# **5G ROAMING OPPORTUNITIES IN A POST-COVID-19 ERA**

A White Paper by Kaleido Intelligence & iBASIS





# **Executive Summary**

This latest edition of the 5G Roaming white paper from iBASIS and Kaleido Intelligence highlights the impact of COVID-19 on mobile roaming strategies, critical changes that 5G will bring for operators, and which must be addressed if successful deployments, customer experience and profitability are to be achieved.

The continued rise in roaming data traffic highlights the importance of 5G services and why operators must persist with the 5G roaming roadmap in order to remain competitive. 5G will drive roaming revenues over the next 5 years and presents operators with an opportunity to innovate and deliver new smarter and consumer-focused data services. Kaleido Intelligence surveyed nearly 70 respondents across tier-1 operators around the world on their 5G roaming plans during January-February 2021 to learn more about their current and future roaming plans as well as commercial and technical requirements for implementing 5G roaming from an IPX, security and signalling perspective.

## **Key Survey Findings**

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Despite the impact of COVID-19, MNOs must realise the importance of launching 5G roaming alongside immediate planned actions to protect roaming revenues and to offset any losses.

• Around 33% of the operator respondents surveyed announced that they will launch 5G NSA roaming in 2021, with 12% confirming 5G SA roaming launch in H2 2021. An additional 20% stated that they will launch 5G SA roaming in 2022.

While launching 5G roaming based on NSA architecture, the most immediate requirements were found to be *Security, VoLTE Roaming and High-bandwidth Support with Extended QoS*.

- The need for security is unsurprising given the elevated attack surface and the enhanced security prerequisites for 5G roaming.
- The sunsetting or shutting down of 2G and 3G networks around the world means that operators must accelerate their plans to support VoLTE and manage inbound roaming revenues.

From a 5G NSA roaming perspective, it was found that consistent and guaranteed QoS to be the top priority, with 67% ranking QoS as very important.

• In comparison, while migrating to 5G SA roaming, once again, operators expected a significant focus on security with 74% ranking it as very or extremely important.

## **Key Survey Findings**

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IPX providers will play an important role in helping operators to deploy SEPP (Security Edge Protection Proxy) for the control plane while migrating to 5G SA roaming. SEPP is an important and mandatory requirement for 5G networks interconnect for roaming in a SA architecture.

- 51% of respondents ranked security as extremely important while rolling out 5G roaming. However, while migrating to 5G SA roaming, operators expected significant focus on security with 74% ranking it as very or extremely important.
- Around 32% viewed the IPX-hosted SEPP/ hybrid SEPP model as a route forward for 5G roaming.
- The need to continuously monitor and manage critical assets from new threats and to avoid revenue loss was found to be the top 2 reasons driving security investments for mobile operators in 2021.

Operators require continued 5G signalling support via HTTP/2. IPX vendors can help operators to introduce this during the early stages of the upgrade to 5G SA network architecture.

- This new protocol will enhance the protection against any new or known interexchange/roaming vulnerabilities.
- According to the survey, around 65% of respondents believed that 5G signalling support via HTTP/2 is very or extremely important in terms of key expectations from their IPX vendor.

Network slicing, where a portion of the available network is sold and run as a separate entity from the rest of the network, will enable operators to provide a truly global network service.

• Nearly 57% of survey respondents in Kaleido's 5G roaming survey observed that the IPX vendor's ability to support advanced network-slicing functions is very or extremely important.



5G roaming traffic is predicted to account for 38% of total data roaming traffic generated by consumer mobile and IoT connections by 2025.

• The operator's IPX vendor must be capable of managing any capacity requirements, with 38% of respondents named meeting the data demand and handling of 5G enhanced mobile broadband as extremely important, with a further 54% noting it as very important.

# **5G Roaming: Market Readiness & Status**

#### **5G Connectivity Outlook**

The global COVID-19 pandemic has significantly disrupted key industry verticals around the world, with unexpected variables essentially resetting investment priorities. Consequently, mobile operators around the world have witnessed a decline in annual service revenues. However, this has not dampened the near-term investments and roll-out of 5G.

In fact, it can be argued that the pandemic has made clear the vital role that 5G will play in enabling ubiquitous access to digital services across all key industrial and consumer sectors.

Many operators reported that bandwidth demands increased during the pandemic, with Verizon in the US reporting an increase of 75% in March 2020 due to remote working, online education, and increased demand for digital services such as gaming and video. This continued rise in data traffic highlights the importance of 5G services and operators must persist with the 5G roadmap in order to remain competitive.

