Introduction

Following the success of the 2014 EANTC report for Ericsson’s Evolved IP Network, the vendor contracted EANTC to create an updated version for 2015 covering additional solution capabilities and newly available products.

The 2014 report accompanied the initial release of Ericsson’s Evolved IP Network solution. Ericsson explained that they take a holistic approach in designing and supporting their end-to-end solution. This approach incorporates protocol and software uniformity across any node in the solution.

Ericsson spent the year since our last report expanding its IP portfolio, developing new capabilities and consolidating the end-to-end solution story. Since the solution has two major software releases per year, we had the opportunity to explore capabilities planned to be released around the same time as this report. By executing this second test phase, EANTC has now tested the complete Ericsson Evolved IP Network solution including all elements of the SSR 8000 router family.

In this report we explore the following main points:

- Network design consistent with previous solution test report
- True multi-service router capabilities with BNG, IPsec, Ethernet and IP/MPLS services are verified
- Service support for fixed and enterprise customers
- Readiness for LTE-Advanced
- 100GbE interfaces and the new Ericsson SSR 8004 router are tested
- Updated Microwave solution MINI-LINK TN is tested
- Network Management System (NMS) is extensively explored

Test Highlights

- Verified multi-service support on Ericsson SSR 8000 family
- Measured 6,000 VPLS instances with 996,000 MAC addresses
- Demonstrated 96,000 subscribers supported on a single line card
- Tested complete service life cycle toolkit capabilities
- Recorded phase stability consistently under 1.1 microseconds
- Confirmed up to 25% improvement in microwave link utilization

a. For 82 bytes frames

Background

Our previous test report highlighted the end-to-end capabilities of the solution starting with the multi-standard base stations, progressing through the microwave radios and exploring the IP/MPLS capabilities. We also spent time exploring the packet clock synchronization and high availability capabilities of the solution.

The 2014 report was not the first time EANTC engineers have tested Ericsson’s products. Ericsson has been supporting EANTC’s interoperability showcases since our 2008 Mobile Backhaul test event, and over the years has shown interoperability in areas such as clock synchronization, IPv6 IP/MPLS and MPLS-TP. All the reports are available on EANTC’s web site.
Having gotten to know the solution well, we pushed Ericsson to demonstrate that the Evolved IP Network solution is truly multi-service by supporting residential, business and mobile subscribers on a single device. We also felt that it was imperative to explore additional clock synchronization functions since, with the growing deployment of Long Term Evolution (LTE) and early deployments of Evolved Multimedia Broadcast Multicast Service (EMBMS), a robust packet clock network is essential for trouble-free mobile network operations.

Ericsson re-stated IP networks as one of their targeted areas in their Q4 2014 report, with sales growth of over 10% in all targeted areas. Ericsson also reported twelve new SSR 8000 contracts during Q4 2014, of which two were for fixed networks, bringing their total for such contracts won to 146. It is evident from the breadth of new features and capabilities that Ericsson brought to this update test, that Ericsson was not simply resting on their laurels. We see the continuous vendor commitment and it seems that the service provider customers are indeed responding.

Tested Devices

The network design, including its layering and guiding principles, remained consistent between the 2014 and 2015 tests. This not only made our life simple when designing the tests, but also attested to Ericsson's commitment to their service provider customers. Clearly, a service provider that purchases the Evolved IP Network solution from Ericsson, would not expect to have to fundamentally change its network a year later.

What did change though was the range of devices provided for test. While in 2014 we had variants of the all-outdoor MINI-LINK PT family in the test, this time around, Ericsson chose to bring the chassis-based MINI-LINK TN in addition to the MINI-LINK PT. The rest of the devices in the access were all Ericsson SP 415 or SP 420 routers (the difference between the two being port count).
Apart from the notable addition of the newest commercially available router – the SSR 8004, the rest of the devices were the same as in the previous test. Under the hood however, there were quite a few new components. For the first time we tested Ericsson’s 100GigabitEthernet line card, the SSC and BNG cards, and an updated alarm/switch fabric card that enables the SSR products to support phase synchronization on existing line cards.

