1. Introduction

This document is intended for anyone who is interested in modern network design. System Architects, Developers, Product and project managers, Network operators, should all find useful information here that will help them better understand the state-of-the-art in networking technology and figure out how the Linux Foundation Networking projects may be used as building blocks for modern networks. This white paper does not intend to prescribe the "right" solution for building a network. There is more than one way of doing that and it all depends on the network designer's preferences and available resources. Instead, we try to introduce the capabilities of each project and suggest potential ways they can be used in harmony. One of the goals of this document is to solicit engagement from potential users and contributors to the Linux Foundation Networks projects. You are strongly encouraged to share your insights and thoughts with the LFN community. The LFN Technical Advisory Committee mailing list is one place to start such engagement. Please see more details in chapter 5.

Just over two decades ago, the network was mainly a fixed voice network in widespread use in mature markets but with limited reach in emerging economies. Cellular and the internet were only just starting to appear. Each regional network was built and run by a Communications Services Provider who would acquire the underlying proprietary technology from Network Equipment Providers and charge subscribers to use the network. The resulting networks were largely homogenous with most of the equipment typically coming from a single vendor.

In this traditional model the technology and product roadmap of the Communications Service Provider was the technology and product roadmap of their Network Equipment Provider which were driven by jointly developed standards. The standards-led product development led to decentralised yet globally compatible service offerings, it enabled worldwide roaming and unprecedented level of compatibility over defined reference points and across many vendors. Development costs for the Network Equipment Providers were high ultimately resulting in an industry consolidation. Capital and operational costs were high for the Communications Service Provider, but these costs were predictable and could be recovered over time from the subscriber population in a relatively uncompetitive market.

Move forward a short twenty years or so and the industry has transformed. Mobile and Internet are booming worldwide. Traffic has moved from circuit-switched voice to packet-switched data. The network has far greater reach: hundreds of millions of people in mature and emerging economies worldwide now stay connected to the network to regularly access valued consumer services such as streaming and business services such as video conferencing. Capacity is significantly increased and demand continues to grow as more devices connect to the network and services consume more bandwidth. Markets are far more competitive and communications services are increasingly commoditised. As consumers, we pay less and get more. The network itself has become the foundation for the new global digital economy of the 21st century. Happy days.

Scratch the surface of the industry a little and we see business models and ways of cooperating around technology remain largely unchanged from twenty or even a hundred years ago.

With network function deployed as physical appliances, being preintegrated bundles of hardware and software, new services require changing the physical structure of the network and this takes as long as months or even years and incurs the cost of a field workforce. With Network Function Virtualisation, there has been movement from appliances to separation of hardware and software which has reduced time to deploy new services.

The industry challenge is that the traditional networks that are the foundation of the Communications Service Provider business can in fact be slowing the business. With consumers paying less to get more each year, the Communications Service Provider must continuously create new services and provide more bandwidth at a lower cost each year just to remain viable as a business. The underlying network technologies and closed supplier ecosystems prevent the Communications Service Provider from leveraging the open market to introduce new capabilities to reduce costs or innovate to create a new service. The tipping point has already been reached in highly competitive markets such as India where CSPs are disappearing from the market or are merging but still losing customers to competition and from the once flourishing NEP ecosystem less than a handful of vendors remain today. Despite the network itself becoming the foundation for the new global digital economy of the 21st century, the industry that provides the network is facing significant challenges.

How then does the communications industry and its suppliers move to the open model of innovation, development and collaboration enjoyed by other technology-based industries? Enter Open Source. Benefits of Open Source in the Enterprise domain include higher quality software, improved security, lower cost of ownership and greater innovation. Linux has long been a leader in open source for Operating Systems, successful as a result of strong governance and collaboration and without one vendor controlling development or direction. Traditionally, the pace of innovation in the networking industry has been determined by a process that included standards creation, separate implementation of it based on each Network Equipment Providers' interpretation and then multi-vendor interoperability testing. Often times several iterations of the process were required until the technology was ready for wide deployment.

Standards and Open Source, Better together: Open Source Software can accelerate and simplify the process as the open source implementation of the standards provides immediate feedback loop to the standard creation, and a reference implementation for Equipment Providers and Network Operators.

In recognising both the importance of communications to the emerging global digital economy and to improving lives of people everywhere, and the challenges facing the communications industry, the Linux Foundation established LFN as the umbrella organisation to provide platforms and building blocks for Network Infrastructure & Services across Service Providers, Cloud Providers, Enterprises, Vendors, System Integrators that enable rapid interoperability, deployment & adoption.

LFN helps by increasing the availability and adoption of quality open source to reduce the cost of building and managing networks, giving Communications Service Provider, Cloud Providers, Enterprises and others the means to:

- significantly reduce cost of the networks on which their businesses depend
- gain control of their network and product roadmap
- introduce new capabilities and service more quickly
- reduce capital and operational costs, for example by increasing the number of functions that can be remotely deployed and maintained, through automating operations and through increased use of commodity hardware
- increase security through having multiple entities review the software

While there are benefits from using open source, the benefits are greater to those who also contribute to open source. This is because "Companies that contribute and give back learn how to better use the open source software in their own environment." Source: Harvard Business Review: Firms that contribute to Open Source capture up to 100% more productive value from Open Source Software than their free-riding peers. https://hbswk.hbs.edu/item/the-hidden-benefit-of-giving-back-to-open-source-software

The value of open source is not missed on the Network Equipment Providers, many of who use Linux as the Operating System for their network equipment. Increased adoption of open source in other areas of their products will help Network Equipment Providers improve quality and output while reducing development and maintenance costs.

China Mobile, at&t and Rakuten are examples of organisations using open source. US military research agency DARPA has stated its intention of establishing an open source program for 5G and US Congress is legislating to provide funding. It is expected the open source will significantly displace proprietary systems from networks in the coming years, and LNF sees it has a significant contribution to make.

As this transition proceeds, in coming years when you scratch the surface of the network, you will see a significantly transformed network underpinning the modern age.