State of the Art Packet and
Optical Networking

5G Changes the Calculus for Wholesale Backhaul

White Paper

Introduction

Wholesale and open-access business models for fibre and network-infrastructure providers are not new. Neither are wholesale connections for mobile operators' backhaul from cell sites. In the past, incumbent fixed-network providers have often offered MNOs products such as leased-line connections for backhaul. However, in recent years despite the arrival of various new competitive fibre owners, there has been only limited emphasis on delivering newer and more innovative models for wholesale backhaul.

While mobile backhaul has often featured as an intention for wholesalers, in some cases it hasn't been a major contributor to revenues or a strategic direction in reality. And where cellular operators have been customers, they have often just wanted dark fibre, rather than lit and managed connectivity.

The 5G era should change this situation, for several reasons:

01 5G radio access networks (RANs) have different technical requirements and architectures that demand new models of backhaul (and fronthaul) delivery. For example, higher-speed but shorter-range radios will demand more backhaul capacity, in more places, for network "densification".

02 New 5G-enabled business models and use-cases will rely on backhaul which may be needed in different locations, with different economic models or architectures – such as private or "sliced" deployments in enterprise.

03 Greater uncertainty about 5G's deployment and usage patterns demands more flexibility around enablers such as backhaul, which could become prohibitively costly with existing approaches.

04 New classes of players – both customers in the mobile space, and suppliers of fixed/backhaul transport – mean different philosophies and preferences in how networks are built and operated. They are all looking for new ways to build business cases for infrastructure investment – and potential new revenue sources and funding models are key.

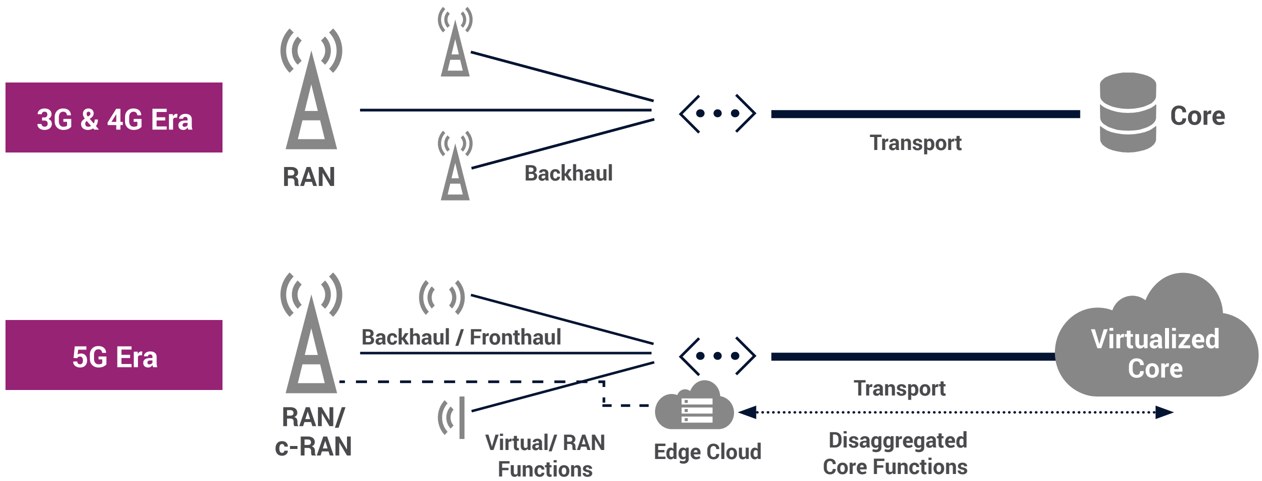
05 Regulators and policymakers are starting to recognise the need for richer options for mobile backhaul. Some authorities also want to own or subsidise national fibre networks or incentivise rural mobile connectivity, which may bring backhaul services along with them.

5G Will Change the Game for Backhaul

Mobile backhaul connections link cellular base-stations back to the operator's core network, usually via multiple tiers of aggregation (such as local, metro and regional hubs) and transport infrastructure. While the details – and the performance – have clearly changed through the 2G, 3G and 4G generations, the basic topology has remained consistent.

The arrival of 5G disrupts the historical status quo. Core network functions are becoming disaggregated and virtualised, with some components becoming decentralised and moving towards the edge. Meanwhile, the RAN is also being virtualised, with some elements becoming more centralised and located further up the chain at aggregation points.

