Executive Briefing

Network Slicing: The greatest thing since sliced bread?

Network slicing could be important to enable service provider business model innovation in the future. However, where are the opportunities, what do they look like, and how likely are we to see them realised?
Preface

The document has been prepared by independent research firm STL Partners, and commissioned by Hewlett Packard Enterprise. It is based on STL Partners' continuous research programme into the future telecoms operator and how to get there.

This report should be read by CIOs, strategy executives, CTOs, CMOs, enterprise architects and planning/operational staff communications service providers, information providers, software vendors, web/hosting firms, cable operators, ISPs, integrators, developers and similar organisations. Mentions of companies in this document are intended as illustrations of market evolution and are not intended as endorsements or product/service recommendations.
Executive Summary

The greatest thing since…

Network slicing is a seductively attractive concept for telcos. It promises new flexibility and agility, and the ability to deliver multiple network instances (e.g. mobile broadband, IoT, etc.) over one infrastructure. Yet it is complex to deliver from today’s start point, and there are risks including that alternative solutions such as SD-WAN and MVNOs can already be used by enterprise customers to deliver some of the potential benefits.

In this report we examine the balance of those forces, identifying five possible business models for slicing, from internal use by a telco only, through to support for vertical solutions, and explore what it would take to make slicing work.

To support this, we spoke to a select group of informed senior telecoms executives to understand the challenges and benefits as they see them, examined the latest industry ‘proof of concepts’, and envisioned how it might work in practice.

Slicing is far from a sure bet to achieve all its theoretical promises, and the topic aroused a surprising level of animated discussion within the STL Partners team. Overall, we believe the concept merits further exploration with conviction, but also with the clear understanding that the path is not straightforward, and that to achieve a balance of probability in favour of slicing will require a number of knotty problems to be solved.

A vision for meeting telcos’ aspirations

Traditional telecoms revenues from communications services (voice and messaging services) are in decline, and the growth in data services will not be enough to fill the gap. To reverse the decline, telecommunications service providers must develop new capabilities, launch new services that more readily meet the needs of old and new customers and then ensure these services remain competitive over time. Despite many years of trying to do this, operators’ track record has not been encouraging. With some notable exceptions, telecoms operators have found it challenging to develop new services on top of their core network services. Much of the growth has come from reselling third party “non-network” capabilities, or developing other offers such as IT services or in-house content.

Expanding communication networks have underpinned whole new industries. However, more often than not the innovators and application providers behind these new industries see operator networks as presenting constraints and problems that need to be overcome with work-arounds (or even shadow core networks of their own). If operators’ networks are to avoid commoditisation and become more relevant, they need to better support applications and solutions: for their services and others’.

To even attempt this, service providers will need to evolve their business practices. Currently, the clearest possible route to achieve this is to adopt cloud business practices and thinking, supported by dynamic virtualisation of core network assets, and managed within an appropriate new form of organisation. However, it is becoming evident that moving networks from a cumbersome stack of proprietary infrastructure to an agile “programmable” telco cloud is a task of significant complexity both technically and operationally. And yet, this is necessary (albeit not sufficient) for achieving the aspired business transformation and reversal of decline that operators seek. Slicing is an option to help manage this complexity.

Defining network slicing

Network slicing is a term that has been around for a while, but has gained prominence in recent months in parallel with the developments of 5G standards. Although linked, they are not synonymous. Slicing can be
seen as a logical extension of policy control, network functions virtualisation (NFV), software-defined networking (SDN), and their orchestration; the move towards software-centric, flexible end-to-end networks. As more network resources become virtual (rather than physical) and functions are broken out into smaller interoperable chunks, operators will need to think carefully about how they organise the delivery of services over reliable networks.

STL Partners defines slicing as:

‘Network slicing is a mechanism to create and dynamically manage functionally-discrete, virtualised networks over a common infrastructure’

How might slicing help?

One vision for slicing sees it realise some of the expected benefits of virtualisation by providing a model for operationalising virtualised and programmable cloud-based infrastructure. Automation and granular orchestration would no longer be ‘nice-to-have’, but a ‘must-have’ to manage the logical slices on top of the underlying infrastructure. Similarly, it would be necessary for network operators to have processes and systems, even internally, to create slices in an easy and efficient way. For most operators today, this will feel a distant aspiration: more in the realms of a lab proof-of-concept than imminent operationalised practice.

