broadband forum

Fixed Access Network Sharing (FANS)

BUSINESS OVERVIEW

1   A new network business model with Fixed Access Network Sharing

This paper examines the potential positive business and operational impact of Fixed Access Network Sharing (**"FANS"**). FANS enables broadband network infrastructure, and network management, to be shared amongst operators with resulting cost and standardization benefits along with the opportunity to handle a wider variety of service offerings.

As the wireline broadband network evolves to gigabit-class deployments with virtualization, the supporting business models are also evolving. FANS enables sharing the costs of gigabit-class broadband deployment while enabling operators to run their own operations.

The paper discusses this evolution for the players involved. Acting in a wholesale role, we define an **Infrastructure Provider** ("InP") as the organization responsible for maintaining the physical resources of the network and making them available to **Virtual Network Operators** ("VNOs") who provide services to their end-user customers.

Compared with deploying multiple parallel networks, FANS can lower capital costs. Moving from a single InP brownfield scenario to FANS may require upgrading systems and operations to enable FANS which could incur costs for the InP. These requirements are discussed in the paper.

This document's principal reference is Broadband Forum TR-370, *Fixed Access Network Sharing - Architecture and Nodal Requirements* published in 2017[1]. FANS is built on a body of related Broadband Forum work cited in the references.

2   What FANS provides

FANS attributes include:

- FANS enables network sharing and wholesale access [2]
- FANS applies when a VNO controls a physical access network that supports virtual unbundling to Virtual Network Operators
- FANS specifies standard interfaces that allow diagnostics and status data to be disseminated to VNOs
- FANS allows a VNO to request or perform changes in network configuration and control their own virtual network
- FANS interfaces enable automated operations spanning InP and VNO domains. An objective of FANS is to enable VNOs to perform operations with virtual unbundling similar to their operations with physical unbundling.

Not only is the physical access network provided by the InP and shared with FANS, but management data, configuration and control are also shared.

This paper describes FANS, its impact and the evolution of FANS in the Broadband Forum.

3   What is FANS?

FANS allows a single physical network to be shared among multiple operators. Figure 1 shows how a single network and its equipment is administered by an InP, and a centralized management system controls the physical network resources so that they are logically divided between several VNOs, each of which has their own virtual network slice.

The access node is generalized terminology for a DSL access multiplexer (DSLAM), optical line terminal (OLT), or Cable Modem Termination System (CMTS). The aggregation node aggregates traffic between access nodes and VNOs.
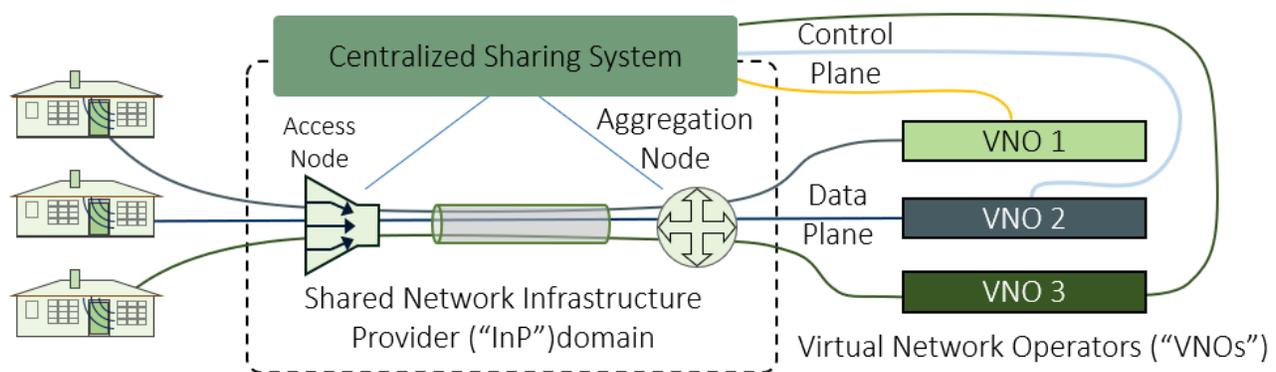

Figure 1. Network sharing, showing network slices in different colors.

