Nominum

Carrier Ethernet for Mobile Broadband Networks

Optimizing Backhaul Networks to Address Performance and Security

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TeleSemana

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Company Overview

We are the **WORLD LEADER** in DNS & DHCP solutions

- Our Chairman, Dr. Paul Mockapetris, invented the DNS
- Team comprised of BIND 8, BIND 9 & ISC-DHCP creators
- 40 issued and pending patents

Our solutions run the world's **MOST DEMANDING** networks

- A decade of service provider experience
- Over 140 Fixed and Mobile service providers
- Serving over 500 million Internet users worldwide

The first & only DNS/DHCP **INTEGRATED ARCHITECTURE**

- DNS/DHCP **engines** provide efficiency, lower costs, higher QoS
- **Platforms** enable agility & faster application development
- **Applications** create differentiation and new revenue sources

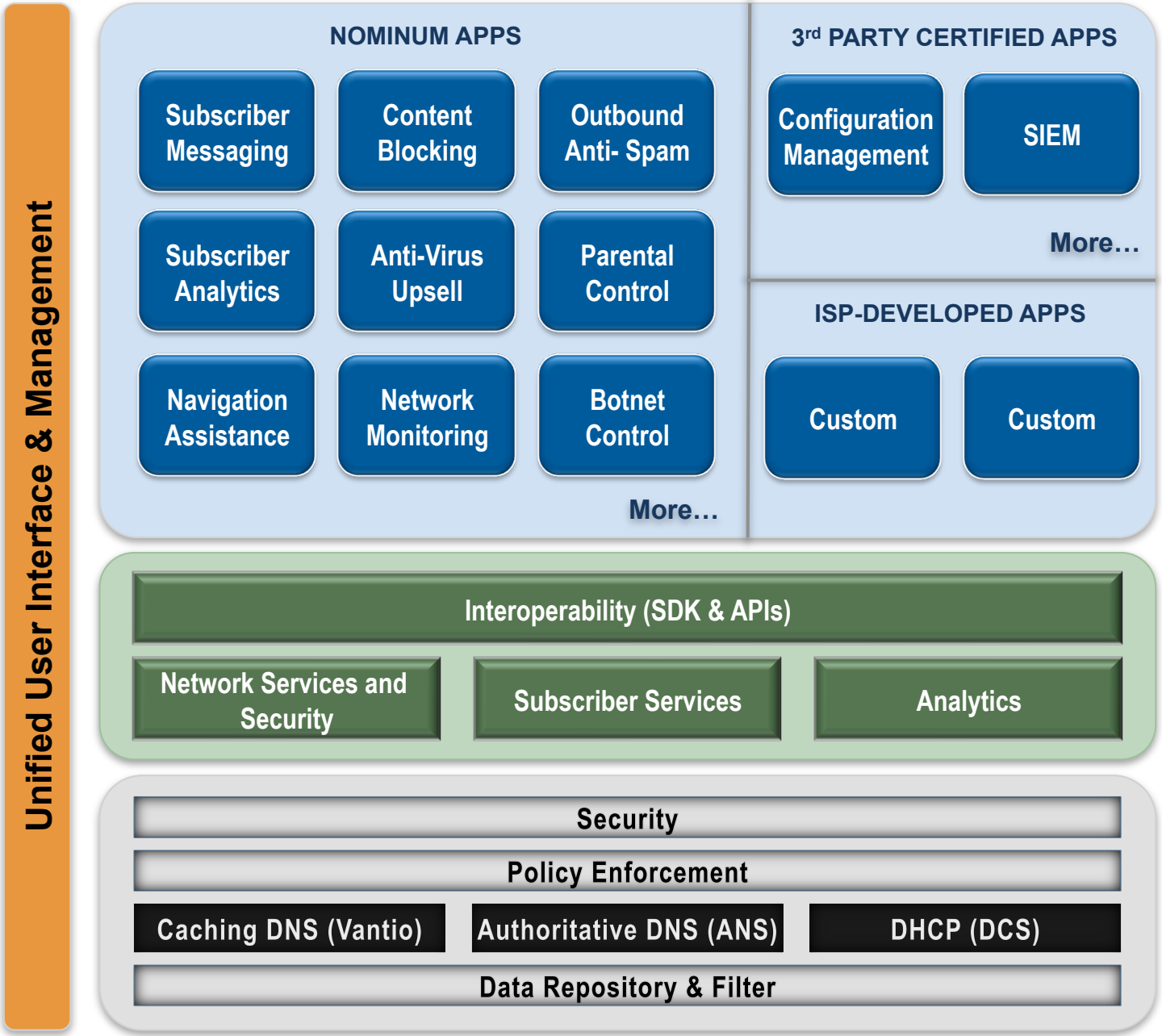
Our mobile customer base includes:

中国电信 CHINA TELECOM, TIM, Telefónica, vodacom, Telstra™, vodafone, CHINA MOBILE, movistar, Claro

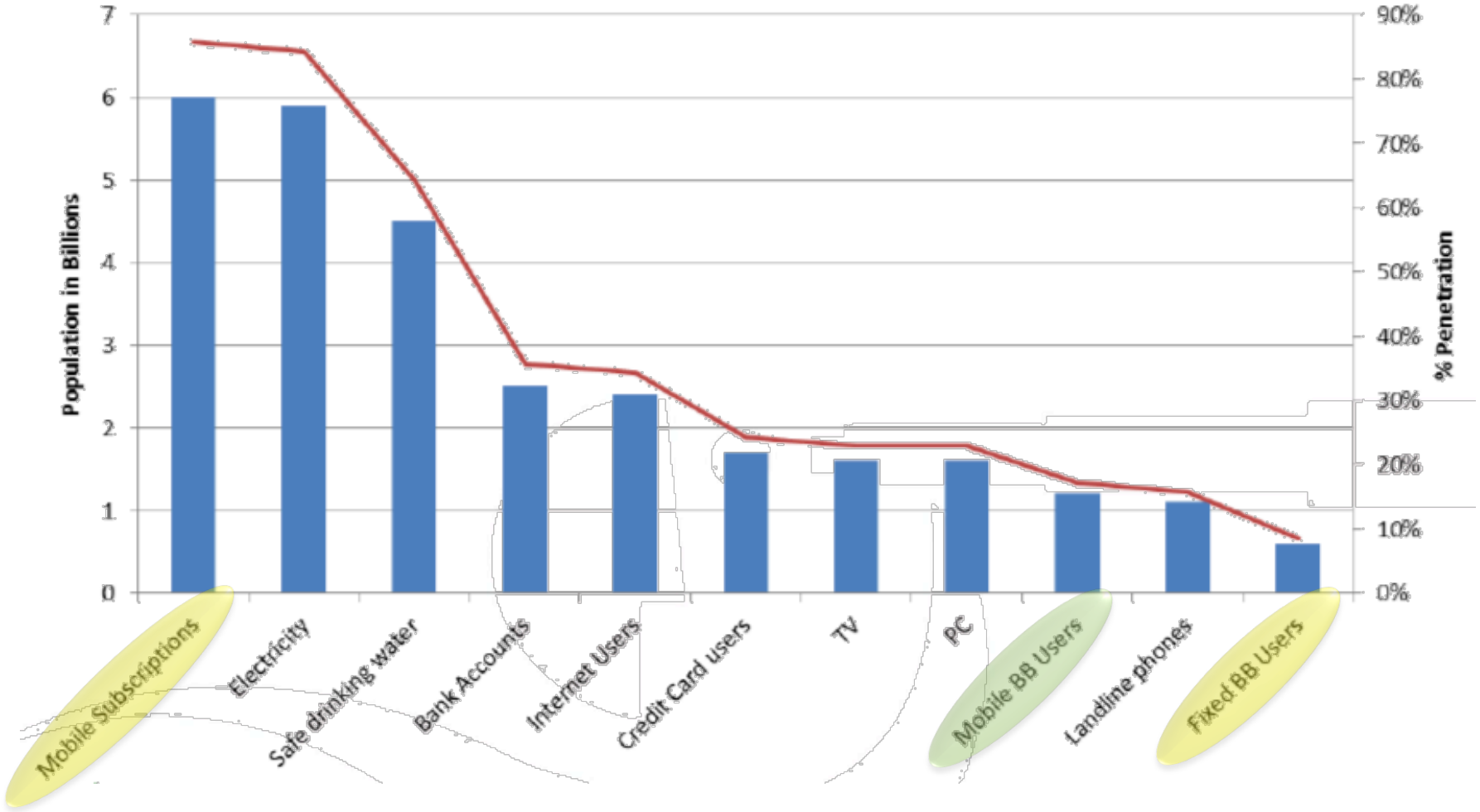
Our fixed broadband customer base includes:

verizon, Comcast, NTT Communications, Virgin media, BT, TELMEX

Three-Tiered Integrated Architecture

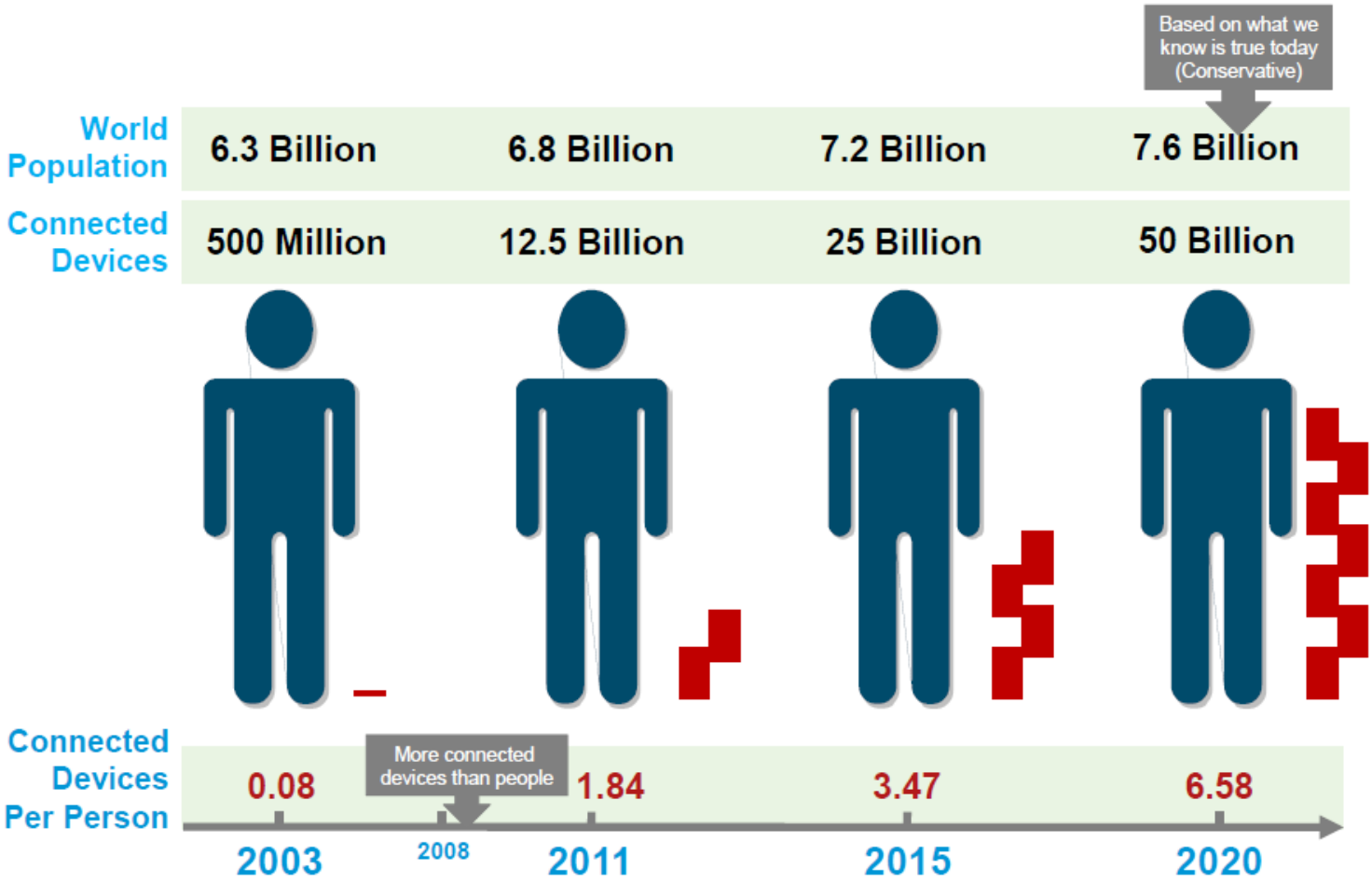


Putting Mobile into Perspective



Source: Chetan Sharma Consulting – 2012

Mobile Devices per User



Source: Cisco IBSG, 2011

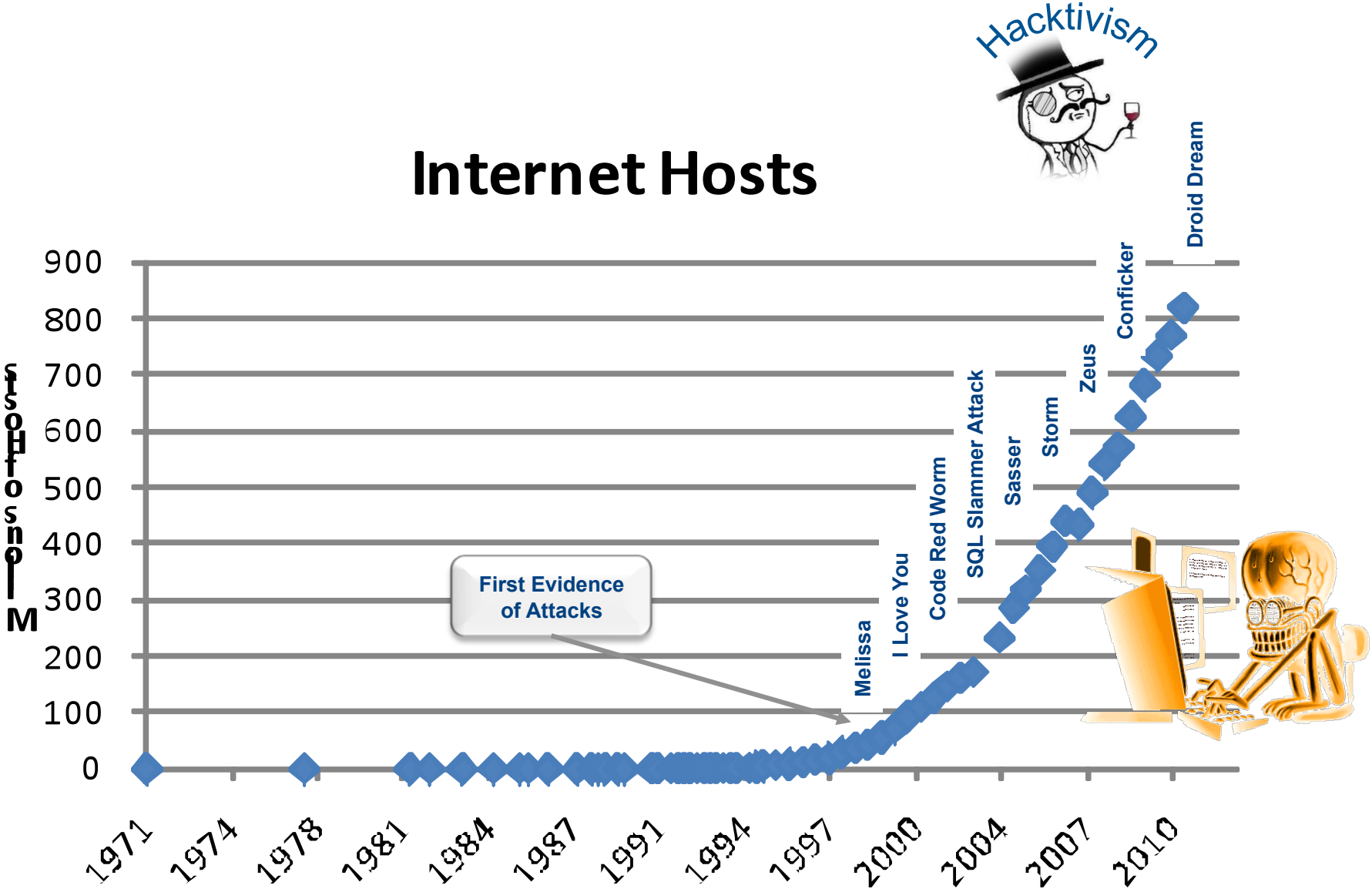
The Changing Face of Mobile




- Connected devices are expanding
  - Not just mobile phones*
    - 175M laptops on the mobile network in 2011
      - 22x more traffic than more traffic than smartphones
    - Tablets to exceed 10% of global mobile data traffic in 2016
    - In 2016, 4G will be 6 percent of connections, but 36 percent of total traffic
  - Mobile devices aren't as protected as home networks
- Spectrum consumption is a constant battle
  - "If we don't get new frequency [in 2012], it will topple our company."
    - *Asahi Shimbun - CTO of Softbank Mobile*
  - "Frequency allocations alone are not the only solution. We need to be as smart as possible in managing our capacity."
    - *Philipp Humm, President and CEO of T-Mobile USA – CTIA 2012*

