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How do you test 5G SA control plane signalling for roaming?

Emblasoft, a test and verification and service enablement solution provider, was approached by Electryon, a consulting and professional services company, to perform secure edge protection proxy (SEPP) testing and verification over a 5G core in order to take the initial steps on the road to SA roaming for a tier-one multinational communications service provider (CSP). But without a 5G core on which to test, how could this be done?

Electryon, a company with deep expertise in mobile roaming, had been working with a large multi-national mobile operator for some years, helping it to perform roaming testing on 2G to 4G networks. More recently, the CSP had come to understand that there was an urgent need to perform 5G roaming testing in order to learn more about the technical requirements and real-world behaviour of 5G roaming – something that had not been done before. With test tools from Emblasoft and its 5G testing capabilities, the result was a quick-win, with in-depth validation of different 5G roaming scenarios.

Project background

The goal of roaming is to keep users seamlessly connected to the network, typically when they move from one country to another. Like previous generations of wireless technologies, 5G roaming will remain vital to CSP revenues, and is expected to be key to the success of many commercial use cases offered by 5G.

5G is growing fast; roaming is a key next step

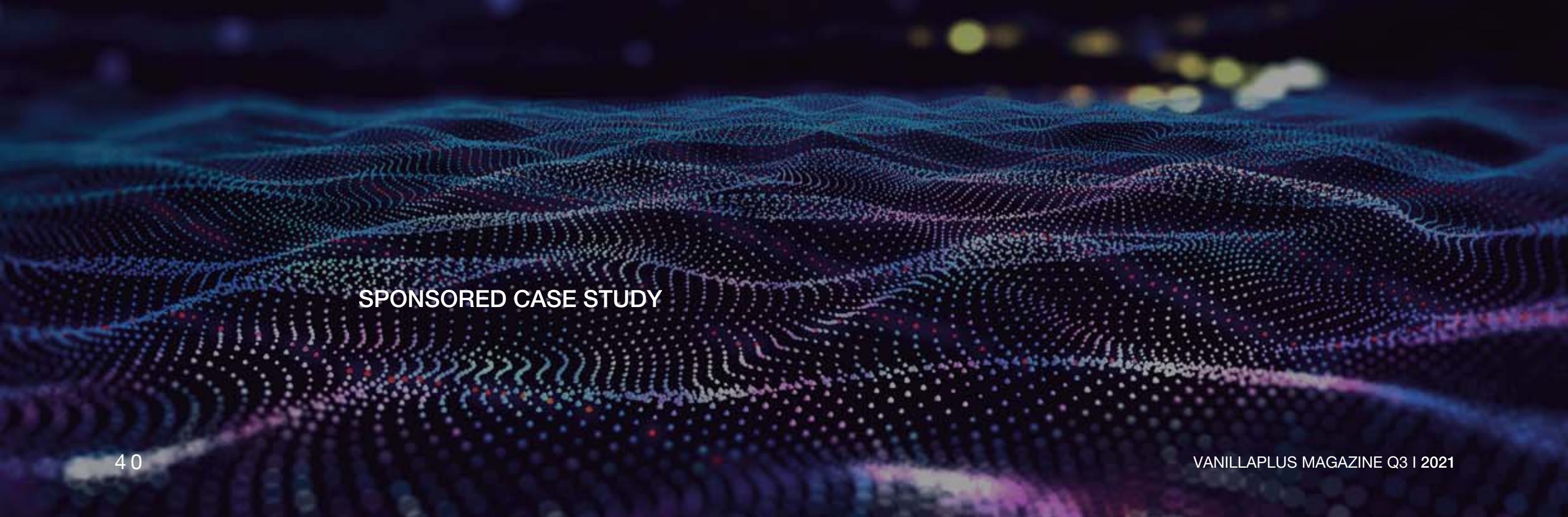
The **Global Mobile Suppliers Association (GSA)** forecasts that 5G subscriptions will comprise nearly 30% of the global mobile market by the end of 2025, accounting for just over three billion subscriptions. It means that CSPs need to do the groundwork for enabling roaming on 5G standalone networks now, in order to realise the revenue opportunities it offers.

A further market update from GSA in August 2021 states that 13 CSPs had launched commercial public 5G SA networks – plus one possible launch to be confirmed, with 45 others planning or deploying 5G SA for public networks – a further 23 operators are involved in tests/trials[1].

