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INFRASTRUCTURE SHARING TO FACILITATE EFFICIENT 5G NETWORKS DEPLOYMENT

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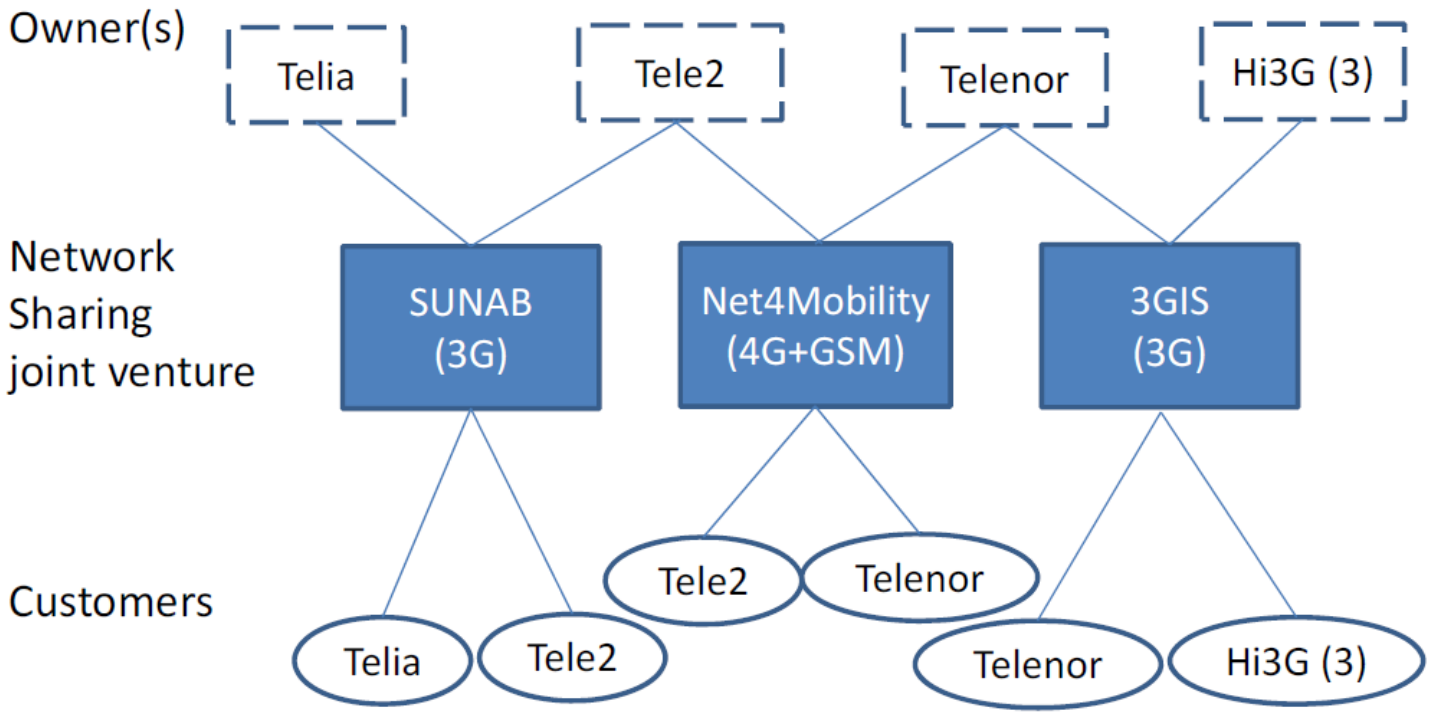
Regulatory, Organizational, Economical, Technical Dimensions of Infrastructure Sharing

Historically Momentous Case

Sweden is the country with the most intense degree of mobile infrastructure sharing (IS) in Europe. Sharing is a sustainable and dominant element of national market structure.



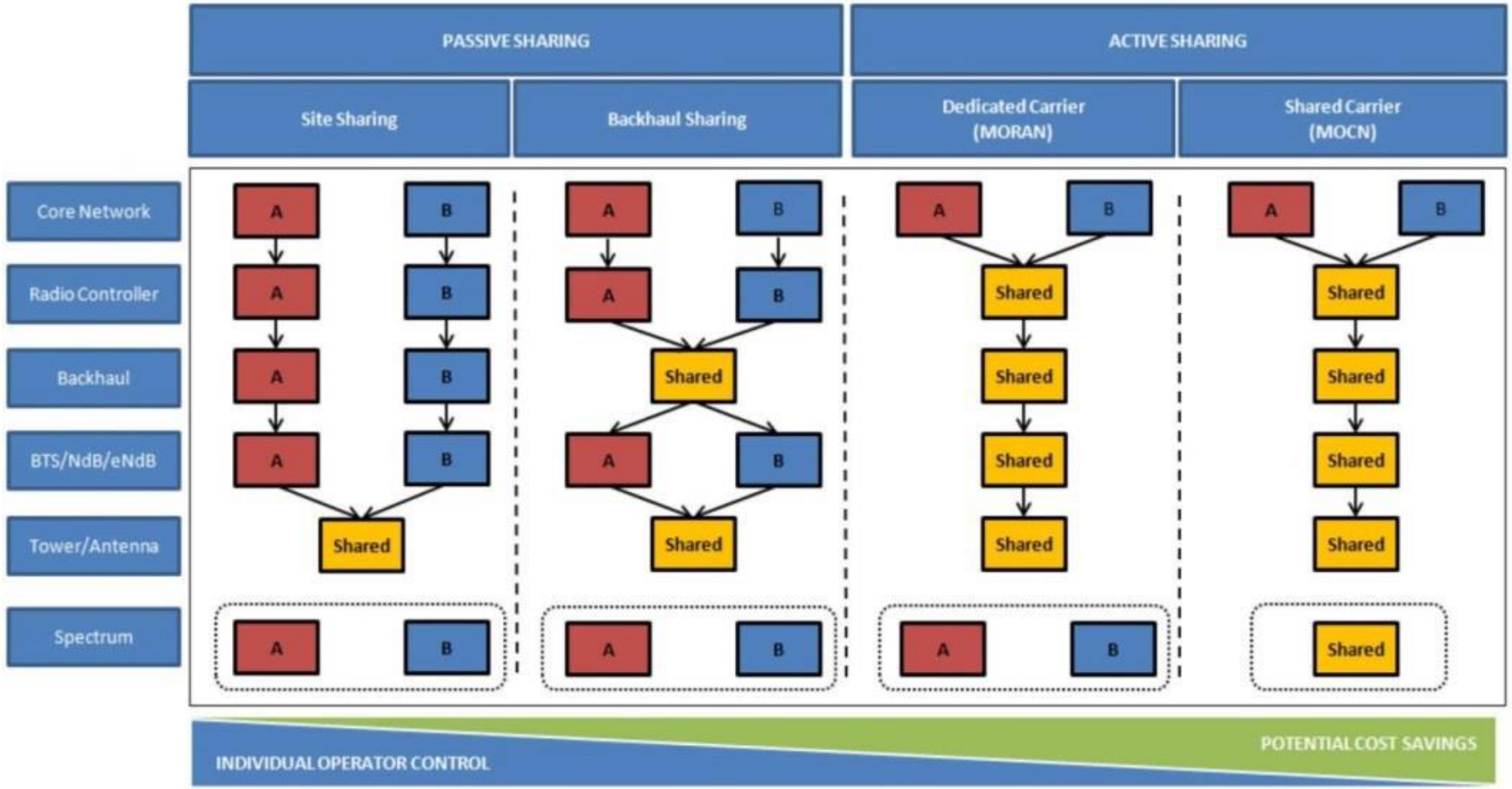
1. In 2000 Telia signed sharing agreement with Tele2 to entry 3G market. Shared network was built by JV SUNAB on the basis of the Tele2 licence and spectrum and the existing infrastructure of Telia. Sharing included the whole RAN, backhaul, spectrum and passive infrastructure.