There are two FANS architectures: Management-system based sharing, and virtual node-based sharing.

3.1   Management-system-based sharing

The centralized management system in Figure 2 is the core of management-system based sharing. With this sharing technique, a management system performs the network partitioning at the management system level and not directly in the equipment itself. The management system supports multi-tenancy, where each VNO is a separate tenant.
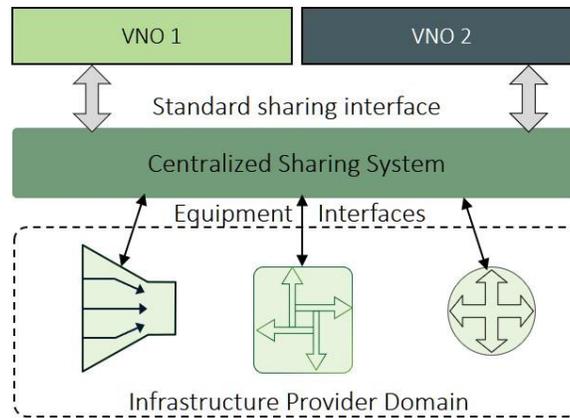

Figure 2. Management System based Sharing: management plane

Management system sharing separates the management plane from the data plane, with sharing and network slicing performed by the management systems. The data plane can remain unchanged, and data-plane functions such as packet forwarding continue to be performed in the network elements. In addition to system functions such as access control and resource allocation, the management system can assign ports, assign access and mediated backhaul bandwidth, and configure access node forwarding cross-connects.

3.2   Virtual node sharing

Virtual node sharing is performed by virtualization both in the cloud and in the equipment, including access nodes, aggregation nodes, and virtual port mappers [1]. A port mapper maps a disparate set of physical ports into a logical set of ports assigned to each VNO. The virtual access node model performs equipment slicing on physical access nodes to abstract them into multiple virtual access nodes, where each VNO accesses a logically separate virtual access node.

Virtual node sharing can be used with access nodes and other network nodes including virtual aggregation nodes (e.g. Ethernet Aggregation Switch, MPLS router, SDN switch) [1].

3.3   Centralized Management System

FANS is likely to be implemented using a centralized management system, as shown in Figure 1 and Figure 2. The centralized management system has Southbound interfaces to equipment, and Northbound interfaces to VNO systems. The centralized management system conceptually glues FANS together and performs functions such as Authentication, Authorization, and Accounting (AAA), privacy, arbitration and assignment of resources, and control and diagnostics signaling. The centralized management system can perform some operations for some VNOs, while other VNOs may perform those operations themselves.

There are additional interfaces between InPs and VNOs beyond FANS that may or may not involve the centralized management system, including Business support system (BSS) interfaces, test and diagnostics interfaces, and logical inventory interfaces.

3.4   Resources management and security

Resources must be assigned to control access permissions, arbitrate conflicts, ensure appropriate resource allocation, ensure that any particular VNO cannot impair another VNO's service, and guarantee availability for the underlying physical infrastructure. Also, resources will be shared in accordance with regulatory constraints and contractual agreements. A VNO cannot be allowed to access any data about another VNO's customers. Computing resources can be shared between any or all of the actors, this is particularly important for virtual functions.

3.5   Backhaul

The backhaul or transport network extends from the access node to a reference point where the data traffic is handed-off to a VNO. This may occur at various points, including: in the outside plant at a cabinet location, at the V-interface between access and backhaul network, at a point in the backhaul provider network, at the interface to backhaul network(s) as defined in TR-178 [4].

Traffic on the backhaul broadband network needs to be segregated between different operators. Backhaul segregation and traffic forwarding can be done via Ethernet VLANs using an Operator VLAN tag, using MPLS tunnels, or using VXLAN tunnels.

