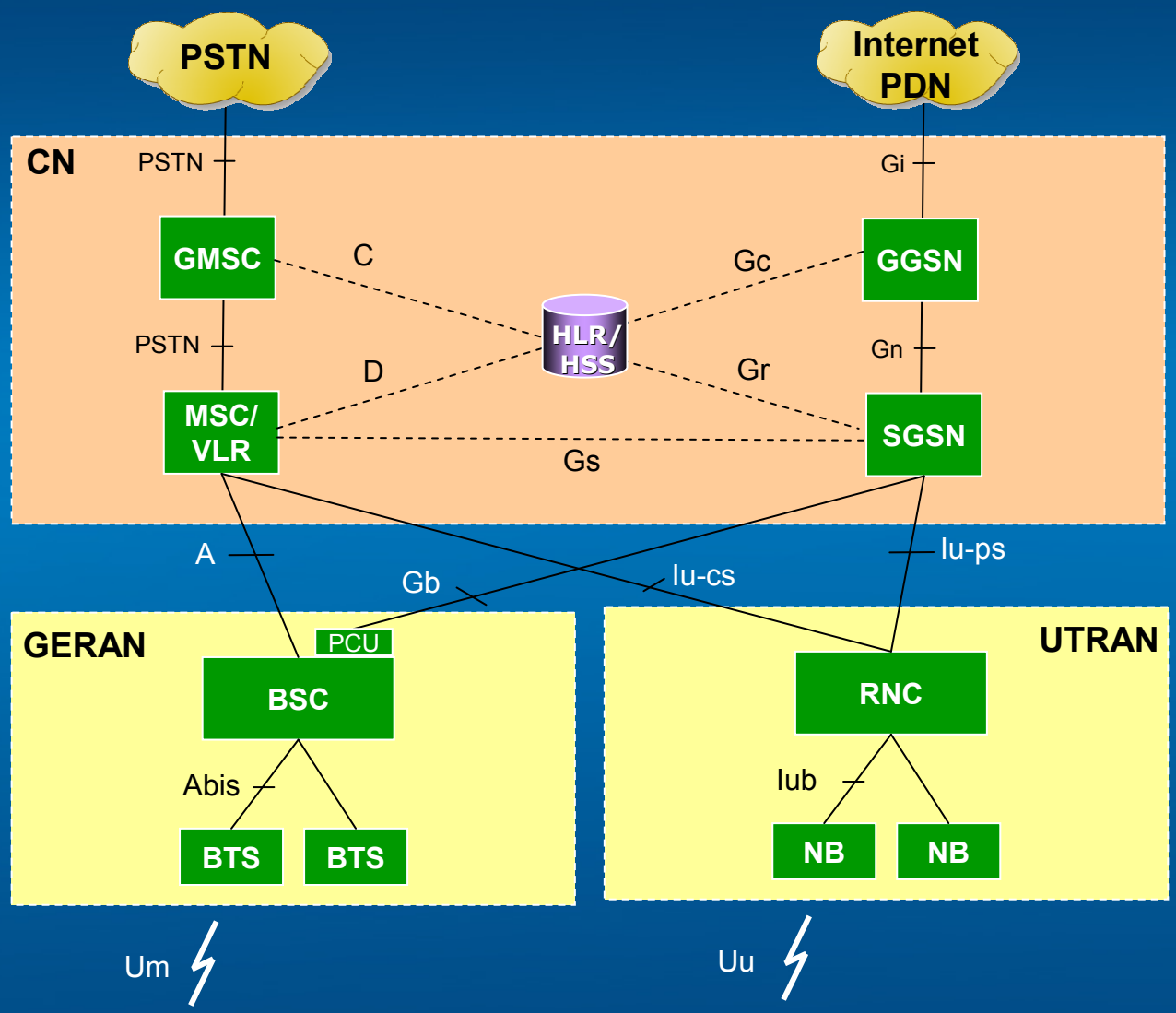


GPRS Introduction



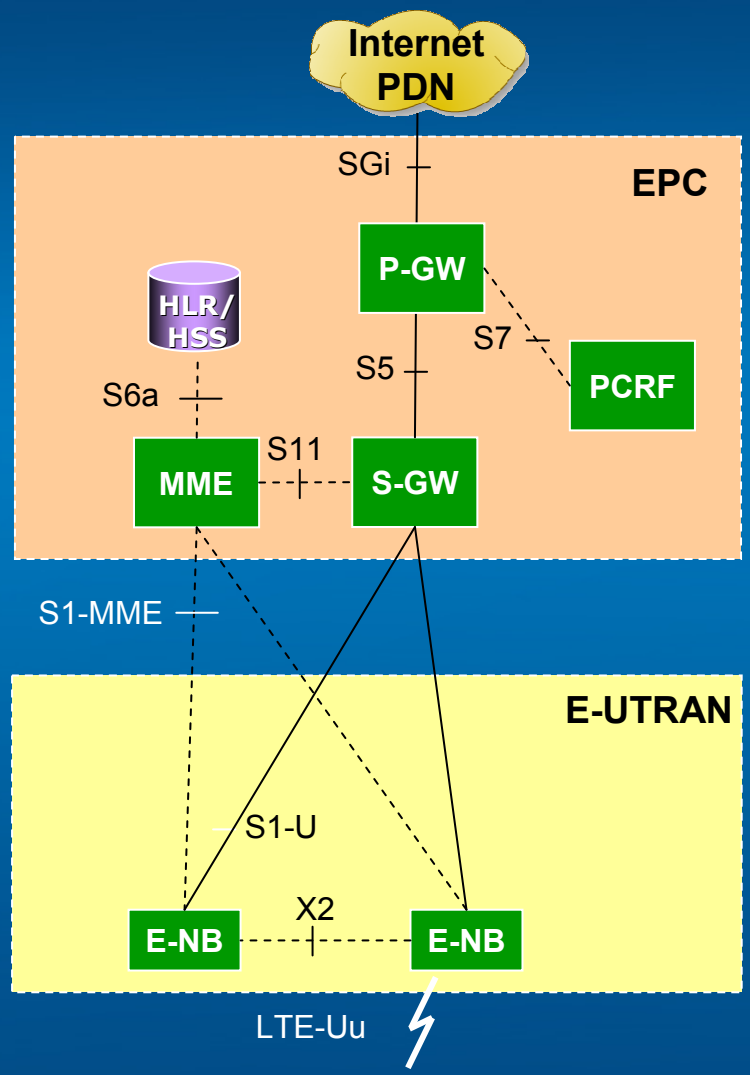
GPRS/EDGE has air-interface backward comparability with GSM
But requires a new packet core

3G Introduction



3G has no air-interface backward comparability with 2G
but UTRAN can interwork with legacy packet and circuit cores