**Test Equipment**

This time we executed the complete project at EANTC's lab in Berlin, Germany. Our lab administrator was overjoyed to welcome boxes and boxes of Ericsson devices which were eventually installed in 4 racks. Ericsson sent a team of engineers to Berlin who spent 6 weeks together with EANTC's test engineers.

The testing was supported by Ixia who provided a multitude of test devices. In addition to the layer 2/3 testers, we also required IPsec and BNG traffic generators. Consequently, the Ixia XG12 we had was filled with cards such as the Lava AP40/100G, FlexAP 10G, LSMXMD and STX4. To measure the clock quality we used Ixia's Anue 3500. In fact, all tests in the project, regardless of their network layer or interface speed, were supported by the same test vendor.

The tests required that test engineers from both EANTC and Ericsson possessed more than single networking layer expertise; it required them to understand the interaction between multiple layers. While IP/MPLS traffic was being emulated end-to-end, we also registered BNG subscribers and IPsec tunnels – all tasks that would traditionally be taken by different operational teams.

**Multi-Service Capabilities**

The Ericsson Smart Services Routers (SSR) are developed fully in-house and are built upon the combination of Ericsson's fixed/mobile telecom heritage and Silicon Valley-based IP competency. After we completed the test project in 2014, we asked Ericsson a seemingly innocent question – what is so ‘smart’ about these routers? Ericsson explained that an example of the smart capabilities is the ability to collapse different services into a single router (with an appropriate combination of cards).

We were intrigued and, for the purposes of these updated tests, asked Ericsson to include these line cards in a typical combination. Ericsson chose to include two functions in addition to the IP/MPLS services that were already planned for the test: IPsec Security Gateway and Broadband Network Gateway (BNG).

The BNG functionality allows a service provider to terminate residential wireline subscribers on the Ericsson router in the aggregation network. In the same router, IPsec tunnels, expected to be established by the mobile base stations, could also be terminated. Of course additional functions and applications could have been added, but we had to limit the efforts somewhere and felt that the three services we could emulate were sufficient to make the point that the routers are indeed smart.

**IPsec Tunnel Scalability**

Based on Ericsson’s Long Term Evolution (LTE) network design recommendation, IPsec tunnels should be setup between base stations (eNodeB) and the core mobile network. In other words, connectivity over the backhaul should be encrypted.

In the topology used for the test, the aggregation network included Ericsson’s SSR 8010 router equipped with a single IPsec termination card (called SSC-1). This will be the logical place in the network to terminate both base station connectivity (before handing that traffic to the Evolved Packet Core) as well as residential and business services.

We used Ixia’s PerfectStorm ONE to measure the number of IPsec tunnels that a single SSC-1 line card could terminate and then generated traffic for all tunnels. We established 8,000 tunnels each using IKEv2 for key exchange and AES128 for tunnel encryption. In addition, we also verified that Ericsson RBS could establish a tunnel to the same SSR 8010.

![Figure 2: IPsec Performance](image-url)
Once tunnels were set, we generated traffic in each of the tunnels and verified that the router is not only adapt at terminating IPsec tunnels, but also is able to forward traffic. We measured 8.16 Gbit/s downstream and 6.79 Gbit/s upstream of traffic using a fixed frame size of 1368 bytes for payload. We measured 3.77 Gbit/s downstream and 2.32 Gbit/s upstream using a mix of packet size. The IPsec test was run using Ericsson’s SSR 14B General Availability (GA) code due to performance improvements for IPsec.

