Unified RAN Transport Solution: Cisco-SIAE MICROELETTRONICA Interoperability

June, 2012

Introduction

Mobile providers are currently experiencing large increases in mobile backhaul capacity requirements. According to recent Cisco® Visual Networking Index (VNI) forecasts, global mobile data traffic will continue to double every year with a total 26-fold increase between 2011 and 2016 (Figure 1). This is especially driven by the introduction of Long-Term Evolution (LTE) services in combination with fourth-generation (4G) ready end-devices. Mobile video will be the dominant type of traffic, accounting for roughly 66 percent of all traffic in 2016 (it was already 50 percent in 2011). The costs associated with providing this increasing bandwidth have not being linearly matched by operator revenue growth. The primary objective is to increase the bandwidth while simultaneously reducing the cost per bit. Existing mobile infrastructures will neither scale to the required bandwidth nor meet the cost reduction requirement.

Figure 1: Global Mobile Traffic Forecasts

The Cisco Unified Radio Access Network (RAN) portfolio, together with SIAE MICROELETTRONICA microwave radio, provides an end-to-end solution that offers an innovative, flexible, cost-optimized, and highly scalable way of deploying and operating the backhaul of multivendor, multigenerational RANs. The solution optimally scales to the bandwidth and functional requirements of LTE, and it simplifies operations by harmonizing the transport protocols to IP Multiprotocol Label Switching (IP/MPLS).

The Cisco and SIAE MICROELETTRONICA end-to-end solution supports time-division multiplexing (TDM), ATM, and high-speed Ethernet interfaces for 2G, 3G and LTE environments, allowing a smooth transition to all-IP architecture. It supports advanced quality of service (QoS), fast convergence, carrier-grade synchronization, and many other features, including Unified MPLS that provide a highly scalable, secure, and easy way of operating an end-to-end MPLS network. The market-leading throughput, given by 1024-QAM modulation over the SIAE MICROELETTRONICA microwave radio links, provides ultra-high capacity in RAN access.

Cisco and SIAE MICROELETTRONICA tested and certified the Unified RAN and microwave radio solution in order to provide proven and cost-efficient backhaul architecture for mobile operators. The solution has been described in this document on the following pages.

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Cisco Unified RAN Portfolio Overview

The Cisco Unified RAN solution offers a complete architecture and product portfolio for aggregation, pre-aggregation and cell-site locations of mobile networks. The wide range of products provides best-of-category features and functionality, optimized power utilization, extended temperature ranges, excellent interface scaling, high throughput, and cost optimization that are essential for the evolution of RANs. The Cisco product portfolio fully meets both current and future network requirements and allows for a smooth migration from TDM and ATM to an all-IP, single-RAN mobile network that optimally addresses the needs of LTE.

Cisco ASR 9000 Series

The Cisco ASR 9000 Series represents an exciting new paradigm in the world of Carrier Ethernet transport, with exceptional scalability, carrier-class reliability, environmentally conscious design, outstanding flexibility, and an attractive price-to-performance benchmark. Cisco ASR 9000 Series Aggregation Services Routers are designed to provide true carrier-class reliability using the modular Cisco IOS® XR operating system, comprehensive system redundancy, and a full complement of network resiliency schemes. The Cisco ASR 9000 Series also offers service and application-level intelligence focused on optimized video delivery and mobile aggregation. The Cisco ASR 9000 Series is designed to simplify and enhance the operational and deployment aspects of service-delivery networks.

The Cisco ASR 9000 Series provides unsurpassed 10-Gigabit Ethernet and 100-Gigabit Ethernet scale and density. The Cisco ASR 9006 and 9010 routers (Figure 2) provide an in-place upgrade roadmap to higher density of 10- and 100-Gigabit Ethernet ports without the need for a complete chassis replacement. Cisco ASR 9000 Series line cards, offered in base and extended-scale configurations, are complemented by the nonblocking fabric and by the innovative backplane, thermal, and economical power infrastructure on the chassis.