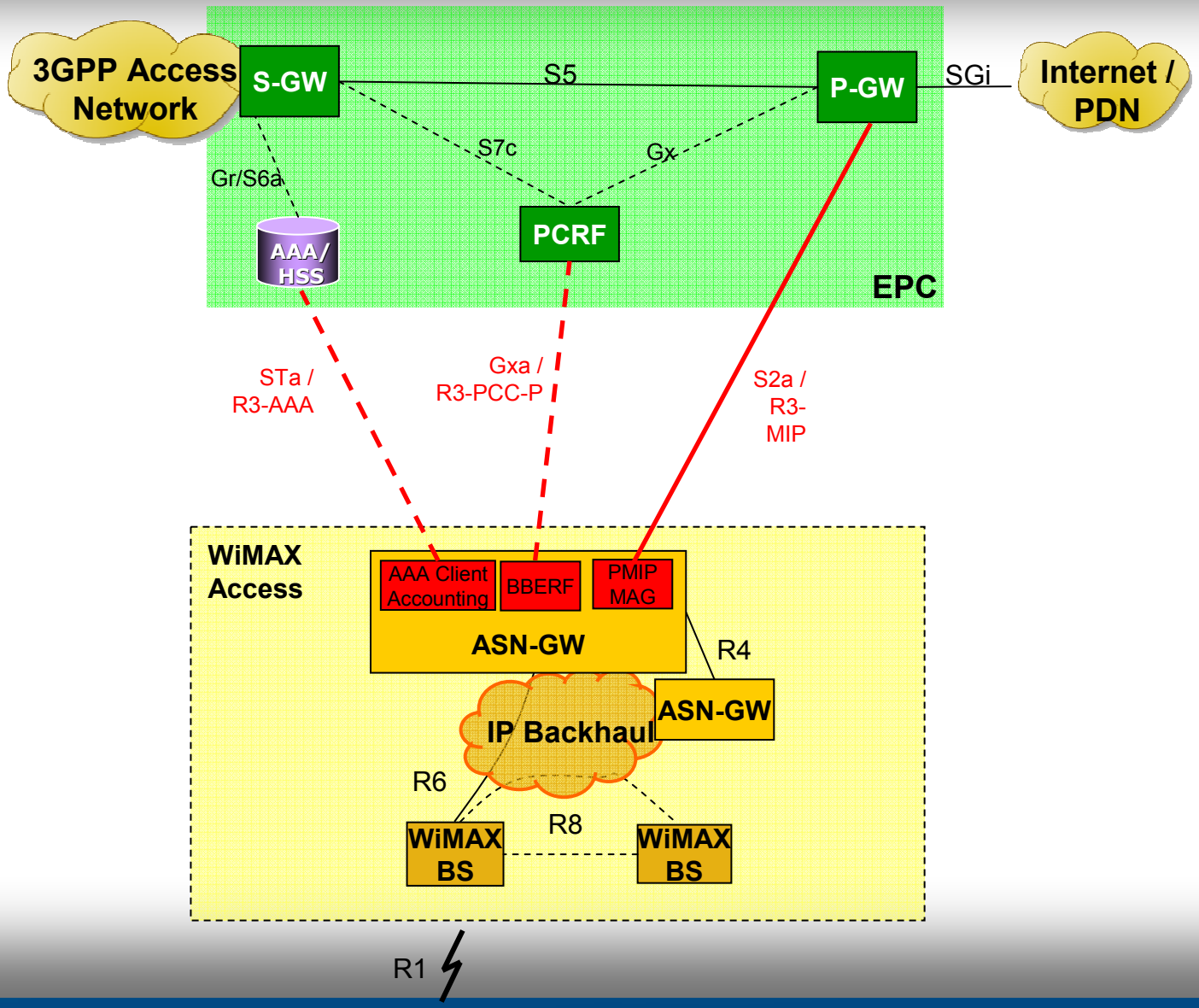
LTE/EPC Network Architecture



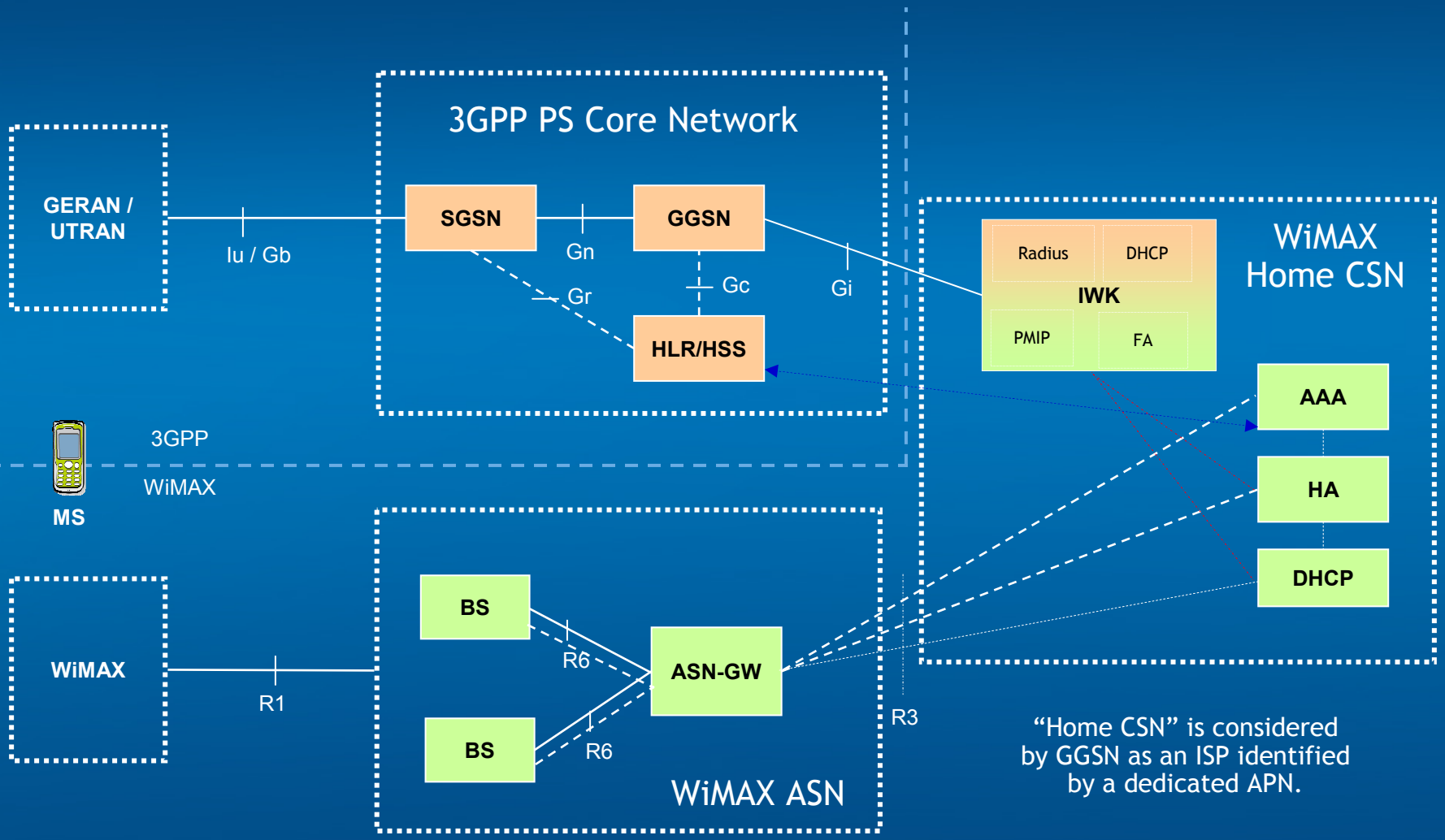
Source: 3GPP TS 23.401

LTE has no air-interface backward comparability with 2G/3G and requires a whole new evolved packet core (EPC)

