NOKIA

High performance IP routing with Nokia FP4 silicon

Delivering intelligence at scale and extensibility

Application note

NOKIA

Contents

NOKIA

Market landscape

Day by day, we embrace richer and more connected experiences. User expectations for personalized content, multimedia sharing and access to the world's information are unbounded. This fuels further creativity in ecosystems that deliver applications, content platforms and social experiences.

The best is yet to come. In the cloud, 5G and Internet of Things (IOT) era, connected devices will enable smart grids, smart cities and an age of digital transformation that will boost productivity and improve our lives like never before. To ensure that these experiences are delivered flawlessly and efficiently, IP networks must also transform on key dimensions. They must be fundamentally safer and more adaptive as they scale without limits.

In scaling out their network infrastructure, service providers, webscale companies and enterprises must achieve two critical goals: to provide the absolute best possible user experience, and to maximize the use of their network resources. In doing so, they can delight their customers while getting the highest return on their investments.

Reimagining IP networks

With the right structural elements, IP networks can scale without limits and adapt to address new opportunities. Breakthrough silicon innovation from Nokia has consistently changed the trajectory for scaling the internet, powering systems that are the industry's biggest, highest density and most advanced routing platforms to date.

The Nokia FP4 chipset represents a massive leap in network processor (NP) silicon for high-performance routing. By far the biggest and most capable routing silicon in the industry, it delivers an unmatched level of integration that maximizes performance with a smaller footprint, less complexity and lower power consumption. The result is a perfect foundation for high-performance routers that will be at the heart of tomorrow's networks—terabits of capacity in a single chipset, with the appropriate level of intelligence at scale, delivered more securely and without sacrificing any of the capabilities expected of the world's best routers.

With the right operational model, IP networks can run efficiently, securely and cost-effectively. An insight-driven and highly automated operations model is clearly required.

Networks must be able to extract volumes of information related to traffic attributes and vulnerabilities in real time. The information must be translated in near-real time to insights on how user experience or resource utilization can be optimized and how security threats can be identified and mitigated.

This insight must then be put into action in a policy-based, automated way, with the network being programmed to operate in a more optimal way based on the latest status of flows and applications traversing the network.

Powered by groundbreaking FP4 silicon, Nokia delivers a new generation of high-performance routers that achieve exactly these objectives. Service providers and webscale operators building and operating the world's most modern networks will benefit from intelligence at scale, visibility with control, and unprecedented extensibility. With these capabilities, they can ensure superior customer experience, intent-based automated operations and optimal network utilization.

Design requirements for modern IP networks

Modern IP networks need massive scale to handle the unrelenting growth of traffic. But the need for scale must go beyond platform size or capacity. IP routers should support massive scale without compromising intelligence and performance; this is referred to as multidimensional scaling.

In addition to supporting an extensive set of capabilities, router performance must be deterministic (predictable) even under stringent traffic conditions and with multiple capabilities enabled concurrently.

Modern networks must support the ability to adapt intelligently to transient conditions with minimal intervention, enabling a new operational model driven by awareness and agility.

We live in a society where we cannot predict the timing or severity of security attacks. Network defense through security threat mitigation can no longer be an afterthought: it needs be a built-in attribute of the IP network and implemented closer to the points of attack in a distributed manner.

The cost for implementing and operating networks is growing faster than the returns from network investments. IP routing platforms should maximize longevity for both hardware and software elements throughout the network evolution life cycle. All current and future enhancements must be supported without needing field swaps.

High-performance routing platforms need to support the highest levels of availability at the hardware and software levels, ensuring protection from attacks against the router itself, graceful recovery from fabric failures and high-availability features.

Energy costs are a real and substantial operational expense for network operators. IP routing platforms must strive to make energy efficiency a key design goal to provide an efficient energy footprint.

FP4 silicon is driven by and designed to address these critical design requirements for modern IP networks.

