

THE REAL-TIME CLOUD

COMBINING CLOUD, NFV AND SERVICE PROVIDER SDN

Operators need to ensure that their networks remain a relevant and vital part of users' everyday experience, and deliver added value in new and unique ways.

Emerging Network-enabled Cloud, Network Functions Virtualization and software-defined networking technologies will help operators do just this, by enabling common management and orchestration across network resources and cloud applications.

CLOUD EVERYWHERE

The popularity of cloud computing-based services and applications, enabled by ever-improving broadband connectivity and smartphone capabilities, has skyrocketed in recent years. Whether for enterprise mail, storage and collaboration tools or consumer music services, photo storage, video sharing and social networking, cloud-based services are becoming engrained in our everyday lives, available to us wherever we go.

Operators often perceive cloud-based services – in which they have little or no role other than to deliver connectivity – as a threat to their business. However, these services also provide an opportunity for operators to add value and improve the timeliness and quality with which they deliver customer services and applications – whether through more efficient telecom and internal IT services or with value-added cloud services for consumers and enterprises.

Operators can turn cloud-based approaches to their advantage and implement new architectures that provide network efficiency, QoE and shorter time to market for innovative services, through network programmability and a common delivery platform.

By including the wide area network (WAN) as an intrinsic component of cloud-based services, network operators hold the key to unlocking their full potential – cutting today's clouds loose from their physical data center “anchors” and opening them up for innovation.

Through a combination of Network-enabled Cloud, Service Provider SDN, and Network Functions Virtualization (NFV) approaches, operators can now simplify their networks, remove the complexities of topology and service creation, and accelerate the process of new service creation and delivery.

Network-enabled Cloud technology brings cloud capabilities into the network with the flexibility and elasticity to deploy software applications wherever and whenever they are needed. Services and applications can be deployed, modified and withdrawn in a matter of minutes.

Service Provider SDN brings SDN capabilities to the network (outside the data center) with policy-based and centralized control for improved network programmability and payload elasticity.

NFV enables applications to share network resources intelligently and be orchestrated efficiently. It entails implementing network functions in software, meaning they can be instantiated from anywhere in the operator's network or data center, as well as in a consumer or enterprise customer premises.

By adopting a layered, virtualized cloud approach, whether centralized or distributed, operators are able to orchestrate the network and cloud in sync with common SDN and operations support systems (OSS) capabilities. This not only optimizes resource utilization, but also ensures a truly dynamic service delivery process and improves user experience – enabling a “personalized” response to changing connectivity requirements in real time.

Together, these technologies transform the network and the cloud into a Network-enabled Cloud – one that is more fluid, more dynamic and more responsive to emerging service needs.

MORE, FASTER, BETTER

Rapid innovation in online content and application provision implies that an ever-greater share of the consumer wallet is being channeled toward application service providers that use broadband connectivity simply as a delivery mechanism. This presents both a challenge and an opportunity. The challenge is to ensure that the relevance of the connectivity is highlighted through solutions that are able to personalize and adapt the connectivity to individual user or application preferences. The opportunity lies in new business models and service offers that operators are now able to explore.

As new services grow in complexity and sophistication, current centralized data center approaches limit the way certain services can be delivered. New services often need resources and service components that reside in different clouds or network domains, well beyond the boundaries of the traditional data center. WANs and data center networks are becoming increasingly interdependent, driving the need for end-to-end network and integration expertise.

Service Level Agreements (SLAs) that embrace distribution and complexity will be an attractive proposition for users, especially within the enterprise segment.

NETWORK PERFORMANCE IS KEY

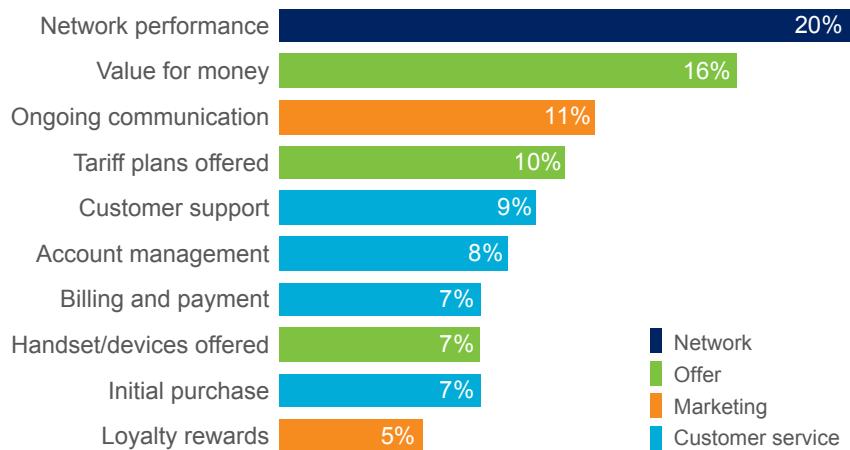
The ever-increasing volumes of data traffic in mobile networks, driven by both the quick uptake of smartphones and the prevalence of streamed audio and video services, create a growing challenge for operators.