The figure of 58 5G SA networks – deployed or planned to be deployed – is an increase of 53% on the previous year, meaning that 5G SA roaming will quickly become an absolute requirement for 5G CSPs.

5G roaming will not just encompass consumer services. A growing number of use cases – for example, connected vehicles travelling multinationally, cross-border IoT-enabled freight movement, and, eventually, movement between private networks and international business sites, among others – will come to rely on seamless 5G roaming.

Many early adopters have launched commercial 5G services by utilising existing 4G/LTE network infrastructure – this is known as 5G non-standalone (NSA), which offers greater speeds and capacity using the LTE network infrastructure as the control plane. ▶



SPONSORED CASE STUDY

What is the security edge protection proxy?

The security edge protection proxy (SEPP) acts as a network separator. It performs filtering and authorisation checks on SBA traffic that enters or exits the network, and therefore handles access control for roaming traffic.

According to 3GPP TS 133.501: The 5G system architecture introduces an SEPP as an entity sitting at the perimeter of the public land mobile network (PLMN) for protecting control plane messages, which is made necessary by control user plan separation (CUPS).
The SEPP enforces inter-PLMN security on the N32 interface.

Figure 1: The 5G system roaming architecture

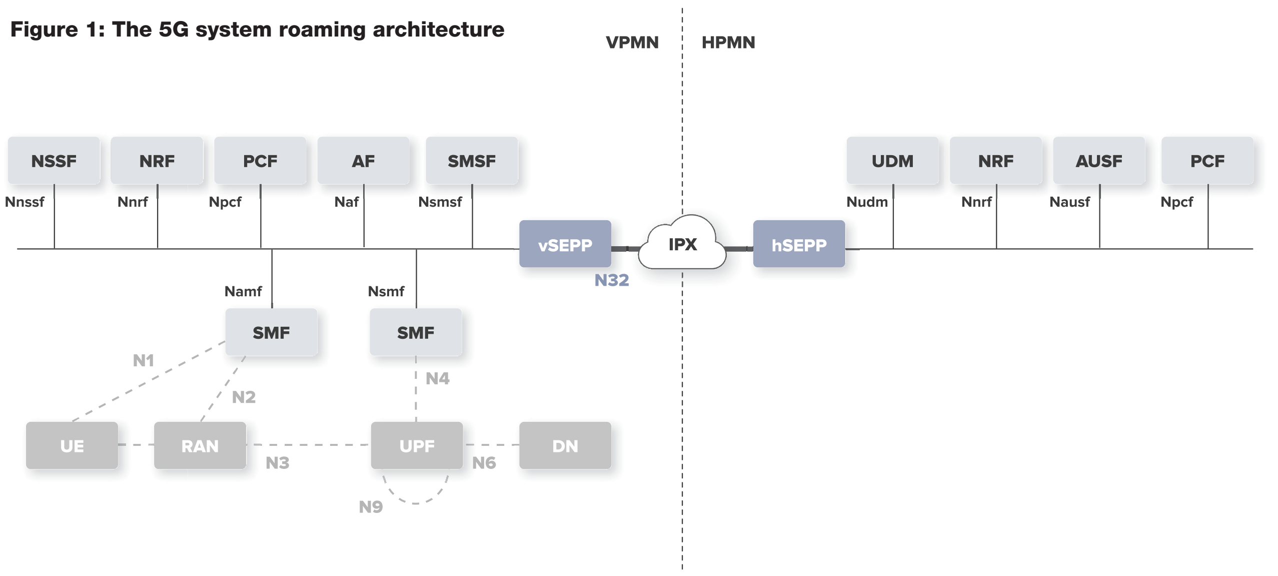


Figure 1 above, illustrates the basic architecture of a direct P2P interconnection from one MNO to another. An alternative is for indirect interconnection via a roaming hub.
vSEPP – visited security edge protection proxy
hSEPP – home security edge protection proxy

5G SA - a new roaming architecture and procedures

But, 5G NSA is just a steppingstone towards 5G SA, which includes a new core network and enables the cloud-native 5G service-based architecture (SBA). 5G SBA utilises network functions (NFs), a set of interconnected, but independent services each with authorisation to access each other's services, to provide a decentralised, distributed architecture and, of course, ultra-fast, low-latency edge computing.