NOKIA

Nokia revolutionizes silicon design

Nokia is dedicated to transforming service provider, webscale and enterprise networks. In evaluating design choices for our next generation of router silicon, we adopted a “no compromises” approach that embraced innovation and integration, and conquered complexity to deliver unprecedented scale, security and performance—without sacrificing capability, intelligence and extensibility.

For structural elements that will be at the heart of the internet and deliver amazing user experiences in the age of the cloud, 5G and the Internet of Things (IoT), there should be no compromise. And now, there is no need to compromise.

Through the years, Nokia has paved the way with an impressive set of industry firsts: first to deliver 10G, 100G and 400G network processor chipsets and first to deliver 100G and 400G clear channel flows. FP4 silicon continues this legacy

FP4 silicon design leadership

- First 3-Tb/s NP
- First NP designed with 16nm FinFET
- 2D and 2.5D System in Package (SiP) construct in networking and first with integrated 3D memories
- First to support intelligent memory design (a Nokia invention)
- First NP to support multiple 1-Tb/s clear channel flows
- First NP to support high scale, enhanced packet intelligence and control technology
- Only next-generation processor that does not compromise functionality at the expense of capacity

FP4 silicon benefits

- 2.5-5 times performance advantage over any NP alternatives; provides better small packet performance and better buffer absorption in fewer components compared to lower capacity NPs
- A single integrated FP4 packet processor package occupies one-fifth the board space of the previous generation of FP silicon, enabling massive system upgrades (up to six times) to existing FP platforms, and allows for new densified FP architectures (Nokia 7750 SR-s)
- Massive silicon miniaturization and memory integration reduce power consumption per packet processed by over 50% (compared with previous generation of FP silicon)
- Supports 400GE, Nx400GE and terabit speeds today

- Enhanced packet intelligence and control technology enables a unique network-integrated approach to DDoS mitigation
- Delivers multidimensional intelligence at scale without compromising capabilities and performance
- Supports deterministic performance under stringent traffic loads, ensuring consistent system operation no matter how QoS, ACLs, IP or MPLS capabilities and network functions are scaled

FP4: Delivering intelligence at scale and extensibility

Nokia FP4 silicon builds on three previous generations of leading-edge NP design and once again sets the pace for innovation in IP routing technology. The FP4 “no compromises” design approach helps FP4-powered routing platforms to address the requirements for modern IP networks.

Multidimensional intelligence at scale

Nokia FP4 silicon delivers multidimensional scaling through a fully programmable FP4 data path with industry-leading throughput of 3 Tb/s.

The FP4 chipset supports dedicated table spaces for IP Forwarding Information Base (FIB), MPLS labels and media access control (MAC) forwarding database (FDB). IP routing, MPLS label processing, IP network functions, buffering and access control list (ACL) scaling do not degrade throughput or scale.

The Nokia 7750 SR-s, the newest member of the Nokia 7750 SR family, is designed to scale up to 288 Tb/s and delivers unprecedented intelligent fan-in/fan-out on each of its 12 Tb/s line card slots.

FP4-based platforms scale beyond the capacity dimension, supporting:

- Millions of IPv4/IPv6 routing FIB) and Routing Information Base (RIB) entries
- Tens of thousands of point-to-point and multipoint VPNs
- Over 500,000 broadband residential subscribers
- Fully deterministic buffering with fine-grained scalable QoS
- Comprehensive statistics (14+ statistics counts per packet)
- Up to 2 million ACLs per router line card.

These capabilities can be supported concurrently without performance degradation.

Deliver deterministic performance with revolutionary chipset design

Designing an NP which supports massive capacity and intelligence at scale required a revolutionary approach to silicon design. IP routing silicon performs a range of functions, including packet processing, traffic management and MAC layer interface logic. Each of these functions needs to be best in class without imposing tradeoffs on features, scale and performance. The functions also need to support backwards compatibility and longevity for software and hardware releases.