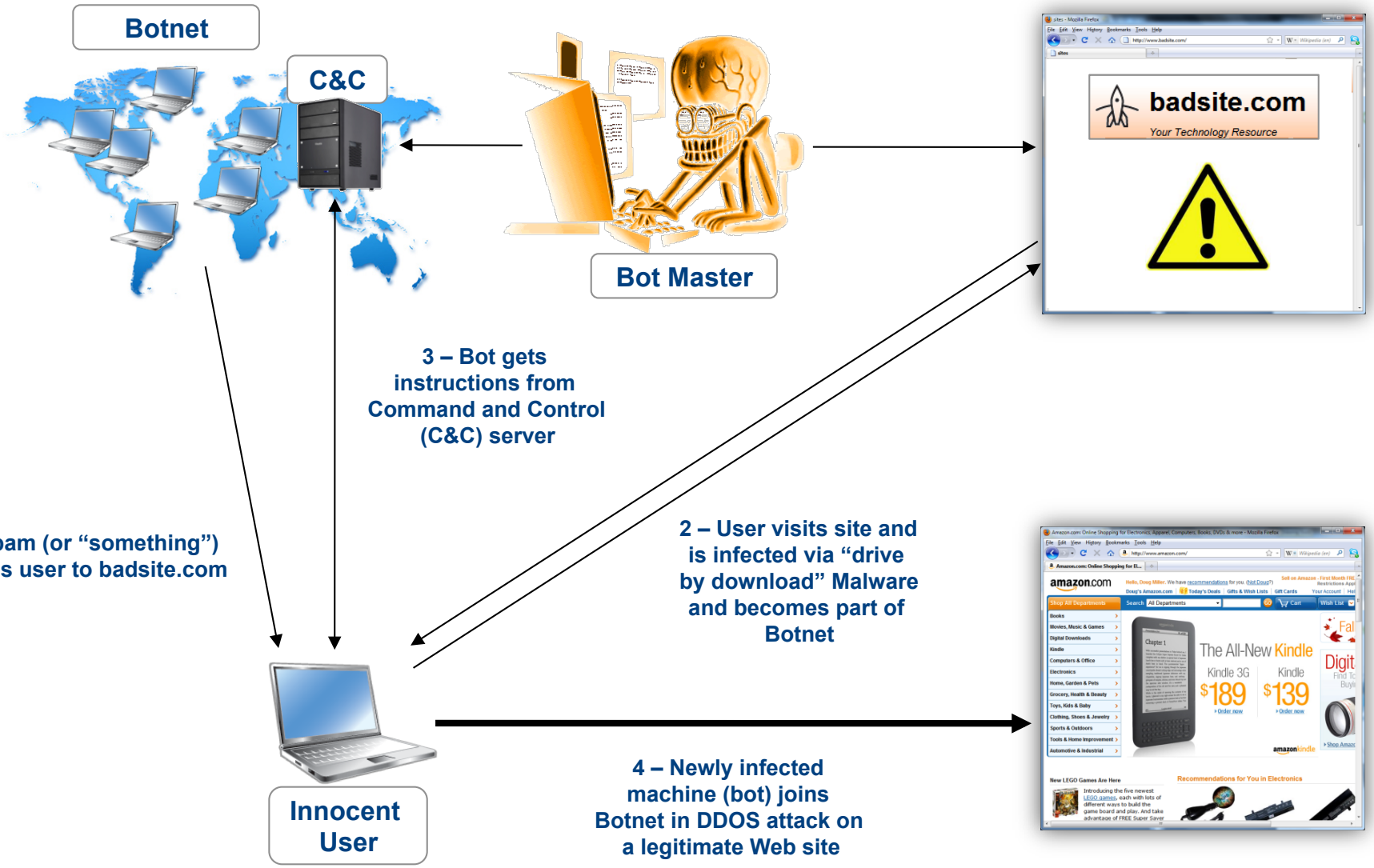
*Note: Cisco Visual Networking Index, 2012

Bots and Malware Landscape



Accelerating Mobile Malware Threats

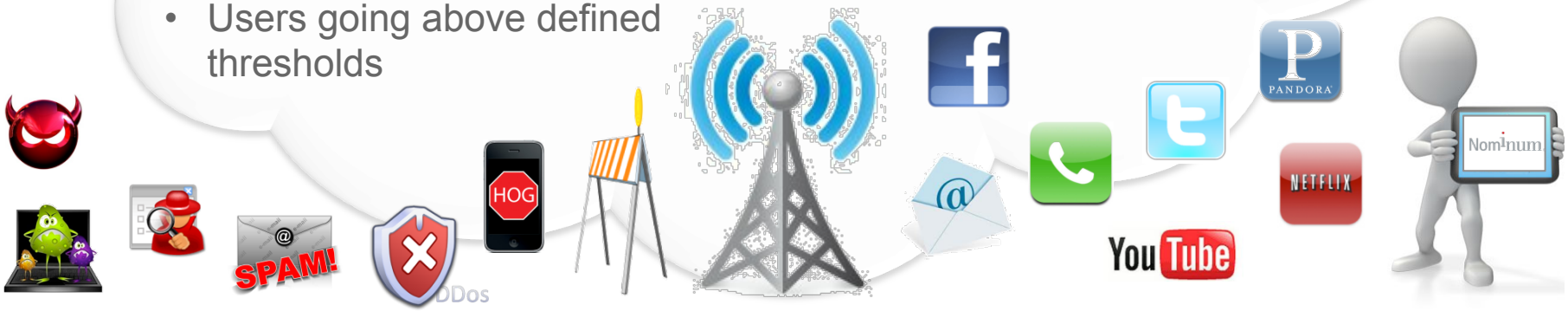
The Lifecycle of a Bot Network



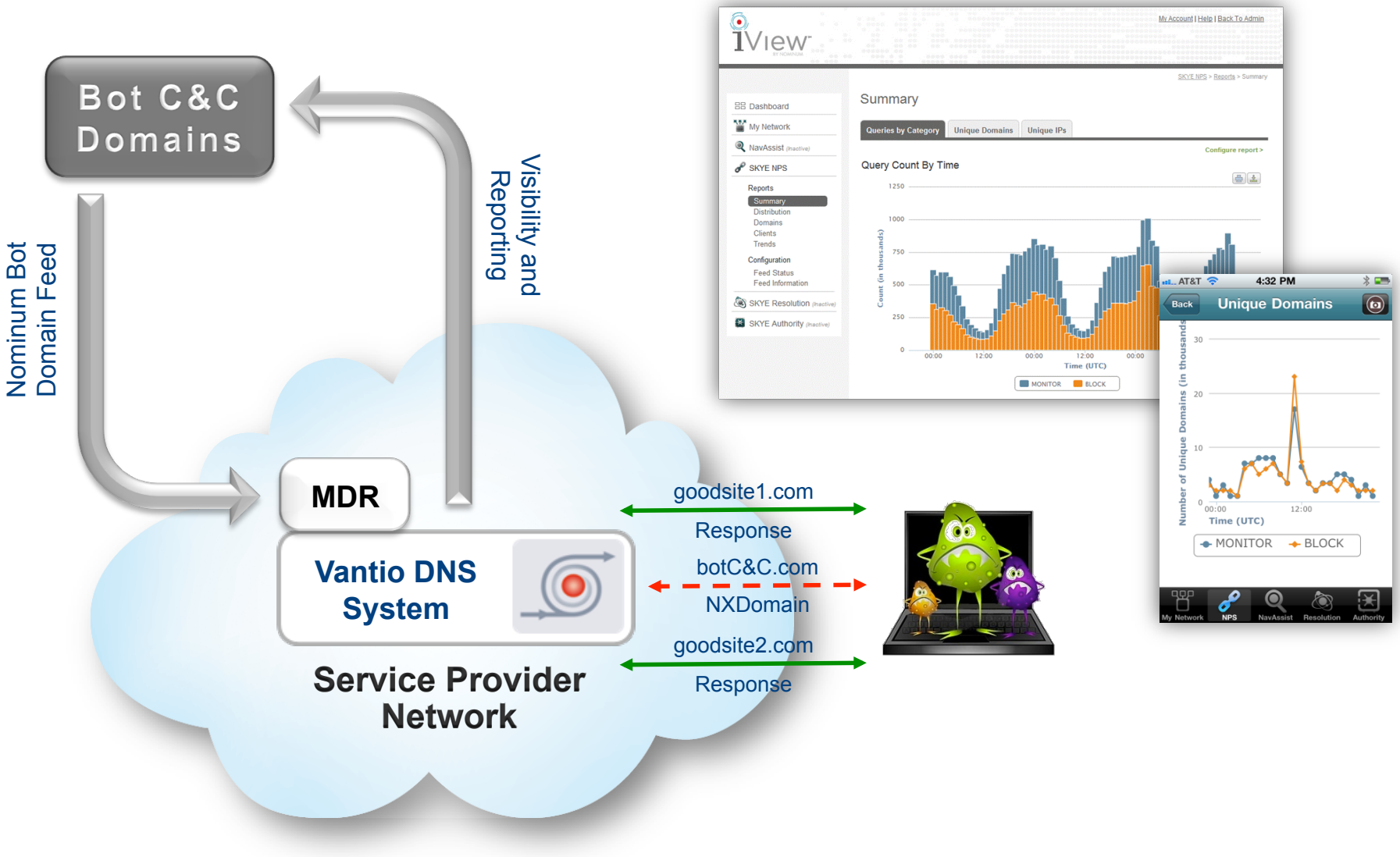
Network Proficiency Solution

- Use network resources more efficiently
  - RAN and Packet Core impacts
    - In combination with offload and HetNet solutions
  - Prevent bot-generated activity and consumption