In 2020, mobile operators around the world accelerated their 5G strategies in terms of strategic planning, testing and expanding rollouts. During the early months of the pandemic, operators and consultants around the world predicted serious disruption to 5G deployment, especially given the logistics uncertainty and supply chain delays.

However, in the months since, it became evident that this has not been the case for most operators, with minimal disruptions reported.

For example, as of December 2020, China accelerated its 5G rollout by deploying a total of more than 718,000 5G base stations, accumulating well over 110 million users. According to the Ministry of Industry and Information Technology in China, this will continue in 2021, with more than 600,000 5G base station deployments expected. Meanwhile, US mobile operators expanded 5G coverage to 75% of the population. In comparison, European 5G coverage is much lower at 25%.

In 2020, mobile operators around the world accelerated their 5G strategies in terms of strategic planning, testing and expanding rollouts.

In addition, operators have also accelerated 5G network sharing strategies in a bid to maximise rollout and coverage, and to minimise expenditure. Active network sharing agreements in place for 3G and 4G are expected to be extended to 5G in the short-term, while new partnerships and agreements will be facilitated in the coming months.

#### Figure 1: Global 5G Connections in Millions, 2019-2026



5G consumer adoption is predicted to be significantly faster than for 4G. Global 5G connections will reach 1.4 billion in 2022, before reaching 3.9 billion in 2026.

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Source: Kaleido Intelligence

Kaleido believes that 2021 will not witness any slowdown in the adoption of 5G services by customers and that the number of total 5G connections will reach 712 million, up from 237 million in 2020.

#### **5G Roaming Outlook**

In summary, 5G networks differentiate themselves from 4G by enabling the following improvements:

- 100x increase in data rates and traffic capacity
- 100x increase in network efficiency
- 10x decrease in latency
- 10x increase in throughput
- 10x increase in connection density

During 2019 and 2020, several global markets switched on 5G and nearly all smartphone vendors are now offering midrange and premium 5G devices.

As of December 2020, 140 operators in 59 countries/territories have launched commercial 5G services, up from 61 commercial networks in 2019. Also, 61 operators are investing in public 5G SA networks (in the form of trials, planned or actual deployments).

While 5G deployments primarily so far have been on non-standalone network (NSA) modes, some operators have launched 5G standalone (SA) networks as well as commercial services in 2020: as of December 2020, 3 operators have launched 5G SA commercial services, with another 8-10 expected to launch services very soon in H1 2021. However, 5G rollouts will continue to be based on the NSA architecture, in the shortto medium-term. 5G NSA deployment models utilise existing 4G infrastructure, i.e., using Evolved Packet Core (EPC) and LTE eNB access. This rollout (primarily Option 3 deployment model, where both LTE and 5G NR radio access are present and controlled by the EPC core) will depend on the use cases that 5G will aim to address initially; for example, eMBB (Enhanced Mobile Broadband) related to 4K-8K videos, AR/VR applications as well as HD communications.

In comparison, 5G roaming is available in around 24 international markets, offered by 31 operators, with another 5-10 market launches expected over the next 6 months. Deployments so far have been on 5G NSA network modes, with 5G SA networks expected to launch later this year.

Indeed, 5G roaming is a very important factor that will drive roaming revenues over the next 5 years and presents operators around the world with an opportunity to innovate and deliver new smarter and consumer-focused data services. Similar to 5G domestic rollouts, COVID-19 has not significantly disrupted the 5G roaming rollouts: according to a mobile operator survey conducted by Kaleido Intelligence in October 2020, 57% of respondents confirmed that all planned roaming rollouts will continue as per pre-COVID roadmap. The survey found that only 4% of the respondents confirmed delays to VoLTE, 5G nonstandalone and 5G standalone roaming rollouts. Amongst the number of respondents reporting delays to 5G roaming rollouts, around 60% reported delays of 6-12 months.

Kaleido surveyed nearly 70 respondents across tier-1 operators around the world on their 5G roaming plans during January-February 2021. Around 33% of the operator respondents surveyed announced that they will launch 5G NSA roaming in 2021, with 12% confirming 5G SA roaming launch in H2 2021. An additional 20% stated that they will launch 5G SA roaming in 2022. However, a small proportion of operators do not have any specific plans to roll out 5G NSA roaming in their roadmap, representing around 9%. In comparison, 25% of the operators surveyed stated that 5G SA roaming was not in their current roadmap.

#### Figure 2: 5G Roaming Deployment Plans

When will you launch 5G roaming? (Select based on NSA/SA architecture) n=69



Based on NSA

Based on SA

With operators investing in numerous 5G use cases including new enhanced voice and data roaming services, the rollout of 5G networks around the world will transform mobile roaming and generate additional revenue opportunities for stakeholders.