With FP4, Nokia implements a multichip architecture where the system MAC is completely decoupled from the packet processor, and where the traffic manager and fabric tap are also completely disaggregated. Breaking devices into their fundamental components allows each to be best in class. Each component can also be used in flexible hardware configurations across different products, maximizing the feature set and system longevity, and providing speed and agility beyond what a single monolithic NP provides.

Deterministic performance is realized as a combination of both our multichip architecture and datapath system memory design. Alternative designs typically rely on low-speed memories for table lookups (restricting chipset speeds), internal memory tables (restricting scale), external TCAMs (restricting flexibility), a combination of low-speed memories and TCAMs (non-deterministic) or have implemented custom memories with limited functions. The Nokia approach, with the creation of intelligent memory, surpasses all these.

Through a high degree of integration and the introduction of Nokia intelligent memories, the FP4 chipset adds logic to our memory lookups, off-loading key functions from our packet processor and optimizing the number of atomic transactions. Key multistep repetitive functions are implemented by single commands. Intelligent memory can be programmed not only as a TCAM but also similarly function as a hash or LPM table for lookups. This provides full flexibility to turn on or enhance functions as required.

16nm FinFET enables an industry-leading number of packet processing cores in each packet processor, for a future-ready, high-performance data path. With the FP4 traffic manager, buffering is always deterministic and does not degrade or cause control plane discards if buffer rate increases, a common shortcoming of partially buffered systems. Increasing capacity does not sacrifice queuing performance, with full support for highly granular queuing and shaping, both ingress and egress, under all circumstances.

Reinvent DDoS mitigation with enhanced packet intelligence and control technology

FP4 silicon supports enhanced packet intelligence and control technology with the ability to go beyond the 5-tuple packet operations supported by a conventional router.

FP4-based IP routing platforms, when combined with Nokia Deepfield DDoS detection (powered by real-time analytics with intelligence to monitor and recognize sophisticated DDoS attacks) redefine the way in which distributed denial of service (DDoS) security and flow optimization applications are delivered. This capability is unmatched by any competing silicon vendor and is enabled as a result of the packet pipeline supported with FP4.

This network-integrated DDoS mitigation capability is a game changer compared with alternative approaches for implementing DDOS mitigation based on scrubbing centers and security appliances. For additional details, see the white paper "Insight-driven automated networking."

Provides a clear path to 1 Tb/s and beyond with a dedicated chip approach

A MAC function is used to couple a physical interface into a packet processor. Nokia follows a unique approach to MAC design with the MAC functions implemented in a dedicated, in-house-developed MAC chip outside the packet processor. This dedicated MAC chip approach, combined with the packet processor's ability to support 1-Tb/s flows, enables flexible support for 100GE, n x100GE, 400GE, nx400GE and terabit-speed interfaces today.

Nokia takes this decoupling one step further by adding complete packet pre-classification, pre-buffering and DDoS protection into this chipset. Where alternative designs must filter, classify and buffer only in their packet processor, we off-load a number of these functions to help guarantee the availability of the control plane for targeted or transient DDoS attacks.

In addition, FP4 uniquely supports Nokia Flex-T for link bundling. Nokia Flex-T is a customized implementation of the ongoing Flex-E standard that allows for the aggregation of multiple 100GE, 200GE or 400GE interfaces into a single logical interface. This creates a single clear-channel terabit flow, supporting elephant flows today in advance of terabit optics. The key advantage of Flex-T is that it enables full usage of all bandwidth in a bundle without the inefficiencies of hashing or Link Aggregation Groups, greatly simplifying network topologies. In addition, Nokia Flex-T bundles still support full QoS at up to 1-T clear-channel, bundle redundancy and all service flexibility.

Deliver high availability with FP4 and the Nokia SR OS

Advanced protection for router control plane

The real world has microbursts, threat attacks and packet storms. None of these conditions can be allowed to compromise the IP router control plane. FP4-based router line cards implement pre-buffering and pre-classification (with priority tagging) in the dedicated MAC chip. This guarantees the availability and protection of the control plane. In addition, Nokia FP-based routers uniquely leverage FP silicon in the router control card, to enable a centralized rate-limiting function on traffic destined for the control plane CPU.