BNG Session Activation Rate

Next we focused our attention on the Broadband Network Gateway (BNG) function residing in the same Ericsson SSR 8010. The first aspect to measure is the rate with which subscribers could be activated. Said rate is an indication of what the service provider could expect should all subscribers attempt to start their DSL-modems at the same time at home. This is a rare event, however, when the event occurs, after a major power failure for example, it is a good idea to keep customers happy by allowing as many as possible to register at the same time.

As the figure below illustrates, we measured an activation rate of 300 sessions per second. The performance was consistent for both single stack PPPoE subscribers (i.e. IPv4 only) and dual stack subscribers. In the latter case, the BNG assigned both IPv4 and IPv6 addresses to the subscriber.

BNG Subscriber Scalability

Once we measured the activation rate, we used the value to also measure the number of subscribers a single BNG card could support and then generated traffic for each of the subscribers. Here we entertained three subscriber types:

- Single Stack – Customer with only IPv4 addresses.
- Dual Stack – Customers with IPv4/IPv6 addresses.
- Quality of Service – Customers that use IPv4 addresses as well as three classes of service.

We were able to reach the advertised number of Single Stack subscribers that Ericsson could support – 96,000. Once all subscribers were activate we measured throughput of 36 Gbit/s.

The number of Dual Stack subscribers we were able to reach was 48,000 and the test showed that the router was then able to demonstrate throughput of 24 Gbit/s. The third condition showed the same results.

VPLS Services Scalability

Having investigated two services that traditionally focus on mobile and residential subscribers, we turned our attention to a business-oriented service: multipoint-to-multipoint layer 2 connectivity. This is the kind of service that could be realized using the Virtual Private LAN Services (VPLS) we tested.

A router’s MAC address and Virtual Switch Instance (VSI) capacities will affect the profitability of the operator’s service offerings. This is because the number of services a carrier could sell to customers interested in multipoint-to-multipoint Ethernet services is limited by these two factors. The latter is typically limited by the number of end points participating in the virtual switch domain – more end points translates to higher signaling load on the router.
We designed the test in such a way that 100 protected services were initiated by the access devices (both SP 420) and were joined by additional sites emulated by the Ixia tester on each SSR 8004 in the aggregation network. We asked Ericsson to configure a total of 6,000 VPLS instances on four different routers and then used two Ixia ports to emulate additional PE routers. This meant that each virtual switch domain included four routers and a total of 12,000 attachment circuits.

Once the configuration was created (a script-intensive activity) we went through the steps of measuring how quickly the routers learn MAC addresses and how many MAC addresses could be learned in total, while also monitoring the CPU load and memory usage on all devices under test.

The result was a MAC learning rate of 30,000 addresses per second for a total of 996,000 MAC addresses. This means that for example all of Orange Business Services’ employees could activate their devices during the same second and immediately start working. An impressive feat for a device that’s designed as a router and is serving as a switch.

Along the way we discovered a small issue. It was not possible to clear the MAC address tables from the command line. Ericsson explained that this command will be supported in the General Availability (GA) code, but as we had an early version of the software it was not supported in that build.

We also observed that while learning took place at 30,000 MAC addresses per second, a few (under 10) MAC addresses took a few more attempts to be inserted into the MAC table. Looking for 10 MACs out of almost a million is a tedious task which is why we took note, and moved on.

**Multi-Service Capabilities Tests Highlights**
- Support 96,000 Single Stack Subscribers
- Support 48,000 Dual Stack Subscribers
- Support 8,000 IPsec tunnels
- Measured up to a million MAC addresses
- Verified up to 6,000 VPLS instances

**Network and Performance Management**

A network service life cycle comprises requirements such as service discovery, creation, modification and trouble shooting. We reported previously that Ericsson was in the process of replacing their NMS. For this year’s updated test, we had the opportunity to verify the functionality of Ericsson’s IP Transport Network Management System (IPT NMS).