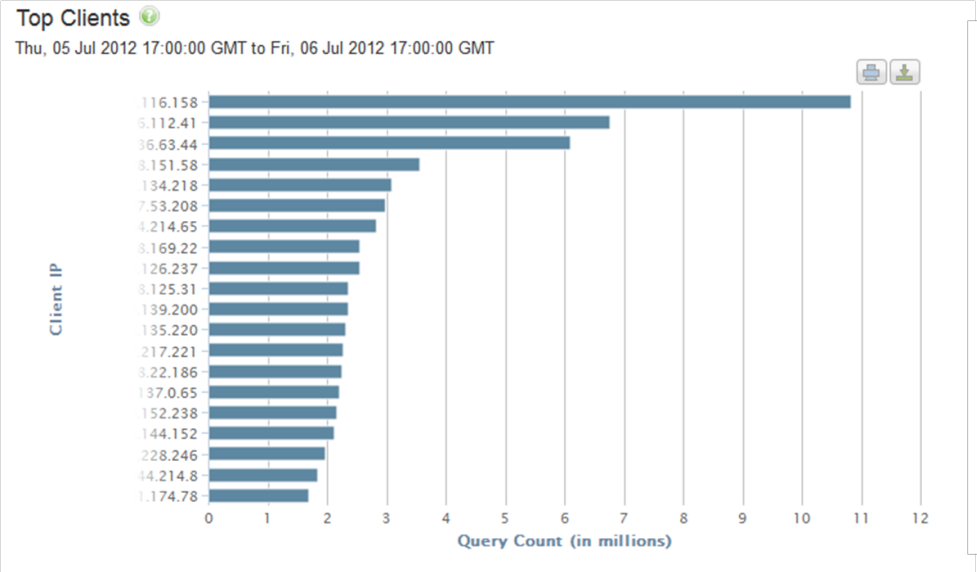
    Note: Yes, even on mobile devices
    - Decrease outbound spam
    - Block internally generated bandwidth floods
  - Segregate abusive customers
    - Infected users
    - Users going above defined thresholds
- Reclaiming spectrum leads to real and immediate benefits
  - Increased availability for new customers and services
  - Leverage network assets over longer timeframes
  - Decreased risk of email black listing (RBLs)
  - Lower cost of delivering service
  - Greater defenses from outages or performance degradation

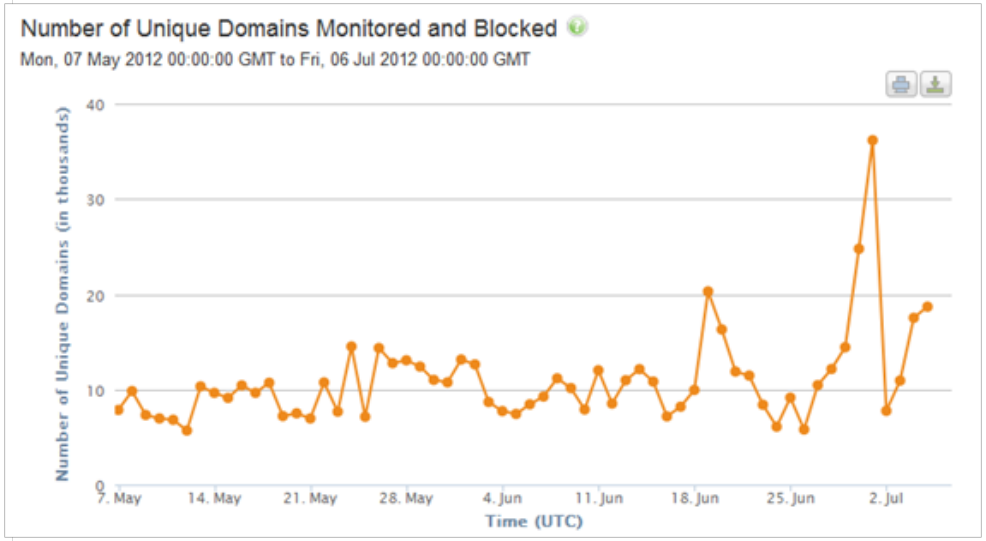


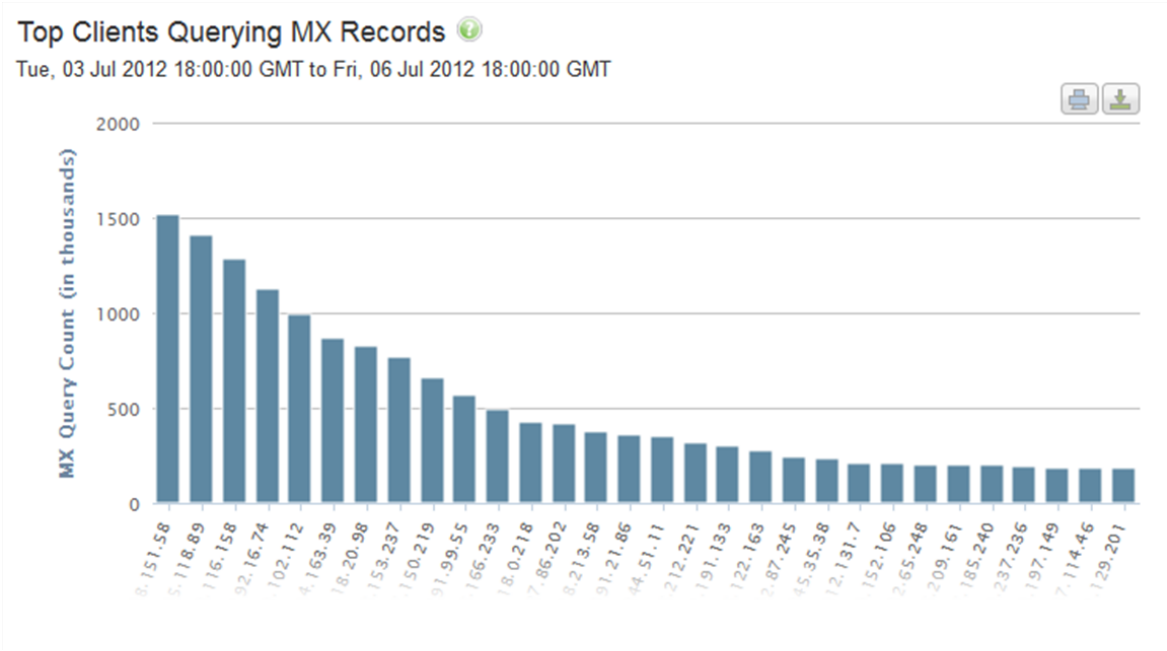
Protecting the Network



Understanding User Trends







Network Proficiency Use Case

- Latin American converged customer
  - 5M mobile customers and 250K broadband customers
- The problem they faced
  - Botnet and malware infection documented to be as high as 10%
    - Infected customers generating nearly half of all DNS traffic
    - 20% of all DNS traffic was determined to be spam-generating
  - Outbound spam was directly impacting end users
    - Customer “AS Numbers” were blacklisted preventing email from being sent
  - Bot related traffic consuming fixed and wireless resources
- Addressing the issue
  - Implemented components of the Network Proficiency Solution
  - Prevented bot-related activity
  - Removed customers from black lists for full email access
  - Decreased consumption of vital network resources

Mobile Packet Core Solution

- Control Plane Functions
  - Ensuring reliable services
    - Intra-network connectivity
    - Roaming across/between carriers
    - Interworking between 3G and 4G networks
  - Multiple interfaces rely on DNS
    - Gn/Gp and S5/S8
    - ENUM
    - Diameter
    - IMS
  - Enhanced features
    - Health monitoring
    - Load balancing between elements
    - Automatic NAPTR record generation

- User Plane Functions
  - Ensuring high performance and complete security
    - Low latency
    - Protection from attack
    - Data assurance
  - Serve as the basis for mobile solutions
    - Network Proficiency
    - Network and User Security
    - Subscriber Loyalty
    - Network and Service Visibility

Nominum Mobile Suite

- Anywhere/Anytime information access
  - **Efficiency:** Highest network performance at the lowest TCO
  - **Differentiation:** Pre-built apps to provide new services/revenues
  - **Agility:** Adapt to market changes and innovate quickly
- Real business issues are addressed by a DNS platform
  - Core network functionality is only the beginning
  - Enhanced applications are built right on top of this existing asset
- Consider the DNS as a critical network element
  - DNS must be carrier grade more so now than ever before
  - DNS is a critical network element & is more so every day

Wireless Environments Have Unique Needs
Nominum Knows Mobile

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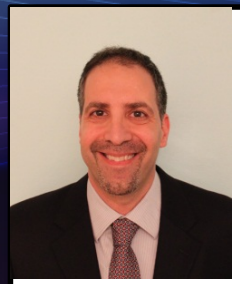
MEF

CE 2.0: Optimize Mobile Backhaul for 4G/LTE



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CE 2.0 Mobile Backhaul Initiative

Significant, Positive Impact for 4G/LTE

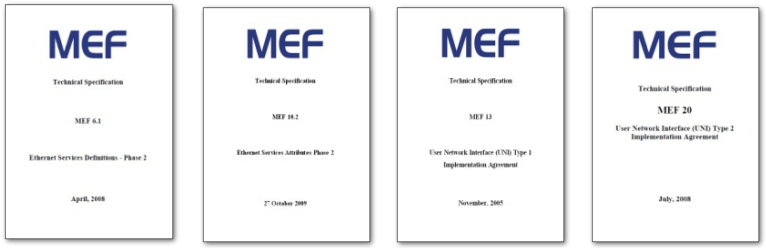
- Builds on the migration of MBH to Ethernet
- Migration from 2G, 3G to 4G/LTE
- A blueprint for implementing synchronization
- Service OAM, Resiliency and Protection
- New multiple classes of service for efficient operations

Mobile Backhaul Suite – Application of CE 2.0

MEF 22.1	MEF 23.1, MEF 6.1 10.2	Multi-CoS Positioning	Multi-CoS Best Practices	Packet Sync for CE over MBH	Microwave Technologies for CE