Each NF exposes its functionality through a service-based interface (SBI), which employs RESTful application programme interfaces (APIs) using the web-based HTTP/2 protocol. SBI is the term given to this API-based communication between NFs, which utilises API calls over the SBI to invoke a specific service or service operation. 5G SA promises new use cases that leverage its ultra-low latency, high reliability, and massive IoT capabilities, enabling operators to explore innovative services and revenue opportunities.

However, it does present a challenge for roaming. The 5G NSA core architectural model uses the evolved packet core (EPC), which is already utilised in existing LTE deployments. Here, Diameter signalling continues to be used for roaming. While CSPs will need to prepare for significant bandwidth increases, and working closely with IPX providers for support, 5G NSA roaming is similar to LTE roaming.

The 5G SA SBA, however, requires the integration of a different protocol – HTTP/2 – for the transfer of 5G signalling, which in turn requires a new roaming paradigm. 5G SBA roaming will be performed through a new functional entity, the SEPP – see panel above – which manages internetworking (roaming) for control plane signalling between CSPs either via a roaming hub or directly between the two. ▶

1 https://gsacom.com

How do you test 5G roaming in practice?

Regardless of where they or their roaming partners are on their 5G journeys, every CSP will expect roaming to continue to work as well or better than before. Smooth interworking between 5G SA networks will therefore be essential.

This is a challenge that is facing all 5G operators and roaming hub providers, as well as future private networks. According to **Kaleido Intelligence**, annual active roaming trips are forecast to exceed 650 million in 2021, up from 442 million in 2020 (in spite of continued travel restrictions due to the Covid pandemic)[2] – a figure that doesn't reflect cross-border traffic from 5G-enabled IoT devices.

It means that it is vital to overcome the 5G SBA roaming challenge, while avoiding the prolonged delays that continue to affect the effective implementation of VoLTE roaming in current networks.

The problem facing Electryon, Emblasoft and its CSP partner, in this case, was how to create a testing solution that could simulate the 5G core in order to test a roaming SEPP solution. However, SEPP evaluation is a new concept and there was no 5G SBA core in place on which to test.

With no 5G core network available, Electryon needed Emblasoft's solution to enable simulation of a realistic environment, in which they could test and measure different parameters, variables and key performance indicators (KPIs) of an SEPP hub. So, how could they do this?

