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Spectrum and Network Sharing Models

Trends & Business Impacts

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Forward-looking access service providers have amassed considerable fiber optical assets complemented by Wi-Fi services. These operators are now considering the next stage of revenue generation and growth. This paper discussed the synergy with Mobile Network Operators (MNOs) in light of ongoing business model and technology developments, with a focus on evolving network and spectrum sharing trends. It also addresses the direct impact on service providers' business models, and concludes on the likely emergence of large-scale Internet and cloud-centric virtual operators.

Network Sharing Models – Situational Overview

There are two angles to the resource-sharing models: the first angle relates to passive infrastructure sharing which is being pursued throughout the world in various forms (e.g. tower sharing) and active infrastructure sharing, and through an extension of it, of spectrum resources. It's the latter angle that is now gaining direct attention where various models under experimentation.

Over the last few years, various forward-looking operators, and specifically fixed-line operators, have taken the lead in building high-speed fiber access networks (FTTx: Fiber to the Premise/Home/Curve). With such achievements, they have, without explicit planning, put together the initial building blocks for global leadership in optimized neutral host and infrastructure sharing service. In fact, as 3G and 4G networks got deployed, requirements for high-speed backhaul grew, which provided some of these operators with a unique opportunity to leverage their fiber infrastructure for this purpose, mostly as wholesale backhaul capacity to mobile network operators. The rapid increase in 3G and 4G capacity requirements driven by the bandwidth requirements of over-the-top applications led to a fast-growing need of complementary technologies to accommodate the growth in demand for capacity. This in turn provided these operators with the opportunity to augment their fiber networks with Wi-Fi rollouts, and leverage Wi-Fi assets as complementary building blocks for their neutral host infrastructure sharing plans through Wi-Fi wholesale and offload offerings. With this, both the fiber and Wi-Fi infrastructures would form the backbone of these operators wholesale and infrastructure sharing strategy.

Active Infrastructure Sharing – Market and Technology Trends

Given this development, the question converges on what additional technology deployment strategies would be required to re-enforce and augment the infrastructure sharing model? Few propositions could be positioned, but the most immediate and relevant would be a direct complement to the backhaul and Wi-Fi plays that would simultaneously address the common customer base of both Wi-Fi and backhaul services (i.e. MNOs and enterprise / business venues), provide a direct competitive advantage against potential competitors, and solves some immediate problems faced by this specific customer base.

In analyzing the various arguments, the following is emphasized:

(a) The most urgent concern of MNOs is to optimize capex and opex while they augment their coverage and capacity requirements. DAS and small cell buildouts are specific areas where this concern is acute, and hence, MNOs are receptive to business models that would allow them to build such complementary networks while keeping their costs in check.

(b) The competitive MNO environment in different telecom markets and the stringent requirements of end users, be they business venues or the customers of such business venues, is forcing MNOs to act promptly on their network coverage and capacity upgrades that adds a time constraint dimension to the capex/opex considerations.

(c) The trend of mobile operators in some markets having to increasingly compete on services rather than coverage, is forcing them to put their energy into the services layer, which provides them an incentive to share more network resources to meet coverage objectives.

(d) In some select telecom markets (example Southeast Asia, Africa, Middle East), some lead operators are in a unique position where, as a non-mobile operators (so far), they are perceived to be neutral and not a threat by the MNOs which is conducive for strategic partnerships.

(e) The architecture of the wireless base stations has evolved to a split architecture that separates the baseband processing from the radio module. Many operators have already or are in the process of migrating to this new base station architecture, which requires fiber connectivity between the baseband module and the remote radio head. The fiber connectivity is referred to as 'fronthaul' and is seen as complementary in function to backhaul that connects the base station baseband module to the core network. This provides a unique opportunity for select network access operators with substantial fiber deployments to provide fronthaul as a service expanding on existing backhaul business with the MNOs.

Pushing Ahead with DAS and Small Cells

Focusing on DAS and small cells technologies with the above in mind, two fundamental questions need to be considered:

(1) What strategy to consider in successfully implementing a DAS and small cell infrastructure-sharing business model?