MEF 22.1 and Relationship to other SDOs

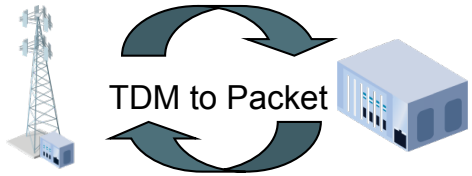
MEF 6.x | MEF 10.x | MEF 13 | MEF 23.1



MEFs own work as the foundation

Other SDOs

Industry trends



Standardized reference points

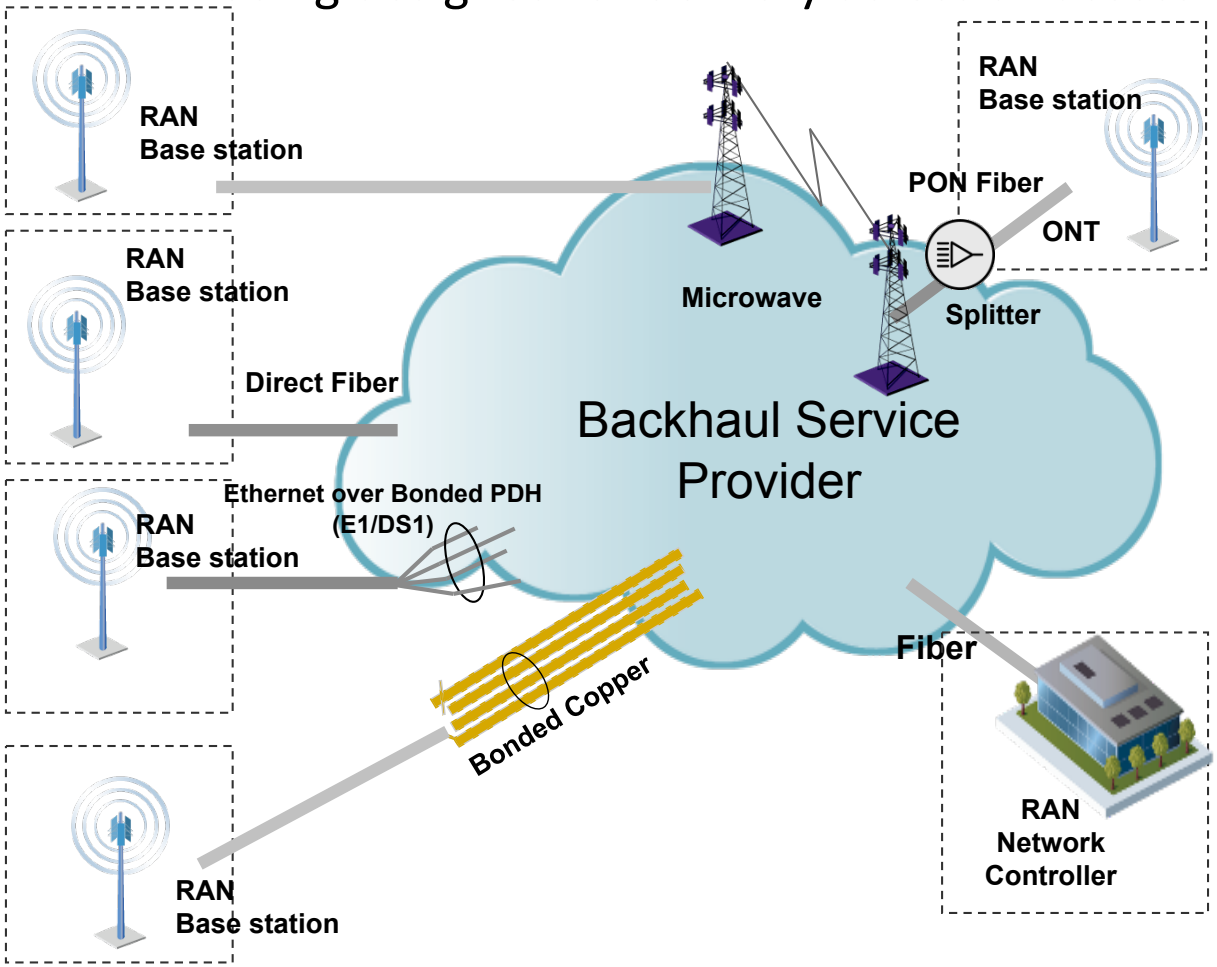
Service Requirements (Service Types, CoS, Eth OAM, etc)

Synchronization Recommendations

Carrier Ethernet and MBH Networks

Carrier Ethernet is transport technology agnostic

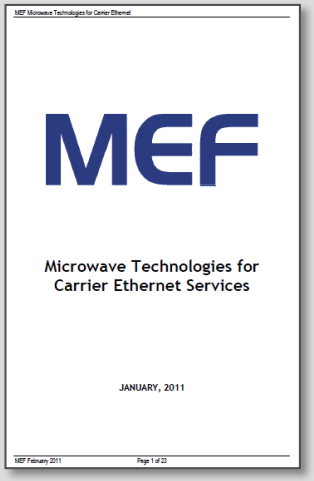
– being designed for delivery across all access transports



Recent
Educational Paper

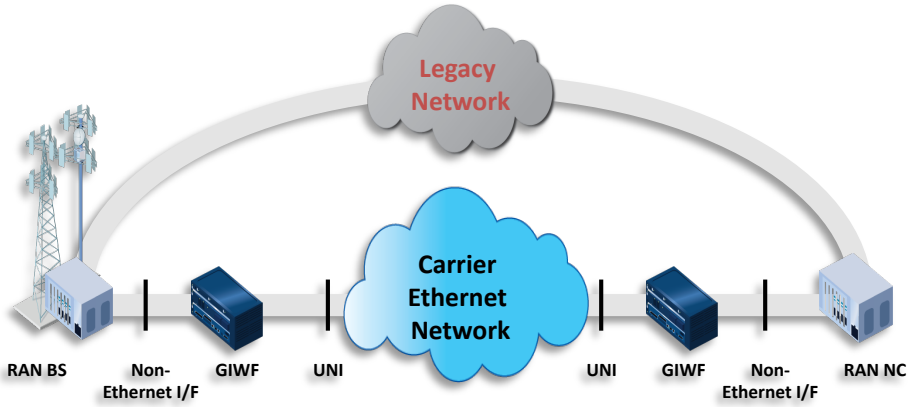
Microwave Technologies For Carrier Ethernet Services

Published by MEF available for download

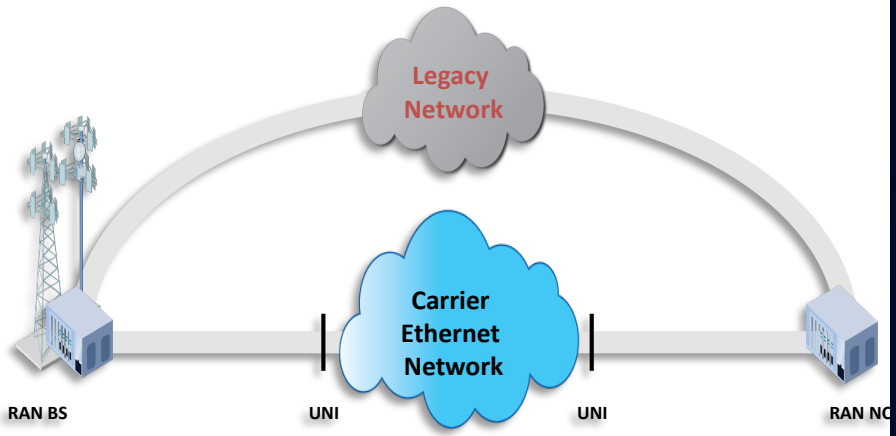


Mobile Backhaul Migration Use Cases

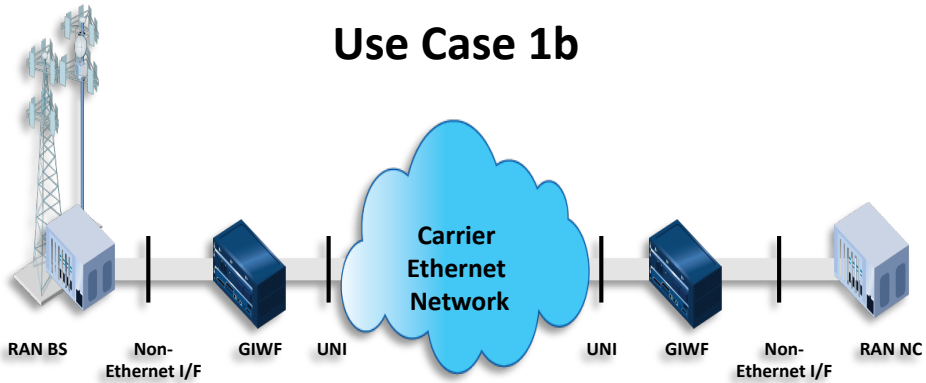
Packet offload over Carrier Ethernet Use Case 1a