The end-to-end nature of a slice, under this vision, means that slices can be decoupled and largely independent of one another (to a point), but it also results in slices being potentially more versatile than traditional networks by incorporating much more than “transport” functionality. These key features of slicing (see Figure 1) could catalyse the change that is required in the industry to enable growth.

Figure 1: Benefits of network slicing

<table>
<thead>
<tr>
<th>End-to-end slice</th>
<th>Agility &amp; Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Cost &amp; Efficiency</td>
</tr>
<tr>
<td>Orchestration</td>
<td>Management</td>
</tr>
<tr>
<td>Virtual Infrastructure</td>
<td>New Services</td>
</tr>
<tr>
<td>Distributed Computing</td>
<td>Innovation</td>
</tr>
<tr>
<td>Platforms</td>
<td></td>
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</tbody>
</table>

It is still unclear exactly how slicing might open new opportunities for network operators to offer new services. One way this may be done is by allowing third parties (customers or partners) to gain access to the network and be able to manage and control, at least part, of a slice. This we have termed as ‘external slicing.’

A (network) slice could be made up of a range of assets and capabilities, which a third party may want to access to better support their processes and services. Slices contain more than just assets and capabilities tied to connectivity or transport, but others which add value on top of connectivity. Customers would want to be able to control and manage some of these resources to provide for a better service, particularly if connectivity and the network are crucial to the customer’s experience.
Slicing could enable new services and new business models

As well as supporting network operators’ own aspirations in offering new services, slicing could also offer new partnership opportunities for operators. STL Partners has outlined five different business models for external slicing below (Figure 3), which examine how different types of customers/partners will impact the type of business model suitable for their demands.

**Figure 3: ‘External’ slicing business models**

<table>
<thead>
<tr>
<th>Description</th>
<th>Domain slice</th>
<th>Customer managed slice</th>
<th>Slice-as-a-platform</th>
<th>VxNO</th>
<th>Network sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited application and/or networking knowledge. They are looking for customisable solutions that work... with others already.</td>
<td>Operator has slices for multiple partners, because they have similar requirements. Telcos can offer customised services to those partners, as they can parameterise and configure their services as needed.</td>
<td>Operator creates a slice for a single customer/partner based on a set of requirements. This could use pre-defined, standard or tailored functions. The partner may want a slice for a specific reason (e.g. security) but not want to manage the operations.</td>
<td>Operator has a platform which interfaces with partners, offering a pre-defined set of APIs to connect to virtual resources. Partner can change features of its network, but only from this ‘menu’ provided by the operator.</td>
<td>The customer has its own slice and can build its own logical network, including using external virtual resources. Some virtual and physical resources would still be managed by operator, but the customer has considerable access and freedom to swap out elements.</td>
<td>Operator shares part of the underlying infrastructure with another operator through an agreement. Operators manage their own networks entirely. Could be extended outside of home territory.</td>
</tr>
<tr>
<td>Limited application and/or networking knowledge. They are looking for customisable solutions that work... with others already.</td>
<td>Limited application and/or networking knowledge. They are looking for tailored solutions that meet very specific (unique) needs. Big but awkward.</td>
<td>High application knowledge, low networking knowledge.</td>
<td>High application, high networking knowledge. Could be an operator in another geography.</td>
<td>High – already a telecoms operator.</td>
<td></td>
</tr>
</tbody>
</table>

But, where is the money?

Through slicing, operators should be able to do far more over one physical infrastructure at a lower cost. It will also allow them to do things differently: different services, different pricing and different combinations of assets and capabilities. If operators choose, they should also be able to use slicing to open more of their assets and capabilities to others: enterprises, application providers, developers, innovators and “co-
opetitors”. Perhaps most critically, under network slicing, development efforts on new and existing services could be decoupled from each other and from the underlying infrastructure. They could each progress under their own constraints and timelines, but still benefit from common infrastructure. This, will be a key benefit from slicing that operators should seek in their bid to remain competitive and relevant.

A great destination, what about the journey?