5G & Virtualisation Changes the Roles & Structure of Backhaul / Transport



The top-level backhaul options for MNOs are:

1. Lit services, which are managed connections (usually Ethernet-based) with a broad array of capabilities and propositions, either at layers 2 or 3. This is the focus of this paper, as modern transport infrastructure is allowing greater sophistication and improved economics.
2. Self-build networks, where the MNO physically deploys a new in-house backhaul network, using existing wireline assets, or potentially digging new trenches, or use third parties' ducts or poles. In other words, there is no reliance on another infrastructure owners dark/lit/dim services – it's all vertically integrated and owned.
3. Dark fibre, where the infrastructure owner only provides "unlit" strands of fibre, and the MNO needs to install and power its own network and termination optical gear and electronics.
4. Dim fibre is a more lightweight approach to offering connectivity than fully-lit services. It allows the customer to get an "open" wavelength with full flexibility about how it is used with their own optical equipment, but with a managed-service "wrapper", and lower needs for real estate.
5. Microwave and (in remote locations) satellite wireless backhaul.
6. Legacy copper-based leased-line services.

Existing 4G networks have evolved rapidly, with huge leaps in capacity, mostly driven by consumers' mobile broadband use. For the most part, backhaul connections have kept pace with this growing demand. Broadly speaking, fibre gets used for the busiest locations – normally in cities, along major highways, or in other densely-trafficked locations like airports. Rural locations and smaller cities have often relied on microwave.

The mix in more developed markets has gradually shifted towards self-built fibre by converged fixed/mobile operators, plus dark fibre and bitstream/Ethernet offers for those operators that can't build that much asset-heavy infrastructure themselves. The proportion of microwave has fallen, but in some locations there still isn't enough (or any) fibre – especially in developing markets outside the main cities, or even in smaller towns or along roads in more advanced nations. 5G will change this progressive evolution of backhaul.

Simply put, 5G needs more fibre, and quickly. In particular, if it is to get close to some of the promises being made about multi-gigabit throughput and sub-10ms latency, or new use-cases, it will need a radical overhaul of backhaul and transport networks. Individual sites may need 10Gbps links, or even multiples of that. While some network operators may prefer to utilise dark fibre that will not always be available or economic, especially for small-cells. Wholesale services such as Ethernet, plus higher-layer intelligence and SDN capabilities, will play an increasingly important role.

Important drivers can be grouped into two sets:

5G Technological Requirements and Features:

- Network densification
- Service assurance
- Lower latency
- Cloud-RAN and fronthaul architecture evolution

5G New Opportunities and Use Cases:

- New applications and demand models for 5G
- Case in point: fixed wireless access (FWA)
- New players in the market

5G Technological Requirements & Features

Network Densification

Given the overall balance of mobile CapEx towards the RAN, one of the most important technical changes with deployment of 5G is the spectrum it will use. Indirectly, this enables the future new services 5G will eventually support, once widely deployed and upgraded to its later variants. For the immediate future, 5G will mostly be enhancing and extending mobile broadband (MBB) and fixed wireless access (FWA) – but that still poses engineering challenges.

To get the promised multi-gigabit speeds and lowest latencies, mobile operators will need to use large blocks of frequencies, ideally in 100MHz or larger chunks. In particular, we are seeing new mid-band spectrum allocations (in the 3-6GHz range) or much-higher mmWave bands - typically in the 24-39GHz range. Lower frequencies – such as "re-farming" the existing 3G or 4G bands - will be more important too, but will have less capacity, albeit with greater range.

However, these higher frequencies bring a particular new challenge: they travel much shorter distances. This means that cell-sites or antennas need to be installed much more closely together, especially in city-centres or along roadways. This "densification" of the network then implies new locations for backhaul connections – ideally fibre-based.

The new 5g cells will typically take three forms:

Powerful macro sites, typically employing new "massive MIMO" (multiple-in, multiple-out) radios. These will use huge amounts of backhaul – perhaps multiple 10Gbps links, especially if they act as hubs or relay points for neighbouring sites as well. Many can be installed on existing 4G sites, but may need additional fibres or managed connectivity, plus scalable capacity as demand grows.

Small cells, often placed on street furniture (such as lighting poles) or attached to buildings' walls – often these are new locations with little existing fibre infrastructure. They too may need 1Gbps connections, or multiples of that, especially if they are used for fixed-wireless access (see following main section).