Figure 2: Cisco ASR 9000 Series Routers

The Cisco ASR 9000 Series incorporates innovative technologies that form the base of the Unified MPLS offering. It provides a complete range of TDM, ATM, and Ethernet services with an advanced feature set of both Layer 2 VPN (L2VPN) and Layer 3 VPN (L3VPN) capabilities. The Cisco ASR 9000 provides the hardware architecture that will deliver scalable Border Gateway Protocol (BGP) capacities-including RFC 3107 and simplified fast convergence techniques such as BGP Prefix Independent Convergence (PIC) and loop free alternates (LFA) Fast Reroute (FRR) for Interior Gateway Protocol (IGP) convergence-with planned enhancements including features like Remote LFA. The architecture includes advanced hierarchical quality of service (HQoS) capabilities and advanced synchronization options for both IEEE 1588 and Synchronous Ethernet (SyncE).

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

The Cisco ASR 9000 Series also provides innovative technologies such as Cisco Network Virtualization (nV) technology, which intelligently blends the edge, aggregation, and access points to simplify operation and accelerate IPv6 services. Three new nV-enabled platforms provide additional flexibility and support to optimize service delivery:

- Cisco ASR 901: High-capacity, low-power routers for 2G, 3G, and 4G mobile cell sites
- Cisco ASR 903: A compact unified Ethernet access router for business, residential, and mobile applications
- Cisco ASR 9001: A smaller 2-rack-unit (RU) version of the industry-leading Cisco ASR 9000 optimized for lower density deployments but with the same feature set as the larger platforms

Working together, the components of Cisco ASR 9000 Series can provide the network scale needed to deliver new mobile Internet services while minimizing operational complexity. For more information, see the Cisco ASR 9000 Series Data Sheet here.

Cisco ASR 903 Router

The Cisco ASR 903 Router (Figure 3) is a fully featured aggregation platform designed for the cost-effective delivery of converged mobile and business services, and forms a major component of the Cisco Unified MPLS strategy. With full redundancy, shallow depth (ETSI), low power consumption and high service scale, this 3-RU router is optimized for small aggregation and remote point-of-presence (POP) applications.

Figure 3: Cisco ASR 903 Router

The Cisco ASR 903 Router is specifically designed to clock, aggregate, and backhaul mixed-generation RAN traffic. The Cisco ASR 903 Router prioritizes and processes voice, data, and signaling traffic as part of the Cisco Unified RAN Backhaul solution for reliable transport across any available backhaul networks, including Gigabit Ethernet, 10-Gigabit Ethernet, STM-1, T1/E1, ATM, Carrier Ethernet, microwave, and service provider Wi-Fi networks.

Designed for pre-aggregation sites and Carrier Ethernet access, the Cisco ASR 903 differentiating features include:

- Redundant control plane, date plane, power, and cooling
- Cisco IOS XE carrier-class operating system with in-service software upgrade support
- High range of interface support (GE, 10GE, STM-1, STM-4, and E1)
- Line rate performance for all Layer 2 and Layer 3 interfaces
- Unified MPLS and intelligent HQoS support
- Flexible clocking options: TDM, BITS, 1588v2, and SyncE
- Extended operating temperatures (-40 to + 65℃)
- Low power consumption (maximum 550W)
- Small form factor: 3 RU with 9.22 in. depth (ETSI compliant)

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

- Future-ready architecture: 360-GB backplane
- All front-access and field replaceable design

For more information, see the Cisco ASR 903 Data Sheet here.

Cisco ASR 901 Series Aggregation Services Routers

The Cisco ASR 901 Series Aggregation Services Routers (Figure 4) are environmentally hardened, high-speed, low-power-consumption routers optimized for any-generation cell-site RAN backhaul and Ethernet access. By using the Cisco ASR 901 routers, operators can reduce backhaul operating costs, simplify and converge their RAN and Ethernet access networks, and enhance their profit opportunities with mobile and premium Ethernet services.

Figure 4: Cisco ASR 901 Series Aggregation Series Router

Deployed as cell-site routers for mobile backhaul, the Cisco ASR 901 routers can aggregate multiple base stations through multiple TDM, Ethernet, and IP interfaces, and can use MPLS, Resilient Ethernet Protocol (REP), Multilink Point-to-Point Protocol (MLPPP), L3VPN, and other common transport protocols for RAN backhaul. Essentially, the routers prioritize, differentiate, and segment any combination of 2G, 3G, or 4G traffic for backhaul over any combination of IP Ethernet and TDM (E1/T1) infrastructures (copper, microwave, or optical).

