



One Network – *Any G, Any Screen*

An abstract image showing a perspective view of a tunnel or corridor with bright blue light streaks radiating from the center, creating a sense of depth and speed.

IP Next-Generation Mobile Infrastructure Test

Peter Gaspar
Consulting System Engineer

Agenda

IP NGN Mobile Test: Overview

IP NGN Mobile Transport

Mobile Packet Core

Virtualized Data Center

Questions?



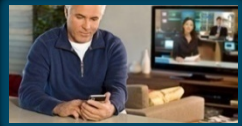
Main Mobile Operator Challenges



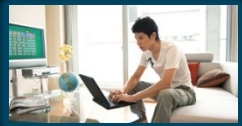
Transparent Mobile Network Transitions



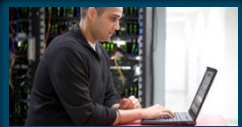
Economical Capture of Dramatic Data Growth



Monetizing over the Top/Video Applications



Always-“on” Services: High Availability



Universal Mobile Services Reach

The Megatest Goals

One Network, Any G, Any Screen

What It Is

- Intelligence
- Performance
- High availability
- Any-G mobile evolution

Benefits

- Investment protection
- High QoE
- Always-“on” services
- Transparent mobility



Mobile Mega Test Objectives

Comprehensive

Largest, most in-depth test, including:

Data Center, IP Core, Mobile Packet Core,
and IP RAN Backhaul

Independent

Light Reading - EANTC
Testing not funded by Cisco

Realistic

Test simulates realistic mobile operator's
network for 2G, 3G and LTE

Mega Test: Massive Scale



2G, 3G and LTE

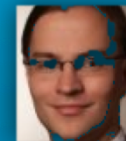


1.5M Active Subscribers



4500+ Emulated Base Stations

“By far the largest and most in-depth public, independent, third-party test of mobile infrastructure vendor performance ever.”



Carsten Rossenhövel
Managing Director, EANTC

Application Awareness

Any-G Profiles (2G and 3G)

Any-G*									
	Traffic Class	Applications	Direction	BW per Session (mbps)	Sessions per tower	BW per Tower (mbps)	Percent of Total BW	Avg Pkt Size (bytes)	Service

2G RAN 5 Mbps per Tower: 33% Data
200 Active Sessions: 20–50 kbps

Internet	ratio)								
			Total (2G)	0.025	200	5.0	100%		
IP RAN	3G (ATM Real time)	Voice, control	Bi-directional	0.020	255	5.1	30%	64	EF (ef)
	3G (ATM Best Effort)	data	Bi-directional (2:1 down/up ratio)	0.124	88	11.8	70%	512	BE (bf)

3G RAN 17 Mbps per Tower: 70% Data
344 Active Sessions: 20–350 kbps

Mobile Internet	3G (Streaming)	on demand, webcast	Unidirectional	0.350	12	4.3	25%	1024	AF (cs4)
	3G (Interactive)	web browsing, data base retrieval, server access	Bi-directional (2:1 down/up ratio)	0.100	34	3.4	20%	512	AF (cs2)
	3G (Background)	email, SMS, downloads	Bi-directional (2:1 down/up ratio)	0.100	43	4.3	25%	512	BE (df)
			Total (3G)	0.049	344	17.0	100%		

Application Awareness

Any-G Profiles (LTE)

Any-G*									
	Traffic Class	Applications	Direction	BW per Session (mbps)	Sessions per tower	BW per Tower (mbps)	Percent of Total BW	Avg Pkt Size (bytes)	Service
	LTE (Real time - Network)	X2 Interface	Bi-directional	0.026	19	0.5	5%	1024	EF (cs5)
	LTE (Real time - User)	voice	Bi-directional	0.020	25	0.5	5%	64	EF (ef)

Any-G LTE 10 Mbps per Tower: 95% Data
51 Active Sessions: 20–350 kbps

		server access							
	LTE (Background)	email, SMS, downloads	Bi-directional (2:1 down/up ratio)	0.350	9	3.3	33%	512	BE (df)
			Total (LTE)	0.197	51	10.0	100%		

Application Awareness

All-IP/LTE Profiles

All-IP LTE									
	Traffic Class	Applications	Direction	BW per Session (mbps)	Sessions per tower	BW per Tower (mbps)	Percent of Total BW	Avg Pkt Size	Service