Not only do they need to manage the increase in traffic load, they also need to meet rising consumer and enterprise expectations for excellent performance throughout their networks. The need for ubiquitous broadband connectivity is becoming critical. A recent Ericsson ConsumerLab report [1] found that enhancing user experience is critical to retaining paying customers. The study found that the biggest influence on customer satisfaction is network performance (as shown in Figure 1), and that increasing the satisfaction level from "medium" to "high" boosts the chances of a subscriber staying with an operator by more than 50 percent.

In addition to the need to handle increasing traffic loads and satisfy growing performance expectations, operators must also roll out new services rapidly. Getting to market quickly with new services represents a vital competitive edge for any operator or enterprise. New service rollouts that take months or even years to complete will no longer be credible or acceptable.

Finally, in every competitive market there is constant pressure to become more efficient; in other words, to maintain or improve performance at a lower operational cost.

Shapley regression analysis, showing the relative impact between each driver and loyalty to operator brand



Source: Ericsson ConsumerLab Network Performance Study 2013.
Base: 12,169 smartphone users in Brazil, China, South Korea, Japan, US, UK, Sweden, Russia and India.

Figure 1: Key influences on customer satisfaction.

COMMON PLATFORM

Cloud-based approaches enable network operators to ensure rapid service creation and rollout by delivering new levels of flexibility, scalability and responsiveness. They also satisfy the growing expectations for service performance and QoE, while handling ever-increasing traffic loads.

Operators are making use of NFV, SDN and cloud technology in three ways:

- Telecom cloud – operators are gradually turning their networks into layered and distributed clouds, in which workloads can be located to optimize QoE or data transport, and to offer the best possible elasticity.
- IT cloud – operators are optimizing the use of internal IT resources to deliver an improved customer experience, to accelerate time to market for innovative and compelling services, and to improve their efficiency for cost reduction.
- Customer cloud – operators leverage a platform, or their own cloud, to resell or broker value-added cloud services.

Although these scenarios are all quite different, they share some common requirements, and operators can benefit from the implementation of a common platform across all three scenarios.

Combining a Network-enabled Cloud approach (which offers flexible management of cloud applications) with NFV (several virtualized applications on a common hardware platform, which reduces opex and capex) and the real-time control capabilities of Service Provider SDN (as shown in Figure 3) yields significant advantages.

First, it enables operators to more easily (and usually automatically) adapt network characteristics and resources to serve the more dynamic and real-time nature of new services.

Second, it extends the virtual infrastructure beyond the traditional computing and storage resources to enable applications to encompass WAN resources – making it easier to engage one or more data centers, as well as any other intelligent nodes in the network.

Network-enabled Cloud delivers the flexibility and elasticity to deploy software applications and virtualized network functions wherever they are needed in the network. This improves time to market and enhances innovation, QoE and network efficiency.

Service Provider SDN adds SDN capabilities to the network with policy-based and centralized control to offer:

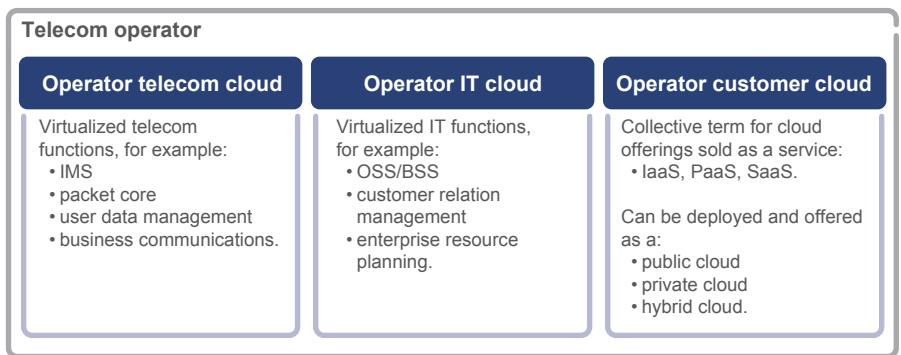


Figure 2: Three operator cloud deployment scenarios.