Slicing is not “the” answer to meeting operators’ aspirations. It is one possible component of introducing new capabilities that operators need to build a sustainable, growing future. To explain and illustrate it more fully, we have made a strong case for slicing in this report, aiming to set out a compelling and useful vision to explore the concept fully, arguing that it potentially offers a viable mechanism for operators to extract the most potential from NFV/SDN, an opportunity of mind-boggling complexity.

We found that slicing is a seductively attractive concept to telcos, because it promises the maximum flexibility/agility of the ‘network on demand’ type solutions. It could allow the network to cope with very different types of scenarios (IoT, MBB etc.) that are hard to combine into a single infrastructure, and beyond that, potentially finer-grained agility within those bigger scenarios. It could help move telcos towards STL Partners’ “telco cloud” vision.

Yet it is difficult to achieve because delivering it from where telcos are today is technically, commercially, organisationally and operationally complex.

It’s also risky because existing alternatives (such as SD-WAN) offer some of the benefits indirectly, the slicing use cases are to an extent theoretical (though there may be many more we haven’t imagined), and to achieve it at scale it would probably require a big bet investment, rather than an extended agile development approach.

So slicing is by no means a certain success. Yet given the attractiveness of the prize of new growth and agility, we believe it is worth exploring with some conviction.

Next steps

In further research we will examine the customer appeal of slicing concepts to pick apart the nuances of the appeal of alternative solutions, and examine vendor approaches and politics on the topic, to more fully flesh out the supply and demand drivers and constraints of slicing. This reflects two other “big picture” questions around networks and services:

- Which is more important (and more easy to implement / appealing to diverse stakeholders): Networks that adapt to applications, or applications that adapt to networks?
- Is the future more about choosing, controlling and slicing each individual network’s capabilities… or about choosing and combining multiple independent networks? Agility, or arbitrage?
NETWORK SLICING: THE GREATEST THING SINCE SLICED BREAD?

Contents

Preface ........................................................................................................................................ 2
Executive Summary ...................................................................................................................... 3
Introduction ................................................................................................................................ 10
Slicing: a vision for fundamental transformation ...................................................................... 13
  Defining slicing is not about the ‘what’, it’s the ‘how’ ............................................................... 13
  How slicing could enable growth .............................................................................................. 16
New services from network slicing ............................................................................................ 20
  Evidence of the demand for slicing .......................................................................................... 20
  Examples of new services ......................................................................................................... 23
  The slicing business models ...................................................................................................... 27
So, where is the money? ................................................................................................................ 29
  Scenarios for the telco of the future ......................................................................................... 29
  The scenarios imply different business models and ways of making money ......................... 31
How slicing might work in practice ............................................................................................ 34
  Key challenges to achieving slicing .......................................................................................... 34
  Early 5G trials and proofs of concept ...................................................................................... 36
  The evolution to slicing ............................................................................................................. 37
  A tricky transition with major obstacles to address ................................................................. 37
Conclusion ..................................................................................................................................... 39
STL Partners and Telco 2.0: Change the Game ......................................................................... 40

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EXECUTIVE BRIEFING

7
Table of Exhibits

Figure 1: Benefits of network slicing ........................................................................................................ 1
Figure 2: How might (operator) assets translate into demand for slices? .................................................. 5
Figure 3: ‘External’ slicing business models ............................................................................................. 5
Figure 4: 68 major telecoms groups – aggregate telecoms revenue, 2009-16 ............................................. 10
Figure 5: UK mobile ARPU and data volumes, 2013-15 ......................................................................... 11
Figure 6: Forecast revenues for converged telco in advanced market .................................................... 12
Figure 7: With slicing, networks can be adapted to customers and applications ..................................... 14
Figure 8: Diagram of slicing .................................................................................................................... 15
Figure 9: Network slicing compared with existing technologies and services ........................................ 16
Figure 10: Potential benefits of network slicing for network operators ............................................... 17
Figure 11: Google Chrome’s release channels – a model for network development? ........................... 19
Figure 12: How operating models could change under network slicing ................................................. 19
Figure 13: How might (operator) assets translate into demand for slices? ............................................. 21
Figure 14: Example 1 – Emergency Services VMNO ............................................................................. 24
Figure 15: Example 2 – Low Power IoT Service ..................................................................................... 24
Figure 16: Example 3 – Pop-up Network ................................................................................................. 25
Figure 17: Example 4 – Global Streaming Service .................................................................................. 25
Figure 18: Example 5 – Smart Meters .................................................................................................... 26
Figure 19: Example 6 – Renewable Energy ............................................................................................. 26
Figure 20: Example 7 – Mining ............................................................................................................... 27
Figure 21: Slicing Business Models ......................................................................................................... 28
Figure 22: Mapping out the scenarios .................................................................................................... 31
Figure 23: Where will revenues come from? .......................................................................................... 32
Figure 24: Traditional telco cost structure and operating model is set up to operate networks not innovate in services .......................................................................................................................... 33
Figure 25: Under the slicing scenarios, the cost structures shift accordingly ....................................... 33
Figure 26: Challenges identified from interview programme .......................................................... 34
Figure 27: Phases of network transformation for slicing future ......................................................... 37
Introduction