2. Other two MNOs formed a network cooperation in form of the Joint Venture 3GIS.

3. In 2009 the sharing structure was further intensified when Tele2 and Telenor formed a new 4G related venture besides the already existing network cooperations. Net4Mobility even owns the joint spectrum.

Extensive IS in Sweden didn't form an obstacle to competition - coverage achieved nearly 100% for 3G and 99,2% for LTE already in 2013. It is in particular impressive with the low population density in the country.

Forms of IS and Jointly Used Network Elements



IS is driven by the motive to save network cost. Deeper level of sharing higher cost savings.

In the socio-economic domain the reason is to jointly provide coverage for rural and remote areas with low customer density at lower cost.

National Roaming and Spectrum Sharing as the Forms of IS

National Roaming

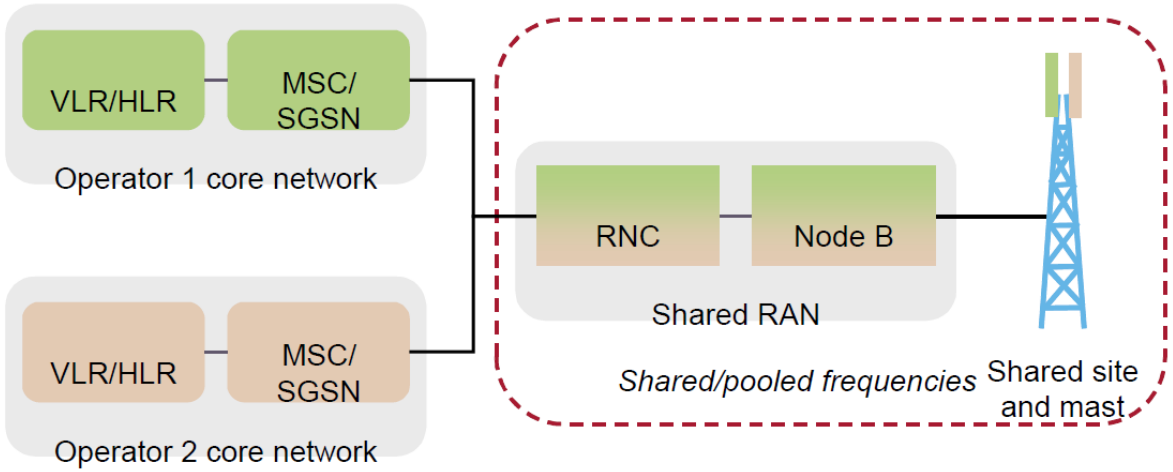
Although only the elements of one network are used in case of national roaming (NR), this form is classified as a highest form of sharing.

With NR the traffic of a customer of MNO A is processed in the network of MNO B. It doesn't require joint network elements, it can just be handled contractually.

NR can be organized symmetrically between MNOs or it can be provided asymmetrically from one to the other operator. NR is mostly used in asymmetric market scenarios, in particular in case of asymmetric market entry.

In case of NR the operators involved still compete at the service level. The ability of the roaming demanding operator to differentiate its services are limited.

Spectrum Sharing



The joint use of spectrum, also called as frequency pooling, means the simultaneous use of the spectrum which has been allocated exclusively to each operator in a particular region.

Users get access to a larger spectrum in a particular radio cell and the capacity of this cell increases correspondingly. RAN sharing in connection with spectrum sharing is called Multi-Operator Core Network (MOCN).

The Organizational Dimension of IS

IS agreement between MNOs

- Contractual agreement is the dominant organizational form of IS.
- IS agreements could be guided and approved by ICT or Competition authorities

Joint venture of the parties involved

- JV could be established to construct shared infrastructure
- Sometimes JV operates the shared part of infrastructure
- Sometimes it even owns the shared spectrum

Outsourcing and third party service providers

- Certain network assets and/or functions are delivered by third party service providers.
- Tower companies represent a major example for such type of cooperation.
- The outsourcing model avoids the potential competition problem of the strategic interest of one MNO to deny access to its network by other MNOs

Reasons for IS (1)

Costs Savings	• Savings, may occur in capital expenditure and in operating expenditures. • In a greenfield scenario the maximum of savings is achievable. MNOs are able to coordinate both new sites in an optimal manner and to jointly use existing site locations. The number of sites can be reduced significantly. • In a brownfield scenario savings are only achievable for the sites which are already in use.
Better use of capital and resources	• Sharing of network elements leads to a better use of capital and other resources. • It is mainly relevant in the case of NR when coverage driven radio cells become better utilized. • In particular relevant in case of asymmetric entry. Second movers can partially compensate against competitive disadvantages of a later market entry by getting access to already existing network resources of competitors.
Time to market	• IS enables faster market entry in case of asymmetric as well as in case of symmetric entry (Significant Market Powers).
Resilience	• NR is a model to maintain service active in case of breakdown of a network or parts of a network. • In case of disaster or network outages the traffic of one network can be (partially) handed over to the network of a competing operator.

Reasons for IS (2)

Extension of network coverage

- IS improves the coverage for users if the footprints of cooperating networks is not identical. At the margin any user might get access to the maximum coverage provided by all networks.
- Improving of coverage by IS is crutial in the roll-out phase of a network but remains relevant also in a mature stage of network deployment.

Environmental and administrative approval advantages

- Getting site approvals and authorizations is a major bottleneck of network expansion in many countries. Site sharing can overcome this bottleneck to some degree.
- In many countries authorities make the joint use of sites a requirement for providing approvals to protect surrounding environment.

Coordination and decreasing the intensity of competition.

- Similar to mergers IS may be motivated by the intention to reduce competition intensity. Depending on the degree of IS network coverage becomes less relevant or might even become neutralized as the competition factor.
- IS leads to the exchange of strategically relevant information (e.g. upgrading to a new radio technology) which enables or makes coordination of behaviour easier.

Regulatory Assessment Dimensions with IS

Regulatory and/or competition authorities which deal or have to establish guidelines with IS agreements, have a variety of concerns and criteria for testing the acceptance of these agreements

Trade-offs between policy objectives and competition impairments

Mergers versus IS

Mobile markets are tight oligopolistic structures. Tighter the structure the more important is independence of MNOs for maintaining effective competition.

IS can be an alternative to a merger between MNOs which enables them to internalize most of the relevant cost savings without destroying the competitive relationship.

Preserving Investment Incentives

IS should not destroy strong investment incentives to build and operate independent networks. The impact of IS on investment needs a careful analysis of the market scenario.