WiMAX Interworking with 3GPP Release 8



WiMAX Interworking with 3GPP Pre-Release 8

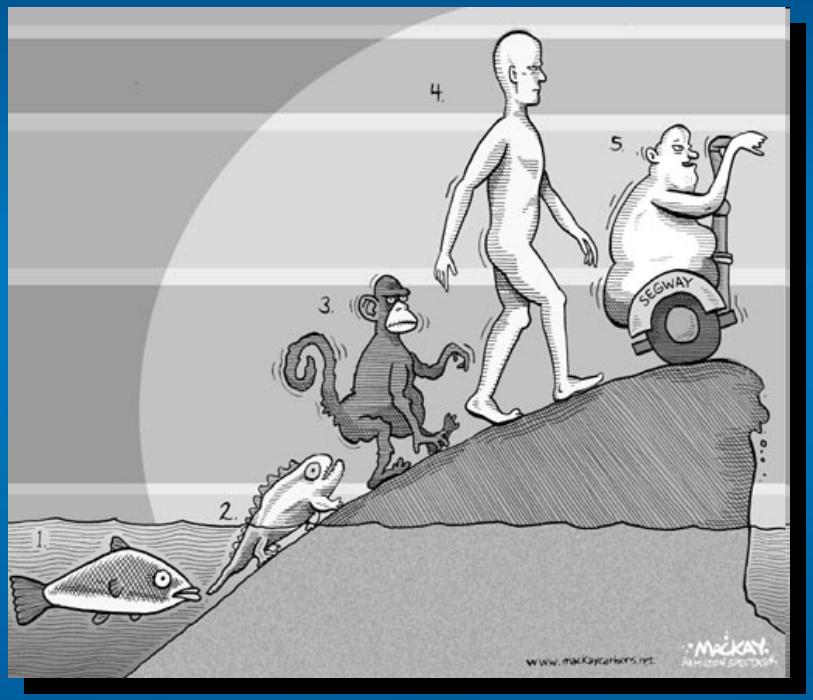


"Home CSN" is considered by GGSN as an ISP identified by a dedicated APN.