4   The Impact of FANS

Deploying gigabit-class broadband networks is very costly in terms of both upfront investment and resources needed for design and implementation. Multiple parallel networks covering the same areas can lead to low take up rate and long return on investment. The ITU Commission for Sustainable Growth [5] and the European Commission have recognized that sharing infrastructure can speed broadband rollouts. In some countries, including Portugal, Spain and the UK; regulatory bodies have taken into account this consideration and have created rules for sharing existing passive infrastructures.

4.1   Stakeholders

FANS specifies interoperable interfaces between an Infrastructure Provider (InP, aka wholesaler) and multiple Virtual Network Operators (VNOs, aka retailers). The InP operates the physical network, while the VNOs interface to broadband consumers.

The InP is responsible for deploying and managing the physical network; the InP:

- Enables physical resource sharing and carries out the required partitioning
- Provides an interface to the VNO for data and control
- Gets revenue from resource leasing

The VNO leases resources from the InP, and the main VNO functions are:

- Utilize the network resources provided by the InP to provide its services
- Operate, control, and manage its own virtual networks
- Run and redesign customized systems in its own virtual network, such as diagnostics and optimization systems
- Provide specific and customized service through its own network
- Obtains revenue by selling services to end-users

4.2   Current multi-operator landscape

Competition today is often enabled by facilities-based physical unbundling at the Central Office (CO) or Exchange, with competitive providers deploying their own access nodes and leasing copper telephone loops from InPs. Physical unbundling (also called passive access [2]) allows a retail operator to run all their own operations and independently offer services. Physical unbundling is very popular in some regions (e.g., Europe) and has, arguably, led to low-cost and high-speed service to consumers.

"Virtual unbundling," (also called active access [2]) allows multiple VNOs to share a broadband network and equipment. Virtual unbundling has two flavors: bitstream and Virtual Unbundled Local Access (VULA). Bitstream is generally provided by giving each VNO access to their customers at the IP layer or at layer 2, and is simple resale of the broadband service provided by the InP. VULA is generally provided by Ethernet-layer active wholesale and can be configured to enable layer 2 class of service differentiation and sometimes multicast. Currently, with both bitstream and VULA, wholesale management operations and backhaul are currently opaque to the VNO, although there are limited exceptions.

FANS allows the cost sharing benefits of active access, but with the management and control operations of passive access.

4.3   Gigabit-class broadband and FANS

As both Fiber to the Node (VDSL), and Fiber to the Distribution Point (Gfast) rely on vectoring [6], physical unbundling beyond the CO/exchange is *technically* unattractive. Physical unbundling with Fiber to the Premises /Fiber to the home using Passive Optical Network technologies is technically feasible using an overlay network or separate wavelengths. However, physical unbundling with such an overlay network is *economically* unattractive since it requires each operator to have their own fiber, increasing the number of fibers needed and so increasing the related costs.

So the future of multi-operator access environments will depend on deployment of virtual unbundling. However, virtual unbundling needs to be enhanced to allow retailers to perform their network operations in a way that essentially matches that of physical unbundling.

4.4   The FANS Solution

FANS encourages multiple operators to pool resources to offer gigabit-class broadband across a wide area to share capital costs at a reasonable spending level for each operator. FANS can support the more agile creation of business-class services, linear video broadcast, and real-time service variations such as turbo-boost, real-time charging, and other functions that are required in a vibrant competitive access environment.

FANS is desirable in its ability to drive economic growth of broadband services at a lower cost and at a lower operational complexity than current alternatives, and to encourage competitive innovation and services differentiation.

New network sharing and management capabilities and interfaces and new business arrangements have to be developed and implemented to enable FANS. While the Broadband Forum is specifying the technical constructs needed for FANS, such as interfaces, commercial offerings and adoption of business arrangements are the purview of others.

4.5   FANS features

Currently operations "interfaces" between InP and VNO are often manual. In conjunction with appropriate business arrangements, the infrastructure and interface of FANS can be used as part of automating operations interactions between InPs and VNOs; including fault, configuration, performance monitoring and optimization. In particular, standardized FANS interfaces allow efficient data exchange between all parties.