As we were testing service lifecycle management, we allowed Ericsson to choose the service type under test. Ericsson chose Layer-3 VPN, and explained this was their primary focus in the current NMS. Other services could be managed in parts of the network, but due to the combination of NMS and router software releases being used the L3VPN was selected. As the NMS release to support SSR 14B was not yet available, Ericsson needed to use the SSR 14A release.

**Service Creation**

The first step in the test was to create a L3VPN service template, and then use this to configure the service (including BGP on PE-CE links). The service span involved two Ericsson devices: the SP 420 and SSR 8010. It took less than 5 minutes to create and configure the service. As soon as we activated the service via the NMS Graphical User Interface (GUI) the service end points and the access circuits were successfully provisioned (roughly within 40 seconds).
Once a service is created, it may be necessary to make changes to it. We extended the same service that originally had two end points by adding a third. This is analogous to a customer asking for an additional site to be connected to an existing VPN. Adding another site required the creation of a new service based upon the pre-existing service. This seemed like a strange approach to a service modification, especially since once we removed the additional site from the service, the system accepted the remove request, but reported that the service was partially deployed. This, as explained by Ericsson, was because of the difference on the IPT NMS compared to the active version of that service running on the routers. Once the configuration was pushed to the routers we observed the expected behaviour.

The next activity in our service life cycle test was service discovery. We already knew that the service we created was installed having sent tester traffic to confirm that everything behaved as expected. We asked Ericsson to tell us if other services were installed in the network. Ericsson created a service reconciliation task and let it loose on the network. The task quickly returned with the correct information: 65 L3VPNs were installed in the network.

Last but not least, we wanted to check the health of the service we created. Ericsson’s IPT NMS was configured to monitor all service end-points using Ping while we configured the tester to send traffic between all end points. The tool reported the average latency for the service and showed all endpoints were active. We then failed one of the access devices (emulated by Ixia) and were immediately notified by IPT NMS of the issue. The alarm was specific enough that we knew not only that there was a problem with the service, but also exactly

**Network and Performance Management Test Highlights**

- IPT NMS covers the complete service life cycle

Network Performance

In the 2014 report we tested two of Ericsson’s Evolved IP Network products at full scale – the SP 420 and the SSR 8010. For this year’s test we turned our attention to Ericsson’s newest product – the SSR 8004.

Alongside the new router, we also expanded our investigation into one of Ericsson’s key product areas: Microwave transport. Ericsson has delivered over 3 million MINI-LINKs\(^1\), and has a market share of 25%, which tells us they take their microwave products very seriously! In this segment of the tests we really looked into throughput as well as optimization methods.

---

SSR 8004 100GigabitEthernet Performance

For the throughput performance test focusing on the SSR 8004 we asked Ericsson to mix two line cards which we believed to be representative of the router’s position in the network: 10GigabitEthernet and 100GigabitEthernet. The logic used for the test was that today the 10GbE interfaces will face the access network, while the 100GbE interfaces will face the core network.

The tests followed the traditional IETF-defined RFC 2544 for throughput measurements. Based on years of experience we ran the tests twice – once to measure the throughput using 30 second tests and then, using the values collected in the short test run, repeated the tests at each frame size for 10 minutes. We expected the results, based on the number of ports in the test, to be 400Gbit/s throughput with latency in the order of tens of microseconds.

Before the tests started Ericsson explained that our expectations may not be accurate. As a consequence of their design choices on these line cards Ericsson, does not consider wirespeed forwarding of smallest packet sizes as a realistic real world use case.

Our tests confirmed Ericsson’s statements. We were able to measure line rate performance at packet sizes of 373 and 1,518 bytes (with latencies of 43 and 51 microseconds respectively), but for the smaller packet sizes of 70 and 128 bytes, we measured 53 and 81 percent of theoretical line rate.

We also ran one test with a mix of packet sizes (called IMIX). Here the tester is configured to send a series of packet sizes with varying weights. Since our IMIX was heavily weighted towards small packet sizes (72% of the packets were smaller than 256 bytes) we were only slightly surprised to see that we could reach 96.87% of line rate. We also observed that latency increased in this test case by up to 1,046 microseconds. Ericsson explained that the increase in latency was due to larger packets delaying the transmission of smaller packets placed behind them in the queues.