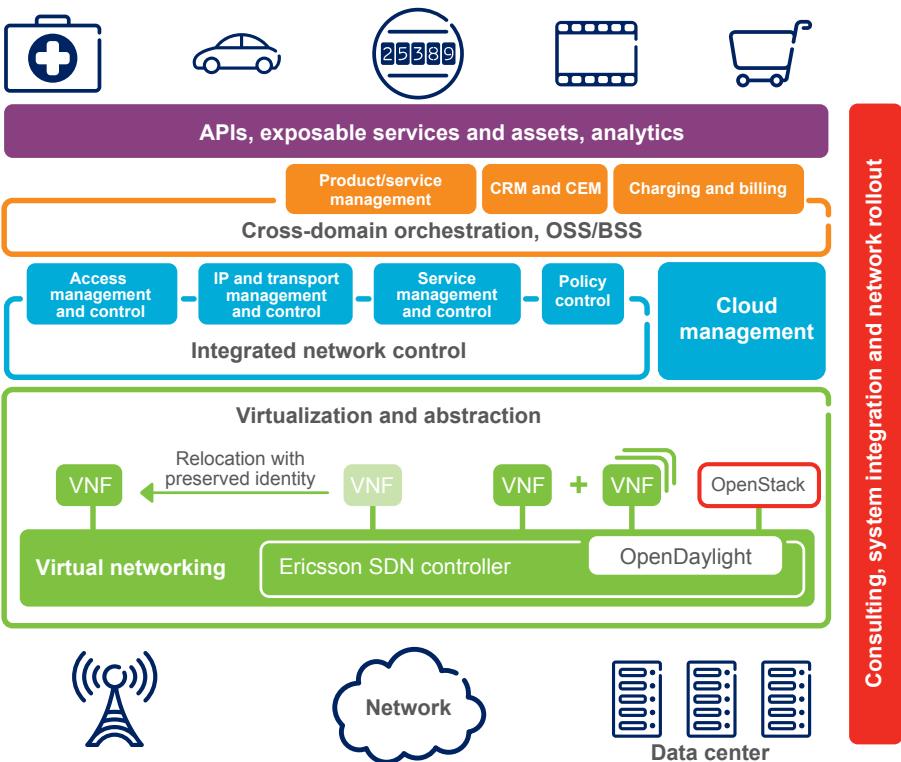


Figure 3: Combining Network-enabled Cloud, NFV and Service Provider SDN.

- > Network programmability, which introduces virtualized, software-based network services onto the Network-enabled Cloud wherever needed.
- > Payload elasticity, which enables resources to be allocated dynamically in real time.
- > Extended reach over the network, without compromising service quality.
- > New levels of information security.

NFV provides the means to virtualize applications and to be able to run them on different hardware platforms, whether telecom grade or commercial off-the-shelf (COTS). The virtualization of a network must include the following characteristics:

- > Seamless user experience of network functionality, whether implemented in legacy architecture or as a virtualized application.
- > Telecom-grade performance, meaning, for example, high availability, redundancy and upgradeability. This can be achieved using telecom grade platforms, or through a redundant and high availability network design of selected third-party provider COTS platforms.
- > Coexistence with the legacy network, as well as a common network management and orchestration.

NETWORK-ENABLED CLOUD

Guaranteeing end-to-end service performance is crucial. Network programmability delivers the flexibility that operators need to offer customer-specific SLAs rather than just best effort connectivity.

Bringing cloud capabilities into the network makes it possible to enhance QoE, while simultaneously improving the efficiency of the network itself. It also enables the distribution of applications to any location in the network, which optimizes the use of available infrastructure and network characteristics such as bandwidth and latency.