How the problem was solved

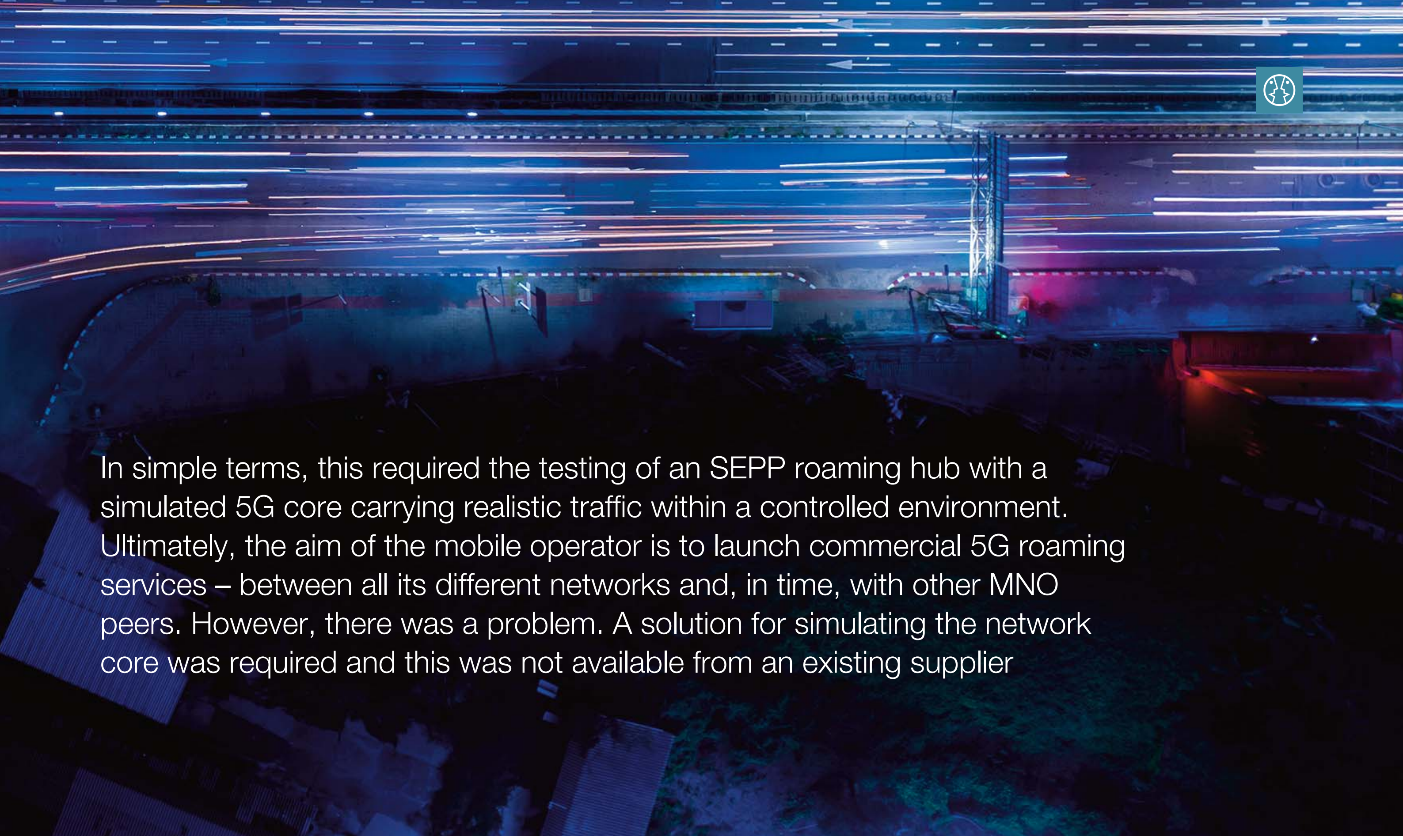
In simple terms, this required the testing of an SEPP roaming hub with a simulated 5G core carrying realistic traffic within a controlled environment. Ultimately, the aim of the mobile operator is to launch commercial 5G roaming services – between all its different networks and, in time, with other mobile network operator peers. However, there was a problem. A solution for simulating the network core was required and this was not available from an existing supplier. After performing due diligence on the market, the multinational mobile operator chose Electryon to provide consultancy to design a test model and programme, as well as to execute the desired tests. This was achieved with 5G core simulation using Emblasoft's solutions, in order to test and validate different parameters, behaviours and KPIs using realistic traffic across an SEPP.

The stakeholder team included:

1. Emblasoft
2. Electryon, offering professional services specialist that works with 5G test vendors
3. The multinational mobile operator partner
4. The SEPP solution and its provider

Emblasoft's solution was chosen for multiple reasons:

- 5G core simulation was available (not many test solution providers can perform this)
- Emblasoft was considered to have shown flexibility in developing and a willingness to tailor the simulated 5G requirements to the needs of the CSP
- Emblasoft was keen to work with all stakeholders to successfully develop and deliver this innovative solution
- The ability to simulate a distributed virtual machine (VM)-based architecture (because one SEPP would be located in a test lab in one country within the multi-national footprint, while a second would be located in another)
- Importantly, the ability to deliver the software-based solution remotely (due to Covid limitations) ▶



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Implementing the test programme

The solution was implemented remotely, and testing was performed between January and May 2021 by the Electryon team. This timeframe included planning, developing and deploying the solution, and then running tests to simulate realistic traffic within different scenarios. The test architecture and programme enabled a number of key goals to be met:

- Simulation of all network functions in the 5G core network connected to vSEPP and hSEPP for some test cases, and also with an SEPP (Hub) between the two
- Functional test of each operation between the visited and home network functions
- Testing with API-Root as well as Telescopic function
- A full location update showing mobility from one access and mobility management function (AMF) to another AMF with all network functions involved
- Simulation of N8, N12 and N27 interfaces
- Full test reports for functionality
- Automation of testing

The SEPP roaming hub provider offered a test book with different SEPP test cases, which were implemented by Electryon over the testing period, including a set of cases for verification of the main procedures – starting from the handshake dialogue to the forwarding rules, while also considering the management of error cases.