Remote radio-heads or relays are antennas that are (essentially) extensions of major hub-sites.

Service Assurance

5G is not just about the New Radio (NR) replacing 4G's LTE technology. The overall system architecture also includes a lot of innovation in the New Core (NC). This reinvents 4G's EPC, with the advent of concepts such as network-slicing - managed by a new entity called the Network Slicing Selection Function, NSSF – and API access to third parties, via the Network Exposure Function, the NEF. Some of these capabilities can be provided in 4G, but the architecture is less-standardised. (Most early 5G deployments still use the existing EPC – this is called "non-standalone 5G", but later versions are expected to have the fully-capable standalone NC to support them).

Eventually this should allow many virtual mobile networks – with different characteristics such as latency and mobility – to be delivered from a single infrastructure. Some will be defined as having "ultra-reliable & low-latency" (URLLC) qualities, suitable for the most demanding applications such as running industrial machinery or health/safety-critical functions. These may come with commercial service-level agreements which give strict conditions on uptime and availability.

Network slicing, in turn, will need smarter backhaul and transport choices, in order to give end-to-end network assurance. There may need to be additional focus on resilience, diverse pathways and self-healing to deal with any network interruptions. This potentially gives scope for much richer and higher-value backhaul services – although where these are delivered as wholesale by another infrastructure owner, they will also attract carefully-defined SLAs.

Low-Latency Applications & Edge Computing

An important component of 5G networks and services is edge computing, where processing and storage of data can take place in or near the network edge itself, rather than in distant datacentres. There are three main reasons for edge computing use:

- The need for a low-latency connection between a user's device and the cloud resource it needs to access. The speed of light, plus extra "hops" through the network, means that physical proximity is becoming more important for some application workloads. Ultimately the goal is for 1 millisecond round-trip times in 5G, although in the near term 10-30ms is more realistic.
- Reduction in the amount of traffic that needs to be transmitted over long distances, for instance by analysing high-definition video data locally for interesting events (or compressing it), and just sending the most-important updates to the cloud.
- Greater desire for control/security by enterprises or governments unhappy with multi-tenancy international cloud sites, for their most sensitive data. Processing or storing some data at the edge is seen as a potential solution in both 5G and fixed broadband.

Telcos and MNOs will themselves need edge-computing, as various of their internal network functions (VNFs and cloud-RAN controllers) will need to be distributed more deeply into the networks for low-latency operations. However, the industry is split regarding the idea of building its own in-network compute resource at cell-towers, network aggregation points, central offices or regional data-centres – this is often classed as MEC (multi-access edge computing).

Other technology industry players such as data-centre companies, hyperscale cloud firms like Amazon and Microsoft, and various startups have their own definitions and expected locations of edge-compute. Disruptive Analysis has developed a model of single/multi-network and single/multi-cloud use-case.

Although many MNOs have aspirations to host 3rd-party cloud and IoT applications in their own MEC-type edge nodes, Disruptive Analysis believes this will only have narrow appeal. We may see the emergence of new classes of "middle mile" product, linked to backhaul, which enable "5G local breakout" to such in-region compute facilities, rather than transporting the traffic all the way to the network core and back out again.

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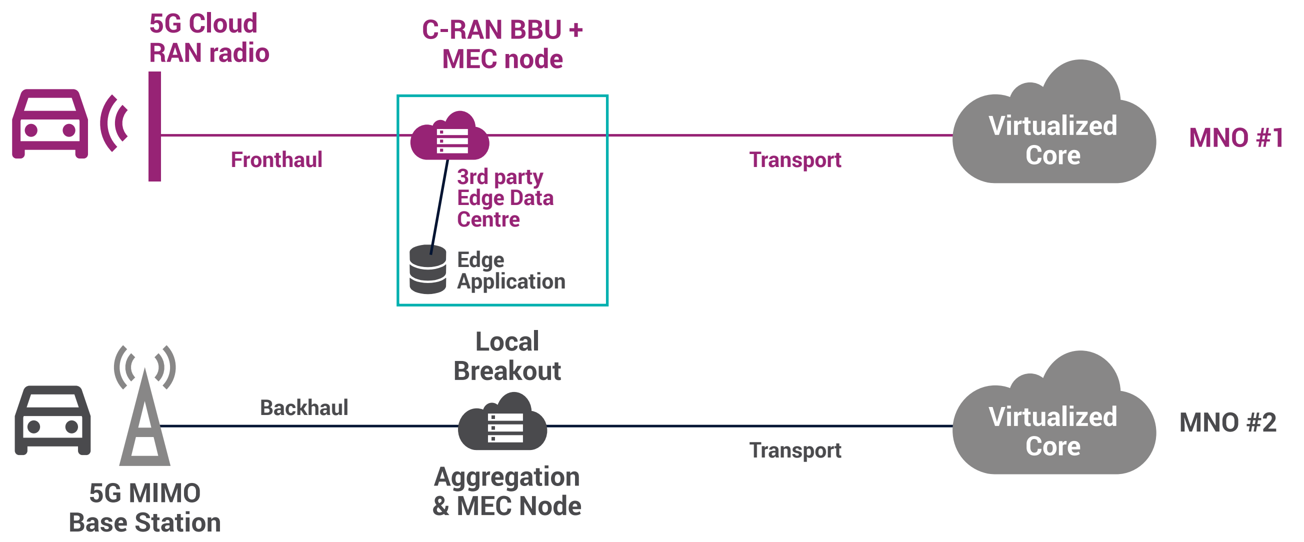