The network-enabled cloud is built on four main criteria:

- > Every node is capable of hosting distributed applications in a cloud-execution environment, based on hardware virtualization.
- > Data centers are located close to the point of data consumption and generation, so that virtualized network functions and innovative software applications can be distributed as needed.
- > Telecom-grade performance and a strong focus on user experience are essential.
- > Perhaps the most attractive benefit of this cloud-based approach is the ability to allocate resources elastically. Operators can scale resources up or down within predefined limits in response to changing demand.

Performance requirements differ between various applications with respect to latency, throughput and cost. Latency-sensitive applications (such as gaming, voice and video) benefit from the characteristics offered by regional, metropolitan or access clouds. Similarly, best effort, non-latency sensitive applications benefit from the cost advantages of national or continent-wide data center solutions. In essence, the cloud should be distributed across a geographical area appropriate to the performance characteristics needed for each service or customer. This means multiple data centers need to be managed at the same time, with a strong emphasis on efficient networking.

A distributed cloud must support the deployment and migration of applications between the infrastructures present in different parts of the network. This is best achieved by using an open cloud execution environment, orchestrated by a flexible cloud manager. Open cloud standards will support the transfer of services between networks and data centers, and will enable the speedy introduction of new services.

NETWORK FUNCTIONS VIRTUALIZATION

NFV leverages standard virtualization technologies to consolidate network applications – which have traditionally been hosted on proprietary hardware appliances – onto industry standard servers, switches and storage. In addition to reducing expenditure on equipment costs, virtualizing network functions also brings benefits such as rapid scaling of applications, faster speed of innovation, increased high availability and improved resource utilization.

However, realizing these benefits requires that the underlying network infrastructure is adapted quickly and automatically. For example, for a network function to either scale up or migrate onto a new piece of hardware, the security and policy configuration associated with that network function may have to be provisioned on a large number of switches and other network functions. The complexity of configuring networks in such a dynamic environment increases greatly as the number of network elements increase.

SERVICE PROVIDER SDN

Software-defined networks separate the control plane – where the logic of path computation for complex networks has been implemented – from the data plane, where packets are forwarded based on decisions made by the control plane. The control plane in software-defined networks works in conjunction with cloud management systems in order to dynamically configure network elements to adapt to changing resource usage decisions made by cloud orchestration systems. SDN provides the infrastructure required to truly realize the potential of NFV.

In cooperation with service providers, the definition and applicability of SDN technology has been expanded beyond data centers (where it has traditionally been used). However, fully realizing the potential of this technology in today's service provider networks means doing more than just separating the forwarding and control planes. This expanded definition of Service Provider SDN includes:

- Integrated network control – this unified control layer controls the data center and network as an integrated entity, in order to deliver the best user experience.
- Orchestrated network and cloud management – a unified approach that includes legacy network management and new cloud management systems. It is this end-to-end orchestration that enables flexible service creation, which in turn makes the network dynamic, adaptive and agile. This cuts introduction and modification cycles for services and removes barriers to innovation.
- Service exposure – the SDN architecture provides network awareness to the application layer through service exposure application programming interfaces (APIs). These APIs not only provide raw network data, but are instead composed APIs that deliver actionable information at the application level.

The promise of Service Provider SDN is to convert the network into a real-time, programmable entity that will enable personalization of connectivity and the services offered through that connectivity. This increases the relevance of the network operator in the new ecosystem. It contributes to increased customer loyalty, and enables business model innovation between the consumer, the network operator, and the content or application provider ecosystem.

One of the benefits of Service Provider SDN, especially from a network-spanning perspective, is network virtualization. This enables the exposure of logical abstractions of a network, rather than direct representations of the physical network.

Service Provider SDN builds upon the concepts of both NFV (the ability to offer virtualized network functions) and SDN (the ability to provide abstractions at the transport layer). The Service Provider SDN architectural model consists of a common orchestration layer that spans multiple network domains (such as transport, access and data center). This service control layer essentially provides abstraction at the service level by offering simple interfaces for service development, deployment, provisioning and management.

With integrated network control and an orchestrated network, operators can use their network features – including QoE, edge functions and real-time activity indicators – to deliver superior user experience. This transformation will necessitate the integration and unification of legacy network management systems with new control systems, in addition to OSS and business support systems (BSS).

The next logical step is to be able to expose key elements of the orchestration platform and the control plane to network and subscriber applications and services. Using northbound APIs, the orchestration platform can be exposed to key network and subscriber applications and services.

Together, the APIs and platforms enable application developers to maximize network capabilities without requiring intimate knowledge of their topology or functions.