Service providers continue to face a decline in revenue

STL Partners has written for some time about the significant pressure faced by communications service providers (CSPs), both from operator rivals and players in adjacent sectors. Traditional telecoms revenue streams such as voice and messaging are shrinking, and as a result operator growth is slowing. Figure 4 shows that the average year-on-year revenue growth rate for 68 major telecoms groups worldwide has fallen since at least 2010:

Figure 4: 68 major telecoms groups – aggregate telecoms revenue, 2009-16

Much of this decline is fuelled by the impact of new competition: digital players such as Google, Facebook (including Whatsapp), Microsoft (including Skype and Skype-for-business) and Netflix, who are equipped to provide their own digital services, including voice- and messaging-enabled applications, without the headache of maintaining capital-intensive network infrastructure. It is now widely acknowledged that voice minutes and SMS bundles will continue to decline as a revenue stream as other players can offer the same, or better, capabilities ‘over-the-top’ to consumers and organisations for much less or free.

Data is not enough to ensure future growth

Of course, in order to use these new digital services, organisations and consumers do need network connectivity and, as a result, data consumption levels have shot up. Currently, the only players able to offer data connectivity are the communications service providers themselves, and therefore many have pointed to data as the primary source of new revenues which might offset the gap left by the decline in voice and messaging. In developed markets, in particular, some operators hope that it may be possible to ‘premiumise’ data services and drive higher average revenues per user (ARPU)1. We do not believe that the evidence

1 For more information, see our December 2016 report ‘Which operator growth strategies will remain viable in 2017 and beyond?’
supports this and anticipate that plummeting data connectivity rates ($/MB) will neutralise growth in volumes resulting in low or no net growth in revenues.

In many developed markets, intense competition and strict regulation restricts the ability of operators to resist data price decline and squeeze more out of customers. Figure 5, for example, shows that despite mobile data consumption in the United Kingdom growing 243% between 2013 and 2015, ARPs actually fell 4.5% over the period. More data, it is clear, does not automatically translate into more money.

**Figure 5: UK mobile ARPs and data volumes, 2013-15**

In Figure 6 below, we show our revenue forecast for a telecoms operator offering converged fixed and mobile telecoms services to both enterprise and consumer customers in a developed market. In this conservative estimate, data revenues grow slightly, but not enough to offset voice and messaging revenues falling by half.
It is STL Partners’ belief that the path to sustainable telecoms growth lies not just in better monetising connectivity, but rather in telcos developing new capabilities of their own, continuously innovating and launching new products and services that more readily meet the needs of their customer base. It is only by doing so, and by leveraging new technology and network assets where possible, that telcos will be able to truly compete with digital players. In essence, communications service providers must either evolve to overcome commoditisation or to embrace it. Either way, they cannot continue business as usual.

Virtualisation and slicing: enablers for change?

STL Partners has written previously about Telco Cloud, a concept in which telcos redefine themselves by adopting cloud business platforms and practices (similar to internet and content players), alongside virtualisation of their core assets. This could lead to increased service agility, and the ability to create new, network-integrated services. In turn, this could drive new revenue growth.

Network virtualisation is still at an early stage, but its adoption is increasingly seen as inevitable. Operators worldwide are already deploying NFV/SDN technology, some setting ambitious virtualisation targets over time. The forthcoming 5G standards, as well as IoT technologies, are being developed with virtualisation in mind, and technology vendors are increasingly evolving their software offerings. If managed effectively, virtualisation could be the catalyst for the transformation towards the digital service provider.