Imagine a citywide “autonomous bus” provider, needing low-latency mobile access from its vehicles to its computer and data-storage facilities in a local data-centre for operational control. That then links to a normal hyperscale cloud provider for analytics and machine-learning, as well as other cloud providers for payments, security and so forth. It may not want to use the telco’s own edge-compute services, but still needs to get data from the bus, via the cell-sites, as quickly as possible off the MNO’s backhaul and transport network. If the fibre network is provided by a city-based infrastructure owner, that type of breakout model may be easier to facilitate.

Fronthaul

Many networks will use cloud-based or virtualised RANs, which separate the main processing functions of a base-station from the antennas. The connections between the two is called fronthaul, where the “raw” radio wave-form is transported digitally.

This is an evolution of a similar concept that has been used for some time (centralised RAN), where the base units are grouped in a local or city-level hub (or “hotel”). Typically, fronthaul has needed dedicated point-to-point fibres, because of the very high bandwidths and ultra-low latencies needed. In the past, a technology called CPRI (Common Public Radio Interface) has been used, usually with vendor-proprietary endpoints, but for 5G this is being evolved to eCPRI and a new standardised interface called F1, which will use Ethernet.

Operators deploying new fibre networks may look at the overall “x-Haul” opportunity holistically, as it seems likely that the same mobile network could use multiple architectures concurrently – but all will need more-dense and more-flexible transport.

5G Opportunities & Use-Cases

The early focus of 5G deployments is mostly on evolving the familiar 4G business model – mobile broadband, especially for consumers’ smartphones. We are seeing higher speeds, better capacity in congested areas, and improved coverage at the edge of cells – but fundamentally, these early 5G services are being utilized by similar devices in the same places for similar applications. From a backhaul point of view, this means that more capacity is needed, but mostly to the same sites, plus extra locations for densification. The economics and broad patterns of demand, however, are fairly well-known and predictable.

It is the other, emerging use-cases for 5G that will change this situation dramatically. While 4G is occasionally used for fixed access, and has a growing role in IoT applications, these tend to be at low-enough volumes that they do not impact traffic patterns or backhaul technology choices, to a significant degree. In future, we can expect more impact on the transport network from the new use-cases.