Highly resilient fabric design

Nokia FP4-based systems implement a single-stage, cell-based, buffered fabric. This design provides key advantages in simplicity, graceful handling of failures and full backwards compatibility. FP4 fabric design handles fabric links or chip failures gracefully, ensuring there is never any traffic black-holing (silent discards). All Nokia FP chipset-based fabrics have always been backwards compatible over the multiple chipset generations, delivering industry-leading investment protection.

SR OS high-availability features

The Nokia Service Router Operating System (SR OS) is built to power the most demanding and dynamic IP networks. The SR OS is purpose-built to meet the reliability demands of an always-available IP network environment. Based on a real-time, modular, fully distributed and highly fault-tolerant design, the SR OS enables the delivery of non-stop routing, non-stop services and In-Service Software Upgrades (ISSU) for both major and minor releases.

Green and efficient router design

Nokia is committed to contributing to an environmentally clean, healthy planet and implementing green router designs. Each generation of FP silicon provides unprecedented speed, scale and functionality while being more energy efficient. These efficiency gains are the result of the advanced silicon technology, allowing the transistors to be more densely packed on the silicon.

FP4 silicon cuts power consumption in half (per Tb) compared to FP3 silicon while offering up to six times more capacity.

Designed for extensibility

Extensibility relates to both hardware and software longevity and is directly linked to network economics and ROI. Major changes in silicon strategy during the life of a routing platform, such as changing NP suppliers or moving from commercial silicon to in-house design, can result in forwards and backwards compatibility issues with successive generations of router line cards.

Since inception, Nokia has adopted a cohesive silicon design strategy that ensures full backwards compatibility between generations of FP silicon. FP4 has been designed to be fully backwards compatible with FP3 such that intermixing FP3 chipsets with FP4 chipsets in the same chassis is fully supported without speed degradation to FP4.

Each generation of Nokia FP silicon has consistently delivered silicon life cycles that are significantly longer than in the rest of the industry—close to a decade; this provides unmatched economic benefits and investment protection. FP silicon programmability and longevity ensures that software features and releases are delivered in short timeframes and without changing the underlying hardware.

Conclusion

The onslaught of connected devices driven by smart homes, grids and cities as well as the availability of staggering bandwidth on the path to 5G and IoT will pave the way for new and enriched experiences. This places a significant load on the networks that deliver these experiences, and network operators are on the path to transforming their IP networking infrastructure to keep pace with these evolving trends.

Intelligent IP routers powered by leading-edge IP routing silicon will continue to be the foundation of modern IP networks. Nokia FP4 is the industry's first multi-terabit (3 Tb/s) NP silicon. The FP4 powers Nokia's newest 7750 SR-s router as well as existing FP-based (7750 SR and 7950 XRS) routing platforms. This latest generation of IP routing silicon delivers multidimensional network scale, adaptability and extensibility, to transform modern service provider and webscale networks.

Learn more

To learn more about Nokia technologies that reimagine IP networks:

- Read the "Insight-driven automated networking" white paper
- Visit the Insight-driven IP networks webpage
- Visit the High-performance IP networking for webscale solution webpage
- Visit the Nokia 7750 SR-s webpage
- Visit the Nokia 7750 SR webpage
- Visit the 7950 Extensible routing systems (XRS) webpage
- Visit the Deepfield Network intelligence, analytics and DDoS security webpage

NOKIA

Acronyms

ACL	access control list
DDoS	distributed denial of service
FIB	Forwarding Information Base
FinFET	Fin Field Effect Transistor
LPM	longest prefix match
MAC	media access control
MPLS	Multiprotocol Label Switching
NP	network processor
QoS	Quality of Service
ROI	return on investment
TCAM	ternary content-addressable memory

Nokia Oyj
Karaportti 3
FI-02610 Espoo
Finland
Tel. +358 (0) 10 44 88 000

Product code: SR1910038780EN (Oct) CID: 201267