All-IP/LTE 68 Mbps per Tower: 95% Data
344 Active Sessions: 20–350 kbps

web browsing, data

1.5M+ Million Mobile Flows per Metro
27 Gbps Any-G + 120-Gbps LTE

Mobile Megatest

Tested Cisco Comprehensive Architecture



Nexus 5000
Nexus 7000



UCS

**Data
Center**



ASR 5000

**Packet
Core**



CRS



ASR 9000



7600

ME 36/3800



ASR1000

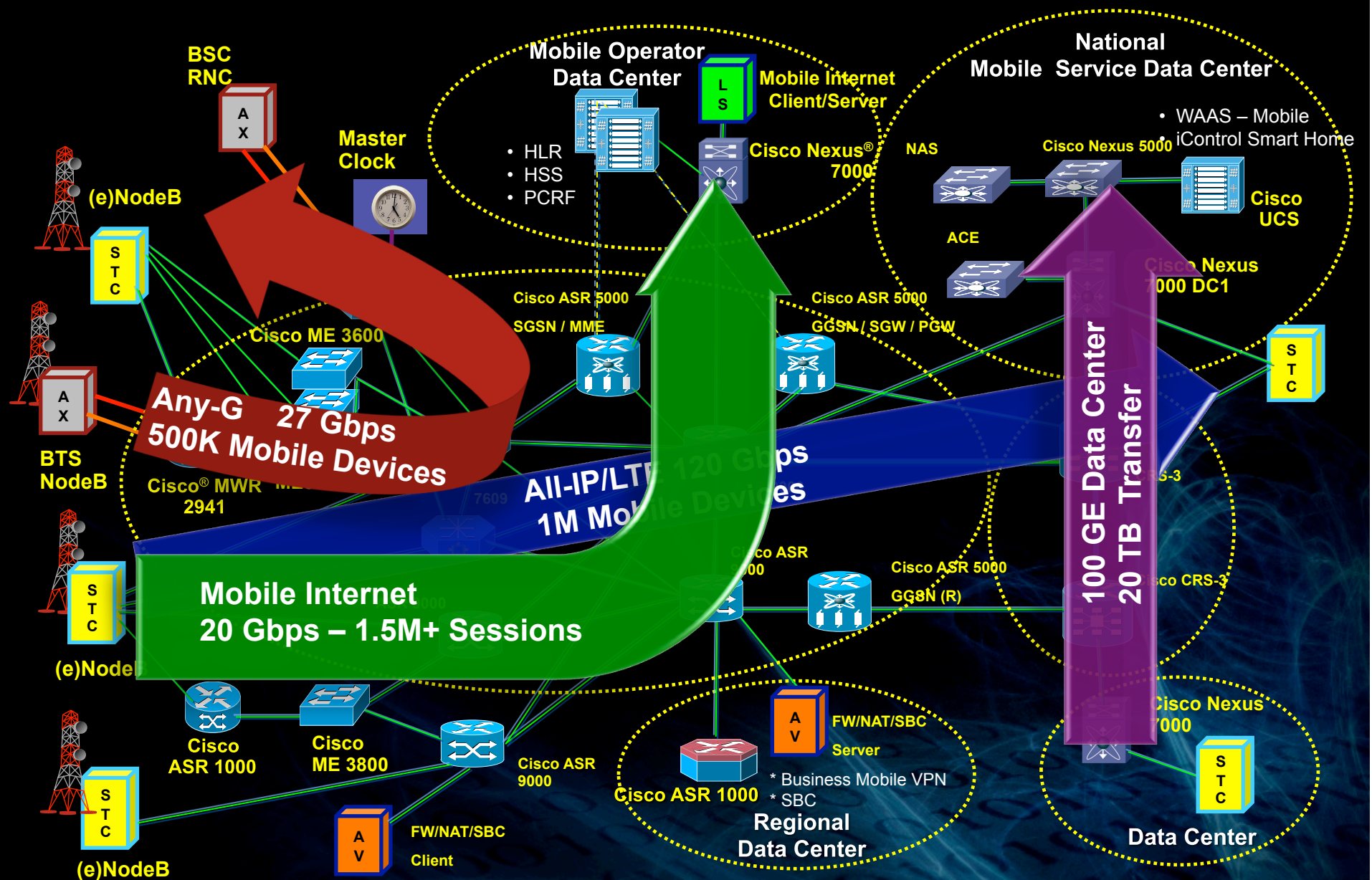


MWR 2941

**Mobile
Transport**



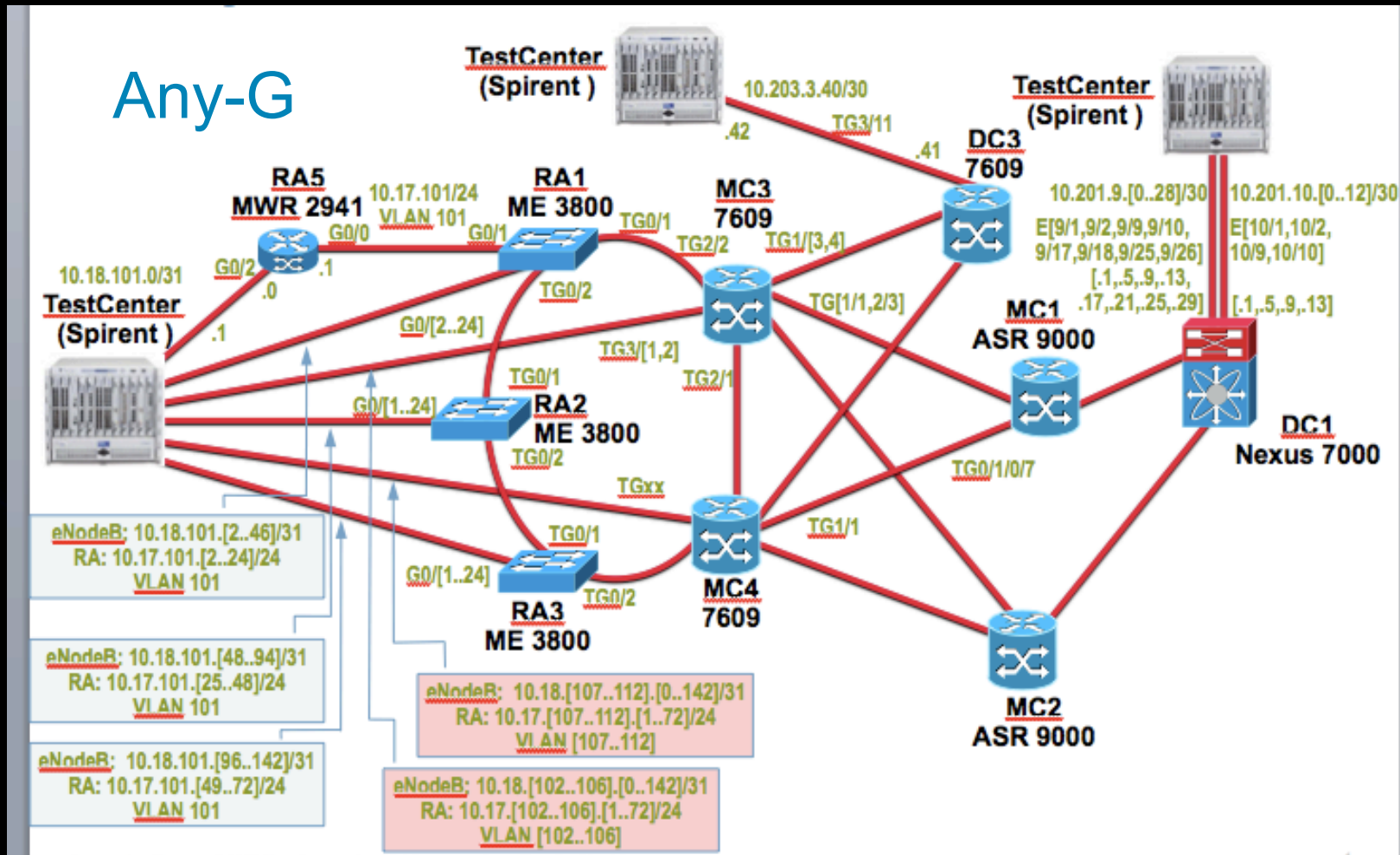
IP NGN Mobile NGN Test Architecture





IP NGN: Unified RAN Transport

Any G IP RAN Backhaul Configuration



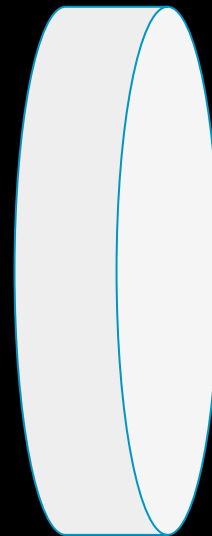
IP RAN Quality of Service

7600 ES+ Configuration Example

```
class-map match-any EF
  match mpls experimental topmost 5
  match ip dscp ef
class-map match-any CS2
  match mpls experimental topmost 2
  match ip dscp cs2
class-map match-any CS4
  match mpls experimental topmost 4
  match ip dscp cs4
class-map match-any Synch
  match mpls experimental topmost 7
  match ip dscp 63
```

```
policy-map LTE-CORE
  class Synch
    police 1000000
    priority level 1
  class EF
    police 500000000
    priority level 2
  class CS4
    bandwidth percent 53
  class CS2
    bandwidth percent 39
  class class-default
    bandwidth percent 1
```

PORT Level



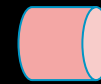
CLASS Level



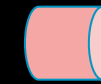
LLQ Priority level for Synch
1588v2 traffic



Priority level for Real Time
and CEM traffics



AF for Streaming



AF for Interactive



Best Effort Data

Service Levels: Quality of Experience

Test Case:

2G/3G/LTE Traffic Guarantees
Five Traffic Classes (Any-G and All-IP)
REP and MPLS FRR Disabled (Prevent Congestion Avoidance)
10G RAN Aggregation Link Failure (7600)
10G MPLS Link Failure (7600 or ASR 9000)

Benefits:

- High quality of experience with massive scale
- Optimized service-aware transport
- Guaranteed premium service-level agreements

Out-of-Service Results:

- Lossless for high-priority (EF) traffic (voice, control, and clock)
- Lossless for streaming video (AF)
- Only best-effort traffic affected by network congestion

Differentiation:

- Industry-leading QoS performance and scale
- >1 million mobile flows per metro

IP RAN High Availability

Test Case:

Link Resiliency: Loss of Signal/Unidirectional Data

ANUE : Inserted in REP and MPLS Links

Cisco 7600 Node Power Failure

Benefits:

- High quality of experience
- Always-“on” services

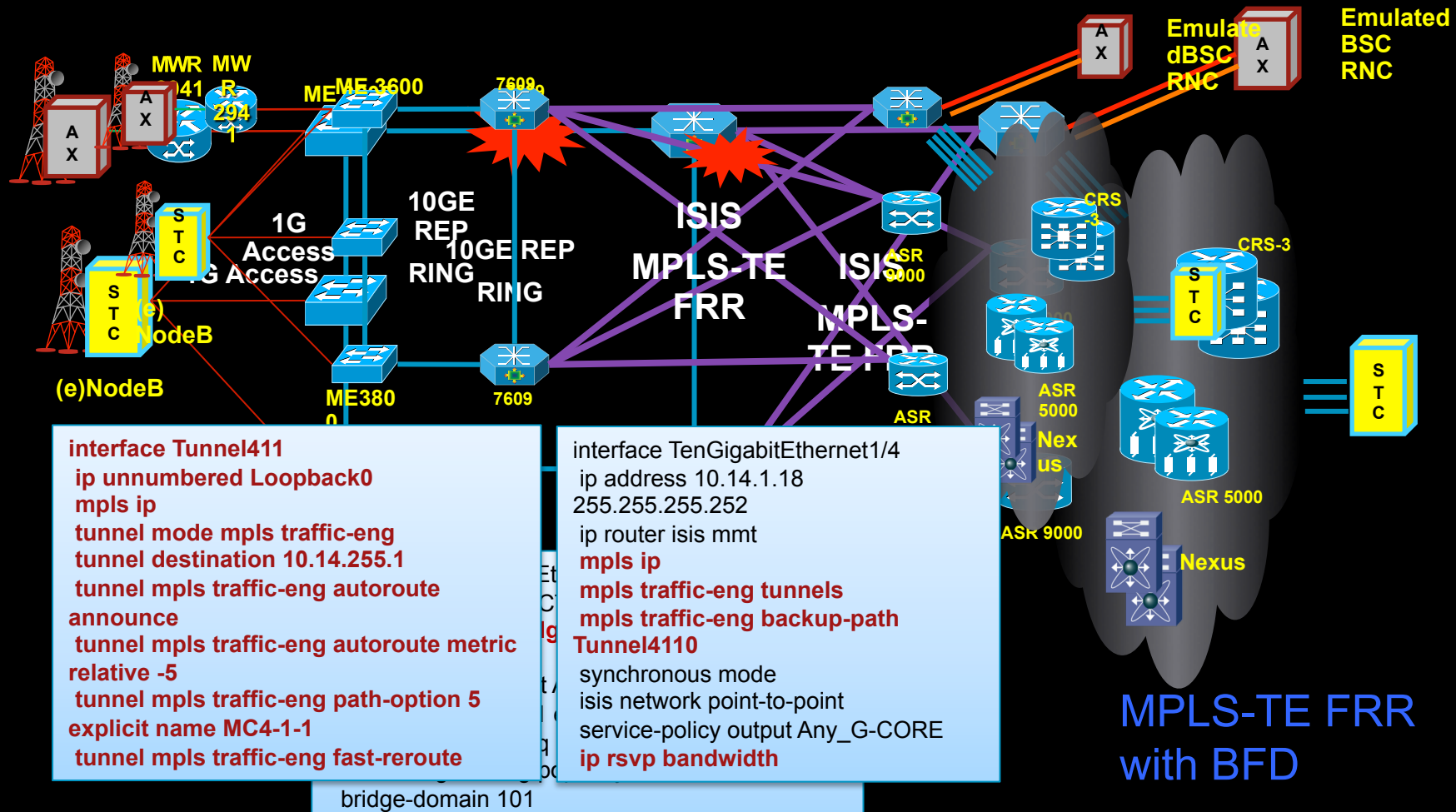
Out-of-Service Results:

- REP access: 71.2 ms/357 ms (Fast Hello)
- MPLS aggregation: 17.8 ms/121 ms (BFD)
- Node failure: 170 ms
- Lossless recovery

Differentiation:

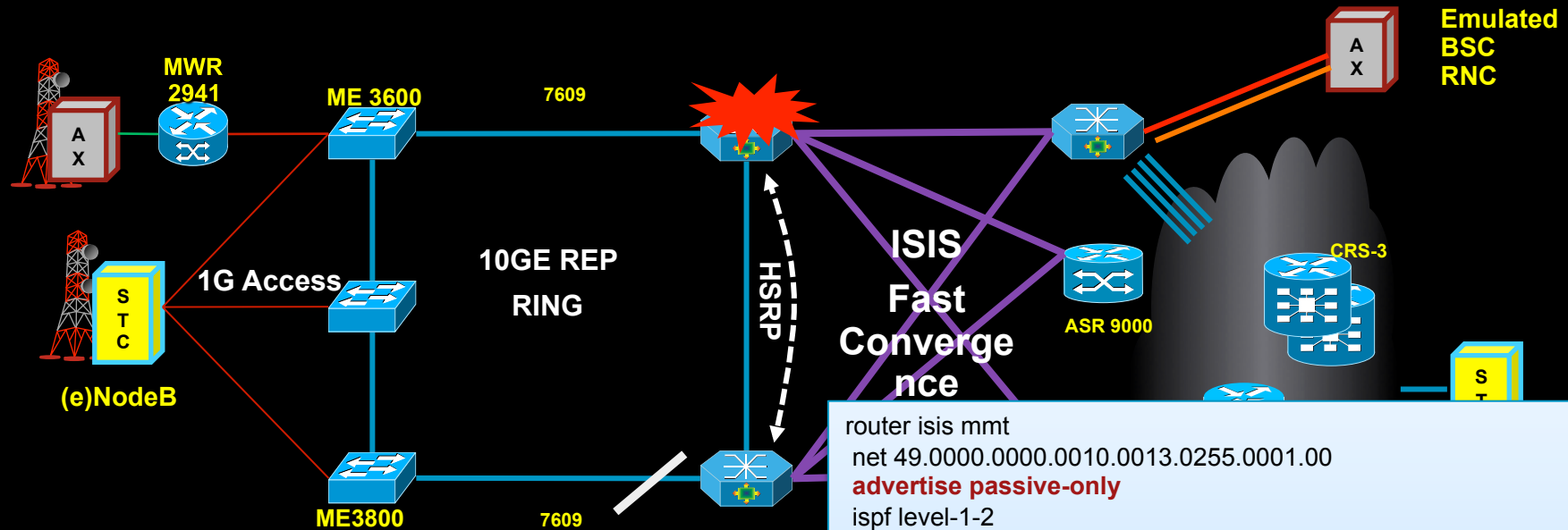
- Robust topology, agnostic Ethernet, and MPLS resiliency
- 2X competitive platforms: Node/Ethernet/unidirectional data loss

IP NGN ANY-G High Availability



Note: 7600 has a minimum BFD timer setting of 50ms x 3.
ASR9K can be configured to 15ms x 2. The negotiated value is 50ms x 2 which allows sub 150ms recovery

IP NGN ANY-G High Availability – Node Power Failure REP+HSRP+ISIS Fast Convergence



```
interface Vlan101
ip address 10.17.101.252 255.255.255.0
mpls ip
standby 101 ip 10.17.101.254
standby 101 timers msec 50 msec 155
standby 101 priority 200
standby 101 track 10 decrement 110
isis tag 100
```

```
router isis mmt
net 49.0000.0000.0010.0013.0255.0001.00
advertise passive-only
ispf level-1-2
metric-style wide
fast-flood
ip route priority high tag 100
set-overload-bit on-startup 300
spf-interval 10 50 50
prc-interval 10 50 50
lsp-gen-interval 10 10 50
no hello padding
nsf ietf
summary-address 10.18.101.0 255.255.255.0 level-1 tag 100
redistribute static ip route-map MWR-MC3 level-1
mpls ldp sync
mpls traffic-eng router-id Loopback0
mpls traffic-eng level-1
```

IP RAN “Hybrid” Synchronization

Test Case:

ITU G.8261 Clock Synchronization (2, 6, and 24 hours)

ANUE Impairment Generator

Effective Hop Count: 13

Run simultaneously with HA and QoS testing

Benefits:

- High quality of experience
- Transparent, uninterrupted roaming

Results:

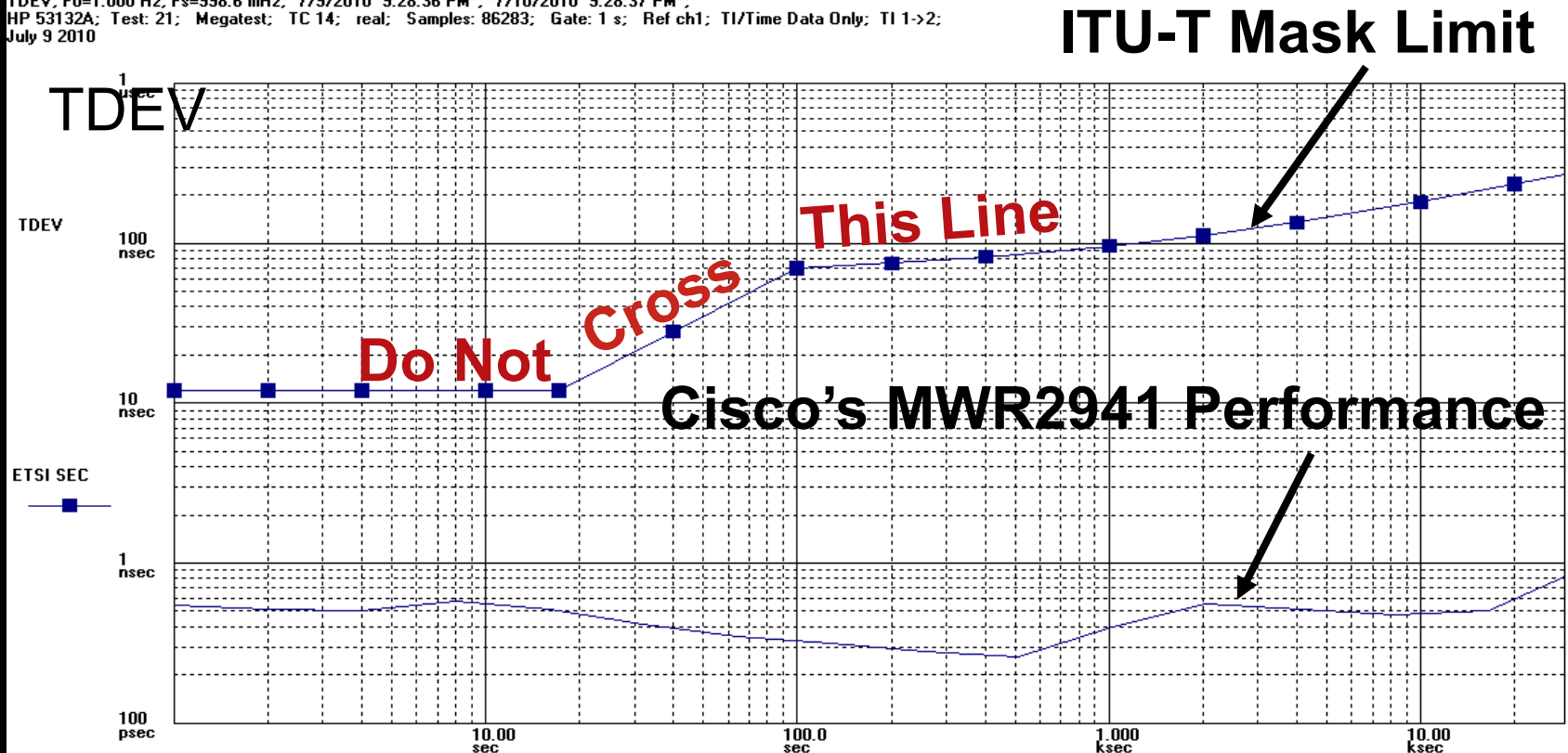
- Comparable to SONET/SDH accuracy (± 50 PPB/50 ns)
- Meets LTE Multimedia Broadcast Media Services (± 0.05 ppm)
- Frequency: 9 ns
- Phase: 40 ns

