Longer Term Vision for Project Sylva

A Linux Foundation Europe Publication

December 2024

Executive Summary

The **Sylva project** represents a pivotal step in advancing the telecommunications industry towards a fully cloud-native infrastructure, particularly in the 5G era. As we navigate the complexities of deploying telco workloads on specialized cloud platforms, **Sylva's mission is to standardize and refine the Telco Cloud, ensuring it meets the evolving demands of next-generation networks**. With 6G on the horizon and emerging technologies like Open RAN and edge computing, Sylva is shaping a future where telecommunications and cloud technologies converge seamlessly.

However, today's challenges are multifaceted. Network workloads, though containerized, are not yet fully optimized for cloud-native scalability or seamless updates. Meanwhile, the data plane faces limitations in today's cloud environments, and telco operations still grapple with unfamiliarity around DevOps and lifecycle management efficiencies. Further, sustainability and carbon footprint reduction in connectivity services are becoming critical priorities for the industry.

Sylva's long-term vision is to address these challenges, laying the groundwork for an **adaptable, scalable, and energy-efficient Telco Cloud infrastructure**. This whitepaper outlines the current state, challenges, and future roadmap for Sylva, focusing on how we will drive innovation and collaboration across both the telecommunications and IT industries to create a truly cloud-native ecosystem.

Table of Contents

Where we are today

With the fifth mobile network generation (5G) in the market, it is the first time that we deploy this technology in a cloud native environment–starting in the core but also looking into the future with Open RAN, O-Cloud, as well as Edge. The focus of the Sylva project is to establish a standardized reference implementation for the deployment of telco workloads onto a specialized cloud platform – often referred to as the Telco Cloud.

Today’s challenges are manifold.

- Firstly, not all network workloads are built to be fully “cloud native”. While they are containerized and capable of running on Kubernetes platforms, they lack the ability to natively scale up or down and be updated without service interruptions.
- Additionally, the data plane has specific networking interface requirements that today's cloud environments struggle to support. We are still managing multiple sources of truth for cloud and network deployments and configurations. Furthermore, offloading and acceleration—often necessary for performance—are not yet part of standard COTS (Commercial Off-the-Shelf) hardware and typically require SmartNICs or DPUs.The telco’s operations departments are not yet too familiar with DevOps/GitOps methodology in order to manage the cloud native infrastructure adequately and most efficiently.
- Moreover, the lifecycle management of the network functions & telco cloud are not yet aligned in a way to achieve a maximum of scalability and resilience.
    - To decrease the Carbon Footprint of the Connectivity services, we need to develop measurement methods, mutualization of hardware, and the capability to adapt the energy consumption to the traffic.

- And finally, even in the contracts for the mobile network components, we haven't yet considered what cloud technology as the infrastructure means to support and maintain as well as feature upgrades.

At Sylva, we are addressing many of these challenges, but as we do, the world will continue evolving. What is certain is that the cloud is here to stay—but it, too, will change as developments in cloud technology continue to be driven by the IT industry.

Let's look at Kubernetes, for example. It started at about the same time as 5G but was brought to production much earlier. It is fair to say that it has revolutionized the way we deploy applications and services again. And yet, there is a new trend—serverless computing.

In the mobile network business, we are looking towards 6G as the next generation, but it will take until 2030 to be implemented in production. It is hard to predict whether serverless —or a new iteration of it—will complement or replace Kubernetes by then. However, we cannot ignore these trends; rather, we must prepare for them.

In the same timeframe, CPUs will develop further, and AI workloads will demand different processors. We just see Data Processing Units (DPU) and Graphics Processing Units (GPU) arriving in our Telco world, but we will see far more of them in any future cloud as AI will dominate computing in the near future. This is something we can build upon when enhancing core functionality capabilities and adding new use cases to the scope of Sylva.

Using the cloud in the way it is intended to be used

When we moved from 2G to 3G, and 10 years later from 3G to 4G, each of these generation shifts brought new specialized appliances, which were built up next to the previous generations.

With 5G, we started to deploy it in a cloud native infrastructure.

Doing so is more than following a trend, it actually brings a lot more flexibility and agility into the setup of our network. What we did with 5G was yet only the start, the following developments need to unfold the full benefits of being in the cloud.