Designed for cell sites and Carrier Ethernet access, the Cisco ASR 901 differentiating features include:

- Low power consumption (about 40-50W)
- Line rate performance for all Layer 2 and Layer 3 interfaces
- Different hardware configurations available:
  - 12 GE + 16 E1/T1 (optional)
  - 12 GE + 8 E1/T1 (optional) + 2 10GE (future release)
- Flexible clocking options: TDM, BITS, 1588v2, and SyncE
- Unified MPLS and intelligent HQoS support
- Extended operating temperatures (-40 to + 65℃)
- Small form factor: 1 RU with 8.3 in. depth (ETSI) compliant
- Redundant power and cooling

For more information, see the Cisco ASR 901 Data Sheet here.

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

SIAE MICROELETTRONICA Portfolio Overview

SIAE MICROELETTRONICA is a multinational company based in Milan, Italy, and is one of the most established and recognized market leaders in delivering innovative wireless network solutions.

The company's Network Services organization delivers all of the services and support worldwide required for network rollout, including network planning, design consultancy, installation and commissioning, maintenance, after-sales support, and project management.

SIAE MICROELETTRONICA products cover a wide range of applications:

- Point-to-point split-mount microwave radio systems up to the 42-GHz frequency band, for Plesiochronous Digital Hierarchy (PDH), SDH, and native IP technologies (including circuit emulation)
- Point-to-point full outdoor microwave radio systems up to the 80-GHz frequency band, for native IP technologies
- Wired solutions
- Network management systems
- Network planning tools

SIAE MICROELETTRONICA ALCplus2e Series

The SIAE MICROELETTRONICA ALCplus2e Series radio equipment (Figure 5) is the split-mount solution developed to meet the different needs of mobile operators, providing cost-effective transport solutions with high spectral efficiency and header-compression-dedicated HW able to highly increment the maximum throughput. The ALCplus2e series provides adaptive modulation, a dual engine for mixed native TDM and Ethernet transport, circuit emulated transport for a fully IP approach, Ethernet switching and QoS support.

Figure 5: SIAE MICROELETTRONICA ALCplus2e

The ALCplus2e Series, equipped with ASN outdoor unit (ASN ODU), have the following outstanding characteristics:

- Data rates up to 1 Gbps per 56 MHz radio channel and 2 Gbps with Cross-Polarization Interference Cancellation (XPIC), in a single platform across the full range of licensed frequency bands
- All channel bandwidths selectable from 7 MHz to 56 MHz for all the modulation schemes

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

- Market-leading Adaptive Coding and Modulation (ACM) with outstanding performance (up to 400 changes per second and up to 100 dB per second)
- Best-in-class system gain in all the frequency range with a single ODU model
- Use of latest technology designs to achieve the highest mean time between failure (MTBF) and the lowest power consumption available on the market
- Synchronous Ethernet support in accordance to ITU-T G.8261, with mixed (TDM and ETH) synchronization
- Support of XPIC and 1+1 configuration using a single 1U high Indoor Unit (IDU)
- Fully hitless 8-profile ACM with TDM and Ethernet classification
- Complete QoS support (including IPv4, IPv6, and MPLS experimental [EXP] bits, congestion avoidance, and multischeduling algorithms
- ASN ODU series provide access to upper-level modulations: 512 QAM and 1024 QAM

For more information, please download the ALS Series leaflet from the SIAE MICROELETTRONICA website, http://www.siaemic.com/.

SIAE MICROELETTRONICA ALFOplus Series

SIAE MICROELETTRONICA, in its continuous effort to be at the leading edge of the telecommunication market, has developed the full outdoor ALFOplus Series radio equipment with adaptive modulation up to 1024 QAM, full-IP architecture to optimize IP and circuit emulation transport, and header-compression-dedicated HW able to highly increment the maximum throughput (Figure 6).

The ALFOplus Series is the last SIAE MICROELETTRONICA solution for modern networks and the ideal system for LTE backhaul.