Proper regulatory remedies regarding the IS model can transpose potentially negative investment incentives into positive incentives (e.g. NR in case of new market entry)

Infrastructure versus Service Competitions

IS makes collusive behavior easier. With active sharing the basic network parameters (coverage, cell capacity, data rates and service features) can no longer be defined or changed independently. If this differentiation is no longer prevail, competition reduces from infrastructure level to service provision level.

For that reason, regulators do not allow specific forms of sharing or impose regulatory remedies which decrease the level of constraints in service creation.

Balance between Social Tasks and Competition

IS might have benefits on certain policy objectives but that should not be in the detriment of competition. E.g. IS decreases costs of MNOs, improves coverage and saves environmental resources. It benefits customers if resulting in lower end-user prices and increased service quality.

Whether or not that will occur depends on the degree of competition in the respective market.

Network sharing will be a key lever to reduce cost and make 5G deployments feasible.

Conclusion from McKinsey & Company investigation

Infrastructure Sharing in 5G Era

Cost and Environmental Savings

Increased cost and disruption to cities

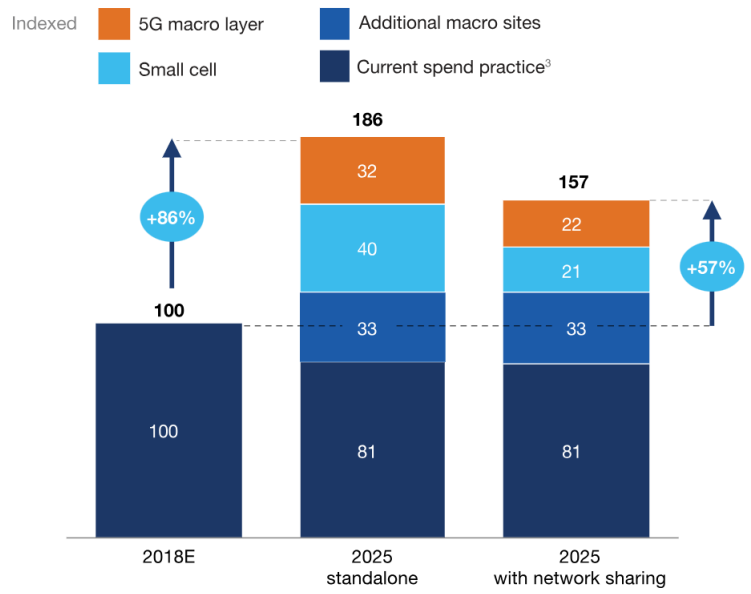
In the unshared case, network investments would have increase by up to 60 percent with a significant increase in OPEX, doubling total costs from 2020 to 2025.

It is required for the deployment of a new, countrywide 5G IoT macro layer, small cells in urban areas, and the evolution of and capacity upgrades to the existing 4G macro network.

Installing the equipment and underground fiber lines required for this level of densification would involve a massive physical disturbance, primarily in already cramped urban settings.

Possible 5G cost reduction of more than 40 percent

By sharing 5G small-cell deployment and building a common, nationwide 5G IoT macro layer, operators could reduce 5G-related investments by more than 40 percent



Results of McKinsey investigation of Total Cost of Ownership with 5G

IS is compatible with different 5G strategies

IS with 5G technology is highly adaptive through depth of sharing (small cell versus 5G macro layer, urban versus rural coverage etc.). It allows MNOs to uncover new savings in various scenarios.

In the most extreme case a single 5G network could be built in which all MNOs gain wholesale access. Entry to the market would still be controlled through spectrum ownership, and competition for services would remain unchanged.

Many players have already started betting on 5G IS. Tower companies have already secured access to lampposts and rights of way in the cities, and buying up fiber infrastructure.

The Rise of TowerCos, FibreCos and NetCos

One of the biggest trends in the last decade has been the divestment of passive assets by MNOs. Operators are disposing their infrastructure into a newly created company (sometimes on a JV basis), which operates either on a captive basis or as a neutral host network opened to other operators.

Benefits for MNOs opting to hive off towercos and fibrecos	Benefits for Investors
• release capital • monetise asset portfolios • reduce costs of capital • reduce capex • optimise and diversify sources of financing for infrastructure deployments • increase efficiencies	• attractive long-term opportunities • low-risk positions • predictable returns and revenues

Practical case
In 2021, Orange implemented several infraco deals across Europe:

•Orange Polska's partnership with APG (financial investor) in a 50:50 JV to roll out fibre in Poland, reaching 2.4 million lines including 1.7 million households over the next five years, for a reported EUR 605m (April 2021).

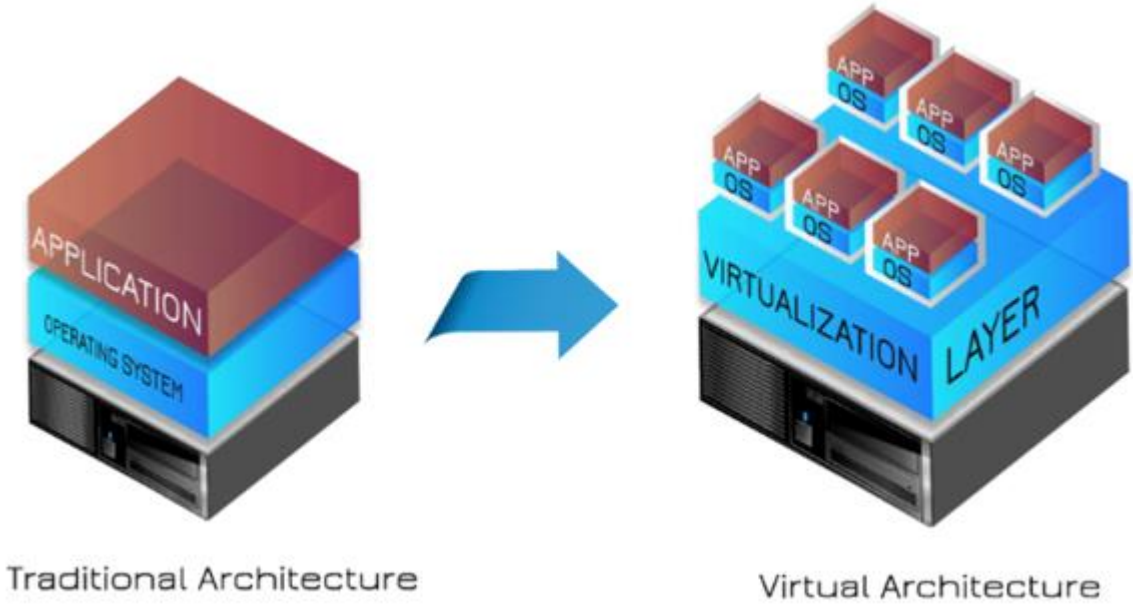
•Orange's announcement of TOTEM, a structurally separate and operationally autonomous company that will initially hold the company's tower and telecoms sites in France and Spain, also serving third-party customers (February 2021).

•Orange's agreement to sell a 50% stake in Orange Concessions to a consortium including La Banque des Territoires (Caisse des Dépôts), CNP Assurances and EDF Invest, a new company that will hold Orange's concessions to operate fibre to the home networks across rural France on behalf of local public authorities (January 2021).

5G Network Virtualization and IS

5G technology enables greater virtualisation of networks, resulting in more easily programmable networks that are less dependent on the underlying hardware.