The tests were built in reference to the following 3GPP standards:

- TS 29.500 – Description of service based architecture, as primitives and NFs.
- TS 29.573 – Description of N32 interfaces between SEPPs.
- TS 33.501 – Description of security guidelines for 5G architecture, including SEPPs. ▶

Figure 2: Test architecture

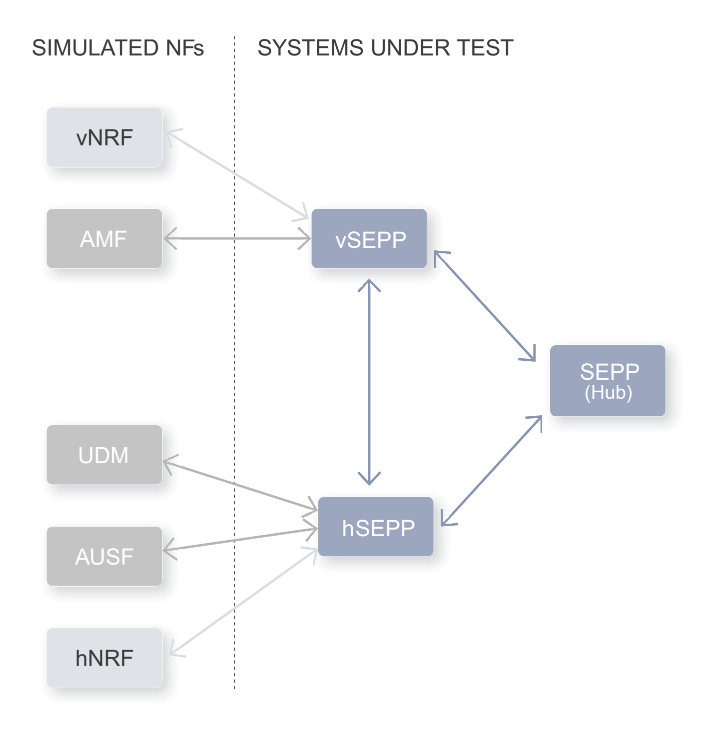

Figure 2, illustrates the test architecture in detail.

2 https://roaming.kaleidointelligence.com/650-million-consumer-roaming-trips-36-growth-in-traffic-predicrted-in-2021-by-kaelido/