MINI-LINK Throughput

One way to think about the MINI-LINK microwave transport solution is as an Ethernet switch, where some of the interfaces are not implemented with copper or fiber. Instead they are based on a radio interface that brings new challenges switches do not normally face, yet must still perform as any other switch would be expected to in a transport network.

To measure the performance of the switch part of the MINI-LINK we ignored the microwave interfaces and connected all 8 GigabitEthernet ports to the tester and ran the same standard RFC-based throughput test we ran with the Ericsson SSR 8004.

We used the same packet sizes and the same duration and received full line rate results for all fixed frame size tests of 30 seconds duration. When repeating the tests with IMIX traffic, we measured 66.65% of total line rate or 5.25 Gbit/s throughput. In this case we also measured increase in latency from 515 ms for 1518 byte packets to 996 ms.

We repeated the test for 10 minutes to verify that the switch will be stable over longer operational periods. In this condition, for each of the frame sizes (fixed and IMIX), we recorded minimal packet loss of 0.001%.
**Microwave Deep Buffers**

The majority of the traffic on the internet today runs over TCP, which utilizes flow control and congestion control mechanisms in order to provide reliable end-to-end transport. TCP is a demanding protocol - it tries to maximize the amount of throughput it receives. Should TCP detect packet loss, it backs up by 50% and slowly tries again.

Microwave links in networks therefore run the risk of becoming a bottleneck, as even if a network has been designed to take into account available link bandwidth, congestion can occur due to adaptive modulation changes (for example caused by heavy rain). To cope with this, Microwave devices should be capable of buffering sufficient frames to be able to continue sending until the sender receives a TCP acknowledgement.

Ericsson explained that the MINI-LINK PT products have up to 8 megabytes of buffer to maximize microwave link utilization. In this test we measured the benefits of these buffers on end-to-end TCP throughput. As HTTP traffic was used for this test, we used the correct 'goodput' term to indicate application level throughput.

In the test setup we created a microwave hop using two MINI-LINK PT, then connected an Ixia port to each device. We configured a large HTTP object of 2 gigabytes and asked Ericsson to use the highest microwave modulation of 1024 QAM. We expect the link, with its 100 ms round trip time, to provide us with 435Mbit/s of goodput.

Initially we configured the microwaves with a traditional small buffer size of 168 Kb. The goodput we were able to measure was 308 Mbit/s. Once we started increasing the buffer to 1 Mb and then 1.4 Mb, we measured 388 and 435 Mbit/s respectively. Increasing the buffer beyond 1.4 Mb led to no further improvement in goodput for our test setup, as at this point the buffer depth was sufficient for the round trip time.

Initially we configured the microwaves with a traditional small buffer size of 168 Kb. The goodput we were able to measure was 308 Mbit/s. Once we started increasing the buffer to 1 Mb and then 1.4 Mb, we measured 388 and 435 Mbit/s respectively. Increasing the buffer beyond 1.4 Mb led to no further improvement in goodput for our test setup, as at this point the buffer depth was sufficient for the round trip time.

Reducing the amount of memory in order to attempt to push down the price of a device, as well as latency, may be common practice, but not for Ericsson. As everything in life, there are tradeoffs to be made. The trade-off in the case of reducing latency and memory can lead to a false economy when considering LTE and LTE-Advanced deployments. These require not only ever-increasing bandwidth, but also ever-increasing goodput. It is therefore important to consider the end-to-end transport solution including microwave, in order to deliver the quality of experience subscribers are looking for.