Summary of Backward Comparability

	Air-interface backward compatibility	Core network backward compatibility	Interworking with legacy systems
2.5G (GPRS/EDGE)	With GSM	Requires new packet core	N/A
3G (WCDMA, HSPA)	None with GSM	Reuses 2G/2.5G core networks	Done via legacy 2G/2.5G core
E-UTRAN (LTE)	None with 2G or 3G	Requires new evolved packet core (EPC)	Possible via EPC
WiMAX	None with 2G or 3G	Requires some interworking elements similar to EPC	Possible via interworking elements or EPC

Mobile WiMAX Evolution



Mobile WiMAX™ Evolution

2008 **2009 - 2010** **2010 - 2011**

* Note: Actual mobility & throughput experienced depends on environmental parameters and Network Operator provisioning

Mobile WiMAX™ (Release 1.0)

Products shipping now

- Full mobility: Up to 120 km/hr*
- Peak sector throughput over 70 Mbps (10 MHz, 2x2 MIMO)*
- MIMO, beam-forming
- TDD support
- Support for 200 active VoIP users in 10 MHz TDD
- All IP flat network
- Basic 3GPP/2 interworking

* Note: Actual mobility & throughput depends on environmental conditions and Service Provider provisioning. Aggregate peak (zero path loss) sector throughput calculated using 10 MHz for DL.

Mobile WiMAX™ (Release 2.0)

2010 **2011**

- Increased mobility: Up to 350 km/hr*
- Peak sector throughput over 300 Mbps DL* (20 MHz, 4x4 MIMO)
- TDD and FDD support
- Multi-carrier support (effective BW of up to 100 MHz)
- Increased VoIP capacity (> 1200 users/sector for 2x20 MHz FDD, 2x2 MIMO)
- Even lower link access latencies
- Better coverage (at least 3 dB better link budget)
- Built-in multi-radio coexistence and inter-technology handover
- Integrated multi-hop relay
- Multi-User MIMO for higher system capacity
- Interference Mitigation Techniques
- Fractional Frequency Reuse (FFR)
- Air interface one-way latency < 10ms and handover latency < 30ms
- Integrated relay capability and femto-cell support
- Improved support for LBS and MBS services
- Support for self-organizing networks

* Note: Actual mobility & throughput depends on environmental conditions and Service Provider provisioning. Aggregate peak sector throughput calculated using 20 MHz for DL. FDD support in 2010

Backward Compatibility of WiMAX-2 (802.16m)

① 802.16e/802.16m system shall/should be able to operate on the same RF carrier with same/different BW (a)

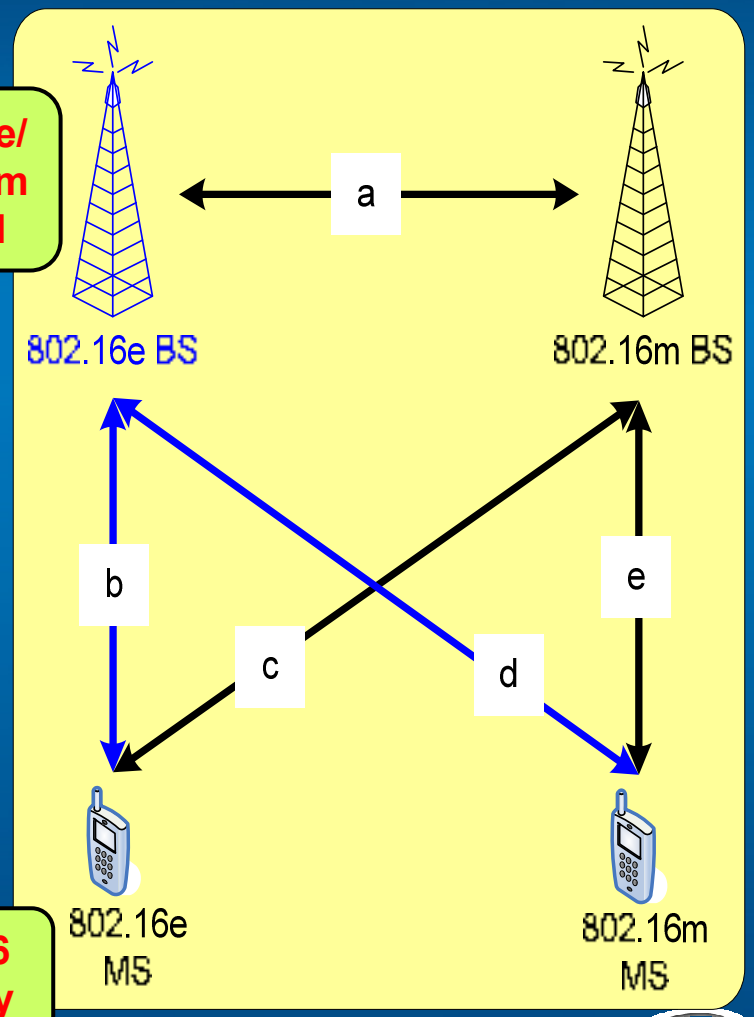
② 802.16m BS shall support a mix of 802.16e and 802.16m MS on the same RF carrier (c and e)