5G will not just enable faster mobile broadband for roaming consumers but will enable new mMTC (massive machine type communication) and uRLLC (ultra-reliable low-latency communication) services. The critical challenges that operators now face is threefold:

- Ensuring capacity to meet the substantial surge in roaming traffic generated by consumer mobile and IoT connections.
- Ensuring QoS and CoS levels to meet the expected premium experience for both consumer and IoT segments.
- Finally, requirements to meet network interconnection and steering security policies.

These challenges, alongside other key issues and benefits, can be duly addressed by partnering with an IPX provider enabling a direct migration path from existing roaming services to 5G roaming solution, including signalling and interconnect, security, clearing and settlement, alongside other value-added services such as analytics and fraud management.

#### **Impact of COVID-19 on Mobile Roaming & Recovery Prediction**

Following the impact of COVID-19, outbound international travel trips fell by 73% in 2020 to reach 552 million, leading to over 1.5 billion fewer trips worldwide.

Kaleido Intelligence predicts that the number of international travel trips is forecast to witness an annual average growth rate of 33% to reach 2.27 billion in 2025.

Consequently, the number of global active outbound roaming trips declined by 69% in 2020, representing a total of 442 million trips. The number of active roaming trips is forecast to reach nearly 2 billion in 2025, representing 86% of total outbound travel trips.

In comparison, growth in IoT connections between 2019 and 2020 was relatively flat, with only 17 million additional roaming connections added during the year.

While mobile calls made by domestic users is on the decline, with traditional methods being replaced by OTT voice calls, the same cannot be said about mobile roaming voice traffic. Following a decline in 2020, consumer mobile and IoT data roaming traffic will recover and exceed pre-COVID-19 levels as early as 2022. The availability of RLAH and daily passes offering unlimited calls, coupled with the fact that VoLTE roaming (therefore switching to data roaming) is not that well developed, means that mobile roaming voice traffic, in terms of minutes of use by active roamers is forecast to grow over the next 4 years, despite a 64% decline in 2020.

Despite the number of roaming trips taking longer to recover (2023-2024 in most cases), voice traffic will reach pre-COVID-19 levels as early as 2022 globally. Kaleido forecasts that consumer mobile and IoT data roaming traffic will exceed pre-COVID-19 levels as early as 2022.

Traffic will witness an average annual growth of 41% over the next four years to exceed 2,200 Petabytes in 2025.

#### **MNO Recovery Strategies & Rollout Plans**

According to an operator COVID-19 impact survey conducted by Kaleido Intelligence in January 2021, participating MNOs are currently in the process of implementing or planning necessary steps to protect roaming revenues in the short and medium term.

Renegotiating wholesale agreements and tariffs was found to be high on the priority list for mobile operators around the world. This was followed by focussing on new IoT services and verticals and cost reduction to manage profits. **Figure 3: Roaming Recovery Strategies: Planned Actions by MNOs** *Is your company taking or planning any actions to protect roaming revenues as a result of the* 

*COVID-19 outbreak? (Select one or more , and indicate level of priority) n=53* 



Source: Kaleido Intelligence

Despite the impact of COVID-19, MNOs must realise the importance of launching 5G roaming alongside immediate planned actions to protect roaming revenues and to offset any revenue losses. Around 36% of respondents confirmed that 5G roaming rollouts will continue as per the pre-COVID-19 roadmap, with only 18% confirming delays in 2020. This is extremely important given the fact that 5G roaming is expected to unlock new revenue streams for the operators.

#### 5G Roaming Revenue: \$18 Billion Cumulative Opportunity

Kaleido predicts that revenues from outbound and inbound roaming traffic generated by 5G consumer mobile and IoT devices will exceed \$11.5 billion in 2025, representing an average annual growth rate of 468% and represents a cumulative revenue of \$18 billion over the next 4 years. 5G roaming revenues from both outbound and inbound traffic will represent well over 40% of total roaming revenues by 2025, this is up from less than 5% in 2021.

5G roaming revenues generated by consumer mobile roamers will drive growth over the next 5 years.

The increase in service quality and bandwidth afforded by 5G, followed by specialised services beyond consumer use cases within key IoT verticals, will be the primary revenue drivers for 5G roaming.

IoT will become the dominant traffic generator for 5G roaming in the future, however, this is at least another 6-7 years away. Within enterprise and IoT roaming, new applications and use cases in the mMTC and uRLLC will drive roaming revenues for the operators.

Overarchingly, key vertical growth areas here will consist of logistics and healthcare sectors, where the European Commission has already called for increased logistics and supply chain transparency, which will be supported by connected solutions.