RAN Virtualization



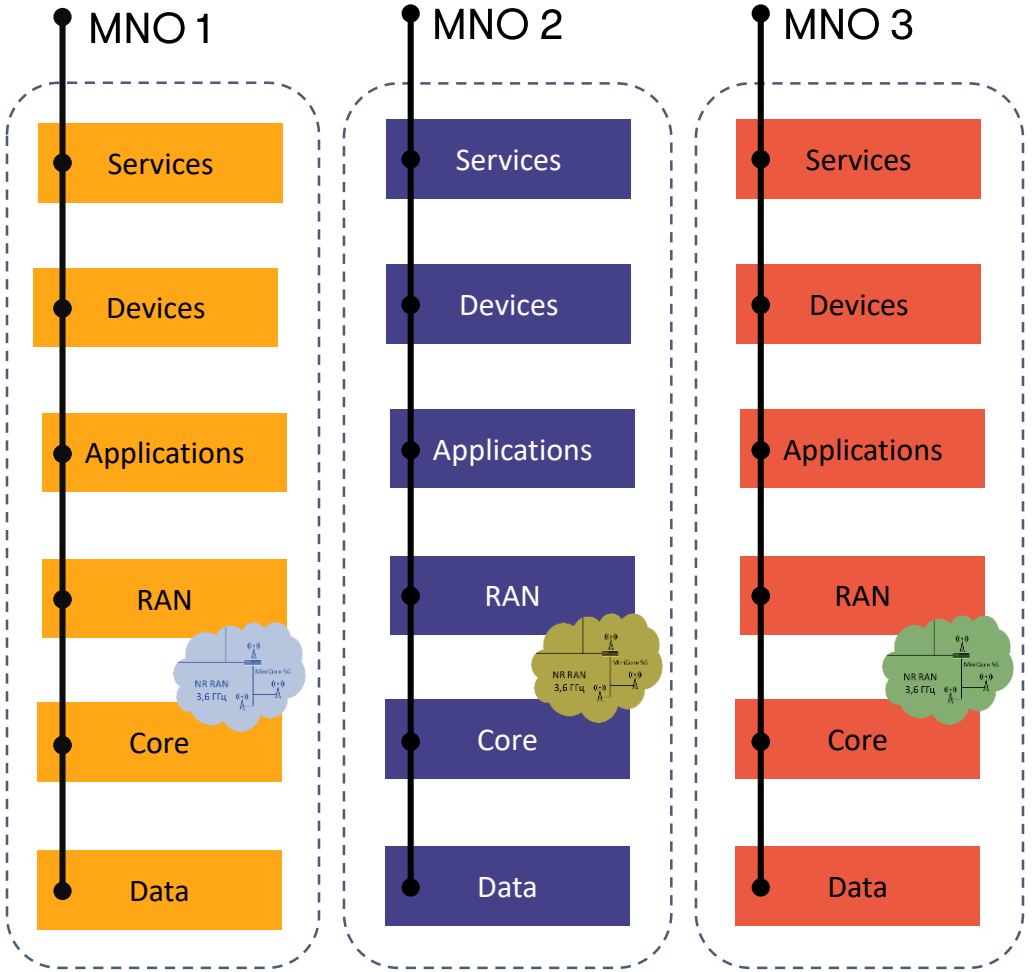
RAN virtualization is a key architecture concept in 5G and it provides the flexibility and scalability for MNOs.

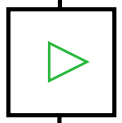
A virtual RAN consists of a centralized pool of baseband units (BBU), virtualized RAN control functions and service delivery optimization. With a virtual RAN, baseband modules are moved away from the site and to a data center.

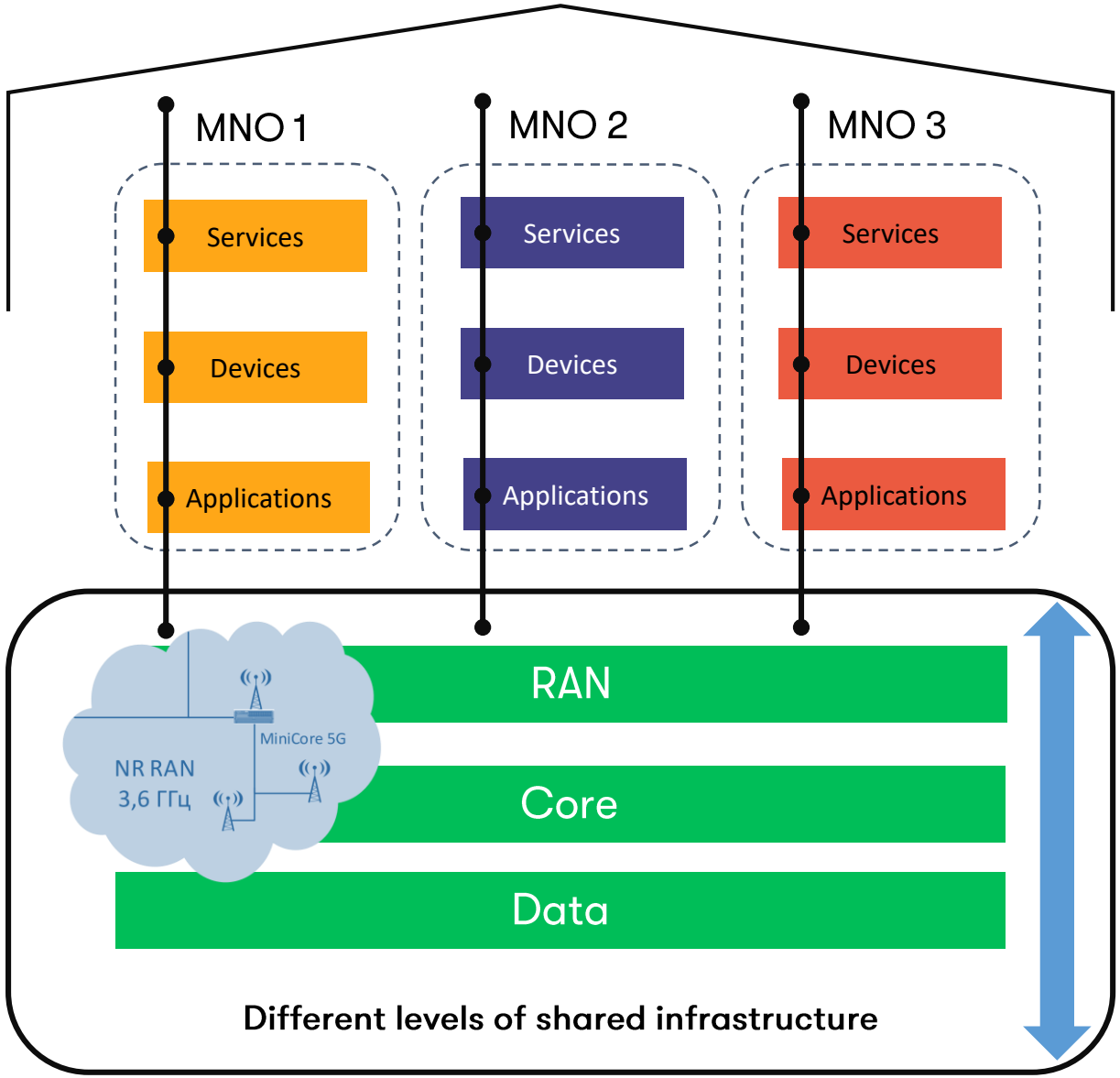
As a result, functions of the BBUs can be implemented with virtual machines in a centralized data center. This provides intelligent scaling of computing resources and new effective option of sharing while decreasing energy consumption and capital expenditure.