There are now two things we should consider when we talk about the upcoming generation in mobile networks, 6G:

- First, we should leverage this last development, which decouples hardware from software deployments, and continue on this path. This means that any future generation must be a cloud-native software deployment first.
- Secondly, we should consider that 6G is not an entirely new generation, but an evolution of 5G with an iterative and relatively seamless update path and not a shift in generations.

However, the second point needs to be discussed in the 3GPP standardization or Sylva. This means that we need to make sure that the underlying cloud native infrastructure is capable of running any workloads in the most flexible and energy-efficient way possible.

Ideally, 6G would be the last generation of mobile networks which is defined as such. For further developments, we should not need a definition of generations technically - nevertheless, it might be required for marketing reasons.

Standard bodies need to evolve leveraging open source projects to build reference implementations that demonstrate the feasibility of such standards and speed up the standardization process significantly.

Is a Telco cloud still needed?

As stated above, Sylva is defining a reference implementation of a Telco cloud stack. But given the anticipated developments in CPU/DPU and cloud software of the coming years, we should consider that the cloud for 6G is no longer a telco-specific cloud. This cloud is going to run Information technology (IT) and networking technology (NT).

- The control and management planes in 5G are already IT-like NT workloads and don't have very specific requirements. They could even be onboarded using the next trends in the IT world, like 'serverless' today.
- The data plane with its high demand for data throughput can rely on future DPUs in standard COTS hardware.
- The required networking functions could be built into standard Kubernetes and used by IT and NT workloads in a similar fashion while still reflecting the special needs from the NT side.

Furthermore, in 6G, there is the idea to have services closely bundled with connectivity – so called 'beyond-connectivity services' – which is forming a service continuum.

Even when these services and the service continuum is not yet well defined, the idea behind is clearly stating that the cloud infrastructure needs to cover both. It will require some sort of isolation, security and/or confidential computing to ensure the integrity of the critical-infrastructure services, which we need to start to think of early.

Secondly, Sylva could also be developed further for IT workloads and be used in other environments. This would bring new synergies and even business opportunities for telcos as communication and data processing services are anyways converging.

The challenge today is that deployment parameters for NT workloads might differ quite a bit today but with some clever deployment options, the complexity of this can be managed.

In addition, we see more and more demand for edge cloud capabilities. While in the telco area, edge cloud is already part of the picture (i.e. O-Cloud), this could potentially be leveraged by IT applications co-located with the network functions.

Finally, the resulting stack could then also be used by companies outside of the telco business, e.g. aerospace and defense, so Sylva might get higher adoption and relevance in the market.

Shoulder-on-shoulder with IT

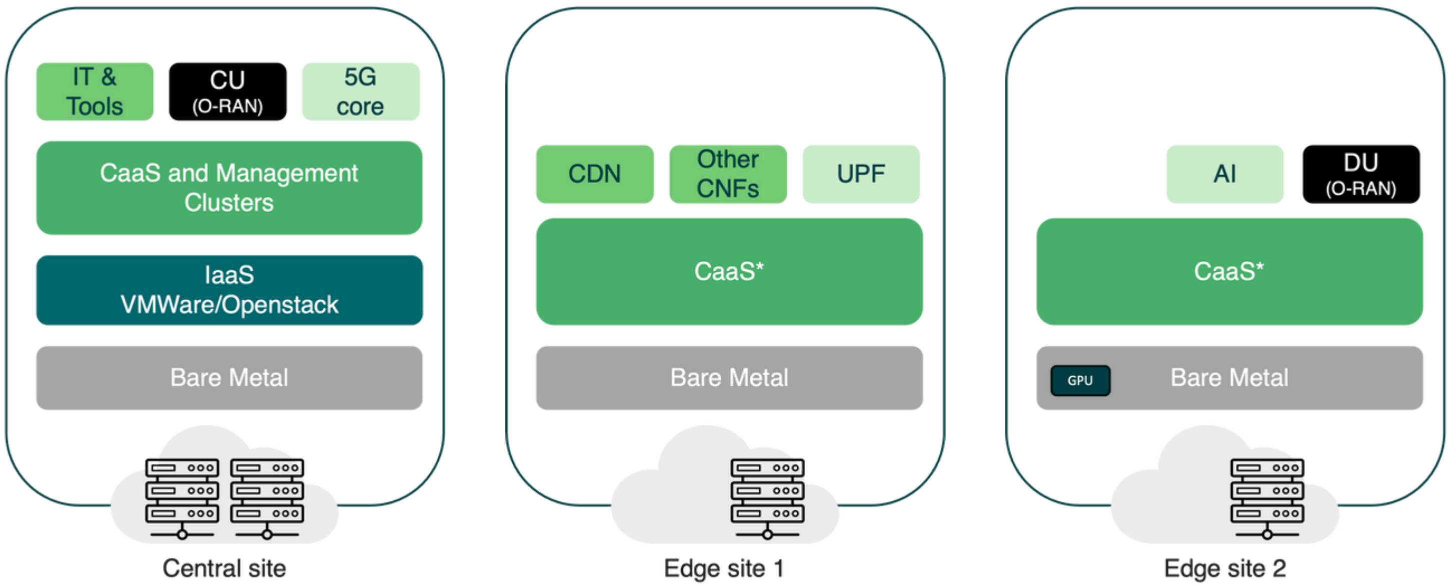
To achieve this efficiently, we need to work closely with the IT industry and the relevant open-source projects. We need to influence any future standards and tools to make them usable for our needs. We need to be on the lookout for new trends, like serverless, AIOps, usage of GPUs and DPUs, energy efficiency, etc.