# Figure 4: Global 5G Roaming Outbound & Inbound Revenues in USD Million Per Annum, 2020-2025



Source: Kaleido Intelligence

Global consumer 5G roaming data traffic is forecast to exceed 645 PB by 2025, up from a predicted 1.3 PB in 2021.

# Ensuring a 5G Success. The Essential Ingredients

#### Introduction

While it is still early days for 5G roaming, it has the potential to enable operators with an opportunity to deliver innovative data services. It can also eliminate existing technological barriers in delivering ultra-low latency and high-speed capabilities.

Mobile roaming data traffic is expected to rise by 295% between 2021 and 2025. This means that operators need the right IPX partner to give them better control over the data demand expected across a range of new consumer and IoT roaming applications.

According to the operator survey conducted by Kaleido in January 2021, the most immediate requirements while launching 5G roaming based on NSA network architecture were found to be focused on security, VoLTE roaming and high-bandwidth support with extended QoS. This is unsurprising given the elevated attack surface and the immediate requirement to transition to VoLTE roaming. 67% of respondents rated VoLTE roaming as very or extremely critical, with 58% saying the same for security.

#### Figure 5: 5G NSA Roaming MNO Requirements

*What do you perceive to be the most immediate requirements while launching 5G roaming based on NSA? (Select based on level of criticality) n=69* 



In comparison, to ensure that 5G SA roaming migration is efficient, a number of significant hurdles will need to be overcome by operators. The most immediate requirement from a 5G SA roaming perspective was found to be interconnect models with 36% of respondents finding it as extremely critical versus 27% for VoLTE and Vo5G roaming support.

#### Figure 6: 5G SA Roaming MNO Requirements

*What do you perceive to be the most immediate requirements while launching 5G roaming based on SA? (Select based on level of criticality)* n=69



Source: Kaleido Intelligence

# IPX Evolution: 5G MNO Requirements & Challenges

Deploying SEPP (Security Edge Protection Proxy) for the control plane is an important and mandatory requirement for 5G networks interconnect for roaming in a SA architecture. 51% of respondents ranked security as extremely important while rolling out 5G roaming. Meanwhile, 38% of respondents named meeting the data demand as extremely important. With 5G roaming traffic expected to account for 38% of total data roaming traffic generated by consumer mobile and IoT connections by 2025, the operator's IPX vendor must be capable of managing any capacity requirements. Operators need IPX vendors capable of meeting all their roaming needs: including reliable interconnectivity services, the ability to manage any capacity requirements, readiness to handle all IoT capabilities and meet security and quality necessities.

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Indeed, faster speeds have always given rise to increased data consumption demands, and this means that IPX vendors must be able to meet any capacity requirements as needed.

From a 5G NSA roaming perspective, it was found that consistent and guaranteed QoS to be the top priority, with 67% ranking QoS as very important. However, while migrating to 5G SA roaming, once again, operators expected a significant focus on security with 74% ranking it as very or extremely important.

Support for advanced network slicing functions was found to be the next most important requirement, with 57% of surveyed operators considering this as very important. Network slicing, where a portion of the available network is sold and run as a separate entity from the rest of the network, will enable the mobile operator to provide a truly global network service. From an IoT perspective, operators will need their IPX vendor to address different 5G slices and standardised business models. Despite some operators trialling federated network slicing and self-service models for 5G, there are no formal standardised slicing models for roaming yet.

#### Figure 7: 5G Data Traffic as a Proportion of Total Roaming Traffic, 2023-25



Source: Kaleido Intelligence

Nearly 57% of survey respondents in Kaleido's 5G roaming survey observed that the ability of the IPX vendor to support advanced network-slicing function is very or extremely important.

#### Figure 8: 5G Roaming IPX Vendor Expectations: Support Advanced Network-Slicing Functions

*What are your expectations from your IPX vendor while launching 5G SA roaming? n=69* 



According to the survey, signalling interworking, data transport and big data analytics were found to be the top 3 most important 5G roaming service innovation that operators expect from their IPX vendor.

#### Figure 9: 5G Roaming Services & Innovation Requirements

What kind of services or innovation do you expect from your IPX provider? n=69



Source: Kaleido Intelligence

#### **Signalling Requirements**

Mobile operators require a more robust and comprehensive signalling solution from the IPX vendor. Migration to 5G NSA and 5G SA will require three signalling protocols: SS7, Diameter and HTTP/2. Signalling and interconnections in 5G will be based primarily on Service Communication Proxy (SCP), Binding Support Function (BSF) and Security Edge Protection Proxy (SEPP) functions.