Network Slicing and IS

Network slicing makes it possible for a single physical network to be separated into multiple virtual networks, allowing MNOs to differentiate services hosted on common infrastructure.

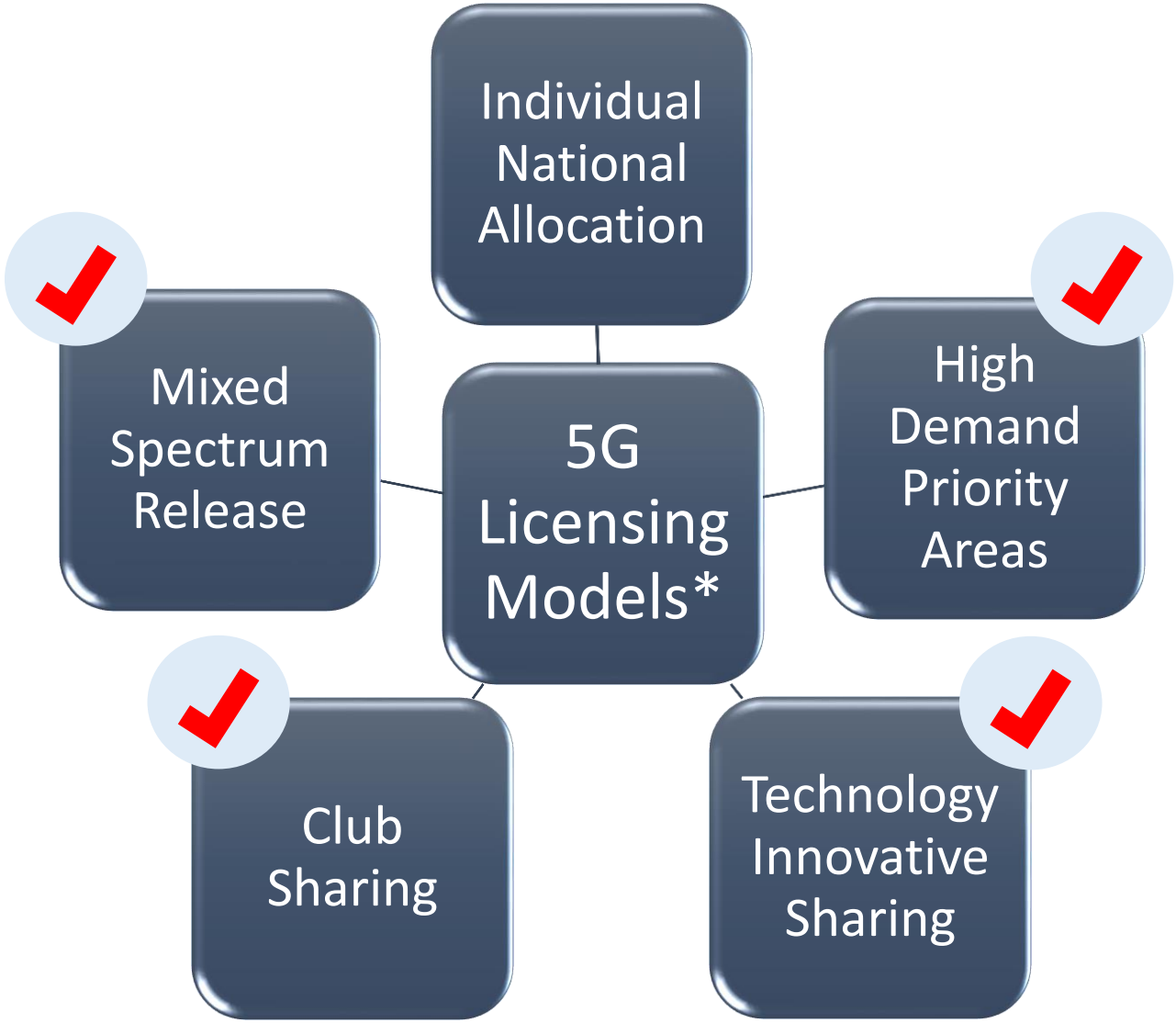






Implication of 5G Technology on Spectrum Sharing and Spectrum Licensing

Modern Spectrum Licensing Models in the Context of 5G

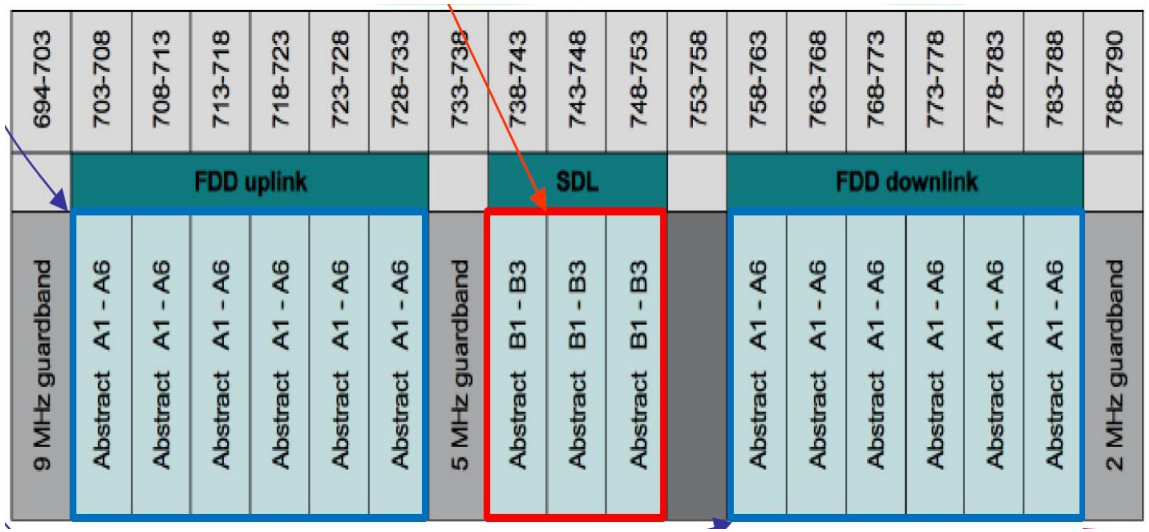


Due to extraordinary high total cost of ownership (TCO), 5G establishes spectrum sharing opportunities on a scale not feasible in previous generations of mobile technology as well as motivates cost sharing (e.g. infrastructure sharing) in order to make deployment economically viable.