Being shoulder-on-shoulder with the IT industry and its developments, we will not miss an opportunity to adjust our developments accordingly.

Sylva Architecture

To address such use cases as 5GCore, Fix Netw, Open RAN, AI & IT, Sylva will provide an architecture able to manage from Central to far edge site.

Example on how Sylva could be deployed in a multi cluster environment



Adopting this paradigm by standard bodies within the telco ecosystems would speed up development times and allow for shorter innovation cycles, lower development cost and faster time to market.

How can AI help manage the cloud?

One other trend we can not ignore, is the trend to use Artificial Intelligence (AI) to manage, steer, optimize and operate the cloud infrastructure and network elements. This brings new challenges and opportunities which need to be balanced efficiently, as we need to make sure that the use of AI is providing more simplification and effectiveness than it would bring complexity and increase the power consumption.

As there are different types of AI, the type of functions are likely being divided between advanced Machine Learning (ML) and Generative AI (GenAI) functions.

For GenAI, the aspects we might want to start looking at are for example

- co-pilot-like functions to create deployment settings for workloads
- analysis and consolidation of logging and events
- incident analysis and solution advice to operations

For the Machine Learning side of AI, we might want to start with

- usage metric analysis and automatic up- and downscaling of resources
- predictive maintenance
- capacity planning

Overall, the Telco services will rely more and more on AI so the Sylva project should address the matter. This encompasses the capabilities to execute the AI inferences but also to train and fine tune the models.

Note that Inference seems well suited for distributed telco cloud environments where Sylva architecture is targeted. However, Large Language Models training requires higher compute power and energy and therefore will mostly be executed in large data centers. Note that the emergence of Small Language Models will lighten these requirements so Sylva should monitor its relevance for this use case.

From a hardware perspective, it will require adapted computing capabilities (CPU, GPU, etc.) and Sylva should have a specific focus on the integration of a relevant yet wide range of solutions. Beyond hardware, training models and executing inferences will require adapted software frameworks and Sylva should monitor the ecosystem for open source initiatives to liaise with.

Versatility and simplification

Since the beginning of Sylva, lifecycle management is at the heart of the solution, because what is the most important now is being able to evolve fluently. In the same way, capability to support several hosting environments, several implementation variants, etc. is one of the most valuable advantages that using Sylva can provide.

The best way to manage future evolutions is to be able to change any solution at any time. Sylva aims to simplify the cloud infrastructure and the interaction with Sylva users. This involves an agreement on a set of common interfaces, abstracting the details of specific designs and tools. This abstraction paradigm then applies to the infrastructure customization, the network integration and to the operational requirements. The adoption of the Kubernetes Resource Model helps to reach this goal in the short term.

Sustainability will become even more important

While Sylva is already working in a separate Working Group on the sustainability of the cloud infrastructure, we likely will need an even stronger focus on the topic. Energy usage is not only driving the CO2 consumption but is also a major cost driver for the cloud. When transitioning to the edge, TelcoCloud must showcase energy-efficient mechanisms and optimizations, particularly in the context of replacing appliances within the O-RAN ecosystem. This needs to be countered with further measures to operate it more efficiently, which could include different CPU architectures and accelerators in the underlying hardware.