SCP enables critical signalling functions including aggregation and routing, load balancing and overload handling, message parameter harmonisation, signalling prioritisation and protection etc. Meanwhile, the 3GPP BSF is the specific 5G function required to bind various and multiple sessions originating from a single subscriber and is similar to the DRA function in 4G; for example, BSF in 5G becomes mandatory to support multiple PCF (Policy Control Function) deployments. 5G brings a new core network signalling protocol: HTTP/2. Operators will need to introduce this to 5G SA network architecture during the early stages of upgrade. These new protocols and functions will enhance the protection against any new or known interexchange/roaming vulnerabilities.

According to the survey, around 65% of respondents believed that 5G signalling support via HTTP/2 is very or extremely important in terms of key expectations from their IPX vendor. IPX vendors must be prepared to offer this as a single and unified solution as operators migrate domestic and roaming networks to 5G SA architecture.

In addition, signalling interworking is a very important requirement for the mobile operators, alongside enabling secure interconnect between 5G networks by introducing SEPP functionality and ensuring end-to-end authenticity and integrity. According to the GSMA, since SA operators provide services that are delivered over standalone 5GC (5G Core), interworking between 5GC and EPC for service continuity for those services will be required.

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Nearly 74% of respondents noted that supporting future interworking and transition to 5G SA, based on the migration path taken, is extremely or very important.

#### Figure 10: 5G Roaming IPX Vendor Expectations: 5G Signalling Support via HTTP/2

What are your expectations from your IPX vendor while launching 5G SA roaming? n=69



#### **Implementing 5G Security & the Importance of Hosted SEPP**

With revenue margins for operators decreasing, they will need to look into fraud protection and security intelligence platforms for managing growth.

Although there is an increase in the awareness of threats and fraud, networks continue to face a constant evolution of risks, hence the need to embrace such solutions, especially as future fraud and security needs will be different from a 5G and IoT perspective. Indeed, signalling security is of major concern to all operators: considering that all the interconnect signalling protocol such as SS7, Diameter and GTP are all vulnerable to various attacks including fraud, infiltration attacks, denial of service and routing attacks. Many IoT devices continue to use SS7 as a means of opening a data channel to the network, which, given the lack of encryption over the SS7 protocol, shows obvious flaws.

Additionally, the relatively long migration to 5G SA will mean that access to the IPX signalling network will continue over SS7 (for 2G/3G) and Diameter (4G) protocols, both of which have several known security flaws. It is expected that 5G will result in a further increase in security threats.

The need for 5G roaming security as reported by the operators was found to be a top priority throughout the survey: 74% ranked it as very or extremely important.

Figure 11: Top 5 Security Investment Drivers in 2021What are the key factors driving your security investments in 2021? n=69



Core network security and implementing SEPP are the top priorities for security investment in 2021.

> The need to continuously monitor and manage critical assets from new threats and to avoid revenue loss was found to be the top 2 reasons driving security investments for mobile operators in 2021.

Operators and IPX vendors are investigating and trialling the best approach to 5G roaming security in terms of efficiency and reliability. This will be based on the concept of 'security by design'. In the case of 5G SA roaming, SEPP becomes the mandatory element of 5GC interconnect. The SEPP offers endto-end security for roaming interconnect messages, offering substantial security enhancements over the simple transport encryption offered by Diameter, and no encryption offered by SS7.

Authentication between operator SEPPs is required to prevent unauthorised communication between networks. The N32 interface is introduced to function alongside the SEPP to ensure that sensitive data between SEPPs is protected. The SCP (Service Communication Proxy) offers networks support in case of any malicious traffic traversing over the network.

It increases the resilience of the network by mitigating network overload instances (such as through signalling storms) and prioritising message handling in cases where the network is overloaded. SEPPs can be deployed by MNOs themselves for interconnection with IPX providers or use a hosted SEPP from the IPX provider.

#### Figure 12: Key Security Investment Priorities in 2021

What are your priorities for security investment plans in 2021? n=69



Source: Kaleido Intelligence

#### **Figure 13: Security Method Preference**

*Which security method(s) do you expect your IPX in 5G to use to provide you VAS services for 5G; how do you expect your IPX provider to address these?* n=69



Source: Kaleido Intelligence

While the majority of the respondents were unsure of which security methods IPXs will use to deliver value-added services for 5G, around 32% viewed the IPX-hosted SEPP/ hybrid SEPP model as a route forward for 5G roaming. In terms of the hosted SEPP, the MNO will outsource the SEPP function to the IPX provider, and the hybrid model combines the hosted SEPP and Direct TLS (Transport Layer Security).

#### How Analytics Will Change the 5G Roaming Landscape?

Roaming analytics has become so important over the years, with more operators expected to implement analytics suite with a large focus on predicting, forecasting, and impact analysis to optimise their 5G roaming revenues. The adoption of such services enabling actionable insights based on real-time analysis, margin management, traffic detection, roam like home, and managed by advanced machine learning algorithms will provide detailed information on 5G roamer behaviour and consumption. This will further enable predictive analytics to support targeted campaigns and better-quality services.