**Microwave multi-layer header compression**

Another method to squeeze more bandwidth from a network link is to compress the traffic itself. Ericsson has implemented multi-layer header compression in their microwave products and asked us to test the MINI-LINK PT 2020 to verify that compression really provides meaningful performance improvements. The compression method used here is multi-layer since it compresses headers such as Ethernet, MPLS and IP. Ericsson claims that this compression will have the greatest impact in mobile networks since the payload itself is likely to be compressed or encrypted by other elements in the network.

From a testing perspective, the use case was simple. We generated bidirectional traffic across a microwave link and ran the test with and without the compression feature enabled. We also used two sets of traffic conditions, an internet mix of packet sizes ranging from 64 bytes to 1518 bytes (with 72% of the packets being smaller than 129 Bytes) and the second with only 82 bytes where we expected to see a bigger impact due to the ratio of header to payload size.

We expected to see more throughput in both cases, but just how much was unclear. While throughput without compression showed 457 Mbit/s across the microwave link, throughput with the Internet mix traffic improved by only 1% to 462 Mbit/s. The improvement was however huge for the small packet size – 18% to 542 Mbit/s. The reason for
the difference was obvious. An MPLS packet size of 82 bytes includes 4 bytes of MPLS headers as well as 20 bytes of IP headers and 8 bytes of UDP header. This means that 39% of the packet size is headers. As we demonstrated, these headers could be compressed and since such a large portion of the packet is headers, the gain of compression is pronounced.

Compression for mobile traffic could take place in two locations in the network – in the access and after the Evolved Packet Core (on the SGi-interface). Ericsson argues that application acceleration should be used on the SGi-interface while Microwave compression, agnostic to the traffic payload, is the best way to achieve efficiency in a mobile access network.

Network Availability

It seems that every test we ever execute includes high availability test cases. This is an indication of how important networks have become to our lives, hence operators' sensitivity to high availability performance. These days, with so many critical businesses operating on the Internet, we simply cannot afford to lose connectivity and hence want the network to be as robust as possible.

We had already successfully tested IP Fast Reroute on the SSR routers, Bidirectional Fault Detection (BFD) between the SSR and SP routers, as well as graceful restart on the SSR in the 2014 activity - therefore we chose to focus this time on new capabilities of the Evolved IP Network solution.

IP Fast Reroute is part of the answer to this question. The goal of the RFCs that define IP Fast Reroute is to “reduce failure reaction time to 10s of milliseconds...” (RFC 5286), and achieve this without the use of RSVP-TE by simply pre-computing an alternate next-hop that is activated when the primary next-hop fails.

Ericsson explained that at the time of the testing the feature was only available on the SSRs which is why we focused our attention on the aggregation network and emulated the failure between SSR 8004 and 8010. We ensured that no RSVP configuration was in use on these routers while we executed the test, only MPLS with LDP fed from IS-IS.

We emulated two failure scenarios in the test: optical layer failure in which BFD was used to detect the issue and the traditional loss of signal failure. Each failure scenario ran three times testing both failure and recovery.

In the test runs which used BFD to detect the failure we measured 107 to 111 ms out of service time between test runs. This certainly was an impressively consistent result. In all recovery tests we also recorded some out of service times in the range of 19 to 27 ms.

In the tests that used loss of signal to detect failure we measured 6 to 24 ms of service disruption. Again, during the recovery phase we measured up to 6 ms service impact.

Ericsson explained that the BFD times should have been much lower (as seen in the previous report), however, a bug in the pre-release software that we were using meant that BFD-detected failures were not triggered as quickly as the loss-of-signal use case. This bug was known before the test was run, and Ericsson confirmed it is fixed in the GA software version.

LFA tool

Together with the other service life-cycle tools we discussed, Ericsson demonstrated an off-line IP Fast Reroute (FRR) Loop-free Alternate (LFA) analyzer, which is integrated with Ericsson’s NetOp EMS. Using this GUI, we created a ring network topology with four nodes, LFA converge metric, non-protected routes as well as links for the destination nodes. The tool allowed us to look into “what if” scenarios, identify where in the topology potential resiliency...
bottlenecks would occur, as well as provide suggested optimized topologies.