New Use-Cases and Demand Models

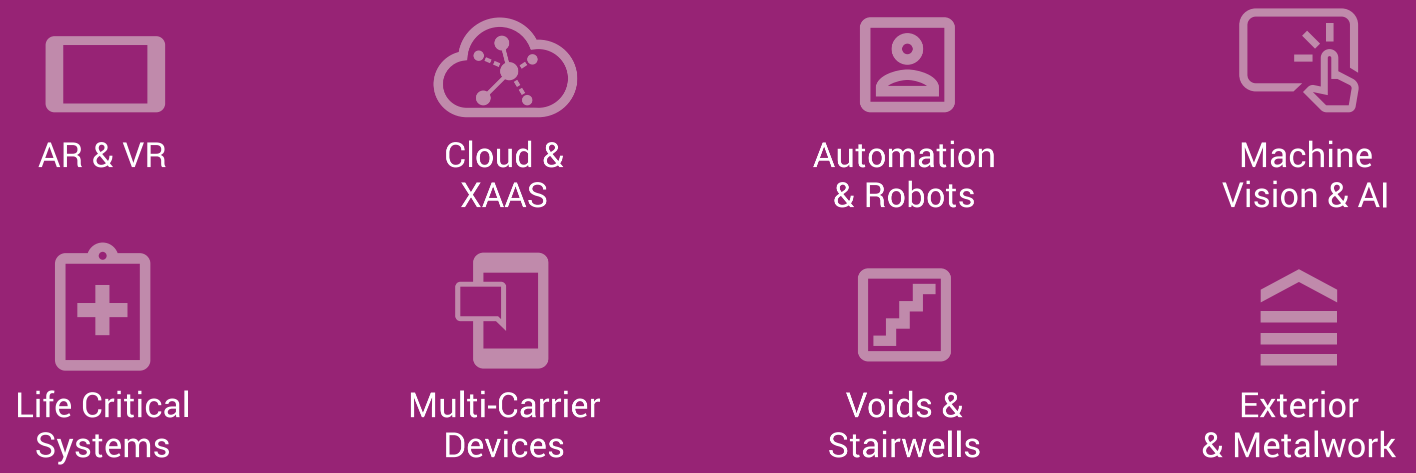
5G will bring many new and unpredictable use-cases for connectivity. This will mean that coverage or extra capacity needs to be added, but often in new locations which may be difficult to reach with self-build fibre by the MNOs. This will drive the business case for alternative network-owners, offering wholesale backhaul.

This is especially true of IoT-type use cases. Connected cars are becoming a major factor in future network-traffic predictions, for instance. But while it is possible to predict rough numbers of new 4G/5G-enabled vehicles, data usage is much harder to gauge. There could be sudden step-changes in demand for mobile data, for instance when software is updated, or when maps switch to higher definitions. Governments or insurers might demand that dashcam video footage or real-time telemetry is streamed to the cloud, with a big impact on roadside cell-towers and their backhaul needs.

There is also growing expectation of a need for 5G coverage for agriculture, in industrial facilities, for remote communities or full national reach for public-safety agencies. We may see drone routes over uninhabited areas, with wireless control needed for autonomous flying devices, or remotely-driven snowploughs connected with 5G to an operator's AR headset in an office building. And new 5G spectrum licenses are likely to come with conditions, especially about minimising the "digital divide" and forcing the MNOs to deploy in deep rural areas that were historically uneconomic to address.

If these visions are to become real, it implies that backhaul will eventually be needed in more places for 5G than for 4G, and often with very constrained budgets. MNOs will not be able to build their own fibre everywhere – and dark fibre may not be available or economically viable. This all points to more wholesale opportunities.

The 5G Era Brings Many New Applications & Use-cases (Also for Wi-Fi & 4G+)



In addition, the uncertainties about exact demand profiles are likely to require more flexibility and intelligence embedded in the backhaul – especially if additional capabilities like edge-computing and network-slicing are needed end-to-end as well.

Fixed Wireless Access (FWA)

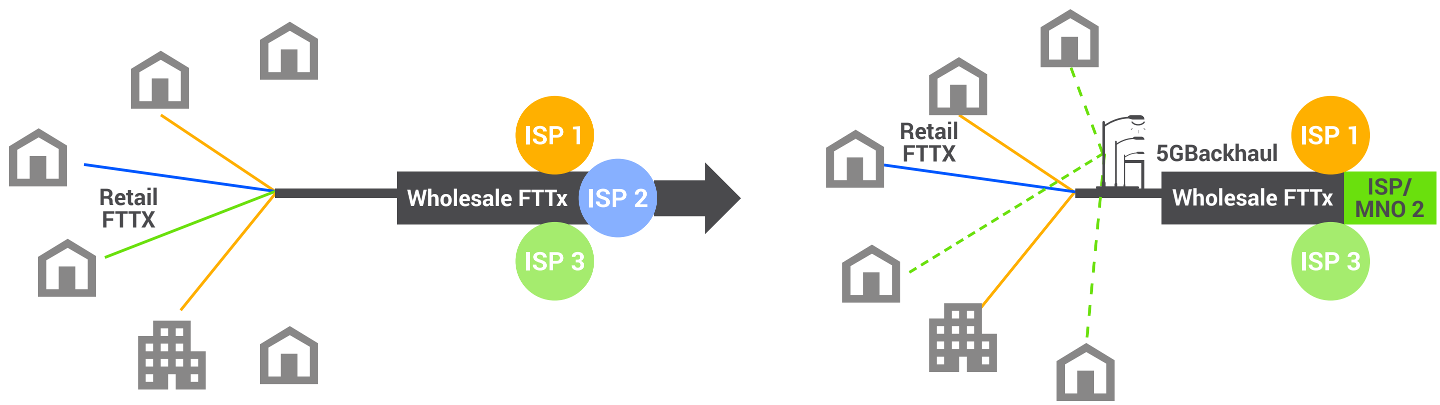
Another major deployment scenario for 5G is for FWA, as an alternative (or substitute) for xDSL, FTTx or cable broadband. Various early launches have already occurred, including by Verizon in the US and SKT in South Korea. For the most part, these early pioneer networks are using self-built fibre for backhaul, but if the market grows rapidly, it is likely that wholesale opportunities will grow as well.