According to the survey, big data analytics and real-time intelligence were amongst the top 3 innovation and services expected by operators from their IPX vendors. In addition, around 16% of respondents expected value-added services such as big data analytics and real-time intelligence platforms to be deployed in the cloud.

In terms of network slicing, analytics will play an important role in monitoring the slice integrity and QoS commitments while expanding services to the international market. Indeed, around 52% of respondents felt that this was extremely or very important, with a further 39% noting it as moderately important while launching 5G SA roaming. A key requirement from operators at this very moment is to implement analytics and real-time management capabilities into their existing platform.

#### Figure 14: 5G SA Roaming IPX Vendor Expectations: Network Slice Integrity & QoS Commitments

*What are your expectations from your IPX vendor while launching 5G SA roaming? n=69* 



Source: Kaleido Intelligence

The advantage of being able to optimise the slices, maintain endto-end integrity and management, and to generate contextualised data will bring multiple possibilities for the operators to offer differentiated services across industry verticals. Mobile operators must evaluate their analytics strategies and IPX partnerships in place to offer demand-driven different levels of service guarantees across network slices. This becomes extremely important once taken into consideration the fact that 5G roaming is expected to continue to evolve over the coming years, unlocking many new opportunities, service levels and usage levels.

#### **Private Network Evolution**

Private LTE networks, in contrast to traditional Wi-Fi or wired networks, offer many new advantages, including in terms of application performance as well as flexibility and security.

Private networks can be deployed in several fashions:

- Local radio hardware connecting to the macro network, with the private network allocated logically via network slicing. The operator is a key service provider, with MEC providing some of the computing power to handle operations and data processing.
- A similar architecture to the above, albeit with a local core deployed close to the private network. MEC will likely power the core as well as provide fog computing power.
- As standalone networks with dedicated spectrum. MEC nodes will likely be controlled and operated by enterprises deploying this type of network.

Almost all private networks will benefit from some kind of connection with the macro network. This means that roaming connections will, in many instances, roam across private and public network instances. It is here that additional opportunities will be afforded, as customers will likely desire specific service levels, both at the local and international interconnect: certainly, affording a high level of security will be in demand, while other customers will look to achieve lower latencies where possible. Sensitive data carried inside a private network becomes vulnerable once that network is connected to a wider public access network.

From a 5G perspective, there is no doubt that private 5G networks will address specific OoS and service needs as well as data storage and processing requirements, be it at a regulatory or corporate level. Given the slow pace and complexity of network slicing development, Kaleido anticipates that large enterprises will inevitably favour the private 5G network route. What this will mean is that the traditional owners of the network, MNOs, lose a position on strength from a contractual perspective.

In turn, MVNOs will likely face pressure for market share not only from MNOs themselves but also from a number of enterprises that choose to enter the space under the private 5G network model.

Players must consider how to position themselves strategically in anticipation of private 5G growth in the medium term. The development of private LTE and, in the future, private 5G networks indicates a market-driven approach that harnesses alternative cellular deployments for specific industry verticals.

#### The Need for Local Breakout & Opportunities

Today, almost all roaming data traffic is tunnelled back to the home network via an IPX carrier network.

Operators are faced with the option to use IPX vendors to carry roaming traffic routed back to the home network or deploy LBO:

- With home routing, data traffic is tunnelled back to the home network and then to the internet.
- In comparison, LBO enables roamers to receive data services directly from the visited network (VPLMN) instead of tunnelling back to the home network (HPLMN). Here the signalling data is routed to the home network for policy control and handling. Depending on the policy set by the home network, depending on the termination of signalling data required, i.e., destined for the home network (LBO-Home Routing) or the visited network; data is routed accordingly.

Key advantages of LBO include:

- Low latency for connected roaming devices
- Low bandwidth requirement for data transfer between home and the visited network

Indeed, all architectures have their respective advantages and disadvantages, depending on the complexity and diversity of the application and retail roaming commercial requirements. However, despite being around for a long time, LBO has witnessed slow progress with operators still not keen on deploying LBO, due to very well understood reasons. IPX vendors can either host traffic and route them or can provide their own local data services via an LBO gateway thereby reducing cost for the operator. It is understood that this then also becomes an attractive proposition to MVNOs to utilise the IPX vendor's network to offer roaming services to customers.