Differentiation:

- 100X competitive solutions
- Cisco “Hybrid” is **Standards-based Survivable Precision**
- SyncE or IEEE1588-only solutions (± 1 microseconds)

IP RAN: Clock Synchronization – Frequency Results

Symmetricon TimeMonitor Analyzer
TDEV: Fo=1.000 Hz; Fs=998.6 mHz; *7/9/2010 9:28:36 PM*; *7/10/2010 9:28:37 PM*;
HP 53132A; Test: 21; Megatest; TC 14; real; Samples: 86283; Gate: 1 s; Ref ch1; TI/Time Data Only; TI 1->2;
July 9 2010



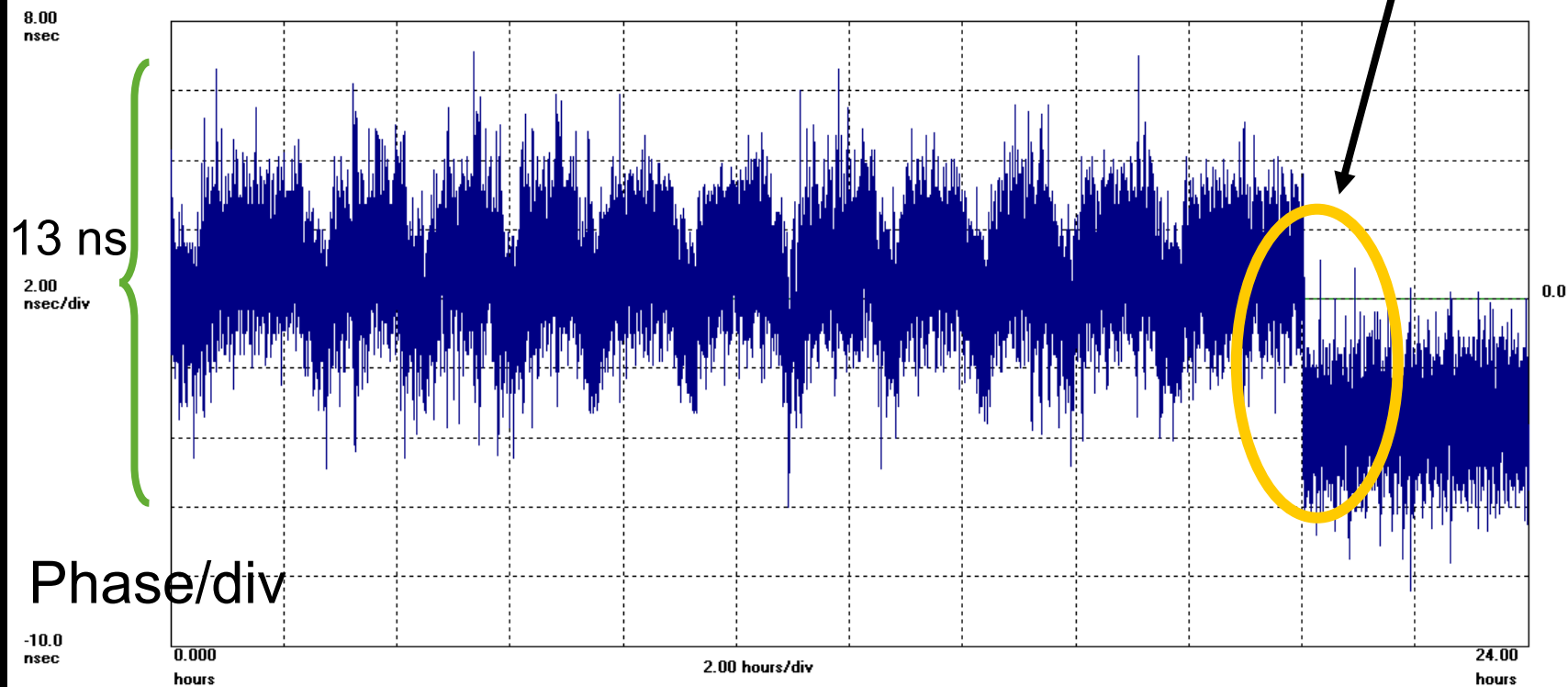
0 10 Sec 1 Min 10 Mins 1 Hr 6 Hrs

Comparable to SONET/SDH
Meets LTE Release 8 Requirements

Phase Results

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time; Fs=998.6 mHz; Fo=1.0000000 Hz; *7/9/2010 9:28:36 PM*; *7/10/2010 9:28:37 PM*;
HP 53132A; Test: 21; Megatest; TC 14; real; Samples: 86283; Gate: 1 s; Ref ch1; TI/Time Data Only; TI 1->2;
July 9 2010

Oscillator Recalibration



0 8 16 24 Hours

Comparable to SONET/SDH
Meets LTE Multimedia Broadcast Media Service Requirements

Precision + Quality = Savings



Up to \$12 Million/yr OPEX Savings
for 10,000 Cell Sites

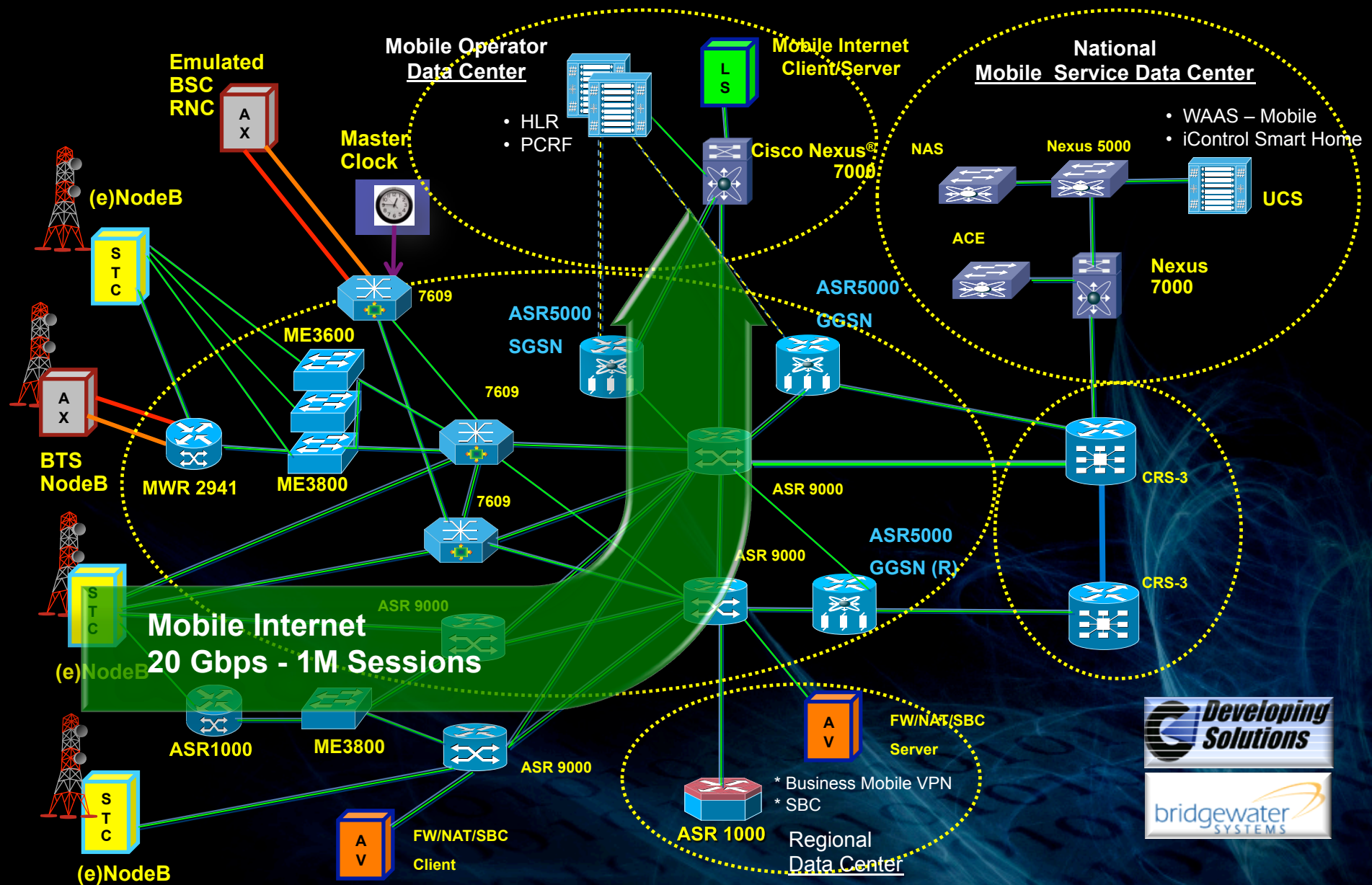
- Replace TDM clocking line with Hybrid Sync Control
- SONET/SDH-Like Precision of Sync & Clock over IP RAN Backhaul
- 100x Precision ITU Specs
- Resilient QoS under Stress