Most open-access fibre networks today primarily connect individual homes and business premises with FTTP access. The wholesalers then sell connections via their retail partners (typically ISPs). However, in some markets these ISPs are actually themselves mobile operators as well – for instance, CityFibre's partner Vodafone in the UK, or Open Fiber and 3 in Italy. These telcos are often aiming for triple/ quadplay services for their customers – offering mobile phone service along with fixed home broadband.

In some markets, MNOs may be happy to sell 5G fixed-wireless access to homes instead of FTTH, to complement their mobile broadband offers for personal devices. This would be particularly attractive if the wholesale costs were cheaper, or if they could obtain greater control, for example by using their own small cells, which could also provide outdoor coverage as well as FWA.

In that case, the wholesale fibre operator could provide backhaul services for localised small-cells, for example to lamp-posts or utility poles (rather than full-sized towers) on each street or neighbourhood. This will need a different product set (for instance Ethernet rather than PON) but could present the infrastructure owner with a different revenue stream. That said, care will be needed to ensure that fixed-broadband ISPs (who are the primary wholesale customers) do not perceive the new 5G FWA players to be an unreasonable competitive threat.

5G Fixed Wireless Access Adds New Backhaul Opportunities for Fibre Operators



New Players in the Market

Historically, the customers for mobile backhaul connectivity have been homogenous – primarily large national MNOs (mobile network operators). There are typically between 2 and 4 MNOs per country, of which one or two usually have their own large fixed networks. Some markets such as the US also have smaller regional or rural MNOs.

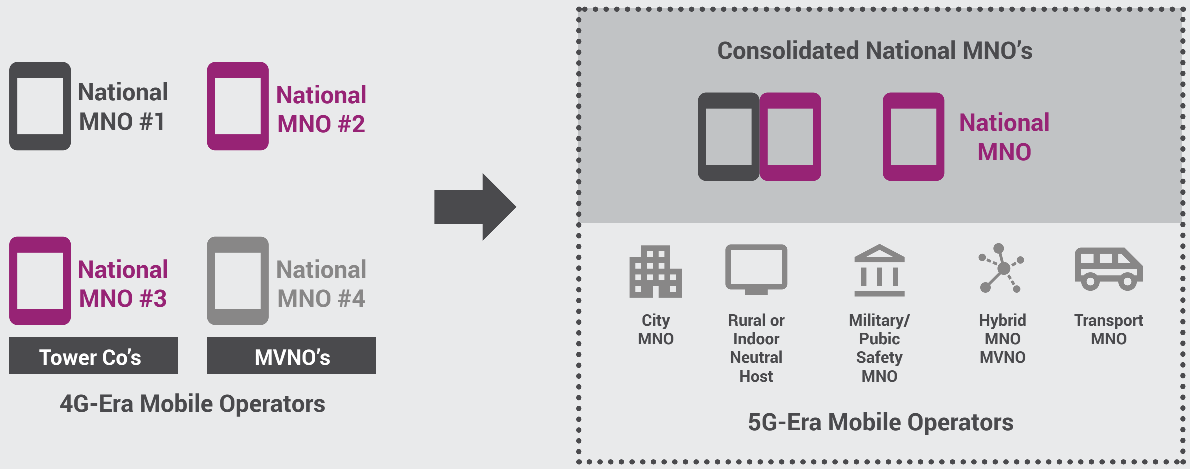
In the 2G-4G eras, these large MNOs have often not viewed backhaul strategically. MNOs owned by the main national fixed-line incumbent(s) have typically preferred to use their own infrastructure for backhaul. Standalone mobile networks have generally used leased connections, again from the incumbents (which are usually forced to offer such products by regulators), or have built their own microwave links. More recently, they have sought to obtain dark fibre where possible for their largest sites, or bitstream/Ethernet services where necessary. Some previous mobile-only operators, such as Vodafone, have acquired sizeable fixed/fibre assets, to build their own transport.