Our detailed analysis of the vendors and their offering in this space, technology readiness, MNO readiness, acceptance and leverage in select markets (Southeast Asia and Middle East) concludes that a shared active DAS deployment model would be the first step to consider mostly because sharing (specifically for passive DAS, and to a large extent for active DAS) is already a common practice between MNOs. Upgrades from passive to active DAS systems are becoming required with the roll out of LTE, particularly as LTE offers high data rates at modulation levels that require good signal quality which passive systems will be challenged to provide not to mention the opening of new frequency bands in 2300 and 2600 MHz that stresses the capability and performance of passive DAS systems. Such developments require fiber connectivity and ultimately provide network access operators with leverage in commercial venues and business relationships.

In parallel, a small cell sharing strategy (including the small cell / Wi-Fi combo solutions) would be built initially on the basis of optimized shared backhaul to small cell sites, and over time evolve to shared small cells when the technology is ready (multi-frequency/channels, virtualized management, etc.) and sufficiently mature to be deployed in a multi macro/small-cells vendor environment where MNOs allow third-party management of the small cells network. As such, priority is currently on active DAS shared deployment first with the building blocks of a small cells sharing model to be put in place over time (backhaul/fronthaul then small cells).

This strategy is enforced by difference in applications between DAS and small cells where the business case for DAS is more efficient than small cells in large venues while small cells are more efficient for small venues.

(2) Given the strategic investment by some of the operators we have analyzed in Wi-Fi, how would such shared active DAS deployment complement the overall plan, and what else could be done to re-enforce it?

Today's Wi-Fi and DAS/small cell networks are distinct, and could play complementary or competitive roles based on how they are positioned. Most MNOs see Wi-Fi and DAS/small cells as complementary, addressing different traffic profiles, usage behaviors, geographical fit, etc. In other words, they are likely to co-exist for the foreseeable future to address complementary needs. Synergies do however exist between these technologies where the possibilities include: leverage of a common management/authentication backend in MNOs' networks, leverage of common user billing platforms, and leverage of similar VAS (specifically if Wi-Fi traffic is backhauled to the network core). At the same time, these technologies re-enforce each other when it comes to new customer acquisition and/or customer retention. With such MNOs having lead on the Wi-Fi angle, a lot of what is already done with Wi-Fi can be leveraged as per the above, from common fiber and backhaul infrastructure already built by these forward-looking operators for their Wi-Fi, to common backend/billing/management, to interaction with common customers/venues that would benefit from the complementarities of Wi-Fi and the DAS/small cell infrastructure. As such, having Wi-Fi and the underlying infrastructure in place highly increases the value proposition of these operators in positioning a sharing model with Wi-Fi and DAS continuously re-enforcing each others in terms of value to the MNOs as the shared infrastructure is built.

New Opportunities Beckoning – Towards Cloud RAN

We have already mentioned that the evolution of the base station to a split architecture introduced the concept of fronthaul, which is the connectivity between the baseband and radio modules. While this can be considered a complementary concept to backhaul, significant differences exist which are driven by the technical requirements. Fronthaul requires an order of magnitude greater capacity than backhaul and is subject to stringent requirements for other technical parameters like delay and jitter. MNOs looking to maximize performance have an option to deploy Cloud RAN architecture in the future where centralized baseband processing drives a number of remote radio heads. The remote radio heads can be deployed in macro cell configuration or in small cell configuration. In both cases superior performance can be achieved over traditional distributed architecture (average 20% on uplink and 5-15% on downlink). To realize these gains, the business case for dark fiber for fronthaul needs to be sufficiently attractive. This is another area where forward-looking access operators can aim at. In our studies of the market, we developed regional business cases that flush out the important parameters for the success of this idea.

Cloud RAN architecture aims to decouple the base station software from the hardware platform which is reduced to COTS servers augmented by processing engines for computationally intensive physical layer operations. In this, Cloud RAN may well open new schemes of infrastructure sharing and/or neutral hosting models especially in markets where the fiber operator is neutral or is a

MNO that does not consider competing on network quality and performance more advantageous than competing on price or service. This case leads us to believe that even more creative business models may develop to operate the wireless network such as the cloud-centric virtual operator discussed below.

In the meantime, access service providers do not have to wait for the full evolution of Cloud RAN. Digital active DAS allows MNOs a similar deployment model and capability to extend coverage into hard to reach areas for base station deployments. In this scenario, the base stations are located at the fiber central office with long runs of fiber (typically < 10 km) to remote radios.