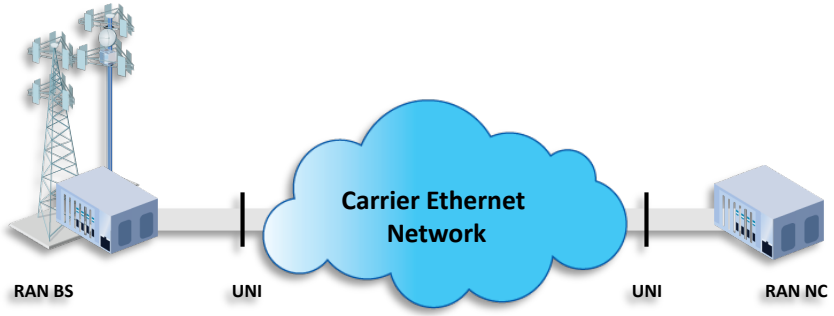
RAN dual stack – Use Case 2a



Emulation over Carrier Ethernet Use Case 1b



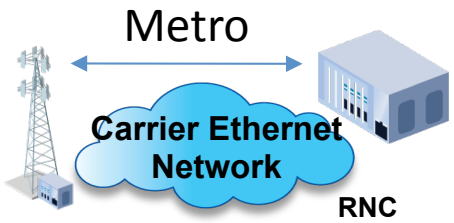
Full Ethernet – Use Case 2b



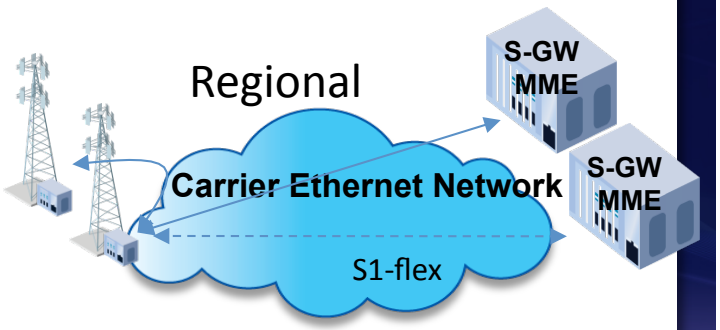
Optimizing Mobile Backhaul
Introducing MEF 22.1

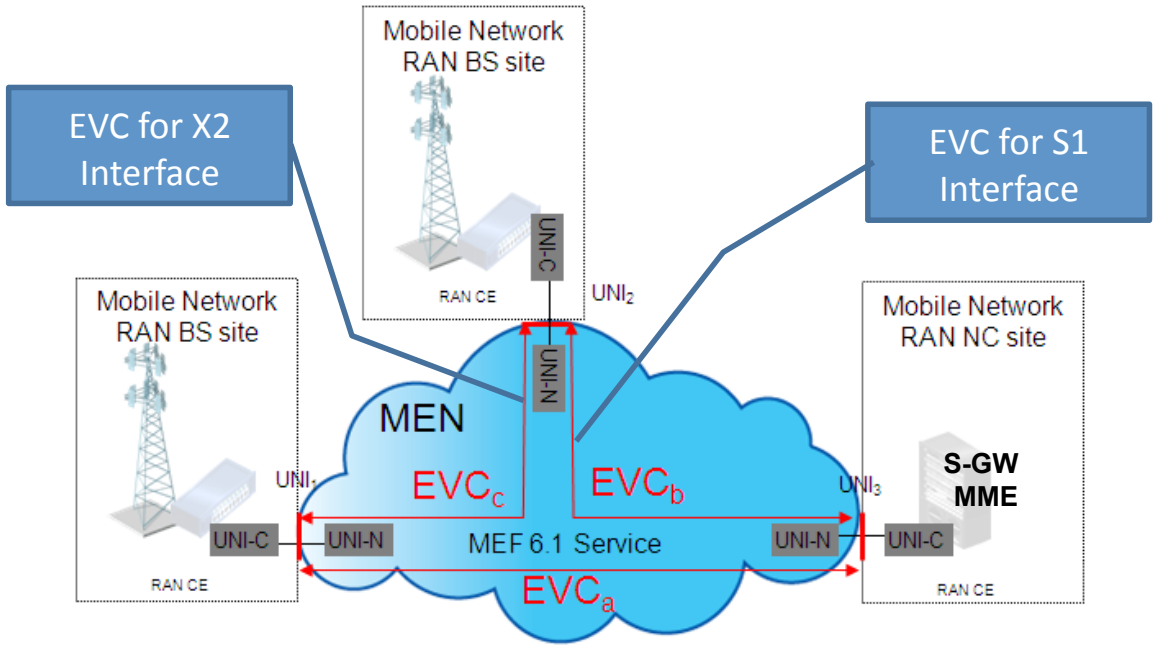
Mobile Backhaul Service for LTE

- **3G Backhaul: ~ 100km (Metro)**



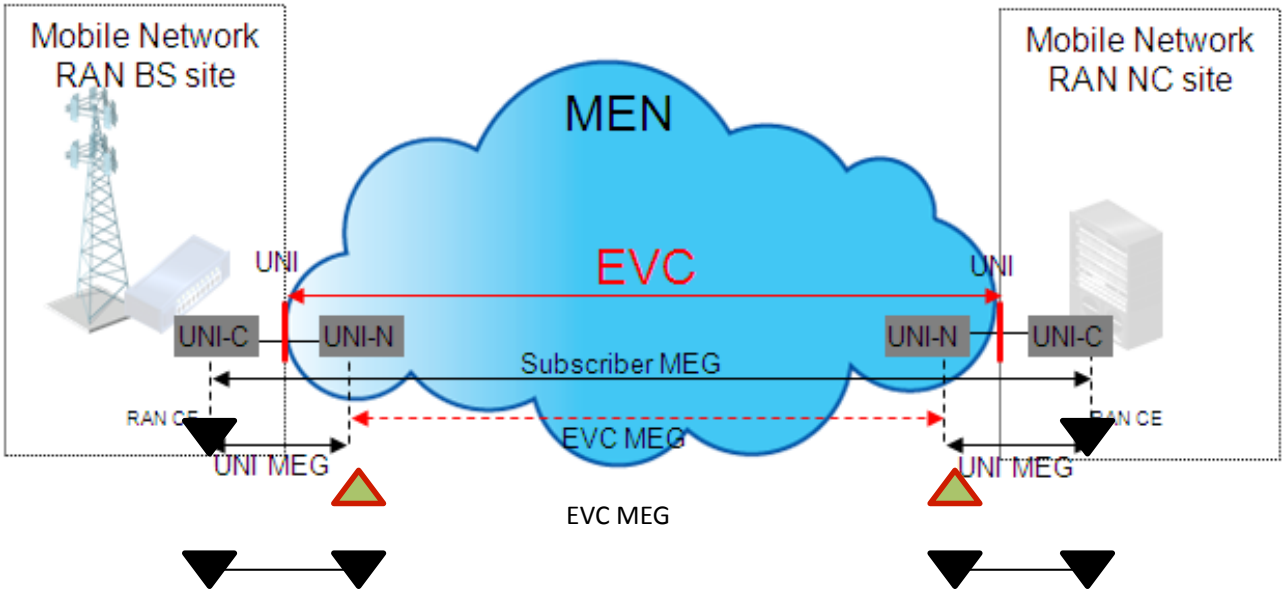
- **LTE Backhaul expanded reach:**
  - **BS to S-GW/MME ~1000km (Regional)**
  - **BS to BS ~ neighbors (10s of km)**





Mobility Management Entity

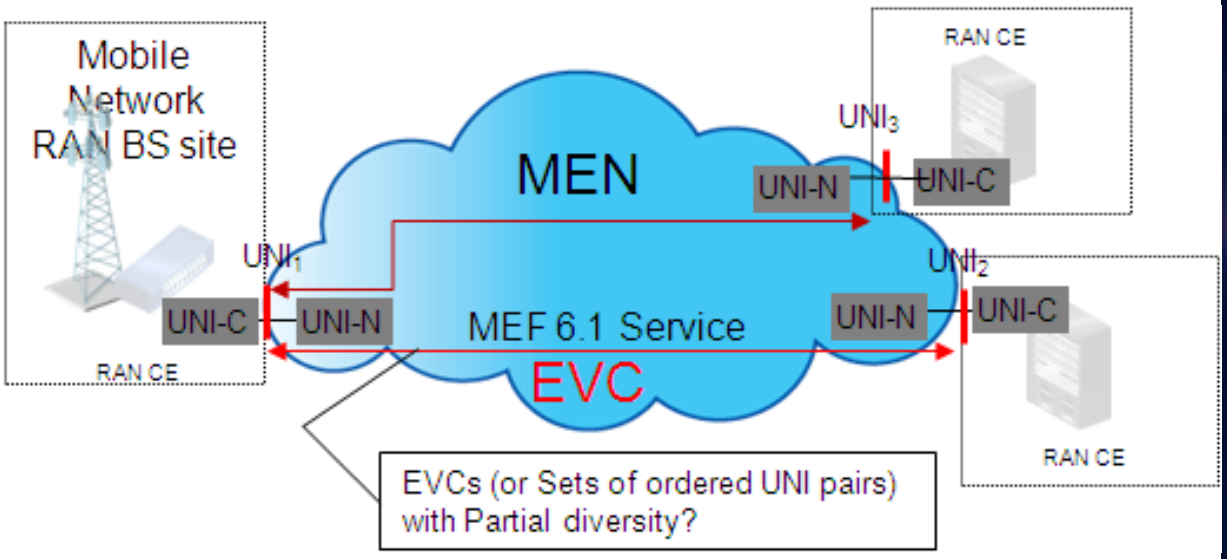
MEF 22.1: Service Management



- **Subscriber MEG for Mobile Operator (as Customer/Subscriber)**
- **EVC MEG (or Operator MEG) for MEN Operator (as Service Provider)**
  - Fault and Performance Management to report EVC Performance
- **UNI MEG used to monitor MEF compliant UNI**
  - eg. RAN CE & MEN using UNI Type 2 with Service OAM capability