Mobile Packet Core

IP NGN Mobile Multimedia: 3G/UMTS Performance

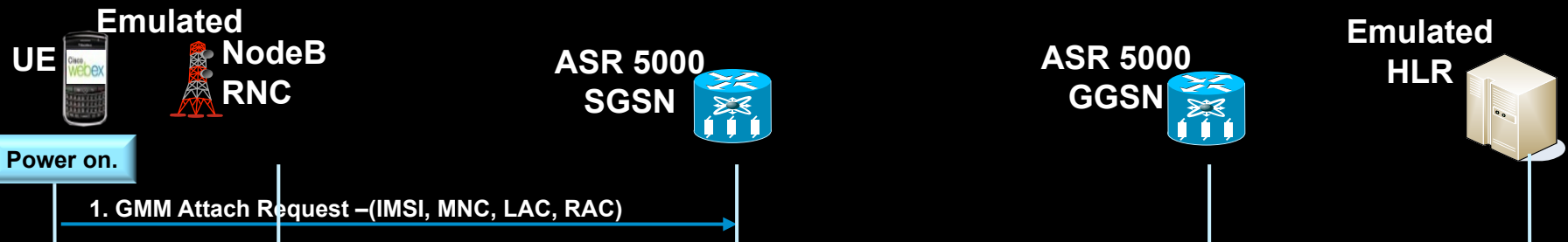


Session Awareness

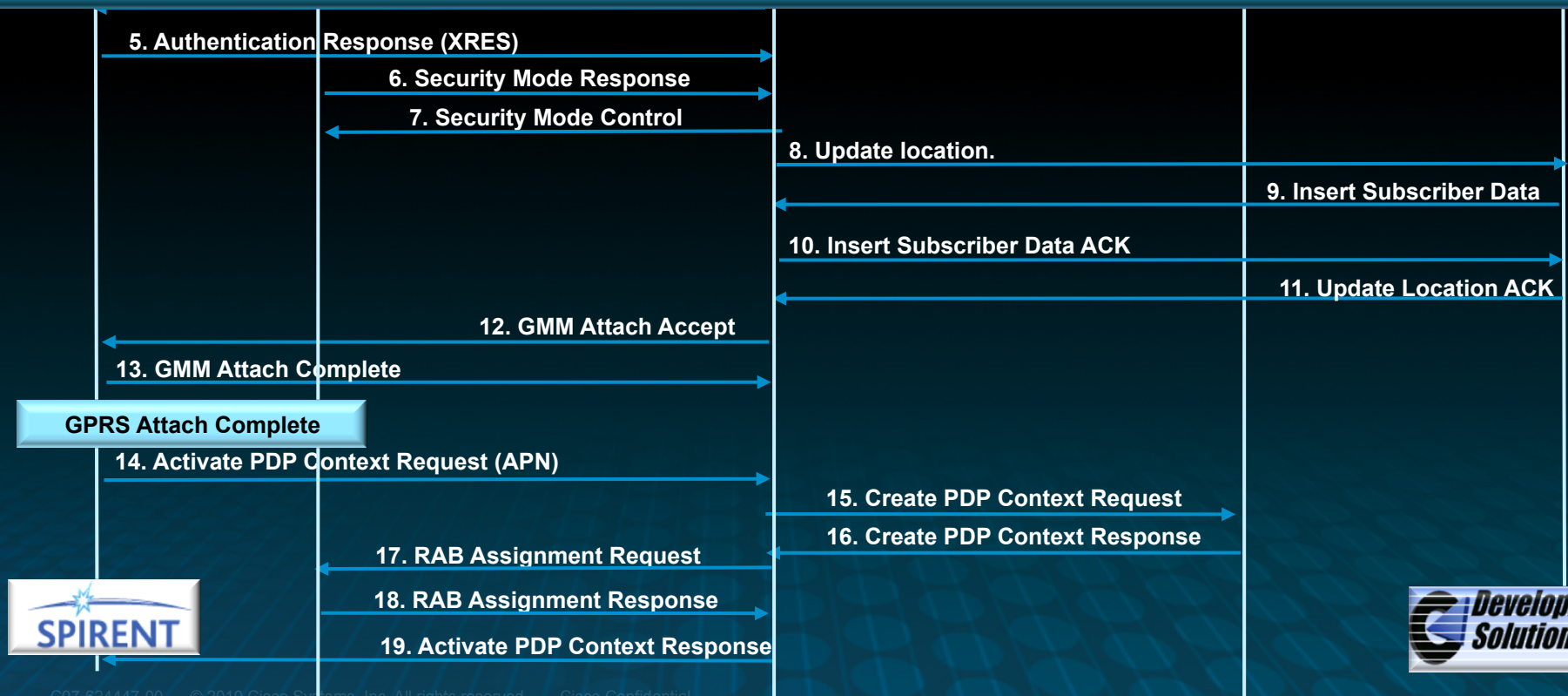
3G/UMTS Call Model/Traffic Profiles

SGSN	
No of Attached Sessions /sec	4,000
GGSN	
PDP Activations/sec	18,000
Total Number Sessions	1,060,000
<i>Total Number of Active Sessions</i>	380,000
<i>Total Number of Idle Sessions</i>	620,000
<i>Total Number of Make/Break Calls</i>	60,000
Make Break Calls	2,000
<i>Make Calls</i>	1,000
<i>Break Calls</i>	1,000
Call hold timer for make/break calls	60 seconds
Downlink Traffic Types	
HTTP	1024 Bytes
P2P	850 Bytes
VOICE	512 Bytes
UDP	650 Bytes
TCP	650 Bytes
Uplink Traffic Type	
HTTP	1024 Bytes
P2P	850 Bytes
VOICE	512 Bytes
UDP	650 Bytes
TCP	650 Bytes
Traffic Breakdown	
Uplink Traffic	30%
Downlink Traffic	70%
Throughput	
Total Throughput	20-25 Gbps
Throughput/Session (kbps/session)	65.782
<i>Avg. Downlink Data Rate (kbps/session)</i>	46.052
<i>Avg. Uplink Data Rate (kbps/session)</i>	19.73

3G/UMTS: SGSN Attachment Call Flows



Transactions Per Second $\neq$ Attachments Per Second



3G/UMTS Performance

Test Case:

3G SGSN Attachment Rate

3G GGSN Activation Rate

3G Session Scale

100% Deep Packet Inspection (Layer 7): 1000 Rules

Policy Charging Enforcement

Benefits:

- Personalizes services and monetizes applications
- Accelerates ARPU growth with granular market segmentation

Results:

- SGSN attachments: 4000+ per second
- GGSN activations: 18000+ per second
- GGSN throughput: 20+ Gbps with 100% DPI
- 1 million mobile sessions per metro
- Home location registry (HLR)
- Policy charging rules function (PCRF)
- Gx interface: 36,000 transactions/sec

Differentiation:

- 3X performance of competitors with 100% DPI enabled

IP NGN Mobile Multimedia: High Availability

Emulated
BSC

Mobile Operator
Data Center



Mobile Internet
Client/Server

National
Mobile Service Data Center

Test Case:

Mobile Packet Core (GGSN) Availability

Packet Services Card (PSC) Failure

System Management Card (SMC) Failure

Inter-chassis Session Recovery (ICSR)

Deep Packet Inspection (Layer 7): 1000 Rules

Benefits:

- Always-“on” uninterrupted mobile services

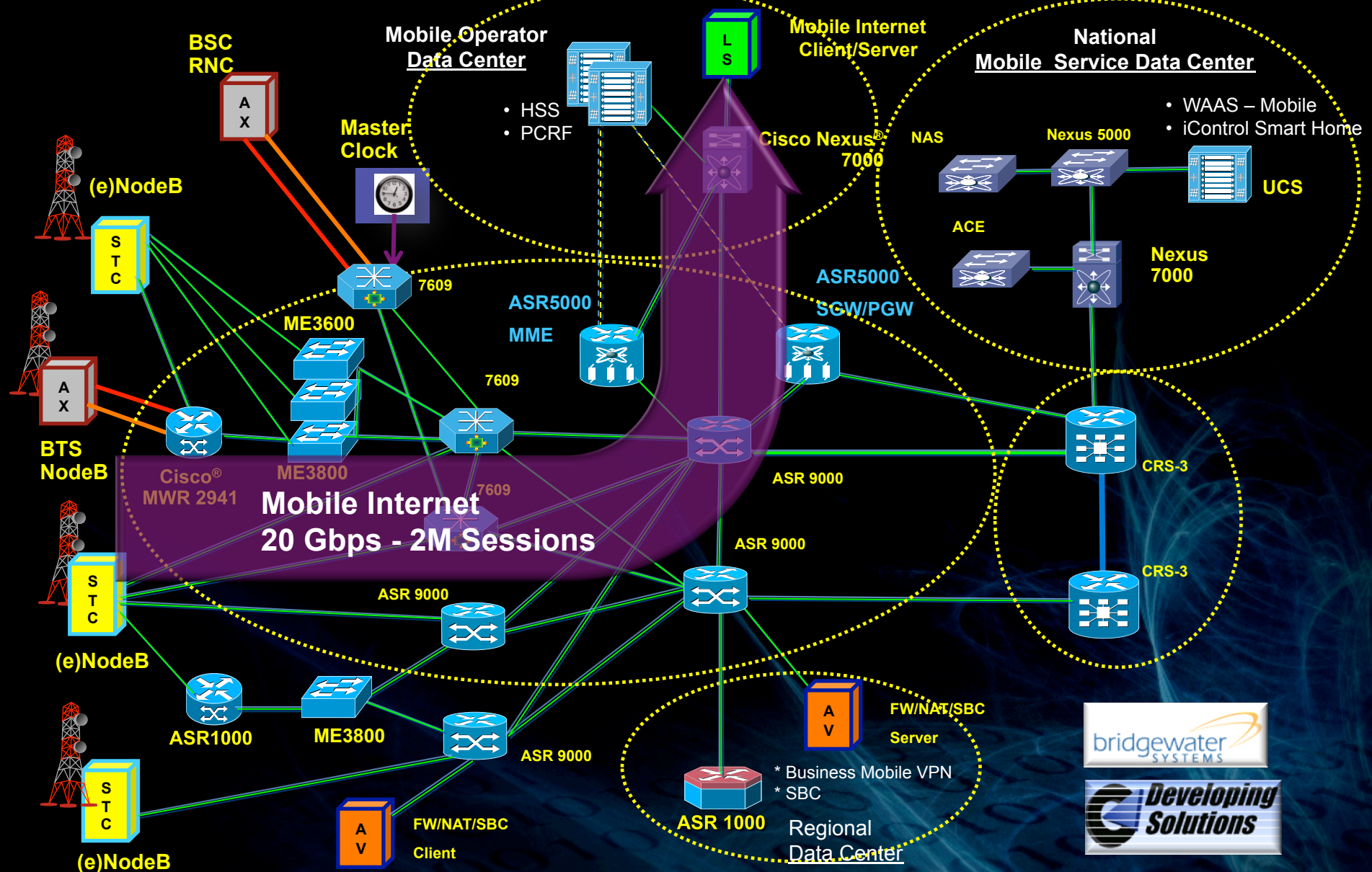
Results:

- 1 million mobile sessions per metro
- 20+ Gbps throughput
- Zero session loss
- State maintained redundant GGSN
- Switchover based upon BGP detection/recovery

Differentiation:

- Industry's only zero-session-loss packet core

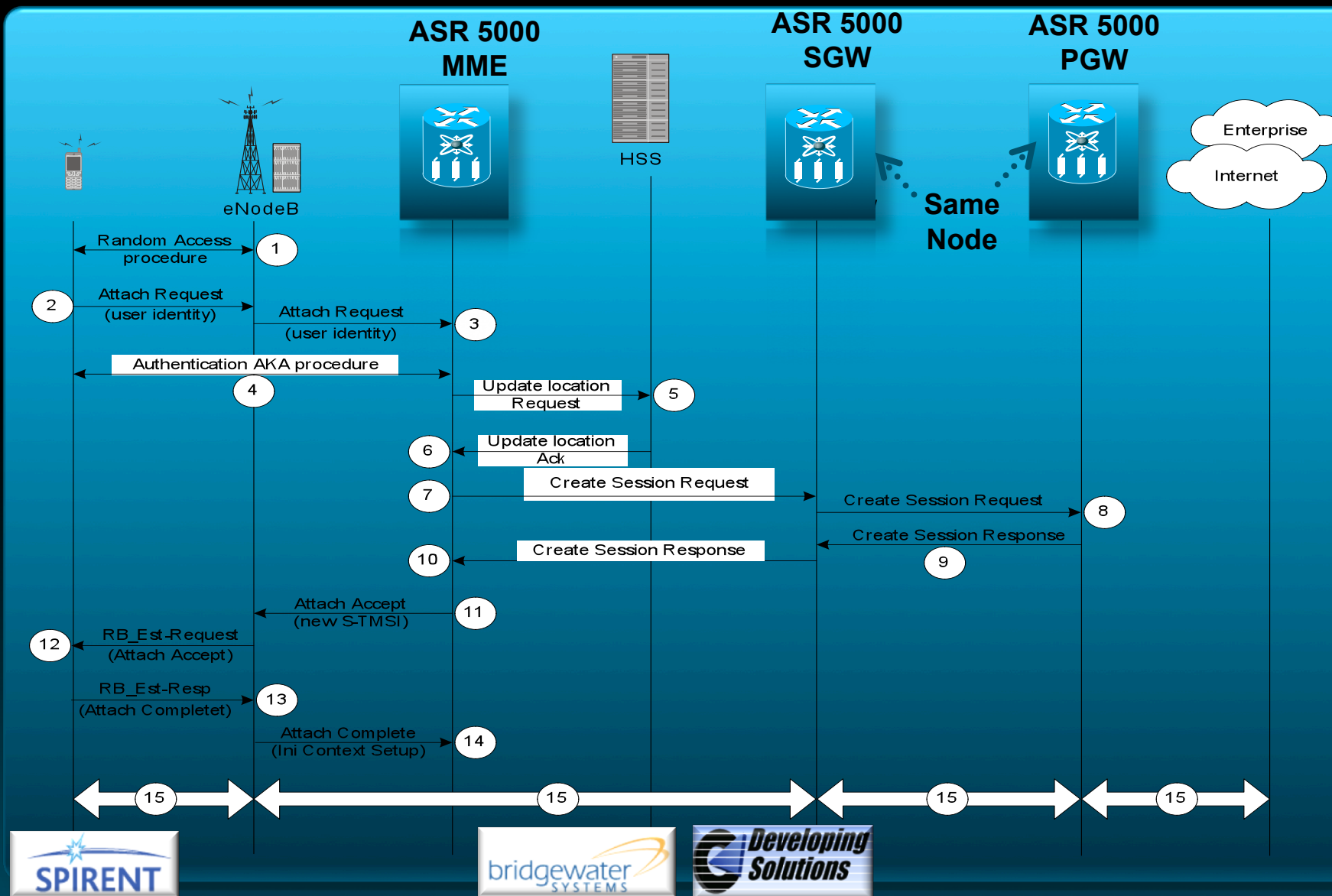
IP NGN Mobile Multimedia: LTE Performance



bridgewater
SYSTEMS

Developing
Solutions

LTE—MME Attachment Call Flow



LTE—Bearer Activation Flows

Test Case:

EPC Performance/Scale/Services

Benefits:

- Transparent services evolution to LTE from 3G/UMTS
- Investment protection: Simplified operations/maintenance
- High-quality user experiences: Multisession on mobile services

Results:

- MME attachments: 5,000+ per second
- Bearer activations: 10,000+ per second
- SGW/PGW throughput: 20+ Gbps
- 1 million mobile sessions per metro
- 2 million mobile bearer sessions per metro (default and dedicated)
- Home subscriber server (HSS)
- Policy charging rules function (PCRF)

Differentiation:

- Industry-leading evolved packet core solution

Session Awareness

LTE Call Model/Traffic Profiles

Results:

- MME attachments: 5000+ per second
- Dedicated bearer activations: 10,000 per second
- Throughput: 20+ Gbps
- 1 million mobile sessions per metro
- 2 million mobile bearers per metro
- Default and dedicated bearer (2 sessions per user)
- 760,000 active sessions
- 60,000 make/break calls
- 65 kbps per session
- 70/30 downlink/uplink rates

Benefits:

- Subscriber-aware services with dramatic scale
- Investment protection: Simplified maintenance

Differentiation:

- Industry-leading evolved packet core services scale

Industry First: 3G/LTE Session Handover

Demonstration:

- Industry-first 3G/LTE handover
- MME/SGW/PGW/GGSN contexts
- Emulated home location register (HSS)
- Emulated home subscriber server (HSS)
- Emulated policy charging rules function (PCRF)
- Activation of both 3G and LTE sessions and contexts
- Video call between 3G/LTE clients
- Switchover every 2 minutes

Benefits:

Transparent services evolution from 3G to LTE

- Investment protection
- Acceleration of time to revenue

Differentiation:

- Industry-first 3G/LTE handover

Cisco Voice over LTE/One Voice

Demonstration:

- Voice over LTE/One Voice
- MME/SGW/PGW contexts
- Integrated IMS server: P-CSCF/S-CSCF
- Emulated home subscriber server
- Activation of both LTE client sessions
- VoIP call completion between client PC devices

Benefits:

- Offers a complete suite of voice and data LTE services

Differentiation:

- Industry-leading VoLTE solution
- All five functions, including IMS, in one Cisco® ASR 5000 Node