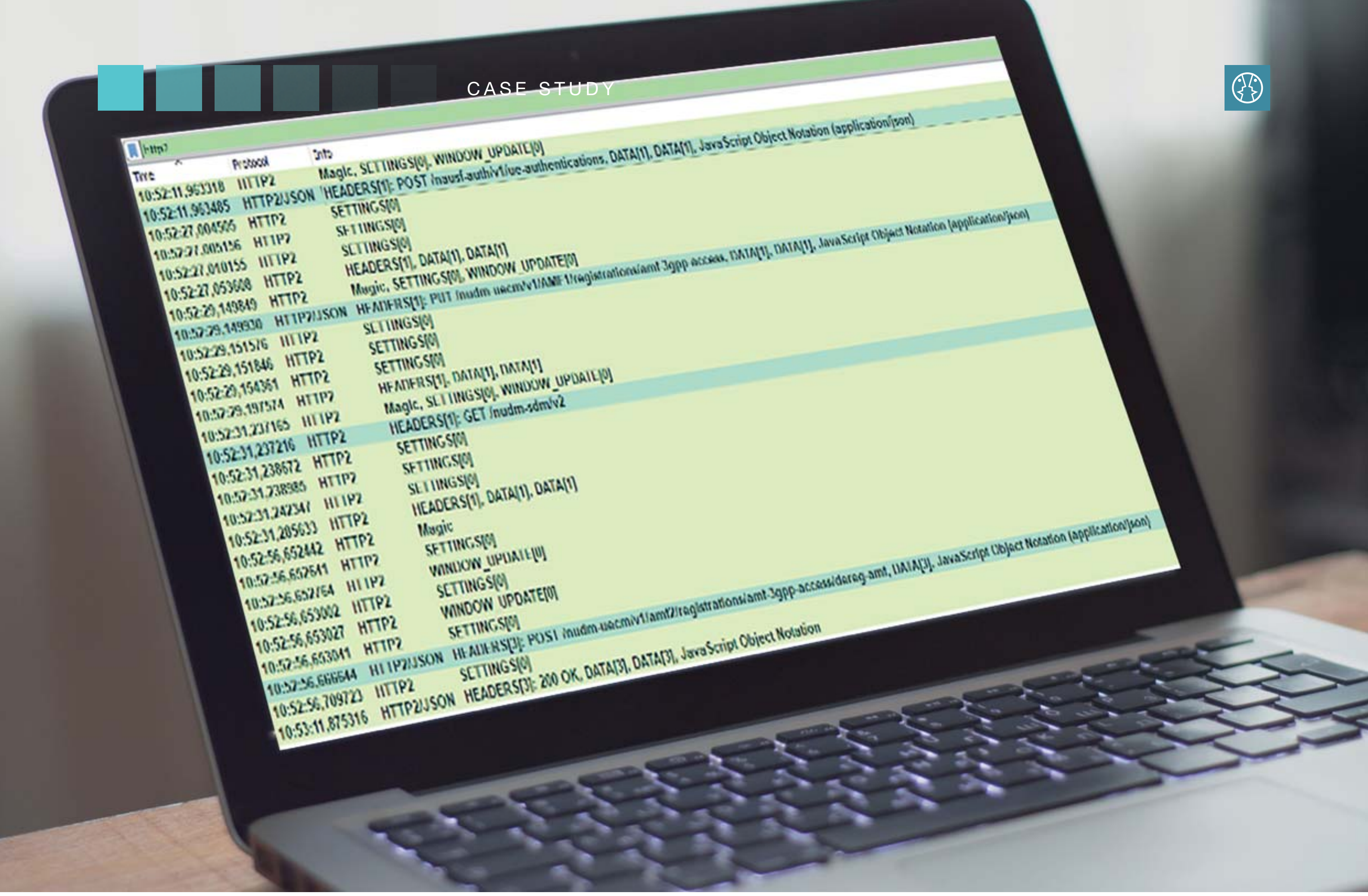

Figure 3: Test screen capture

- TS 29.571 – Description of data model adopted for provisioning on SEPPs.
- TS 23.501 – Description of NFs and related API primitives, including 5G roaming.

An example of the error case testing was to check behaviour if an "unknown" <MNC> (Mobile Network Code) and <MCC> (Mobile Country Code) was sent, or what happens if both were not present within a certain message. **Figure 3** illustrates data from a test session.

Multiple protocol tests and roaming procedures were tested – which included, for example:

- Nnrf NF_Discovery Request /_Response
- Nausf_UEAuthenticate (from AMF to AUSF)
- Nudm_UEContextManagement_Registration
- Nudm_SubscriberDataManagement_Registration/ Deregistration
- Nnrf_NFDiscovery Request / Response.

During the testing period, different entities were emulated individually, and then in their entirety, performing registration, attach, location update and detach procedures.

All tests supported the latest version of the GSMA NG.113 standard and covered 3GPP TS 29.573 / TS 33.501 definitions for security architecture and procedures for 5G system.

Outcome and benefits

Ultimately, the project tested and verified the ability to perform 5G roaming on full SA networks. Installation, test case creation, building scripts, running tests and reporting were all completed within the required timeframe. All test cases were successfully completed and shown to be completely replicable – essential for future automation through CI/CD processes.

The Emblasoft solution successfully simulated roaming users moving from one 5G network to another over a simulated 5G core. It was able to send information to the SEPP which, in turn, was able to select what information to send to either the home or visited network.

Only functional testing was performed during the test period, but load testing could have been performed at scale with real traffic volumes. In the future, Electryon and Emblasoft will seek to perform functional and load testing for different roaming scenarios – P2P, P2H2P, and so on. Start your 5G roaming journey by allowing Emblasoft to deploy a 5G core simulated system for testing different SEPP suppliers and scenarios – in an SEPP-neutral environment. Ultimately, Emblasoft's testing solutions can simulate and create a template for CSPs to be able to perform testing scenarios in multi-vendor environments and with complete interoperability – ensuring smooth rollout and assurance of essential 5G roaming services.

Find out more: **contact@emblasoft.com** | **www.emblasoft.com**