COMMON MANAGEMENT AND ORCHESTRATION

Managing resources in the cloud requires a structured, disciplined approach, which automates and orchestrates the provisioning processes and makes resources available on demand. However, the approach must also be capable of managing these resources in the context of complex, dynamic systems that require resource access control, as well as service quality management and optimization. It should be flexible enough to enable operators to create services from scratch, or to reuse internal resources and broker an ecosystem involving third parties, where the brokering adds value primarily through management.

Cloud management encompasses:

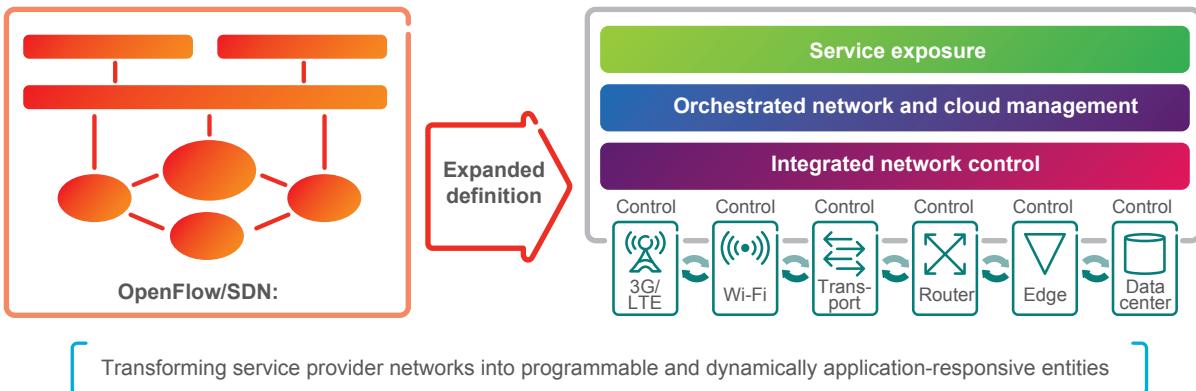


Figure 4: : Expanded definition of Service Provider SDN.

- > Self-service portals, which enable rapid uptake of new services.
- > Automatic orchestration of the provisioning of software applications onto virtualized resources, either owned or accessed from third parties.
- > Cloud business models, which provide billing based on measured usage and allocated capacity.
- > The definition, implementation, enforcement and validation of end-to-end SLAs.

Security is also a key requirement. Operators need to meet customer expectations, while optimizing the use of resources in compliance with all legal and regulatory restrictions. Self-provisioning capabilities must also come with appropriate levels of security.

The service control layer of the Service Provider SDN architecture brings elastic, real-time allocation of resources for networking services. It enables these services to be defined and provisioned through self-service portals in a matter of minutes, rather than the days, weeks or even months that are traditionally required.

This demands a platform with integrated control across networking domains that exposes “composed APIs” for new revenue generation. An end-to-end network management system across IP and transport infrastructure provides further efficiencies, develops greater responsiveness, and enables more reliable planning, provisioning, activation, adaptation and control of new service connections.

The goal is to couple cloud management to a programmable network, via SDN controllers, to achieve full integration of the cloud and network, where cloud resources are no longer confined to a single data center, but are spread throughout the network.

Using common orchestration for end-to-end service management as well as for operations, administration and maintenance reduces operating costs in areas such as provisioning, monitoring and faultfinding.

More importantly, end-to-end orchestration enables flexible service creation, which makes the network dynamic, adaptive and agile.

USE CASES

A cloud system that integrates seamlessly with a real-time, programmable network – enabled by Service Provider SDN – can provide significant value to network operators and their subscribers (both consumers and enterprises). Today, most subscribers do not rely on connectivity alone. Instead, they demand a wide range of services that are cloud-hosted, and they require the network to play a role in offering the right connectivity for the desired application. This is where the real value of a Service Provider SDN-based, real-time programmable network and cloud becomes apparent.

A “meta” use case is the ability to slice and offer consumers/enterprises a piece of the network-plus-cloud for their dedicated, personalized use. There are multiple variants of use cases that are based on this concept of the ability to slice networks to suit different applications and enterprise needs.