③ 802.16m BS shall support 802.16e MS with the same performance as 802.16e BS (b=c)

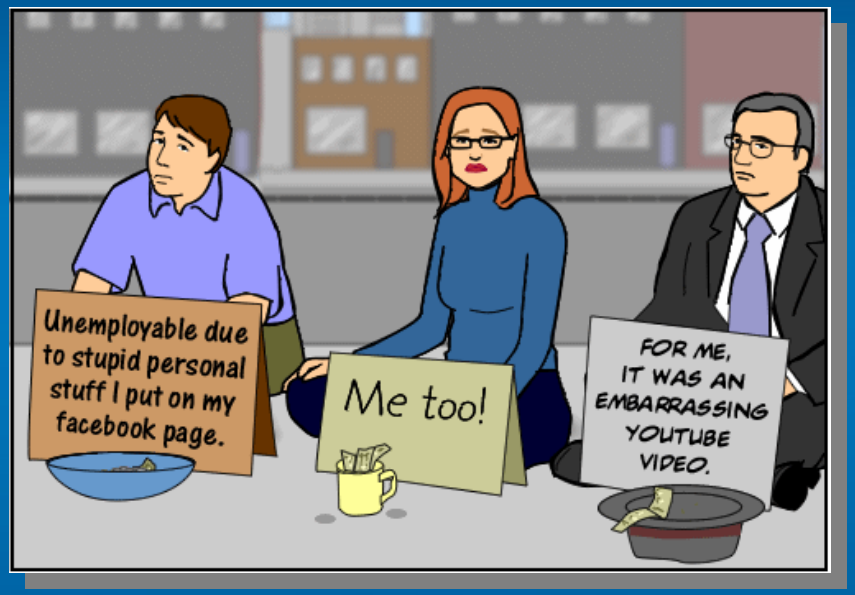
④ 802.16m BS shall support handover of 802.16e MS to/from 802.16e BS (b <--> c)

⑤ 802.16m MS shall be able to operate with 802.16e BS with the same performance as 802.16e MS (b=d)

⑥ 802.16m shall provide the ability to disable legacy support (e only)