- four out of five modern spectrum licensing models for 5G assume spectrum sharing

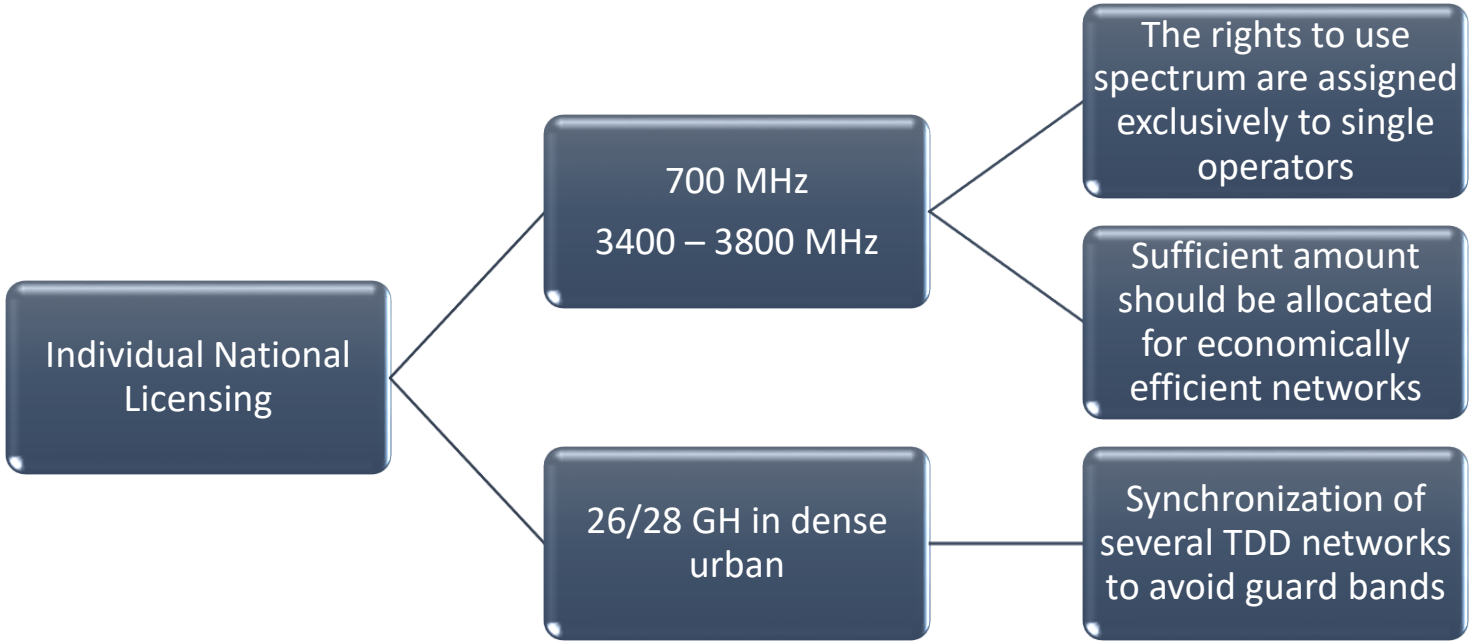
** - classification as proposed by UK Spectrum Policy Forum to form the basis of advice to DCMS and Ofcom on 26 GHz licensing*

Individual National Spectrum Allocation



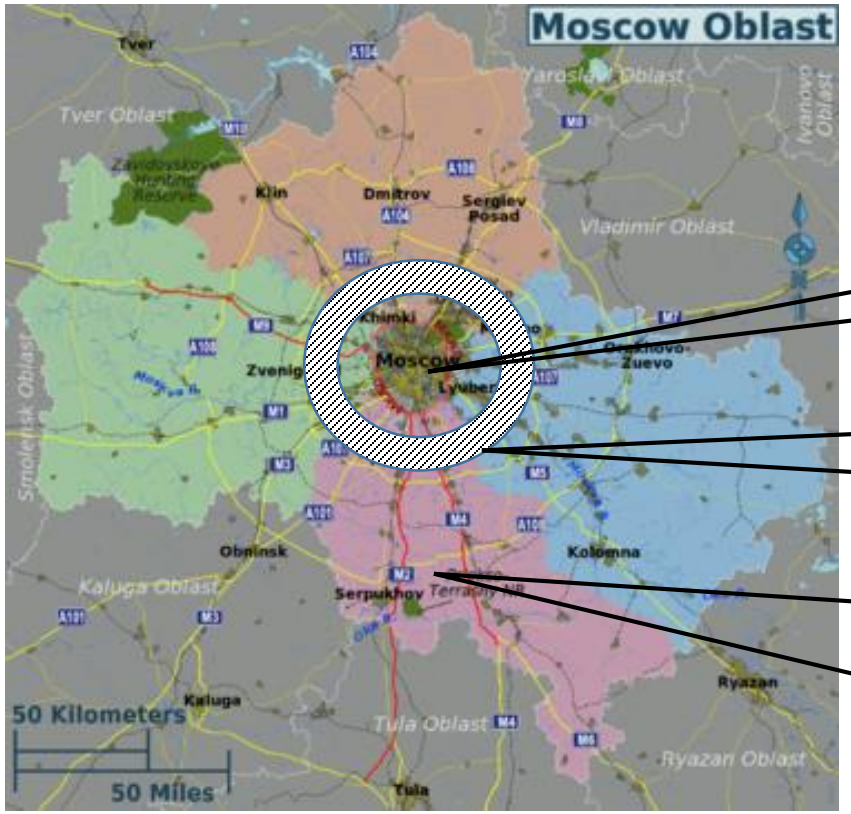
Individual (exclusive) national spectrum licensing is the 'conventional' model, which will remain of central importance in 5G as key enabler of:

- promoting competition;
- supporting significant investments in networks;
- development of a devices ecosystem;
- delivering guaranteed QoS to consumers.



Mixed Spectrum Release Model

5G mmWaves (26/28 GHz) are limiting range, increasing costs of wide-area coverage to unsupportable levels with significantly reduced or a total lack of indoor penetration. Simultaneously mmWaves are facilitating innovations in spectrum sharing by virtue of the greater radio isolation achieved between indoor and outdoor environments, and the more localized propagation when used outdoors. Scenario with two distinct components:



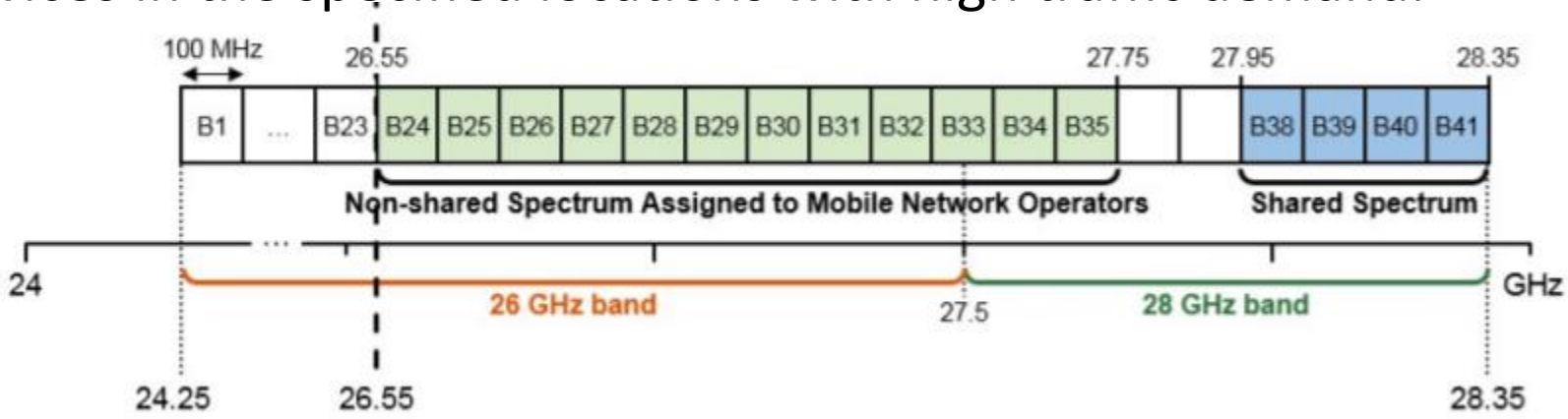
High Population Density Area with Exclusive Allocations where spectrum blocks are auctioned for exclusive use by individual MNOs. The exact boundary should be established through consultation by a regulator.