MEF 22.1: Resiliency Performance

- **Service availability depends on protection of both UNI and EVC**
- **Diversity for higher Availability**
  - UNI Resiliency (Link Aggregation)
  - MEN Resiliency Model (MEN Operator implements protection)
  - RAN Resiliency Model (Mobile Operator implements protection)
  - Partial vs Full Diversity (some or no shared infrastructure)
- **Use Cases**
  - S1-flex in LTE
  - Protect synchronization
- **Group Availability**
  - Set of EVCs
- **Care for:**
  - Long term disruptions
  - Short term loss in signaling can bring down a cell site

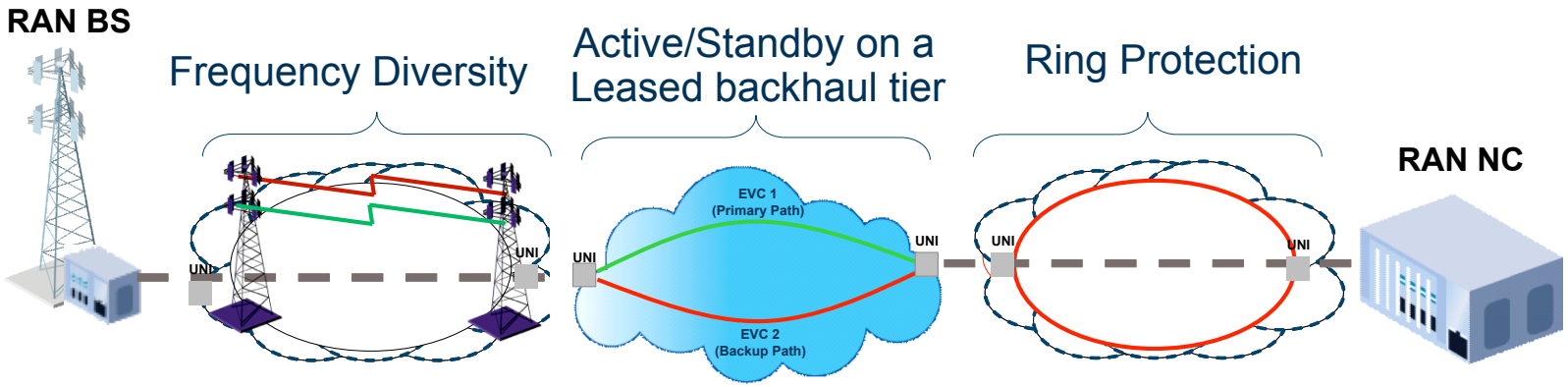


MEF 22.1: Resiliency/Protection

- **MEF Service Specifications augment industry standards**
- **Address port and service protection, fault detection and restoration**
  - At the UNI ports
  - At the ENNI (for direct and Exchange connections)
  - For UNI to UNI (EVCs)
  - UNI-ENNI OVCs

Protection Examples
✓ 1+1 APS (Active/Standby)
✓ LAG (802.1AX)
✓ Dual Homing
✓ Ring Protection (G.8032)
✓ Linear Protection (G.8031)
✓ Spatial Diversity (Microwave)
✓ Frequency Diversity (Microwave)

- **The following is an example of few backhaul resiliency methods**



MEF 22.1: Performance Objectives

One Way Performance Objectives

Performance Attributes	CoS Label H	CoS Label M	CoS Label L	Applicability
Frame Delay (ms)	≤ 10	≤ 20	≤ 37	At least one of either FD or MFD required
MFD (ms)	≤ 7	≤ 13	≤ 28	
Inter-Frame Delay Variation (ms)	≤ 3	≤ 8 or N/S	N/S	At least one of either FDR or IFDV required
Frame Delay Range (ms)	≤ 5	≤ 10 or N/S	N/S	
Frame Loss Ratio	≤ .01% i.e. 10-4	≤ .01% i.e. 10-4	≤ .1% i.e. 10-3	

Reference: MEF 23.1 Performance Tier 1 (Metro) CoS Performance Objectives

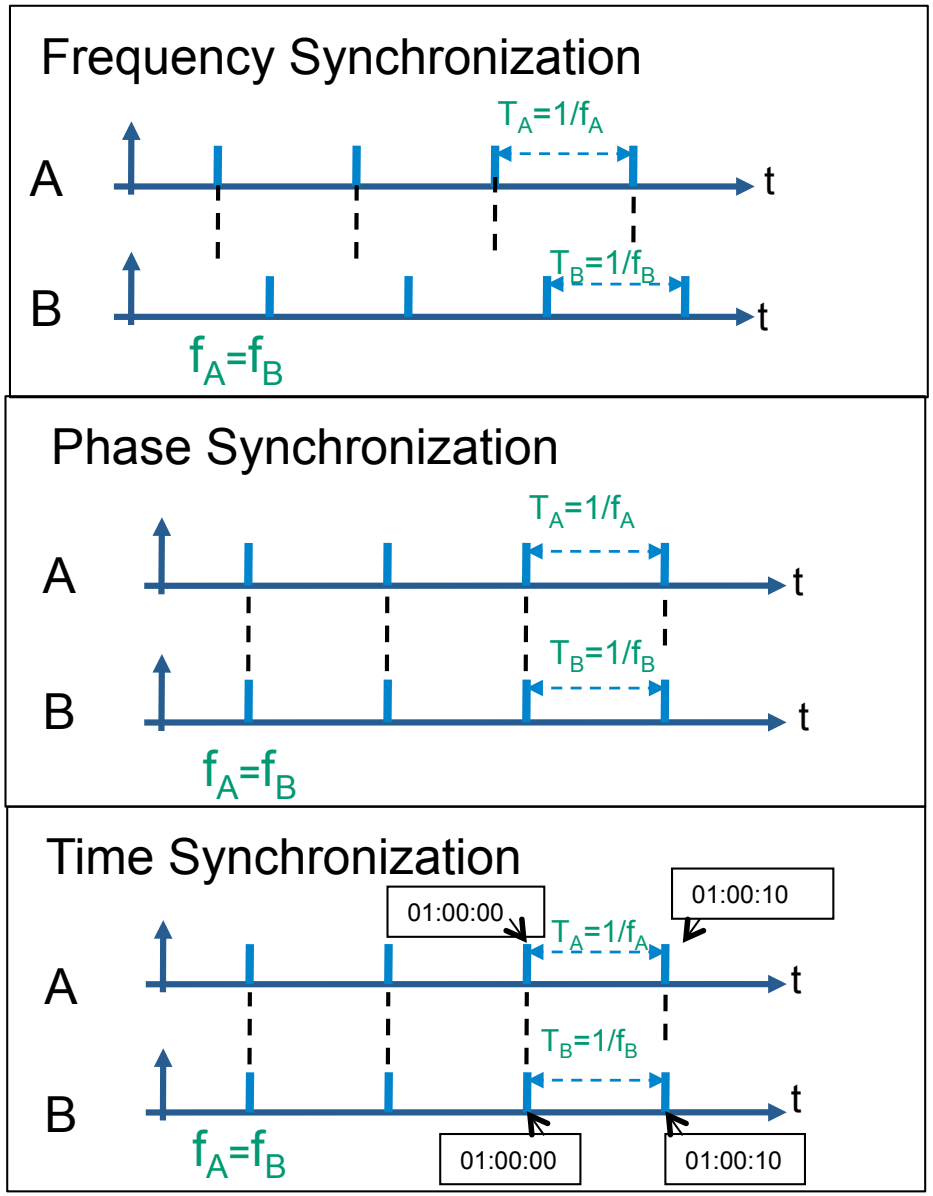
MEF 22.1: Service Mapping

- **The following shows how backhaul services can be integrated between mobile operators and access providers even when the services offered are not the same:**

CoS Names	Generic Traffic Classes Mapping to CoS Names			
	4 CoS Names	3 CoS Names	2 CoS Names	2 CoS Names
Very High (H+)	Synchronization	-	-	-
High (H)	Conversational, Signaling, Network Management and Control	Synchronization, Conversational, Signaling, Network Management and Control	Synchronization, Conversational, Signaling, Network Management Control, and Streaming media	Synchronization, Conversational, Signaling, Network Management, Control, and Streaming media
Medium (M)	Streaming media	Streaming media	-	Interactive and Background
Low (L)	Interactive and Background	Interactive and Background	Interactive and Background	

MEF 22.1: Examples of MBH Traffic Classes mapping to CoS Names in a Carrier Ethernet Backhaul network