RSVP on SP 400

In the previous report we tested the failure in the aggregation and core networks. This time we focused our attention on the access network. Since Ericsson added support for Resource Reservation Protocol - Traffic Engineering (RSVP-TE) in its SP 400 devices they could now protect MPLS tunnels originating in the cell site routers. We were more than happy to oblige in testing this functionality.

Ericsson chose to configure static backup tunnels with explicit routes which, if one is looking to adhere strictly to our industry’s nomenclature, means that the test was not verifying RSVP-TE Fast Reroute. Still, the test verified the solution’s ability to protect MPLS tunnels in the access network.

We chose a link between the Ericsson SP 420 and the SSR 8004 and disconnected it while traffic was flowing for one of our services. We then measured the out of service time based on the number of packets that were missing and verified that the service indeed returned to normal operation. We repeated the test three times in order to rule out outliers.

The results satisfied Ericsson’s expectations. In the upstream direction the highest measured out of service time was 256 ms with the lowest being 248 ms. In the downstream direction we measured between 127 and 84 ms out of service time.

We also evaluated if a recovery from the failure would result in service disruption. We reconnected the link between the Ericsson SP 420 and the SSR 8004. No packet loss was observed at all in the downstream direction. In the upstream direction, leaving the SP 420 towards the SSR 8004, a maximum out of service time of 89 ms was recorded. Ericsson explained that the minimal loss of traffic, which was expected (as per the test plan), was the result of hardware differences between the SP 420 and the SSR 8004.

LTE-A Readiness

In our 2014 test we spent a great deal of reporting real estate on clock synchronization. We demonstrated that the Ericsson Evolved IP Network solution was ready to support Long Term Evolution (LTE) deployment and included not only clock accuracy, but also clock robustness.

That was 2014. The conversation amongst mobile operators has moved on to the higher capacities and lower latency that both LTE-Advanced and 5G are promising. For these the importance of clock accuracy, stability, and robustness become ever more pronounced. Ericsson was eager to demonstrate that their Evolved IP Network solution is more than capable of meeting such requirements.

There is a plethora of new aspects in these tests. Since the tests were performed at EANTC’s lab, where, at the time, both Microsemi and Meinberg had GrandMaster clocks installed, Ericsson was able to demonstrate a dual-grandmaster clock strategy. Each test performed in this section was
executed twice, once using the Meinberg LANTIME M3000 as clock source and again with the Microsemi 2700 GrandMaster.

Ericsson explained that to enable IEEE 1588 on the SSR requires only an updated version of the ALSW (Alarm and Switch Fabric) card. The card can be upgraded in-service without disruption to an existing network. All SSRs required to distribute clocking information were equipped with this new card (ALSW-T), so what did we actually test?

**Full Path End-to-End Clock Synchronization**

Full path timing support is defined as each node in the network playing a role in the clock delivery service. In Ericsson’s case that meant all routers and microwave devices between the GrandMaster clocks and the RBS were configured to function as a Boundary Clock.

In line with ITU-T G.8273.2, Ericsson configured their devices to use physical layer frequency support from Synchronous Ethernet, with phase information distributed using the Precision Time Protocol (PTP) profile specified by G.8275.1. The goals for the test were in line with the standards and frequency deviation of no more than 16 parts per billion (ppb) with phase error within ±1.1 µs. The standards actually call for phase error limits within ±1.5 µs, but Ericsson explained that the additional 400 nanoseconds is an air interface budget.

We ran the test without any traffic in the network for 15 minutes once the slave clock showed a lock state. The results of this test, which we considered as baseline, were great. The frequency offset ranged between 1.6 and 3.8 ppb. The maximum time error ranged between 124 and 155 nanoseconds – an order of magnitude better than expected.