#### Figure 15: Importance of Local Breakout (LBO) in 5G Roaming



With 5G supporting various enterprise and consumer use cases, there is a need to support both LBO and home routed architectures. Around 33% of the respondents believe LBO will play an important role in the future as opposed to critical (29%). LBO will be required for use cases such as 4K/8K video services, V2X (Vehicle-to-Everything) communications and other low latency applications and services where offloading data to the local network is recommended. Indeed, for mission-critical uRLLC applications, local processing via edge computing nodes will be required. However, this will mostly be driven by private network deployments.

Operators must start preparing for the full transition towards 5G roaming. Consequently, operators will expect IPX providers to offer both regional and local breakout to support their 5G roaming needs. This will enable specific traffic profiles to be differentiated and optimise 5G roaming.

#### **5G Roaming Use Cases & New Applications**

5G will create innovation and value services across all industry verticals.

5G roaming is not necessarily about faster connections while abroad, but also about extending connections to IoT devices overseas and other mMTC and uRLLC roaming applications.

Within enterprise and IoT roaming, it is expected that new applications and use cases in the mMTC and uRLLC will drive roaming revenues for the operators.

Kaleido's research identified critical use cases that 5G roaming will drive across eMBB, mMTC and URLLC:

#### Figure 16: 5G Roaming Uses Cases & Services

*What are your expectations from 5G, from a roaming use-cases and services point of view?* n=69



- High-speed 4k-12k video streaming for consumers.
- Industrial applications, where operational effectiveness can be enhanced, and costs reduced.
- Automotive use cases, where V2X and autonomous vehicle technologies will rely on the reliability and low latency.
- Immersive media experience, i.e., AR/VR applications, across both consumer retail and healthcare sectors.
- Healthcare telemedicine applications which benefit from connection reliability, low latency and improved data security.

These verticals were reflected in Kaleido's 5G roaming survey to operators: according to the 5G roaming survey, 71% of respondents named industrial automation and applications as high or highest importance, 11% more than those who chose connected vehicle applications.

However, in terms of international uRLLC services, respondents noted demand for vehicle applications, industrial services and healthcare applications. In comparison, around 14% stated that they had no plans for such services in their current roadmap.

Mobile consumer low latency services, such as VR/AR applications are still at a very early phase of adoption. Edge computing will be deployed to handle much of the computing power required: however, supporting a substantial number of users per node will require considerable challenges in terms of planning and power supply: this will inevitably take time, while there is a risk of potential low demand from users themselves. Current precursor technologies that will eventually support autonomous vehicles, such as V2I and V2V (Vehicle-to-Infrastructure and Vehicle-to-Vehicle) will not emerge as mainstream vehicle technologies until the middle of the decade.

In the medium-term, broader edge computing use cases will begin to emerge, as sufficient infrastructure is rolled out. Planning ahead, focus must centre on the needs of application developers. High-demand applications such as AR/VR will certainly require the ability to hand off computing power to a number of MEC nodes, meaning that high availability will be needed.

#### Figure 17: uRLLC Roaming Services Rollout

What are your plans for uRLLC services? Specifically, which international ones? n=69





# The 5G Roaming Roadmap & Future Outlook

Based on the various key requirements we discussed above, the below roadmap graphic illustrates key milestones for 5G roaming and outlines. strategic recommendations on what operators need to put in place and when.

#### Figure 18: 5G Roaming Outlook & Roadmap



Source: Kaleido Intelligence

Operators need to prioritise and define a 5G roaming strategy and work with their IPX vendors to overcome all technical challenges with an emphasis on capacity, analytics, security and introducing new signalling and interworking protocols and functions. Over the past 2 years, we witnessed 5G roaming becoming a reality and stakeholders building on the momentum to launch early commercial services and 5G roaming agreements. In 2021, operators will need to continue to prepare for 5G roaming as domestic rollout and adoption of the technology accelerate. With more operators focusing on 5G rollout and with 4G becoming mainstream, VoLTE roaming has become necessary for operators worldwide; this is compounded by a rising number of 2G and 3G network shutdowns. This also means that operators will necessitate any work towards expediting VoLTE rollout as the transition towards 5G SA commences.

Despite some delays in 2020 following the impact of COVID-19, operators must continue with VoLTE roaming rollouts without any futher delays in order to support both short- and long-term objectives.

In addition, following the launch of 5G NSA and commercial roaming agreements, eMBB applications applications will continue to drive roaming traffic over the next 4-5 years. Operators must ensure that IPX vendors are ready for the next generation of data services as well as being capable of handling the capacity, roaming coverage and quality of service requirements.

Following this, interworking with 4G and private networks will become critical as well as extending IPX to support all new possible roaming use cases delivering massive IoT and low latency communication services. This means that operators will need to build the foundation to handle any capacity requirements, support new use cases, provide slice management, integrate testing platforms for these new use cases, from at least 2021 onwards.