FANS can improve customer satisfaction by enabling rapid response times, increase the number of customers and enhance competitiveness with other broadband media. The InP can offer enhanced product offerings to the VNOs, with enhanced value for providing access to automated data and control interfaces.

FANS features include the following (note that some of this functionality can be done without FANS):

Performance monitoring and optimization allows each VNO to have automated real-time access to performance monitoring and fault data. Further, together with data sharing [3] multi-line optimizations can be performed across multiple operators' lines by a centralized management system, which can increase performance of all lines.

Fault correlation can be performed using shared data to correlate multiple faults across multiple lines and multiple service providers; and this can further be used to help coordinate and avoid duplication of dispatches.

Configuration can be automated, so that a VNO can rapidly turn-up service. VNOs can offer services with different QoS levels, for example to maximize speed or stability, or to minimize delay or power usage.

Services innovation can flourish, for example VNOs can provide different types of services, business class services, sponsored services, real-time services, etc. This can build on basic broadband offerings to grow the pie for all entities.

Network planning can be enhanced with network topology and capacity data. Lines in a small geographic area should all have about the same performance; this data can be anonymized by a sharing system to provide line performance projections to VNOs.

A **single operator** can exploit FANS within their company, segmenting the network among different operation teams serving business customers, consumer broadband, mobile backhaul etc. - thus providing each internal business area with its own customized services, management criteria, and customer interfaces.

4.6   Introducing Network Sharing – Considerations for the InP

There are a number of considerations that an InP needs to take into account. Most InPs already have processes and systems in place for both retail and wholesale business services as well as consumer services, however implementing FANS may involve extensions to these.

Best practices should be applied to ensure no leak of commercial or customer information between VNOs proper security, privacy, GDPR implications, preservation of net-neutrality, performance reporting and automated support monitoring and reporting, planned maintenance, etc. This will also include how

existing network capacity planning and resource management are handled. All of which are business as usual so that no disruption is envisaged with the introduction of Network Sharing.

In the Network Sharing model, InPs will need to consider the extent to which they allow VNOs to directly configure, monitor and diagnose services in a way that preserves the technical integrity and business confidentially of their services. This will be certainly dependent on the service offerings, use or exposure of existing or required portals or APIs to allowed well-controlled remote resource or service requests.

It is also likely that InPs and VNOs will require enhancements to management/OSS systems to support specific service requirements.

It is suggested that not all of these need to be introduced immediately but can be developed incrementally based on successful adoption.

4.7   Network Sharing Start up considerations

Providing a shareable, single infrastructure is undoubtedly more cost-effective than multiple infrastructure providers over-building in the same area. To make the infrastructure shareable the InP should examine the considerations in the previous sections to determine if additional functionality is required immediately or can be added incrementally as funded by the additional revenue generated. For example, the additional increasingly automated functionality can be entertained after the services are turned up and experience is gained by the parties. In the case where VNOs require upgrades to OSS/Orchestration then this is a matter for discussion on how these are best funded.

As there are many possible business scenarios it's beyond the scope of this paper to make specific recommendations against all possibilities. As one example, however, if an InP is in a position to take on a number of initial VNOs then there are many ways that the specific requirements could be funded from revenues rather than non-recurring engineering costs.

5   FANS in the Broadband Forum

The Broadband Forum has a global constituency with broadband operators and vendors of many types, and so is positioned to specify common architecture, methods and interfaces to support FANS. The Broadband Forum FANS project investigates aspects associated with FANS that involve access network functionality, including operations, management, interfaces, access nodes and aggregation nodes.

BBF MR-229 [2] presented relevant Broadband Forum and MEF specifications for next generation broadband access networks operating in an open access environment, including architectures, service definitions, interconnections, Quality of Service, multicast, and Ethernet Operations, Administration, and Maintenance (OAM).

The Broadband Forum has defined the interface for data sharing for managing DSL in TR-349 [3]. This was built on initial work in the UK [7] on data sharing for DSM.