Sustainability objectives also need that IT and Telco infrastructures are unified to maximize the mutualization of installed hardware. Widening out the scope of Sylva to be used for IT workloads which may be colocated with NT workloads at the edge of future networks facilitate the dynamic allocation of free resources and simple move of workloads to optimize infrastructure usage will help to achieve a higher sustainability.

Security

In recent years, the cyber threat landscape has undergone a significant transformation, presenting new challenges for Communication Service Providers (CSPs). The Sylva project has recognized security as a fundamental pillar in mitigating these risks from the beginning. Looking ahead, the industry anticipates key innovations to address these evolving threats.

Traditionally, legacy infrastructure protection was focused on perimeter security, primarily utilizing firewalls. However, in today's Cloud-Native infrastructure, this approach is no longer adequate. In particular, the security of the supply chain has become critical at every stage of the DevOps/GitOps workflows. The SLSA guidelines (https://slsa.dev/) should be applied to prevent the introduction of software artifacts with malicious functions and vulnerabilities.

The adoption of a Horizontal Cloud strategy, hosting multiple Network Functions (NF) belonging to different domains of responsibility on the same cloud layer, introduces new security challenges, namely to guarantee strong isolation between these domains.

- In this environment, implementing a minimum authorization approach becomes particularly important. Role-based access control (RBAC) enables this approach, but implementing the appropriate least privilege for users/admins and Network Functions will require a phased approach with progressive levels of maturity.
- Moreover, in a Horizontal Cloud Deployment with CaaS on BareMetal, ensuring a high level of isolation between different critical network functions is essential. Currently, dedicated hardware is often allocated per domain. This is not sustainable in terms of CO2 emissions and CAPEX in the future. Mechanisms need to be validated in terms of security and performance in collaboration with state regulatory bodies (e.g., Kubevirt, CataContainer) to increase hardware mutualization.

Lastly, to enhance the resilience of the cloud infrastructure, efficient configuration control of the TelcoCloud is crucial. In the Sylva project, the declarative approach to building the infrastructure is one step towards achieving this goal. Furthermore, the Sylva project should support Ransomware Protected Configuration Backup, along with regular restore tests, to ensure robust protection against potential cyber threats.

Tasks for the Sylva project

Sylva is not defining how 6G workloads will work, cannot assure that these are meeting the trends of the IT world and progressively AI Workloads. But Sylva has the capability to prepare the infrastructure so that it will stay up-to-date, modern, flexible and most energy efficient, and that is done by aligning with the IT industry, with other open-source projects we rely on today or which will come out in the future. Finally, with the adoption of Sylva, we can also influence the Telco workloads cloud requirements and implementation processes.

Sylva delivers a reference implementation that champions cloud-native principles within the Telco industry, integrating autonomous infrastructure management to streamline operations. By adopting an intent-based architecture, such as GitOps, it facilitates the independent management of infrastructure that supports workloads across a distributed multicloud Telco ecosystem.

The Linux Foundation is a perfect base to engage with our peers and find allies in the world of cloud:

- Anuket is looking into Reference Architectures and Models while Sylva creates the Reference Implementation.
- Cloud Native Telecom Initiative (CNTI) will provide some advance tool to evaluate conformance of Telco Cloud & NT workloads.

- Nephio is exploring a breakthrough approach to manage NT configurations with the latest IT innovation with KRM Kubernetes Resource Management. The benefits are to deploy consistently, manage efficiently, and scale dynamically NT workloads.

Furthermore, we have the capability to discuss these trends with our members and even have some explorational activities started to pave the way to the future.

Acknowledgments

Thanks to the Sylva Fund governing board members and staff members who contributed to this paper:

Kai Steuernagel, Deutsche Telekom; Hanen Garcia, Red Hat; Guillaume Nevicato & Nicolas Homo, Orange; Luis Velarde, Telefónica; Carlo Cavazzoni, Telecom Italia; Nicoleta Patroni, Vodafone; Tim Irnich, Suse

Sylva

Sylva provides implementations and extensions needed to address challenges associated with telco and edge use cases within the EU and globally. Launched with support from leading telcos, network function vendors, and IT editors.