**Long Term Clock Stability**

After the baseline test was completed we moved towards a more realistic test case, as no network is expected to run without traffic. This time we used the industry standard measurement guidelines from ITU-T G.8261 to generate traffic in the network. We used the two most often referenced test cases, 12 and 13, and ran the tests for more than 1 hour and more than 14 hours respectively.

We measured frequency offset of at most 6.56 ppb and maximum time error of up to 157 nanoseconds. The change between a ‘clean’ network and a network with emulated traffic was therefore almost non-existent, highlighting the benefit of the full timing support model.

**Clock Robustness**

Now that we have seen how the network works in normal conditions, we asked Ericsson to demonstrate what happens when the network is experiencing failure. In our network there were two obvious failure scenarios – a failure in the links between the routers and a failure caused by micro-
wave nodes losing their air interface. Both scenarios require that the last node implements a function called holdover which allows the node to continue delivering a clock signal without announcing to the world “I am lost!” and suppressing the clock output altogether.

This year we also had a small cell radio base station from Ericsson, the multi-standard outdoor micro base station known as RBS 6501, which participated in the packet clock distribution infrastructure and was in fact the last node in the chain. While we could not measure the clock quality on the mobile air interface (for lack of instrumentation) we did verify that the RBS was reporting a lock to the clock signal during all of the test runs, proving that it remained locked while the transport network was in a holdover state.

The first scenario investigated the microwave failure. Here we simply disconnected the RF cables between the two antennas while measuring the clock quality. We also verified that the devices never reported “Free-running” state.

Shutting off the Microwave link actually meant that the SP router, positioned in front of the microwave router had to perform the hold over function. In both test scenarios (i.e. with both GrandMaster clocks) we were able to measure frequency deviation of at most 6.12 ppb. The maximum time error recorded was 191.2 nanoseconds.

We also used this opportunity to investigate what happens when the microwave was not completely turned off, but the frequency modulation was reduced. We used an attenuator to repeat the test twice: once with 512 QAM and once with 16 QAM. Both tests showed that the clock signal was not affected by modulation changes and the values recorded were along the lines of all other tests.

The results of the link failure between the SP 420 and the SSR 8004, the last failure condition we measured, were similar to the above. The maximum time error we recorded was -309 nanoseconds. Again, the RBS reported remaining locked, and none of the devices went into holdover mode.

<table>
<thead>
<tr>
<th>LTE-A Readiness Tests Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>➔ Phase accuracy consistently under 310 nanoseconds including failover scenarios</td>
</tr>
<tr>
<td>➔ Full on-path clock synchronization support</td>
</tr>
<tr>
<td>➔ Microwave adaptive modulation does not affect clock performance</td>
</tr>
</tbody>
</table>

Ericsson Evolved IP Network Solution Tests Summary

We applaud Ericsson’s commitment to continuous solution development and independent validation. We are also pleased to see the Evolved IP Network solution continue to progress and report success in the market.

With this updated report we can confirm that Ericsson’s Smart Services Router (SSR) lives up to its name and is capable of delivering truly converged and concurrent multi-services such as BNG, IPsec, Ethernet and IP/MPLS.

Multi-service is not the only capability highlighted here, but is a critical element in Ericsson’s commitment to being a dependable solution to their service provider customers as they grow their networks. Looking at the clock synchronization results as well as the integration of the base station with the transport infrastructure, we get a definite sense that Ericsson is planning to provide their customers with a verified solution that anticipates the challenges involved with 3GPP and 5G migration.

About EANTC

The European Advanced Networking Test Center (EANTC) offers vendor-neutral network test services for manufacturers, service providers and enterprise customers. Primary business areas include interoperability, conformance and performance testing for IP, MPLS, Mobile Backhaul, VoIP, Carrier Ethernet, Triple Play, and IP applications.

EANTC AG
Salzufer 14, 10587 Berlin, Germany
info@eantc.com, http://www.eantc.com/