5.1   Broadband Forum FANS Architecture

The Broadband Forum FANS project is generating various specifications, the first of which is TR-370 defining architectures and interface points for FANS. Both management-system based sharing (described in Section 3.1), and virtual access node-based sharing (described in Section 3.2) are included in TR-370. The relationship of FANS and ETSI NFV, requirements, and OAM aspects are also in TR-370.

5.2 Broadband Forum FANS Interfaces

A document entitled "Fixed Access Network Sharing - Access Network Sharing Interfaces" is in progress. This includes descriptions of capabilities exposed by FANS interfaces between VNO and InP, information exchange between FANS systems and operations surrounding this exchange, and actual definitions of YANG data models or other interfaces that implement FANS.

Further FANS specifications being considered by the Broadband Forum include SDN-enabled FANS and access network virtualization.

5.3 Virtualization and Broadband Forum CloudCO

The Broadband Forum CloudCO project [8]is defining how to virtualize Access Nodes and functions and it can be an enabler for facilitating FANS deployment.

6 Summary

Gigabit-class broadband deployments are changing the competitive landscape. Moreover, the coverage of next generation access networks (e.g. FTTx) continues to increase. With current bitstream or VULA virtual unbundling, operations "interfaces" between InP and VNO are often not real-time, and VNOs provide simple resale with little or no services differentiation.

FANS extends virtual unbundling to unbundle management and control functions, enabling network sharing and data sharing. FANS opens up management and control interfaces such that VNOs can perform the same operations as they would with physical unbundling. This enables competition based upon differentiation of offered services between providers. Much as the Internet offers a platform for innovative applications, so FANS can offer a platform for innovative broadband services.

Standardized interfaces and a centralized management system are keys to enabling FANS in the near-term. Longer-term, virtual nodes, and full virtualization will all feed into enabling FANS. Resource control, AAA, security and configuration control must be carefully administered with FANS to ensure privacy and avoid harm to the network.

FANS benefits, both to InPs and VNOs, include

- Multiple companies can share the costs of network upgrades to gigabit-class broadband
- Automated interfaces lower operational costs relative to manual interfaces, both for the InP and the VNOs
- FANS enables enhanced service levels, services differentiation, and innovation.
- The InP can offer enhanced services to the VNOs
- The VNOs can offer enhanced services to the broadband customers, e.g., enterprise
- Fault correlation across multiple operators' lines and multi-line optimizations are enabled

7 References and Abbreviations

The following is a limited list of references and abbreviations. Please download TR-384 for a complete list.

7.1 References/Links

[1]	TR-370	Fixed Access Network Sharing - Architecture and Nodal Requirements	BBF	2017
[2]	MR-229	ADSL Transceivers	BBF	2010
[3]	TR-349	DSL Data Sharing	BBF	2016
[4]	TR-178i1	Multi-service Broadband Network Architecture and Nodal Requirements	BBF	2014
[5]		The State of Broadband: Broadband catalyzing sustainable development	ITU	2016
[6]	MR-257	An Overview of G.993.5 Vectoring	BBF	2016
[7]	ND1518	Data Sharing for DSM	NICC	2015
[8]	TR-384	Cloud Central Office Reference Architectural Framework	BBF	2018

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7.2 Abbreviations

InP	Infrastructure Provider: the organization responsible for maintaining the physical resources of the network and making them available to VNOs
VNO	Virtual Network Operator
VULA	Virtual Unbundled Local Access

8 Acknowledgements

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9 About the Broadband Forum

The Broadband Forum, a non-profit industry organization, is focused on engineering smarter and faster broadband networks. The Forum's flagship TR-069 CPE WAN Management Protocol has now exceeded 800 million installations worldwide.

The Broadband Forum's work defines best practices specifications and software for global networks, enables new revenue-generating service and content delivery, establishes technology migration strategies and service management for the connected home, Cloud, Access and 5G broadband ecosystem.

The Forum's Open Broadband strategy brings together open source agility and standards-based architecture to enable large-scale markets. We develop test interoperability and certification specifications and programs to accelerate deployment. Visit www.broadband-forum.org. Twitter @Broadband_Forum.

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