Spectrum Sharing and Shared Spectrum

Sharing spectrum assets between operators has proven to be contentious in many markets in part due to operators' own competitive behavior, and in other part due to regulatory rules. Yet, we do see many examples where MNOs came to the understanding that service and revenue generation trumps capital and operational expenditures necessary to maintain competitive edge in performance and quality which is not sustainable in the long run due to the nature of wireless signal propagation, coverage performance, and interference management that are critical for capacity. In other words, there is a plateau in service quality and diminishing returns to expenditure on network quality. Additionally, MNOs in markets where ARPUs cannot sustain continuous development for high level of service performance have taken the pragmatic lead to share spectrum and the radio access network to provide a better service than otherwise would be possible.

Today, in addition to sharing spectrum assets between operators who have primary ownership of these assets, a new regime for shared spectrum access is developing with a focus on bands occupied by government and military users, such as 3.5 GHz in the United States and 2.3 GHz in Europe. Dynamic spectrum access will allow operators to access spectrum on a secondary basis particularly for small cells that are used to augment capacity on targeted basis. While the regulatory regime for spectrum access is still under discussion, there is great determination to realize this approach by regulators who are eager to kick-start a new wave of innovation and its accompanying economic benefits.

Resources Sharing and the Emergence of the Cloud-Centric Virtual Operator

Developments in wireless network architecture towards virtualization and increased resources sharing, such as Cloud RAN where the radio access network is transformed into a common hardware infrastructure, would not occur in vacuum and can be accompanied by equally innovative business models for the MNOs and the (over the top) OTTs running on top. Given the substantial holdings of spectrum by a number of wireless players around the world, including spectrum that would be optimal for re-farming from alternative technologies (e.g. WiMAX, CDMA, etc.), there is a case to be made for the emergence of utility-oriented mobile Internet providers. Google, Apple, Amazon, Ali Baba, Tencent and various large-scale Internet and cloud players, have an opportunity to operate a virtually isolated network, or network service provider (NSP), within various disruptive business models ranging from device or applications priced-in bandwidth to

select volume unit billing models. These various ways of sharing spectrum and network assets with Internet players will form a new breed of mobile virtual network operators (MVNO).

In fact, and as the mobile Internet becomes an elementary expectation and as participation in the global conversation becomes more critical to the individual, the wireless operator market will likely evolve towards this position. This would come in as a handy deployment model due to the fact that the incumbent service providers cannot achieve the low cost of capacity required to enable this model.

Unlike the "cellular Internet," the opportunity exists to develop a mobile Internet utility ecosystem that builds upon intelligent sharing of spectrum and network assets. It will enable business models that would drive revenue for the Internet players using both subscriber conversions to an ad-free service, and premium fine-grained advertising utilizing location, declared interests, and preferences. This revenue will allow bandwidth pricing of the service and allow for various models of revenue sharing with spectrum and network resources players. This will take advantage of the mobile Internet utility model to deliver access to Digital Divide or poverty-unconnected users with low cost devices and pricing models, made possible by the optimal spectrum and network resources sharing, as well as optimal arbitrage between available network and cloud computing resources. Finally, it will deliver computationally intensive cloud applications to the handset without consuming precious resources by taking into account the scaling characteristics of cloud computational models.

Take aways

The increase in bandwidth requirements of wireless services has paradoxically increased dependence on fixed-access infrastructure (fiber optical networks), and heightened attention on alternative complementary access schemes (Wi-Fi). This, in addition to developments in base station and mobile network architecture have led to the emergence of new trends in active network resource sharing that are complementary to ones we have witnessed over the past decade. Although various active resource-sharing models are possible, we anticipate that they will be mainly complementary to and built on top of the existing fiber/backhaul, Wi-Fi and passive DAS models which would be extended into active DAS, small cells and Cloud RAN architectures. Furthermore, as a direct continuation of this evolution, new spectrum and airwaves resource sharing will emerge. A direct consequence of this, in our opinion, is the rise of Internet and cloud-centric virtual network operators who will take advantage of optimized network sharing and wholesale delivery models, and introduce novel business, pricing and revenue share models that will constitute a significant disruption in how mobile Internet services are provided.

Acronyms

COTS	Commercial off the Shelf
DAS	Distributed Antenna System
FTTx	Fiber to the x
HetNet	Heterogeneous Network
LTE	Long Term Evolution
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NSP	Network Service Provider
RAN	Radio Access Network
SEA	Southeast Asia

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