One such case is the Virtual Enterprise IT Infrastructure – in which an SDN-based gateway can be extended to the enterprise premises. The solution features tight coordination between a feature-rich cloud controller and an SDN controller. This enables the instantiating, replicating and migrating of network and cloud-based services to the best available location, based on the

tenant's requirements, overall network congestion and cloud availability. True to the ideal of not tying cloud services to the constraints of a physical data center, this solution implements flow tracking and policy enforcement at a "logical" cloud level. This encompasses multiple operator data centers, irrespective of their geographic locations and the network infrastructure connecting them.

Another case is the virtual home gateway. This is an example of virtualizing some of the functions of a traditional home gateway and hosting them in a Network-enabled Cloud. Virtualization reduces the complexity of the home gateway by moving most of the sophisticated functions into the network. As a result, operators can prolong the home gateway refreshment cycle, cut maintenance costs and reduce time to market for new services. The most important aspect of this solution, however, is that it gives the network visibility to all the devices that were traditionally hidden behind the home gateway. This opens up significant revenue opportunities through the ability to offer services that are personalized in a much more granular way.

Another case that brings out the value of a combined real-time programmable network and cloud solution is the ability to dynamically extend network functions into the cloud – with SDN, NFV and the cloud all working together. As the load on a network appliance increases, the SDN controller can request a peer cloud manager to instantiate a virtual network function in the cloud and to start load balancing between the physical appliance and the virtual appliance, treating it as a common entity.

The more traditional and now widely accepted Service Provider SDN use case of dynamic service chaining* itself relies on tight interaction between the network and the cloud. For inline services, such as content filtering, header enrichment, firewalls and Network Address Translation (NAT), operators use different appliances, or value-added services to manage subscriber traffic. These inline services can be hosted on dedicated physical hardware or on virtual machines (software appliances running in a virtualized cloud environment). Service chaining is required to route certain subscriber traffic through more than one such service. Solutions currently available are either static or their flexibility is significantly limited by scalability inefficiencies.

Dynamic service chaining can optimize the use of extensive high-touch services by either selectively steering traffic through specific services or bypassing them completely. This can provide capex savings through efficient use of capacity. Greater control over traffic and the use of subscriber-based selection of inline services can lead to the creation of new offerings and new ways to monetize networks.

The Network-enabled Cloud provides the necessary virtual resources for software appliances, whether on dedicated physical hardware or on virtual machines, and supports efficient distribution of these resources wherever needed in the network, such as to best meet latency requirements.

Scaling a software appliance can be achieved either by requesting more cloud capacity in the Network-enabled Cloud or by requesting virtual resources in a centralized cloud data center. The flexibility of the distributed cloud is greatly enhanced using the Service Provider SDN real-time control mechanism, in which software appliances can be moved within or between clouds while preserving the networking attributes and requirements.

* Selectively steering traffic through specific services such as NAT and deep packet inspection without needing to pass dedicated hardware for each service.

CONCLUSION

Operators are in a unique position to offer services that transcend the boundaries of the traditional data center without compromising on quality. New levels of innovation are possible when leveraging resources residing in different clouds or network domains.

These new capabilities are made possible by implementing a combination of:

- > Network-enabled Cloud, which extends virtual infrastructure beyond the traditional computing and storage resources to encompass network resources.
- > Virtualization of network functionality, allowing portability of virtualized network functions to different hardware platforms, which reduces the number of platforms in the operator network.
- > Real-time control capabilities of Service Provider SDN, which enables operators to more easily adapt their networks to the real-time requirements of newer services.

The result will be an improved experience for both consumers and enterprises with greater efficiency, lower costs and higher margins for operators.

GLOSSARY

API	application programming interface
BSS	business support systems
CEM	customer experience management
CRM	customer relationship management
COTS	commercial off-the-shelf
IaaS	infrastructure as a service
NAT	Network Address Translation
NFV	Network Functions Virtualization
OSS	operations support systems
PaaS	platform as a service
SaaS	software as a service
SDN	software-defined networking
SLA	Service Level Agreement
VNF	virtual network function

REFERENCES

1. Ericsson, June 2013, Keeping Smartphone Users Loyal – assessing the impact of network performance on consumer loyalty to operators. Available at:
<http://www.ericsson.com/res/docs/2013/consumerlab/keeping-smartphone-users-loyal.pdf>

FURTHER READING

Ericsson, November 2013, Ericsson Mobility Report. Available at: <http://www.ericsson.com/ericsson-mobility-report>