One way in which virtualisation might enable this change is through the concept of ‘network slicing’, under which network operators would be able to operate multiple logically separate virtual networks over a single network infrastructure. This paper examines what network slicing might look like in practise, and what that could mean for CSPs.

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2 For more information, see our April 2016 report ‘Telco Cloud: Translating New Capabilities into New Revenue’
Slicing: a vision for fundamental transformation

Defining slicing is not about the ‘what’, it’s the ‘how’

Network slicing is a term that has been discussed quietly in the industry for some time, but it has gained prominence more recently in parallel with the industry’s developing new 5G standards. Slicing has recently become the focus of a public disagreement between industry players involved in driving 5G standards. In essence, one group of operators and vendors are keen on accelerating New Radio (NR) standards in 5G, whereas another group see this as potentially undermining future standards in end-to-end slicing. A related debate also exists within operators between the core network and radio access teams, but that is neither new, nor surprising. These debates are not about slicing, since most parties appear to broadly agree on its potential, but more about how 5G will be introduced: as an evolution of 4G or as a completely new network.

A few considerations

In recent years, network slicing has also gained prominence as a way of creating unified 5G networks, which cover multiple very-different use-cases with a single infrastructure. Turning a necessity into a virtue, this technical “fix” is now being seen as a possible basis for extra capabilities and new services. However, many of the benefits could – and should – be achievable before 5G.

While network-slicing can in theory extend all the way through core networks and down to the radio connection, it is still subject to the laws of physics: if there is no coverage, poor RF propagation, or limited overall capacity, there is a hard limit to what performance can be guaranteed. There are also boundaries at the device, 3rd-party server/cloud interface, or where other networks interconnect, which mean that “end-to-end control” doesn’t always mean an entire system.

It’s important not to fall into the trap of thinking that because we have a slicing “hammer” that all problems start to look like “nails”. Telcos have many other approaches to future service creation and revenue expansion, that lie outside the core network. Content partnerships, vertical-industry solutions, in-home automation and new forms of connectivity all offer opportunities. If network-slicing does not reach its aspirations, there are still plenty of other options for the industry to prosper.

Independently of the 5G debate, slicing can be considered part of a wider trend (in both fixed and wireless networks) towards a more software-centric infrastructure leading to more flexible networks. As more network resources become virtual (rather than physical), operators could readily allocate resources to a particular ‘network slice.’ Hence, slicing is arguably really about the orchestration of operator assets and how an operator is able to effectively manage its network.

This vision affirms that the ‘one size fits all’ model will not applicable for the future where a diverse set of requirements will need to addressed with more customised services: from (enhanced) mobile broadband (eMBB), to ultra-low latency types (uRLLC), to low-power machine-type communications for IoT devices (mMTC).

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3 For more information, see our September 2016 report “5G: How Will It Play Out?”
Figure 7: With slicing, networks can be adapted to customers and applications

Taking the work done by industry organisations, such as The Next Generation Mobile Networks (NGMN) Alliance⁴, 5G Americas⁵ and the Open Networking Foundation (ONF)⁶ into consideration, STL Partners has developed the following definition for network slicing as the basis for this paper:

‘Network slicing is a mechanism to create and dynamically manage functionally-discrete virtualised networks over a common infrastructure’

Highlighted terms are explained in more details below:

- **Mechanism**: For both network operators and third parties (via APIs, within the limits set by the network operator).

- **Dynamic**: Slices are elastic; they can be provisioned, altered and removed in an automated way, eventually in real-time.

- **Discrete**: The network operator will be able to operate isolated network slices in parallel. This "isolation" between slices will be possible to a certain point only as different slices will still share finite resources, including spectrum.

- **Virtualised Networks**: These ‘virtualised networks’ will be different to networks as we know them today; they will be end-to-end in nature, from the application to the network layer, all the way up to the BSS. They would include fixed or wireless access, supported by virtualised and non-virtualised functions and resources, including access, core network, virtual private networks (VPNs), firewalls, cloud capabilities (network, computer, storage) and services, data, etc.