Evolution of Services



What is the killer application?*

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PersianBlog.Com

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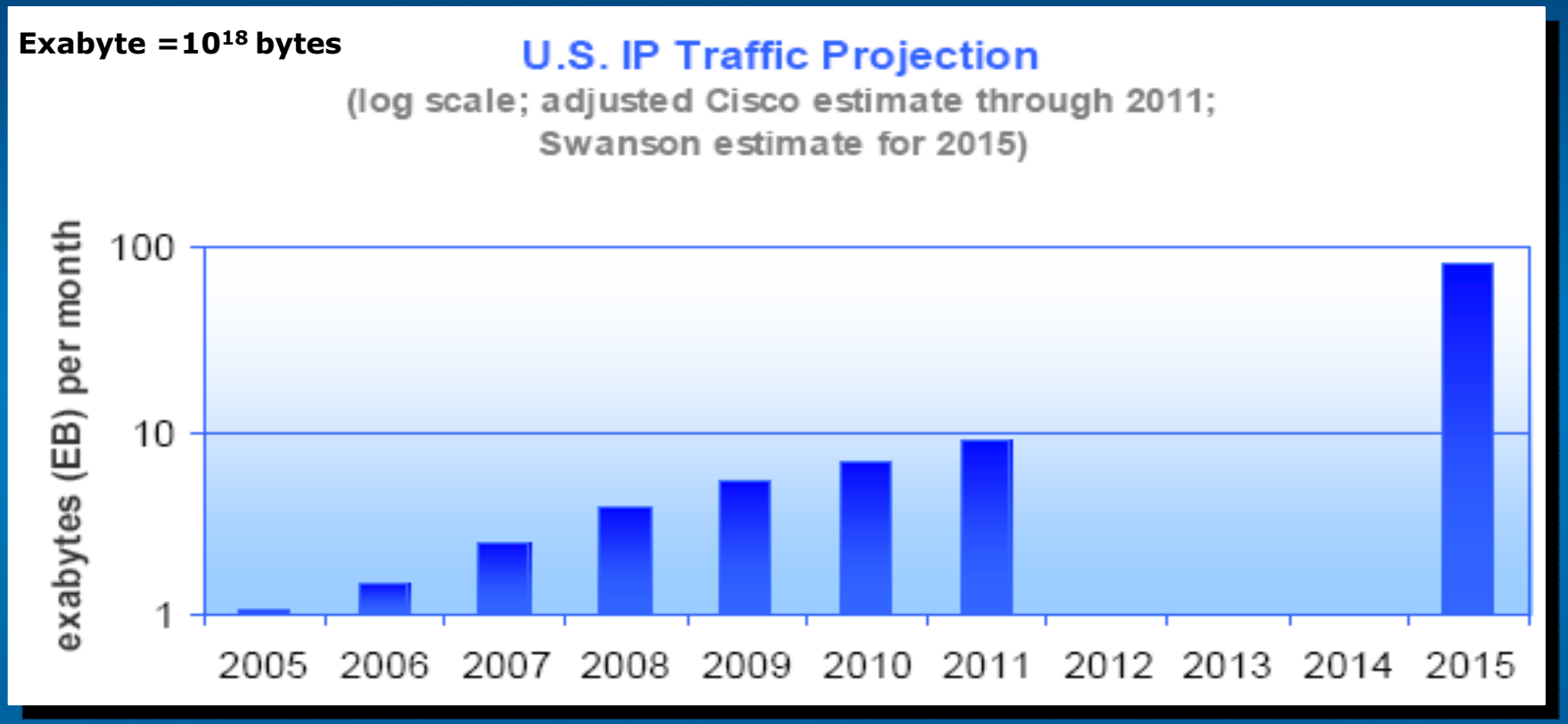
Anything Internet Can Provide & More

State of Internet



- US Internet Traffic Projection (Discovery Institute & Cisco)
  - 2011 could reach 100 Exabyte (10^{20} bytes) annual traffic
  - Seems to double every two years
  - Nemertes Research study indicates an additional investment in infrastructure of $137 Billion will be needed to satisfy bandwidth demands by 2015