In the 5G era two simultaneous, but opposing, trends are occurring:

Consolidation of the national MNOs, where telecom and competition regulatory authorities permit. In markets where full mergers are difficult, we see other related models, such as infrastructure-sharing, or mobile/fixed/cable consolidation.

Fragmentation with the emergence of various new classes of MNO, targeting particular local areas, industries, rural/indoor coverage or business models, which have been poorly served by the historical national MNOs. Such newcomers will have less legacy infrastructure, different economic models, and may be less culturally-averse to buying backhaul services rather than self-building.

Future 5G Cellular Networks Will Be Operated by a More Diverse Set of MNOs



A future ECI white paper will examine the new classes of operator in more depth. Some of the more interesting types include: Neutral Host Networks (NHNs), cable MSOs, enterprise cellular operators, governments and public safety companies.

5G Challenges can be Addressed by Wholesalers

A major challenge for 5G operators deploying infrastructure is the level and types of "unknowns" they face:

01 How fast will demand for 5G capacity grow? Will it be uniform or very "spiky"? Will it be driven by events such as new device and service launches?

02 Will IoT, localised FWA or other new uses change the pattern of demand in unanticipated ways?

03 Which locations will need 5G backhaul, compared with historical 4G sites? And how will this change over time?

04 How much will 5G demand in a given location be driven by slicing and applications with extra QoS requirements, versus "normal" mobile broadband? How fast will this vary?

05 Where will edge-computing facilities linked to 5G applications be located?

06 Where should network break-out occur? Will data still have to go all the way back to, and through, the telco core, before connecting to the wider Internet? Or will there be distributed gateways (which can still enforce policy and charging) at local edge nodes?

07 Will new spectrum releases, or enhanced antenna technologies, lead to rapidly-changing new requirements on backhaul and transport networks?

Since 5G use is going to be less-predictable than 4G, backhaul requirements will also be harder to predict. The result: Need to add software-driven flexibility to scale demand, route traffic appropriately, and deal with end-to-end slicing more effectively. It also means that operators may choose to buy or lease fibre, rather than build, as a form of risk-management, at least for some locations.

Basic lit-fibre services can have significant limitations, however. If deployed in a hub-and-spoke fashion, they can add in inefficiencies, and make it hard to interwork between macro-cells and small cells properly, for example in terms of mobility, interference-management, timing-synchronisation or aggregation.

Next Steps: The Way Forward for New Fibre Owners

Many markets are seeing the emergence of new fibre owners. In both urban and rural areas, wholesale-centric infrastructure providers are getting regulatory support and funding. Such companies are from a variety of backgrounds – private equity-backed startups, utility firms, city/regional authorities, highway agencies, tower companies and more. Some governments are stimulating the market, including creating national broadband infrastructures.

While their initial focus is on supplying retail ISPs with FTTH/FTTB access, Disruptive Analysis believes there is growing opportunity for mobile backhaul as well. In the near-term this is likely to focus on 4G in many countries, but it also offers a strong medium-term future path to 5G as its adoption matures.

We will likely see multiple tiers of wholesale – for example, a rural network owner selling to a wholesale-backhaul specialist, which then offers Ethernet services suitable for macro or small cells. Case in point, when asked about opportunities for the forthcoming rural-focused National Broadband network in Ireland, the main bidder's chief replied: "It's an open access network for any provider to use for any use case, so backhaul is a perfect use case".

Organisations currently planning, deploying or upgrading wholesale-oriented fibre networks should give more thought to the changing wireless landscape. For 5G to attain many of the new use-cases and transformational goals promised, it will need more backhaul capacity and flexibility.

The top-level backhaul options for MNOs are:

Understand the changing landscape in their markets for mobile spectrum in detail, especially if new rules will encourage new entrants, or force incumbents to cover additional territory.