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⁴ Description of Network Slicing Concept, January 2016
⁵ Network Slicing for 5G Networks and Services, 5G Americas December 2016
⁶ Applying SDN Architecture to 5G Slicing, ONF April 2016
In many ways, the promised benefits of network slicing are already addressed by established proven technologies and services. Below (Figure 8) is a comparison of how network slicing compares to current technologies and services: VPNs, Narrow-Band Internet of Things (NB-IoT) and Software-defined Wide Area Networking (SD-WAN). This seeks to explain how slicing might represent something genuinely new and different beyond cost savings. It also offers an indication of where slicing might find demand.

Although these technologies and services are not strictly comparable in totality, it is worth looking at the key features of each when assessing network slicing as a concept. There are some similarities; for example, NB-IoT and (some use cases for) slicing both rest on the assumption of the need to create a separate logical network to meet specific requirements – cost and power in this instance. Indeed, some operators have referred to NB-IoT as “proto-slicing”. On the other hand, they differ in many ways, particularly in terms of the dynamic nature of a slice vis-à-vis an NB-IoT network. In slicing, network resources would be elastic (a slice expanded and shrunk to meet demand). This is not the case for static NB-IoT networks.
How slicing could enable growth

In previous Telco 2.0 Executive Briefings, Solution: Transforming to the Telco Cloud Service Provider (Part 2) and Telco Cloud: Translating New Capabilities into New Revenue, the potential benefits of virtualisation have been discussed: the reduction in costs, improved product lifecycle management improvement and greater agility. This is derived from the nature of a software-centric, more automated infrastructure, which results in greater programmability, flexibility and scalability. ‘Telco Cloud’ could enable these benefits through the adoption of cloud business practices, enabling telcos to move faster to simplify processes, increase automation and more effectively manage resources, allowing for even greater agility and the ability to innovate in faster and more productive ways.

Slicing could potentially take the benefits of virtualisation a step further by bringing together a new model for making the most of a virtualised and programmable cloud-based infrastructure. Under this vision, full automation and orchestration would no longer be ‘nice-to-have’, but a ‘must-have’ in order to manage the escalating complexity. Similarly, it would be necessary for network operators to manage platforms and systems, even internally, to be able to create slices in a straightforward and efficient way. Finally, the end-to-end nature of a slice means that slices could be independent of one another (to a point), as well adding more value on top of ‘traditional networks’ by incorporating much more than transport components.

The expected characteristics of slicing (see Figure 10) and the outcomes, additional benefits to operators, should catalyse the change that is required in the industry to enable growth.
Figure 10: Potential benefits of network slicing for network operators

End-to-end slice
Automation
Orchestration
Virtual Infrastructure
Distributed Computing
Platforms

Agility & Flexibility
Cost & Efficiency
Management
New Services
Innovation

Agility and flexibility

Virtualisation and the adoption of cloud business practices coupled with the modular nature of a slicing-based infrastructure, should allow operators to be more agile and flexible. This is both in terms of how they might operate and manage their internal processes, but also in how they could create products and services that better meet customer needs.

Slicing could provide for the logical separation of virtual networks for different services, which would be independent of each other. This means that teams within the organisation could similarly become more independent in how they work; changes to a particular slice could be made without having to consider the implications across the entirety of the network and all stakeholders or customers involved. For example, if the operator were to introduce something new and potentially very different to the current core services, there would not be a need to reengineer the whole network every time.

Operators are not currently organised or equipped to exploit this opportunity. They will need to determine who or what in the organisation is the “slice manager”. For example, if the IPTV business unit wants a new slice, they would have to request it from somewhere, through a pre-defined process, including necessary cross-functional approvals. Ideally, this could be automated through a “slice definition and provisioning subsystem”, but these do not exist yet.

Cost and efficiency

An underlying assumption behind the thinking on slicing is that the current one-size-fits all nature of networks is an inefficient way to run the network of the future; the entire network becomes “bloated” as it has to include every function and capability to provide for every eventuality and support all potential applications and use cases at once. Or, alternatively, new networks must be built to serve needs not well met by existing networks. For example, for certain IoT sensor-based applications, the network and cost requirements are low, therefore the network needs to be designed in a way to address this, by ‘trimming’ the network, removing unnecessary functionality (for instance around mobility, voice communications, etc.) and adding new technologies (such as to reduce power consumption, etc.)