Figure 6: SIAE MICROELETTRONICA ALFOplus

The ALFOplus Series products have the following outstanding characteristics:

- Data rates up to 1 Gbps per 56 MHz, in a single platform across the full range of licensed frequency bands
- All channel bandwidths selectable from 7 MHz to 56 MHz for all the modulation schemes
- Market-leading ACM with outstanding performance (up to 400 changes per second and up to 100 dB per second)
- Best-in-class system gain in all of the frequency range
- Use of latest technology design to achieve the highest MTBF figure and the lowest power consumption available on the market
- SyncE support in accordance to ITU-T G.8261
- Fully hitless 10-profile ACM with Ethernet classification
- Complete QoS support (including IPv4, IPv6, and MPLS EXP bits), congestion avoidance, and multischeduling algorithms

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

- Support for a full range of modulations from 4 QAM to 512 QAM and 1024 QAM

The ALFOplus Series includes ALFOplus80, a 100 percent in-house designed and developed equipment for E-Band applications as with all SIAE MICROELETTRONICA products (Figure 7).

Figure 7: SIAE MICROELETTRONICA ALFOplus80

ALFOplus80 can provide, with high spectral efficiency and wide channel bandwidth, up to 2.0 Gbps capacities with adaptive modulation up to 64 QAM. This high-throughput-class equipment is fundamental for “fiber like” gigabit connection and for the evolution of RAN segments towards LTE and next-generation networks.

Here are some of the ALFOplus80 outstanding characteristics:

- Data rates up to 1.0 Gbps on 1000-MHz channel bandwidth (with 4-QAM modulation) and up to 2.0 Gbps per 500 MHz channel (with 64 QAM modulation)
- Selectable channel bandwidths (250 MHz and 500 MHz in High Density mode)
- Market-leading hitless and errorless ACM with outstanding performance (up to 400 changes per second and up to 100 dB per second)
- Best in class Tx output power, fully compliant with relevant ETSI Recommendation
- Use of latest technology design to achieve the highest MTBF figure and the lowest power consumption available on the market
- SyncE support in accordance to ITU-T G.8261
- Complete QoS support (including IPv4, IPv6, and MPLS EXP bits), congestion avoidance, and multischeduling algorithms

For more information, please download the ALFOplus Series leaflet from the SIAE MICROELETTRONICA’s website, http://www.siaemic.com/.

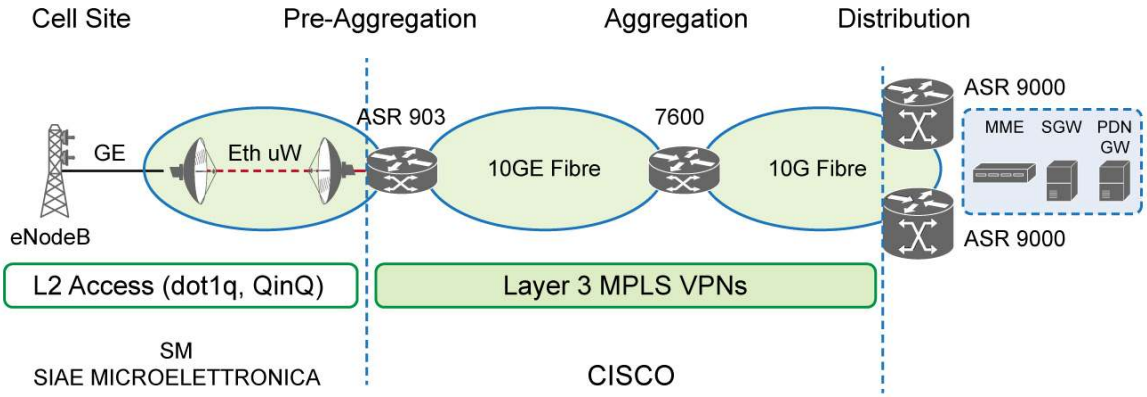
Interoperability Test Setup

The end-to-end Unified RAN transport solution (Cisco Unified RAN solution and SIAE MICROELETTRONICA microwave radio solution) interoperability tests have been run in two different network scenarios that both optimally address the requirements of next-generation mobile aggregation networks:

- Option A: Layer 2 support in the access with the pre-aggregation offering L3VPN functionality for native Ethernet and LTE service offerings
- Option B: Unified MPLS support in the access with a cell-site gateway (CSG) to support hybrid TDM, ATM, and Ethernet service offerings

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Figure 8: Topology Used in the Interoperability Test (IOT) That Demonstrates Option A



The Unified RAN transport solution is divided into multiple concentration points that represent different aggregation scaling requirements. The distribution layer is the main concentration point and is also likely to host mobile core equipment, including the Media Gateways (MGWs), Serving Gateway and Packet Data Network Gateway (S-GW/P-GW). The functions of distribution, aggregation and pre-aggregation are to aggregate the entire access network, provide QoS treatment, offer resiliency, and optimally route the traffic toward the core. Depending on the network size, it may be possible to combine the aggregation and pre-aggregation layer. In many cases the pre-aggregation layer acts as the border toward the microwave access network.

The Cisco and SIAE MICROELETTRONICA platforms positioned for the various network functions have been selected to best match the requirements in terms of scale and functionality of the described sites. The following Cisco platforms were selected:

- Distribution: Cisco ASR 9000
- Aggregation: Cisco ASR 9000 and Cisco 7600 Router
- Pre-aggregation: Cisco ASR 903
- Cell site gateway: Cisco ASR 901 (see topology for option B below)

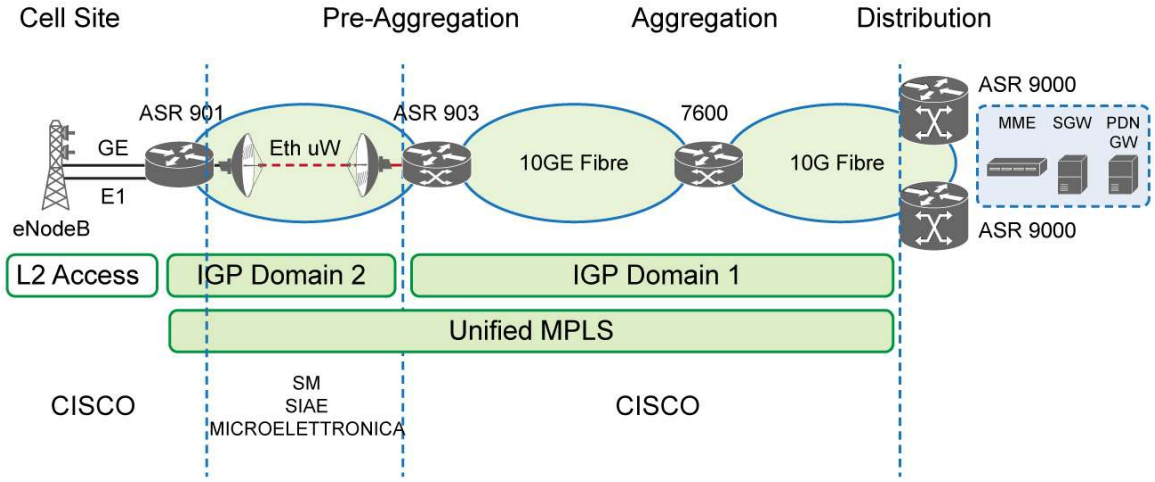
The following SIAE MICROELETTRONICA platforms were selected for the microwave radio connection between pre-aggregation and cell site locations:

- ALCplus2e: Hybrid microwave radio
- ALFOplus: Full outdoor microwave radio

The interoperability testing also included a network setup with cell site router Cisco ASR 901 (Figure 9). This architecture allows for the efficient transport of legacy TDM and ATM traffic through MPLS pseudowires across the MPLS backhaul network. This will provide mobile operators with a smooth transition from existing interface support to an all-IP, single-RAN mobile network.

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Figure 9: Topology Used in the IOT for Option B



Unified MPLS

The network topology, as outlined in Option B, demonstrates the capabilities of Unified MPLS. Unified MPLS provides an architecture that combines all the latest developments within MPLS to support simplified and highly scalable MPLS deployments.