Emerging Facts

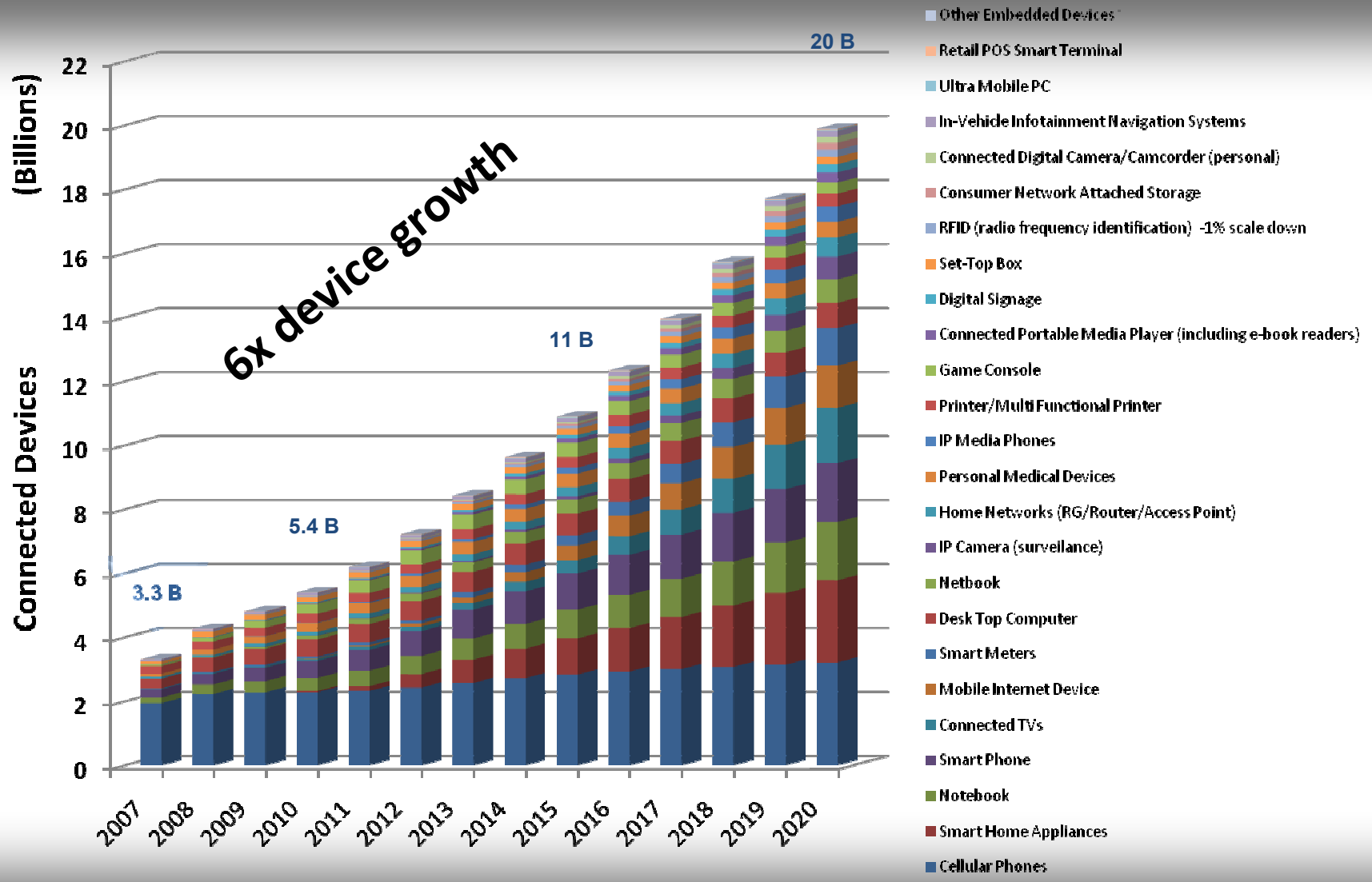
- Access: Being commoditized
- Device Distribution Channels: Open retail distribution
- Device APIs: Open APIs
  - enabling apps developers access value-add capabilities such as location
- Contents and apps are the kings

Growth Potentials

- Connecting any device anywhere to the Internet
  - Handset, smart-phones, notebooks, net-books, net-tops, cars, trucks, e-books, cameras, camcorders…..
- Traditional models wont work
  - Monthly subscription per device not scalable
  - More powerful consumer brand results in open retail distribution
  - End-user may not even have a billing relationship with operator
  - Requires very low cost-per-bit for operator
  - Devices could be activated over any or multiple operators
  - Wireless add-on cost should be quite low to enable this model

Growth comes from more connectivity

Worldwide Device Growth



Sources: Intel DEG Network Study Q209, Technology Analysts, Cisco, Ericsson, Alcatel-Lucent, Level 3

Example: Amazon Kindle

- **Millions of people now own Kindles," said Jeff Bezos, founder and CEO of Amazon.com yesterday. That surprised analysts, who thought that Amazon would sell 2.5 million or so of the devices by the end of 2010, nearly a year from now. http://www.techcrunch.com/2010/01/29/3-million-amazon-kindles-sold-apparently/**

	Kindle (Global Wireless)	Kindle DX (Global Wireless)
Display	6" diagonal E Ink®	9.7" diagonal E Ink®
Size	8" x 5.3" x 0.36"	10.4" x 7.2" x 0.38"
Storage	1,500 books	3,500 books
Books in Under 60 Seconds	✓	✓
3G Wireless	✓	✓
Wireless Coverage	Global	Global
Native PDF Support	✓	✓
Text-to-Speech	✓	✓
Whispersync	✓	✓
Rotating Display	Manual Rotation	Auto-Rotation
Price	$259.00	$489.00
	This page	See details

Closing Statements

- Connecting any device anywhere is driving the need for mobile broadband
- Mobile broadband solutions all have the same ingredients (OFDMA/MIMO, all-IP networks). Following physics law, they would have similar performance
- Mobile WiMAX is being deployed all around the world
- New services require a business model evolution

Thanks for listening…

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