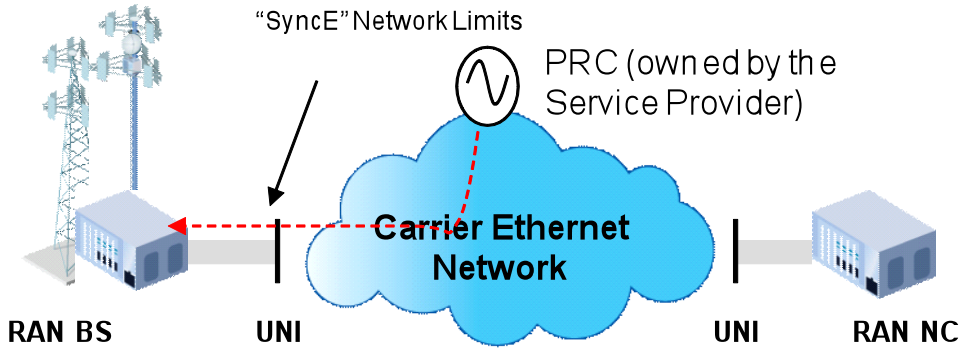
Synchronization Requirements



Mobile Network Architecture	Frequency Sync	Time-of-day / Phase Sync
CDMA2000		✓
GSM	✓	
UMTS-FDD	✓	
LTE-FDD	✓	
UMTS-TDD	✓	✓
LTE-FDD with advanced features	✓	✓
LTE-TDD	✓	✓
Mobile WiMAX	✓	✓
TD-SCDMA	✓	✓

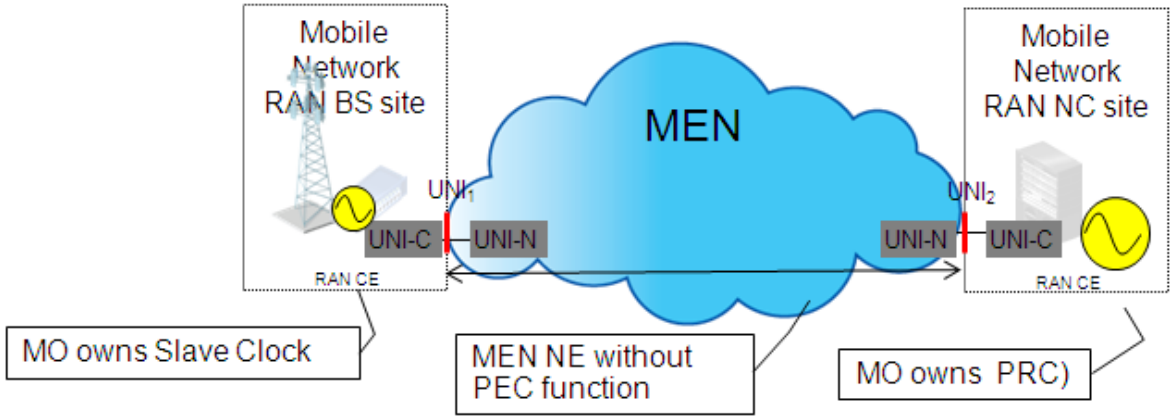
Synchronous Ethernet

- **UNI PHY**
  - Synchronous mode of operation (Synchronous Ethernet)
    - Locked to Ethernet Equipment Clock (EEC)
- **Interoperable operation of Synchronous Ethernet**
  - Synchronous messages: Generation & processing rules
  - Clock Quality Level (QL) indication & processing rules
  - Direction of clock distribution: MEN to Base Station
- **Recommendation to support QL processing in Base Station**
  - Failure conditions & Switchover to alternate Primary reference



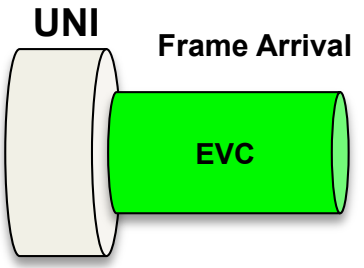
Service Class for Sync Traffic

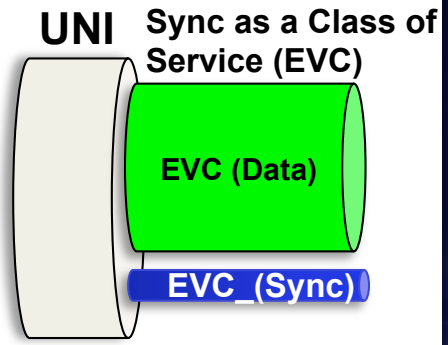
- Using sync embedded in the data
  - Sync/data is in a high priority EVC
    - Inter-arrival rate using Adaptive Clock Recovery (ACR)
    - Can also use CES RTP optional header for synchronization timestamps
- Using a sync protocol (e.g.. IEEE1588v2)
  - Separate EVCs
    - Each EVC will have its own performance
  - Separate Class of Service within the same EVC
    - Sync is marked with higher CoS

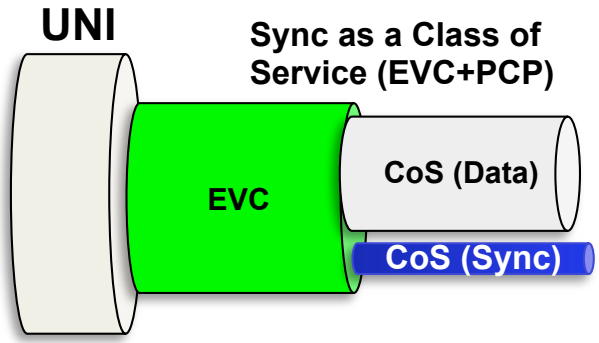


MO: Mobile Operator
NE: Network Element
PEC: Packet Equipment Clock

PRC: Primary Reference Clock
PCP: Priority Code Point



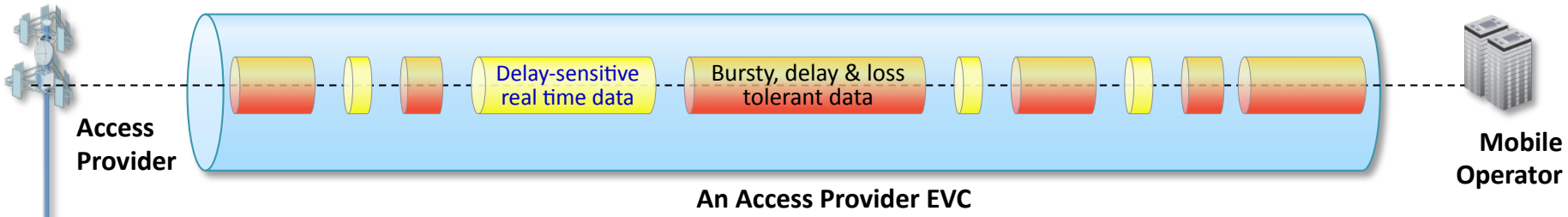




Single Class vs. Multiple Classes (1)

Many providers have taken first steps to Carrier Ethernet

- But with simplistic, one Class of Service approach: simple but costly, and with QoS issues

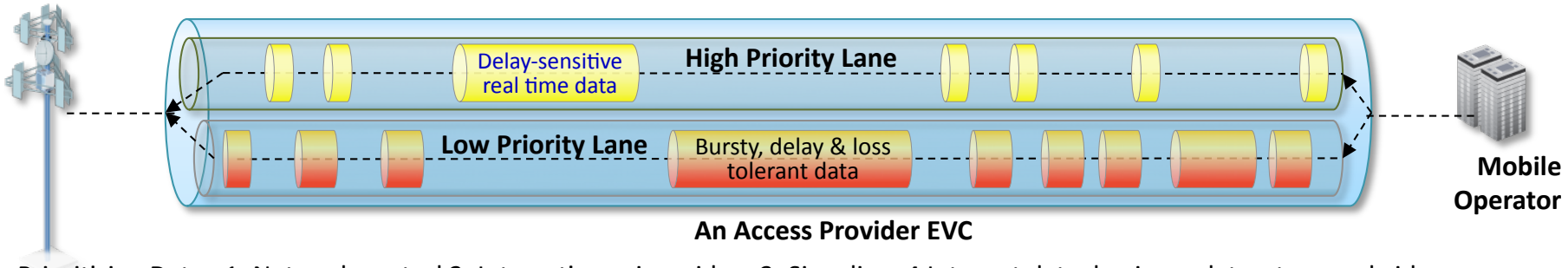


Result/Impact

- **Needs very costly overbuild**
- **Does not scale - recipe for going out of business**
- **High priority traffic subject to delay – especially during traffic bursts and peaks**

Single Class vs. Multiple Classes (2)

Multiple-Classes of Service: more complex but great rewards



Prioritizing Data: 1. Network control 2. Interactive voice, video, 3. Signaling, 4 Internet data, business data, streamed video

Result/Impact

Access Providers

- More revenue for same cost: more users, more responsive QoS
- Avoids costly over-build
- Maximize profitability – leverage Ethernet packet efficiency

Mobile Operators

- Enabled Savings in a multi-billion Industry
- Enables resolution of most critical challenge:

"Handling unprecedented growth of data while preserving or improving QoS."

Summary of the New MBH Initiative

- **Ethernet adoption accepted by vast majority**
- **MEF: new solutions for optimization of MBH**
  - Packet & network-based synchronization
  - MEF 22.1: Multi-CoS, Service mapping, Link & Service OAM, Resiliency performance
  - Supports efficient deployment of 4G/LTE
  - Plus 2G, 3G and migration use cases
- **Impact of new MEF work**
  - CapEx savings, Potential OpEx savings for Operators
  - Better bandwidth utilization and service quality
  - Sustainable future for MBH