Operators are currently undergoing phenomenal change in relation to their network requirements. In the past, it was their sole responsibility to manage and provide networks that were scalable and reliable. Recently, there has been a change in emphasis toward supporting specific application and service requirements and bandwidth demand, especially in relation to video support.

With application support, virtualization support is required from the access network, across the core, and into the data center. This leads to an architecture that provides cloud services. It is now generally accepted that there will be convergence of architectures where mobile, Carrier Ethernet, and wireline services will need to be supported on a single network.

This evolution mandates simplifying the network layer from the technology, provisioning, management, and maintenance points of view. It is clear that operational efficiency is an essential deliverable and that end-to-end provisioning, troubleshooting, and performance monitoring is required. Operator analysis has shown that one of the primary ways of improving operational efficiency is introducing a single technology type from end to end. Reducing the number of operating points alone can account for operational savings of up to 40 percent.

Cisco has developed a unified technology strategy around this concept, referred to as Unified MPLS. Unified MPLS is not a specific technology but rather an architecture that uses multiple proven technologies that help provide a network that can scale and be managed in a simple fashion. While MPLS is a proven technology, there have been some challenges in the past that need to be addressed. These include:

- Complexity of achieving 50-millisecond convergence with TE-FRR (node, link, and path)
- Sophisticated interworking between routing protocols and Layer 2 protocols
- Requirement to split large networks into domains (ownership, geographical, and routing) while still delivering services on an end-to-end basis
- Requirement to provide common end-to-end convergence and resiliency mechanisms in a simple manner
- Requirement to provide end-to-end provisioning and troubleshooting across multiple domains in a simple manner

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Unified MPLS takes the traditional MPLS capabilities and provides them on an end-to-end-basis, supplementing this with advanced technologies and features that address the traditional challenges outlined previously:

- Common MPLS technology from core, aggregation, pre-aggregation, and potentially in access
- Ability to support multiple technology variants in access: for example, Layer 2, MPLS-TP, and Unified MPLS
- RFC 3107 label allocation to introduce hierarchy that provides end-to-end reachability in a scalable and secure manner
- BGP filtering mechanisms to help the network learn what is needed, where it is needed, and when it is needed in a secure manner
- LFA FRR for 50-msec convergence with no configuration required (LFA FRR now, with remote LFA FRR in the future)
- BGP PIC to make the 3107 hierarchy converge quickly
- Contiguous and consistent transport and service operations, administration, and maintenance (OAM) and performance monitoring based on RFC 6374
- Support for virtualized Layer and Layer 3 services edge using MPLS VPN, VPWS, and VPLS

With Unified MPLS, service providers can easily extend the MPLS technology from the core into the RAN without the scaling issues associated with standard MPLS and still provide traditional emulated ATM, TDM, and Ethernet services (L2VPN) and full L3VPN services. The core and the aggregation network can be put into separate IGP domains (multi-AS, multi-area, or divergent processes) that can be operated independently from each other. This means that they can scale easily and converge independently, and that any link flaps or security incidents stay within one domain. The concept introduces a hierarchy that allows communicating across domains (label distributed through BGP RFC 3107). In summary, Unified MPLS allows operators to build extremely large-scale, easy-to-operate and simplified converged networks.