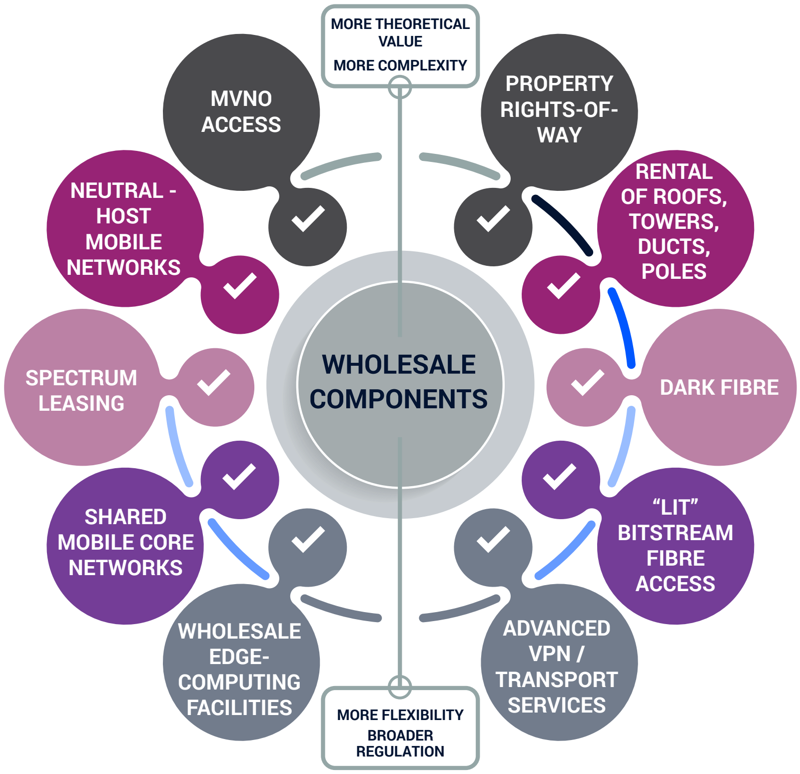
Identify major organisations in the relevant national market that are considering building networks or bidding for spectrum. Look at companies filing responses to regulators' consultation requests or attending workshops and conferences on mobile policy.

Work to build relationships and trust with national MNOs, emerging neutral-host players and key vendors. Understand strategies around small cells, urban densification, rural networks, key use-cases for IoT and vertical industries and existing backhaul usage.

Assess any regulatory or technical obstacles to adding PtP backhaul services to residential-type PON wholesale on the network.

Consider whether local initiatives for edge-computing could yield opportunities for local-breakout or middle-mile interconnection from cell backhaul/transport to regional datacentres.

The Cellular Industry Relies on a Complex "Stack" of Wholesale Components



One Point Referenced Above – Regulation - Is Critical Here

Existing or future infrastructure providers should be engaging with authorities to accelerate the market's evolution.

Regulatory Variables Can Both Accelerate & Slow New Backhaul Opportunities

- Improved rights-of-way & planning rules (fibre digs, cell sites etc)
- Spectrum options available for new entrants / verticals
- Better rights to access incumbents' poles / ducts
- More liberal stance on infrastructure-sharing
- Coverage requirements forcing faster rural 5G deployment
- Policymaker enthusiasm for "full fibre" & infrastructure competition
- Government-run / sponsored wholesale-centric fibre or 5G networks

- Protection of incumbent network owners from competition
- Vertical-specific rules limiting wholesale network use
- Slowed 5G deployment because of spectrum licensing/ other rules
- Focus on residential/business FTTP vs. 5G cell locations
- Onerous reporting restrictions
- Local planning rules & fees limiting small cells/ upgrades to 4G sites

This paper has discussed developments with 5G, and the shifting dynamics of both alternative fibre infrastructure and MNO marketplaces. Numerous changes are happening simultaneously, and this brings significant opportunities – as well as some challenges, such as unpredictability of some use-cases' timing and demand.

One of the few certainties is that the backhaul landscape will become larger in size, yet more diverse in terms of business model and value-chain. New technologies for building and operating transport networks are emerging that allow more flexible and dynamic forms of connectivity. These are suitable for both internal requirements of integrated SPs, and also wholesale business models for fibre-only players. Segment routing, SDN and improved traffic-engineering toolkits will all be relevant.

Overall, Disruptive Analysis believes that the overall wholesale market in telecoms is about to undergo a renaissance. Backhaul for 5G mobile networks is a central element of that broader trend, and should be a priority for both new and incumbent fixed infrastructure operators.

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Contact us for more information on the 5G wholesale opportunity at rbbn.com

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