Buffer Area is desirable to be calculated by means of on-line access to a spectrum management tool/database

Non-Urban Model with Shared Access could be based on assignment principle “first come first served”. May be unsuitable for backhaul use cases with higher reliability and QoS requirements. May be restricted due to the need for TDD network synchronization leading to guard-bands between operators, or an acceptance of unpredictable interference.

High Traffic Demand Priority Areas (Hong Kong Model)

The Communications Authority (CA) of Hong Kong has subdivided 26/28 GHz band into the non-shared and shared spectrum. 400 MHz (27,95 – 28,35 GHz) is allocated on a non-exclusive and geographically sharing basis (“Shared Spectrum”) for the provision of innovative wireless broadband services in the specified locations with high traffic demand.



- Services will in general be wireless data-centric communications provided to specific groups of users in specified locations of the territory.

- Assignees of the Shared Spectrum should not deploy the spectrum assigned on a wholesale or retail basis to provide conventinal public mobile services.

- An assignee of the Shared spectrum shall deploy the spectrum assigned for the provision of innovative wireless broadband services in specified locations in accordance with the intended service areas and subject to a limit on total network coverage of no greater than 50 square km.

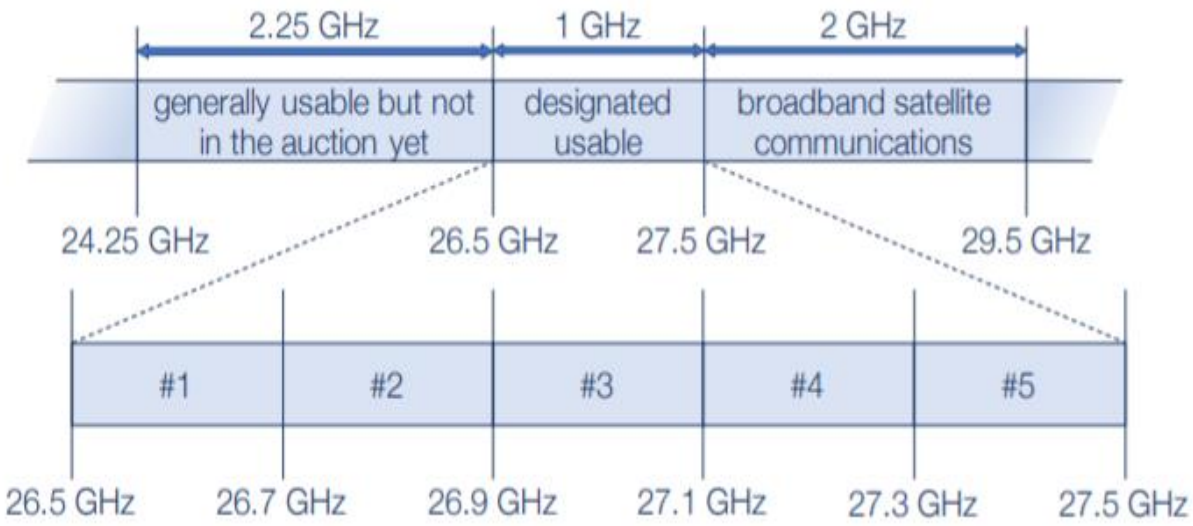
- Spectrum is assigned based on “first come first served” principle.

- Spectrum cap is 400 MHz per operator.

CA encourages commercial agreements for the sharing of “bottleneck” facilities.

- CA may direct sharing of “bottleneck” facilities and determine the terms for such sharing.

Club Sharing



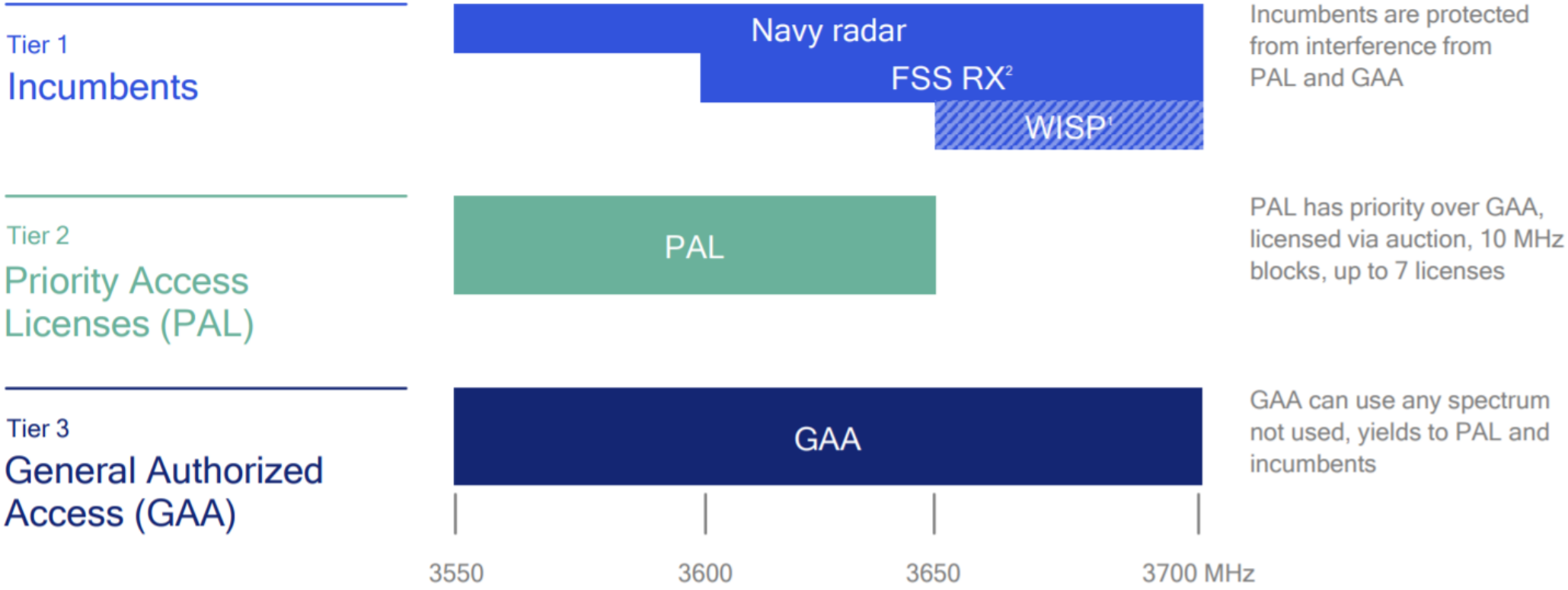
Italian Model - Club is comprised of MNOs with exclusive 200 MHz blocks. Where a MNO is the sole 5G provider at a particular location, it is entitled to use the whole bandwidth of the club. When another MNO appears at the same location, the club spectrum is shared on some agreed basis. Every MNO always has priority over their own assigned block of 200 MHz.