Security has been observed as the most important requirement and is recommended that operators follow the principle of 'security-by-design', in order to build the best protection scenarios and maintain interconnect security in the case of 5G roaming.

However, to fully capitalise on the 5G roaming opportunities presented by uRLLC and mMTC services, these use cases must be first established. IPX vendors will therefore need to prepare operators by delivering greater flexibility and scalability in terms of 5G roaming solutions and infrastructure, ranging from signalling and steering to clearing and settlement. While network slicing will play an important role in future IoT roaming networks, it will not

see significant growth until after 2023.

Prior to this, operators will rely on private LTE, and eventually private 5G networks, for the above-mentioned use cases.

Finally, the rollout of 5G roaming services for uRLLC and mMTC use cases, when established, will be highly dependent on operators' ability to secure a return on investment. These will only be ascertained beyond 2026, meaning the immediate focus of network operators and IPX vendors will be on network upgrades to 5G SA and improving capacity to meet eMBB requirements.

## Conclusion

Despite the global impact of the COVID-19 pandemic on mobile roaming traffic and wholesale and retail revenues, the perspective for 5G mobile roaming remains strong and positive.

This has accelerated digital transformation strategies and technology adoption across consumer and enterprise industry sectors.

It is imperative that operators now plan well for extending the premium domestic experiences afforded by 5G to consumers when travel resumes and roaming traffic recovers.

With 5G consumer adoption predicted to be significantly faster than for 4G and operators expected to invest in new consumer and IoT use cases, 5G will transform mobile roaming and generate additional revenue opportunities for stakeholders.

5G is expected to enable numerous use cases, with roaming services delivered with consistent experience and improvements in delivering high-bandwidth mobile broadband and low-latency communication services. However, as evidenced by Kaleido's research and operator survey, there are critical challenges that operators now face to deliver a seamless 5G roaming experience. These include ensuring capacity to meet traffic requirements and bandwidth demand, ensuring the highest level of experience and service to customers, implementing real-time intelligence and analytics to manage roaming KPIs and finally, meeting mobile network signalling and interconnect security requirements.

Operators must collaborate and partner with the right vendors to accelerate their 5G roaming roadmap and the commercial introduction of 5G roaming services and business opportunities, alongside fostering innovations in signalling, clearing and security. Operators will need a reliable, robust and comprehensive IPX solution to support the expected growth in roaming data traffic alongside support for newer protocols and network functions such as SEPP and HTTP/2. This means finding the right partner to ensure launch testing of 5G SA roaming rollouts using these new signalling protocols.

#### **OPERATOR SURVEY METHODOLOGY & DEMOGRAPHICS**

This operator survey was conducted by Kaleido Intelligence in Q1 2021. The questionnaire was developed by Kaleido in partnership with leading industry stakeholders and contained 25 Questions (available on request). The survey was completed by 69 respondents across tier-1 operators around the world and were typically from the roaming business units. The demographics for regional distribution are provided below:

- North Americas: 4%
- · Latin America & Caribbean: 4%
- Europe: 54%
- · Africa & Middle East: 17%
- · Asia & Pacific: 20%

#### **ABOUT iBASIS**

iBASIS is the leading communications solutions provider enabling operators and digital players worldwide to perform and transform. Powered by Tofane Global, the new iBASIS is the first independent communications specialist, ranking third largest global wholesale voice operator and Top 3 LTE IPX vendor with 700+ LTE destinations. With the integration of Tofane's acquisition of the Altice Europe N.V. international voice carrier business in France, Portugal, and the Dominican Republic, iBASIS today serves 1,000+ customers across 18 offices worldwide. iBASIS is taking major steps to help mobile operators experience a fast, secure and easy migration to 5G roaming with a flexible step by step approach. iBASIS is now introducing its 5G signaling exchange testing platform for 5G Stand Alone (SA), a comprehensive trial environment in preparation for launching commercial 5G roaming services with new service based architecture including new signaling protocol -http/2-.

To know more about the multiple scenario and use case testing please contact:

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#### **ABOUT KALEIDO INTELLIGENCE**

Kaleido Intelligence is a specialist consulting and market research firm with a proven track record delivering telecom research at the highest level. Kaleido Intelligence is the only research company addressing mobile roaming in its entirety. Our Mobile Roaming research service covers industry leading market intelligence and publications on Wholesale & Retail Roaming, 5G Roaming, IPX, IoT Roaming and Analytics & Fraud in Roaming. Research is led by expert analysts, each with significant experience delivering roaming insights that matter.

For more information on this market study or if you have further requirements, please contact:

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