Cisco nV Technology

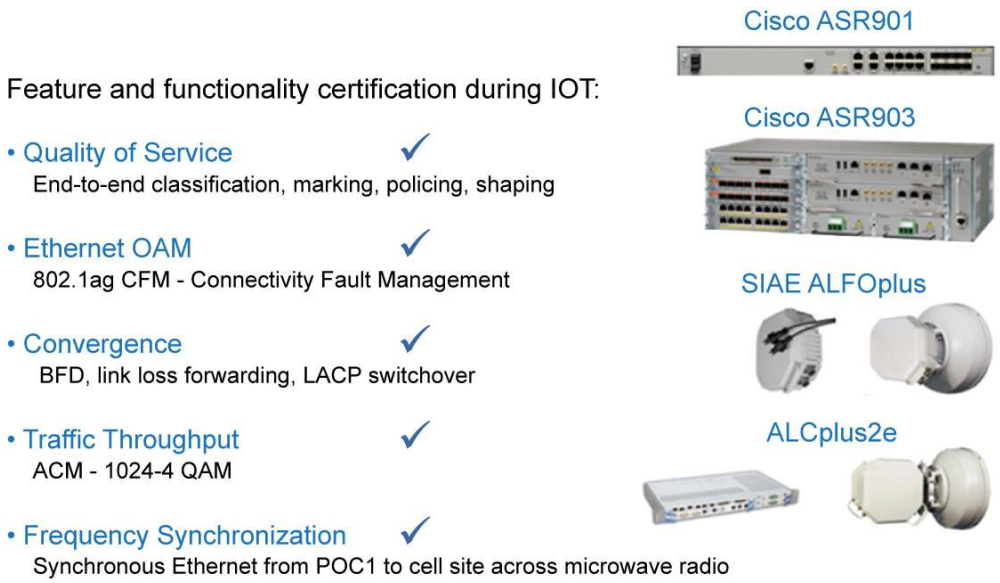
Although not part of the initial IOT between Cisco and SIAE MICROELETTRONICA, Cisco's network virtualization (nV) technology could complement the solution by providing significant benefits in simplifying the network and delivering a more fully converged solution. The concept is based on a cluster (Cisco ASR 9000) and satellite (Cisco ASR 9000v, ASR 903, and ASR 901) configuration that groups devices together that are then managed as a single virtual entity. The satellites (for example, those positioned at pre-aggregation) can be seen as virtual port extenders of the host system (for example, Cisco ASR 9000 at distribution) and therefore would not require any management or operation of the device. With Cisco nV, all configuration and software maintenance is done only on the host site (zero-touch deployment).

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Interoperability Test Findings

The Cisco Unified RAN solution and SIAE MICROELETTRONICA microwave radio solution were subject to a number of interoperability tests in various areas. The tests highlighted the following points shown in Figure 10.

Figure 10: Cisco and SIAE MICROELETTRONICA Alignment in Unified RAN Transport



QoS and Adaptive Coding and Modulation (ACM) Management

Quality of service is an essential feature when aggregating different services, including voice, video, data, and network management traffic, specifically on a converged network that carries residential and business users. The QoS assigned to an IP service is crucial to guarantee no packet loss to specific service classes as well as minimum latency and jitter for the services that require it. The quality of service tests have been done in different scenarios, including classification and marking of MPLS EXP and Dot1p, traffic shaping at pre-aggregation (Cisco ASR 903), and transmitting various traffic profiles. The results showed:

- Zero packet loss on high-priority streams, even when loaded with lower-priority traffic or switching to lower radio transmission rates
- Only best-effort traffic was dropped, as expected when total available bandwidth was exceeded or modulation level was manually reduced
- Traffic shaping on the Cisco ASR 903 pre-aggregation router proved to reduce the best-effort traffic transmitted to the microwave radio link to a level that did not exceed the available radio capacity

Ethernet Operations, Administration, and Maintenance (EOAM)

When building Ethernet networks, some of the main areas to be addressed are service fault identification and isolation, and fast convergence triggering. The network will be responsible for such capabilities and there are solutions for per-link and segment checks. Ethernet OAM Connectivity Fault Management (CFM)-IEEE 802.1ag-allows service providers to monitor, on an end-to-end basis, individual customer services for service failures. CFM includes three message types that work together to help administrators debug Ethernet networks. These are continuity check, link trace, and loopback messages. The interoperability test between Cisco and SIAE MICROELETTRONICA proved:

- Protocol interworking (802.1ag) between SIAE MICROELETTRONICA and Cisco components, with exchange of Continuity Check Messages (CCM), Loopback Messages (LBM) and Link Trace Messages (LTM)

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

- Successful Ethernet pings between SIAE MICROELETTRONICA and Cisco components to the MEP and MIP addresses

Convergence

SIAE MICROELETTRONICA radio link failures have been tested by disconnecting cables toward the Cisco equipment as well as by interrupting the radio throughput below an acceptable level. The convergence tests have been conducted in three different scenarios: link loss forwarding, bidirectional forwarding detection (BFD), and link bundle redundancy through Link aggregation control protocol (LACP). The tests proved:

- Link loss forwarding immediately forwarded link up or down notifications to local and remote interfaces, notifying the connected Cisco equipment within milliseconds of radio link failures.
- Bidirectional forwarding detection (BFD) detected link failures within 150 milliseconds and triggered routing protocol convergence.
- LACP in the link bundle scenario detected link failures in the range of 500ms.