Dynamic Abandoning Italian Model – a MNO being the sole 5G provider at a particular location, could use the entire band on an opportunistic basis. However, it must dynamically release any exclusive spectrum belonging to another mobile operator, should that operator turn up to run a competitive service in the same location. How fast is “dynamic” is a matter of definition and could include a period of notice to vacate the borrowed spectrum.

With both models, a regulator should create a fair sharing framework allowing flexibility, when assignments are turned into working systems yet having the powers to deter squatters and hoarding.

Technology Innovation Driven Sharing

Tiered Model (Citizens Broadband Radio Service (CBRS) in the USA)

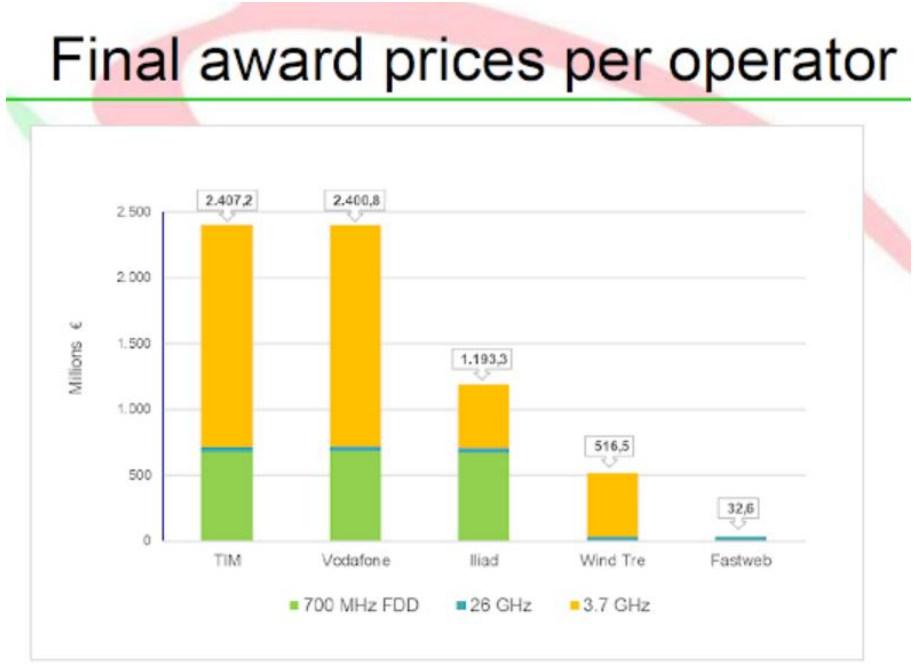


AI Technologies

In the longer term, advances in AI technologies will enable spectrum resources to be flexibly linked, in real time, to instantaneous local demand. When it becomes feasible, it could be more readily applied to the Club Spectrum. It could become an option for exclusive spectrum holders where, when and if spectrum owners decide to pool spectrum for any purpose.

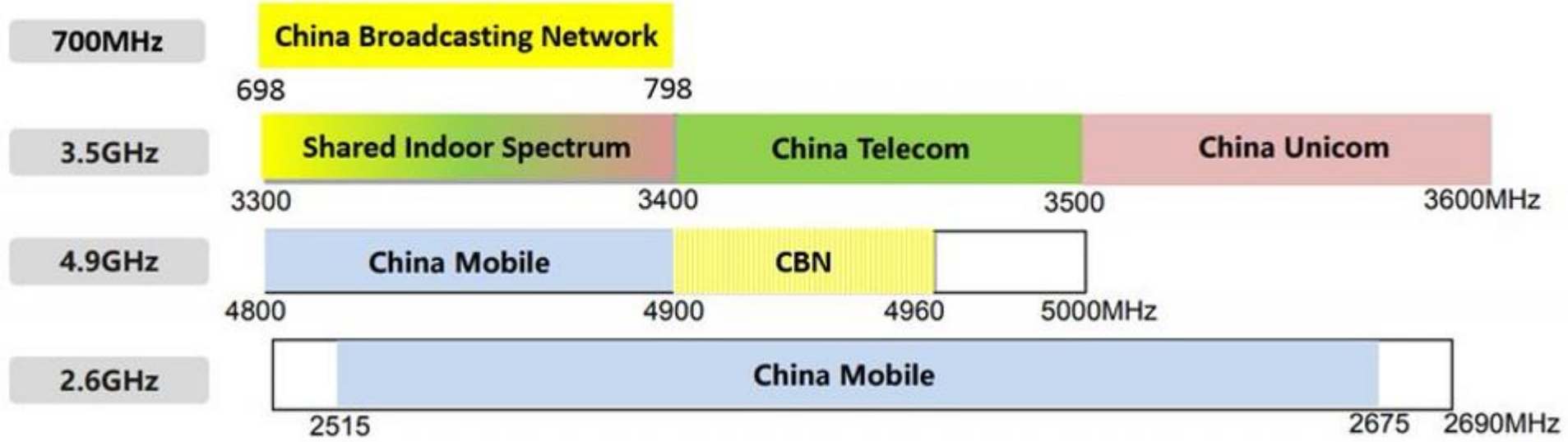
5G mmWaves Club Sharing in Italy

Italy has proposed a club licensing model, which is a form of concurrent shared access enabling licensees to share any unused spectrum from other licensees. Each licensee can dynamically use all the awarded spectrum (up to 1GHz) in areas, where frequencies are not used by other licensees. Licensees can stipulate commercial nondiscriminatory agreements, proportionally sharing the costs of the infrastructure.



Each license holder has the preemptive right of its assigned lot of 200MHz. Licensees can assign a third party the task of managing the use of the spectrum to prevent any harmful interference. Under the Italian regime, other players are also allowed to have access to develop 5G services. If the requester asks for access in areas already covered, then the access is provided by the existing operator, whereas in areas not yet covered, licensees handle the request collectively or through the trusted third party.

Three Sharing Parties of MNOs in China



China Mobile - CBN	China Telecom – China Unicom	CBN – China Telecom – China Unicom
• May, 2020. Collaborative framework agreement in relation to 5G co-construction and sharing • To carry out 5G co-construction and sharing as well as content and platform collaboration. • Jointly invest in the construction of the 700MHz 5G wireless network, jointly own and have the right to use the 700MHz 5G wireless network assets • CBN may share China Mobile's 2G/4G/5G networks on a paid basis	• September, 2019. Framework Agreement on Co-building and Co-sharing 5G Networks. • By sharing their spectrum allocations the companies built together and share one 5G radio access network in 15 major cities, including Beijing, Shanghai, Shenzhen, Guangzhou, etc. • Two companies built their own separate 5G networks in other parts of the country. • The 5G core networks were built separately.	• February, 2020. Three Chinese MNOs signed agreement to share 3300 – 3400 MHz spectrum for indoor 5G coverage. • The companies are leveraging the co-development and sharing of 5G indoor access networks to cut costs and boost efficiency.

Thank You For Attention