IP NGN Core Transport

IP NGN Core: 100 GE Performance

Test Case:

RFC 2544 Throughput/Latency

98-Byte IPv4, 124-Byte IPv6, IMIX, IMIX+18, and IPv4/IPv6

Benefits:

- Designed to support exponential data and services growth
- Optimized service-aware transport
- Guaranteed premium service-level agreements

Results:

- Zero packet loss at 100GE Line Rate for all packet sizes / combinations
- Throughput greater than 100 Mpps, Low Latency ~ 30 μ s
- Single 100GE Flow and Multi-flow IPv4/IPV6 Services

Differentiation:

- Industry-leading 100 GE core router performance

IP NGN Core: High Availability

Test Case:

Cisco® CRS-3 RP Redundancy (NSR)

Cisco CRS-1 to CRS-3 Fabric Upgrade (322 Tbps)

Benefits:

- Lossless service delivery at massive scale

Results:

- Zero BGP session loss (failure and recovery)
- Zero traffic loss during upgrade

Differentiation:

- Industry-leading hitless fabric upgrade with Zero Loss

Mobile: Carrier-Grade IPv6

Machine-to-Machine Applications

Test Case:

Carrier-Grade IPv6 Performance (NAT64)

Carrier-Grade IPv6 Availability

Benefits:

- Enables IPv6 for 10's of millions of machine-to-machine devices
- Offers high availability for mobile smart home/grid, connected health

Results:

- 40 million IPv6 translations across two CGSE modules
- 1 million stateless translations per second
- Sub-second CGv6 out of service times: 120 ms

Differentiation:

- Industry-leading CGv6 (40M+) with high availability



Mobile Service Delivery

IP NGN Core: 100 GE DC Interconnect

Overlay Transport Virtualization

Test Case:

100 GE Data Center Interconnect CRS-3 / Nexus 7000
Nexus 7000 : Overlay Transport Virtualization (OTV)
Virtualized Data Center
20-TB Transfer at 100 Gbps Line Rate

Benefits:

- Optimized service-aware transport
- Bandwidth efficiency: Ease of operations

Results:

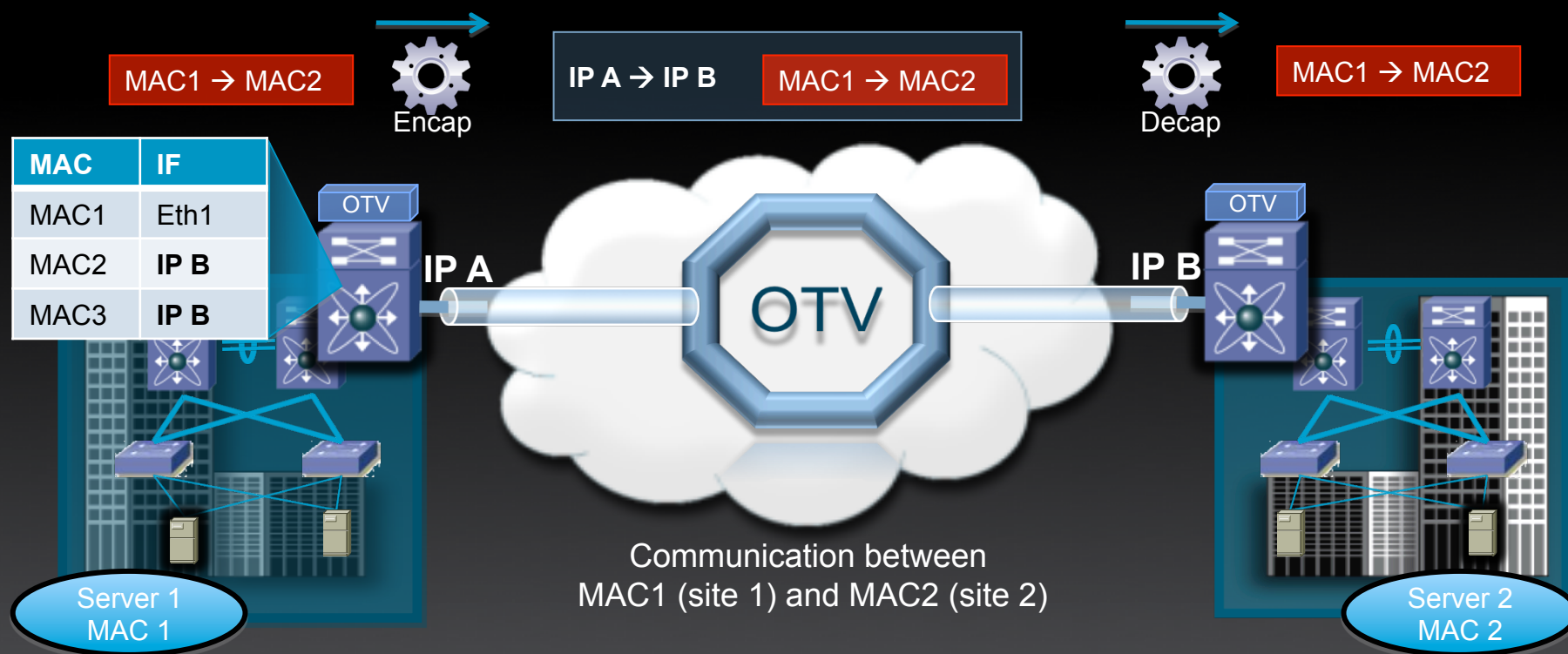
- 20 Terabytes between data centers In less than 30 minutes (1600 sec)
- Zero Packet Loss for all transfers at 100Gbps Line Rate

Differentiation:

- Industry-leading 100 GE core router performance
- Industry-first 100 GE data center virtualization

OTV at a Glance

- Ethernet traffic between sites is encapsulated in IP: “MAC in IP”
- Dynamic encapsulation based on MAC routing table
- No Pseudo-Wire or Tunnel state maintained



Overlay Transport Virtualization – OTV

Simplified Ethernet VPNs

- IP based Ethernet (L2) VPN solution

Logically a Shared Ethernet Segment

MAC routing

IP encapsulated forwarding

- Core and Site Transparency

Works across IP/MPLS

- Packet Switching

Multi-point connectivity

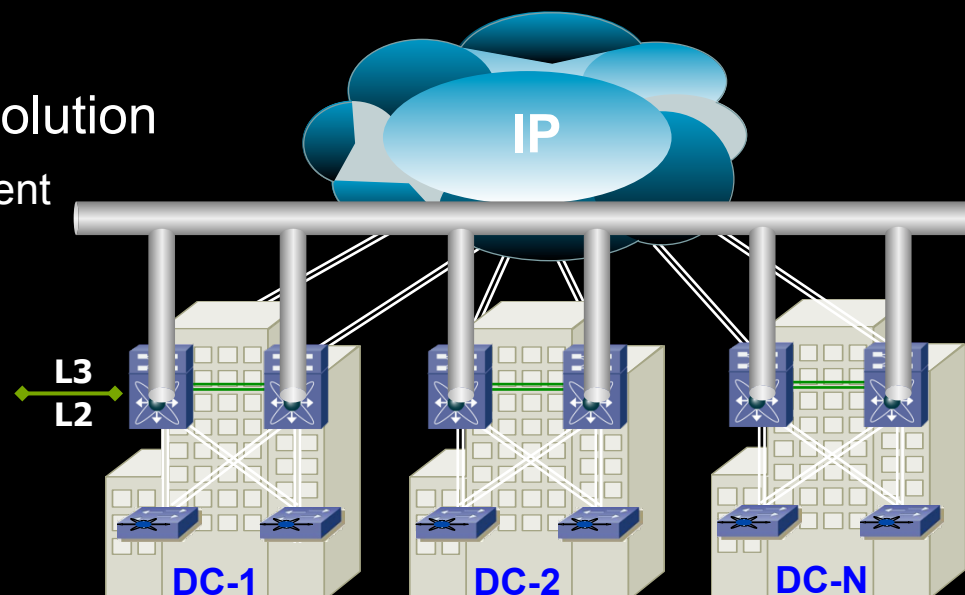
No PW state preserved

Optimal m-cast replication

- Full cross-sectional BW

Equal cost multi-pathing

All-active multi-homing



- Protocol Learning

No STP: Built-in loop prevention

Failure domain is bound

Floods/b-casts can be suppressed

- Seamless adds/removes

WAAS Mobile—Cloud Service

Application Acceleration

Test Case:

Virtualized Service Delivery
Wide Area Acceleration Services: Mobile
File Transfer Rates with Acceleration

Benefits:

- Offers WAN acceleration to laptop clients for 3G/LTE
- Enables hosted services in virtualized data center
- Reduces carbon footprint (4X) for service delivery and operations

Results:

- Set 3G traffic rates at 1 Mbps down/64 kbps up
- Set LTE traffic rates at 4 Mbps down/1 Mbps up
 - Measured up to 8X improvement in file upload rates
 - Measured 5X improvement in file download rates

Differentiation:

- Virtualized Applications in Cisco Unified Computing System™ (UCS)

Virtualized Smart Home

Smart Home Back Office

Test Case:

Virtualized Service Delivery

Smart Home (iControl)

50,000 Panel Sessions

10,000 Video-Enabled Panels

Benefits:

- **Offers hosted smart-home control services**
- **Reduces carbon footprint (4X): Services and operations**

Results:

- Emulated 50,000 smart panel clients
- iControl application deployed on 12 virtual machines
- 4X reduction in compute and power resources
- 230,000 video clips (1 MB/30 sec) transferred per hour
- Enhanced performance of reference solution by 15%

Differentiation:

- Virtualized application performance - UCS
- 4X reduction in compute and power resources

IP NGN: Premium Business Services

BSC

Mobile Operator
Data Center



Mobile Internet
Client/Server

National

Test Case:
Premium Business Services
FW/NAT Capacity/Performance
VoIP/Session Border Control with IMS

Benefits:

- Offers hosted enterprise VoIP/security services
- Generates premium business service revenue

Results:

- 1 million simultaneous firewall/NAT sessions
- 200,000 sessions per second: 10 Gbps
- 40,000 unique VoIP sessions with SIP registration/IMS
- 231 SIP calls per second: G.711/G.729
- No effect on SIP header manipulation

Differentiation:

- Scalable business services in small edge router
- 10X FW/NAT session rate

Mobile Infrastructure Testimonials



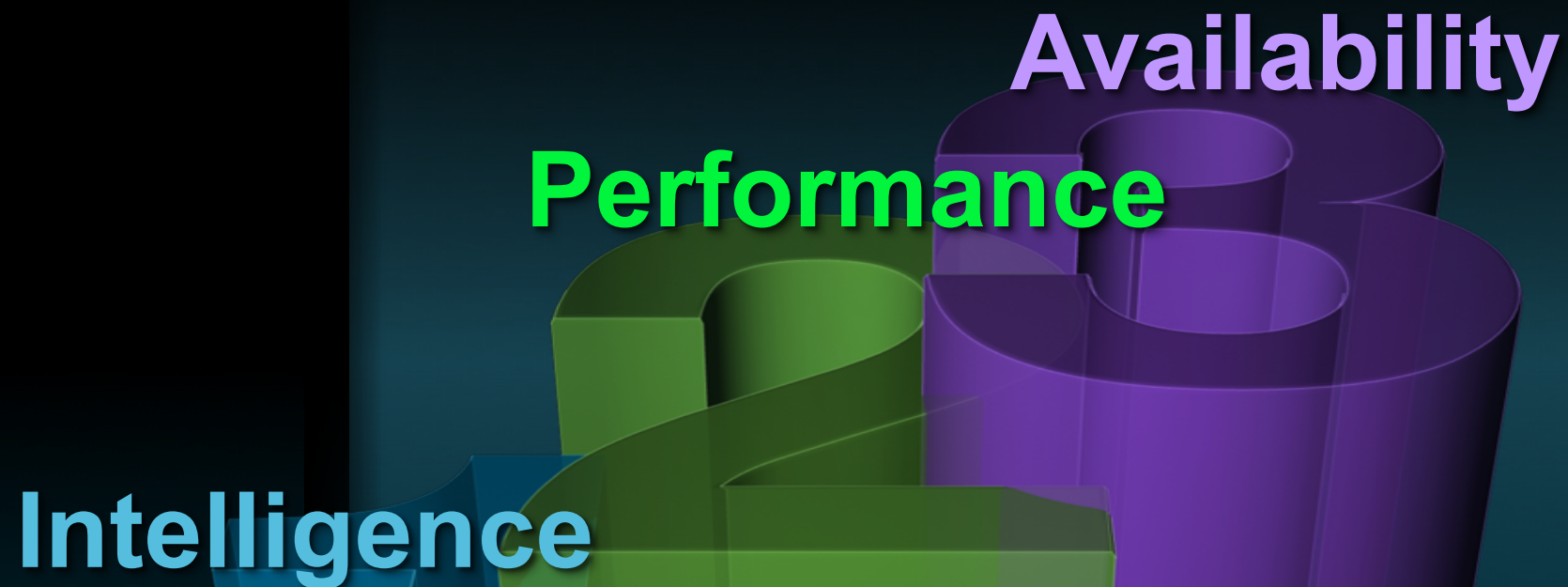
“This aggressive test of Cisco's mobile IP network shows that network operators can effectively scale their technology to match the data demands of the modern mobile consumer.”

Phil Harvey, Editor-in-Chief, Light Reading

“Cisco showed reassuring scalability and state-of-the-art functionality across all mobile technologies... this test really was outstanding, a true industry-first, an innovative and courageous undertaking,...”

**Carsten Rossenhoëvel, Managing Director
EANTC (AG)**

Cisco IP Next-Generation Mobile Network



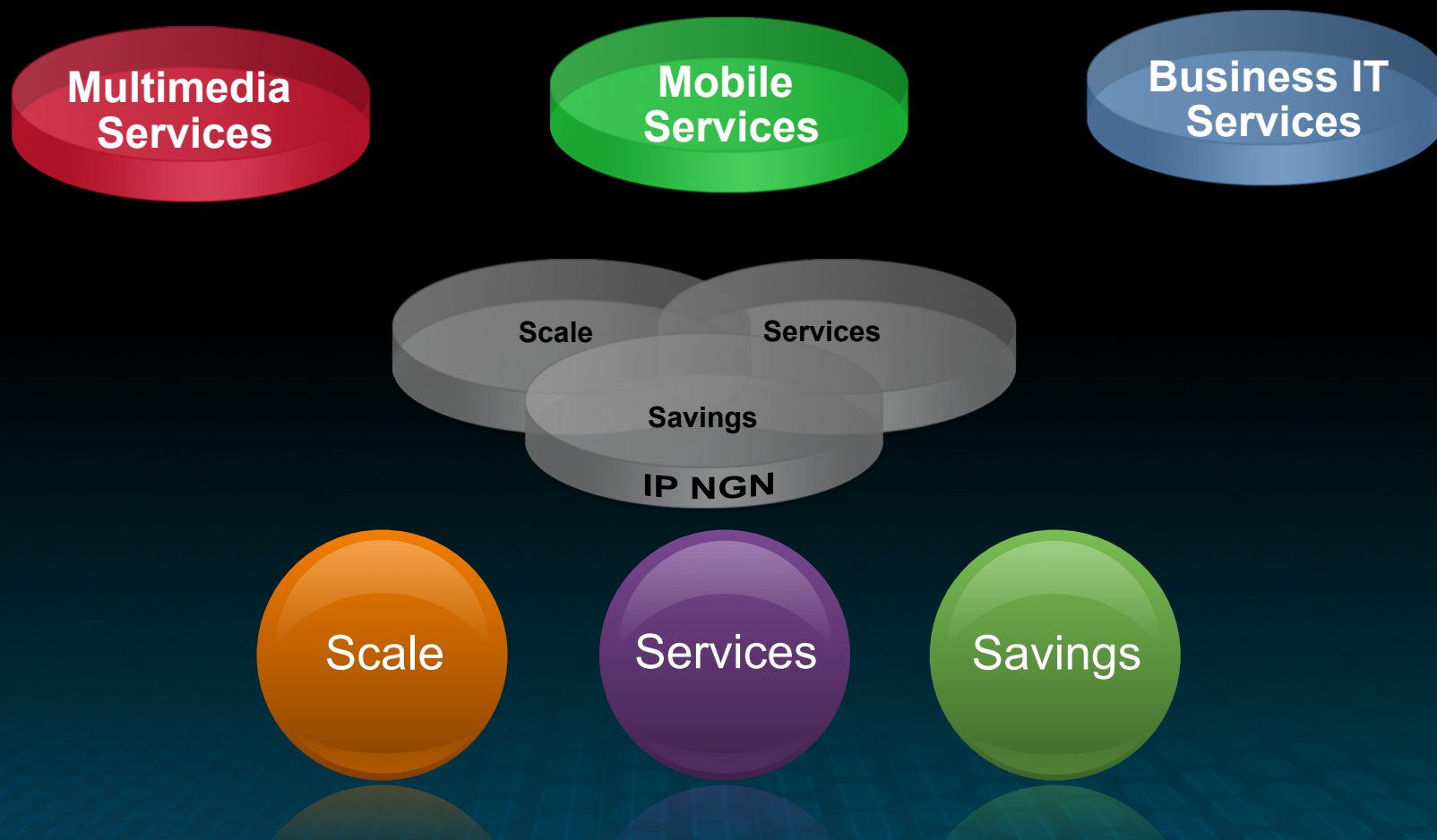
Intelligence

Performance

Availability

Enabling You to Deliver

Next-Generation Mobile Services: Economically with High-Quality Experience



Begin the Transformation

**Over 200
Mobile Service Provider
Deployments**





Light Reading - Independent Mobile Test
<http://www.lightreading.com/mobiletest>