Traffic Throughput

The effective traffic throughput carried by the ALFOplus series is based on the following two scenarios.

Scenario 1 (Table 1) shows the benefit of header compression when traffic is transported using the following protocol stack: C-TAG + S-TAGs with IPv4 traffic in UDP sessions G729. In this case header compression works using only a single-layer compression process.

Table 1: Maximum Radio Throughput at Point X/X' for Ethernet 64-B or 72-B Traffic, in Mbps

Channel	4 Strong QAM	4 QAM	16 Strong QAM	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM
7 MHz	17	23	34	44	51	63	75	94	100	112
14 MHz	34	46	69	89	103	128	152	190	202	226
28 MHz	69	92	138	179	208	257	307	383	406	455
56 MHz	137	185	276	358	416	514	613	765	811	**910**

Scenario 2 (Table 2) has the throughput calculated in a typical VoIP environment. The traffic is transported using C-TAG, S-TAG, MPLS, IPv4, and GTP layers and then VoIP short packets are encapsulated into IPv6 (with UDP and RTP).

Table 2: Maximum Radio Throughput at Point X/X' for Ethernet 136-B Traffic, in Mbps

Channel	4 Strong QAM	4 QAM	16 Strong QAM	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM
7 MHz	23	31	46	59	69	85	101	127	134	150
14 MHz	46	62	92	120	139	172	205	256	272	305
28 MHz	93	124	186	241	280	346	413	515	546	613
56 MHz	185	249	371	482	560	693	826	1000	1000	**1000**

© 2012 Cisco | SIAE MICROELETTRONICA All rights reserved.

Network Synchronization

Capabilities such as SyncE (Synchronous Ethernet) and packet-based capabilities such as IEEE 1588 version 2 and Network Time Protocol (NTP) are supported to provide network synchronization over the IP RAN transport infrastructure. SyncE is the ability to provide PHY-level frequency distribution through an Ethernet port. The test between SIAE MICROELETTRONICA and Cisco focused on SyncE, since this is a hop-by-hop physical layer protocol that relies on vendor interoperability. The tests proved:

- Synchronous Ethernet has been successfully distributed across the entire chain of network elements from the clock source (Symmetricom TP 5000) over the Cisco ASR 9000, Cisco ASR 903, SIAE MICROELETTRONICA ALCplus2e, and SIAE MICROELETTRONICA ALFOplus microwave link towards the Cisco ASR 901.
- Two E1 pseudowires (SAToP and CESoPSN) were running over the synchronized microwave radio link (between ASR 901 and ASR 903) with no errors on the E1 test appliance.

Summary

Cisco and SIAE MICROELETTRONICA have tested and verified a proven and reliable end-to-end solution that will allow mobile operators to evolve toward offering a next-generation, highly efficient and scalable, multiservice RAN backhaul network.

The interoperability tests have shown full interworking of a wide set of features between Cisco and SIAE MICROELETTRONICA products and demonstrated the resiliency of the solution in case of link failures and congestion scenarios, as well as link modulation changes.

The solution has been proven to reliably reach the maximum possible traffic throughput when the applicable traffic mixes were used. Even in heavy congestion conditions, the entire high-priority traffic was transported without any packet loss. The frequency distribution methods have also been successfully verified and exceed carrier-class requirements.

The tests showed that Cisco´s and SIAE MICROELETTRONICA's Unified RAN solution is highly reliable and offers network capabilities that will help enable mobile operators to optimally serve the requirements of next-generation mobile services.

© 2012 Cisco and/or its affiliates. All rights reserved. Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: www.cisco.com/go/trademarks. Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

© 2007 SIAE MICROELETTRONICA S.p.A. All rights reserved. SIAE MICROELETTRONICA and SIAE MICROELETTRONICA logo are trademarks of SIAE MICROELETTRONICA S.p.A.

C11-707543-00 07/12