Slicing could be a way to address the CTO’s problem of ensuring the network is able to cater to different requirements in a cost-effective manner. In the IoT sensor example, we are already seeing how the industry is trying to address the problem of differing requirements with the developments of NB-IoT, LTE-M (and EC-GSM-IoT), which address slightly different use cases within the IoT domain. However, these all require dedicated resources for each network type. Using virtualised slices could enable the cost-effective use of
resources by having a common underlying infrastructure, where resources can be partitioned, as well as shared, to be optimised, so that total cost of ownership (TCO) may be reduced.

There are other cases where the sharing of resources will be a valuable benefit, particularly for larger operators with operations that span multiple countries. By decoupling the physical and virtual infrastructure, an operator would be able to have a single, shared physical infrastructure and run slices on top for each of their operations, maximising the use of their resources.

Management

In addition to reducing the cost of network resources, slicing could also help operators rationalise their wider resources (including those outside of the network infrastructure) and systems to align them for specific services and (groups of) customers.

This includes IT resources and systems. CIOs today need to consider different security paradigms, device management, billing, configuration, permission, sensor/terminal data and information for different groups of customers. Having separate slices for different types of customers with streamlined (IT) systems could allow the operator to better manage services, rather than have to operate them all within one network. This could have further benefits when it comes to designing revenue models and the associated systems for particular sets of customers. For example, for IoT providers with low-cost devices that send very small amounts of data, the traditional model of a subscription service paid per MB of data may not be appropriate. Currently, it is difficult for an operator to think about segmenting revenue models by customer type, due to the cost and effort associated with changing revenue management systems, however with the advantages of slicing, this could be made more possible. (See our examples for more details.)

In the short term, there is an opportunity for operators to apply this concept to better manage transitions from legacy services. However, supporting hybrid networks (2G/3G/4G/5G) and hybrid virtualised/non-virtualised legacy networks will also present notable transition challenges. This is discussed later in the report.

Ability to build, develop and maintain (new) services

Slicing could help service providers to develop services that are more relevant to their customers, opening up new revenue opportunities. Further details on what those services might look like and who the customers may be will be addressed in the next section, nonetheless it is the underlying process developing and maintaining services which offer an opportunity to unlock new sources of revenue. This could be achieved in two ways:

- **Internal slicing**: Using network slicing for internal processes or for the operator’s own services. The slices may not be visible to customers. Typical internal customers might be IoT application teams, certain Enterprise solutions groups, media / content divisions. Also, slicing could be a way to emulate the old networks on the new core, to help migration or efficiently (and profitably) manage decline.

- **External slicing**: Slices may be controlled by partners/customers, by opening up the infrastructure. The slice could be used to meet demands and guarantee customers with particular service-level agreements (SLAs) and requirements.

Changing innovation and operating models for “evergreen” services

The current “one network” approach to network development is well-established and extremely thorough. Development cycles include extensive evaluation, impact analysis, testing and third-party sign-off for new releases. The result is well-designed, high-specification, reliable networks, which meet defined standards for even the most demanding services.
The drawback to such an approach is that it requires substantial investment of time and money. Release cycles are slow (six months or more), which lead to a significant delay before new features are made available. Internal and external business owners looking to use new capabilities quickly are often forced to seek workarounds, which may mean resorting to work-around (aka OTT) solutions. Service providers need to keep up with customers who are innovating fast and, if they cannot, the customers will look elsewhere.

Under network slicing, different service development efforts could be decoupled from each other and from the underlying infrastructure, and run in separate slices, similar to the channel-based development approach used in the development of software such as Google Chrome. Some slices would continue to follow the established approach, in order to ensure compliance and secure approval from third parties such as regulators and roaming partners. Others, however, could employ more agile, lean or “live beta” development approaches to quickly build, pilot and evolve new features and services. These new features would then trickle down into the slower, “stable” slices over time.

**Figure 11: Google Chrome’s release channels – a model for network development?**

Arrows show features trickling down from channel to channel

Internal slicing in this manner could support fundamentally different business practices, processes, risk profiles and innovation models. Network releases would cease to be thought of as goals in and of themselves, but instead as a means to get features out to users. Costs would also be reduced, as developers would be able to test (and fail) new services and network upgrades fast and more cheaply, without the risk of impacting on an entire user base. Business owners would be encouraged to explore solutions that exploit distinct advantages of the service provider’s infrastructure, rather than looking elsewhere.

**Figure 12: How operating models could change under network slicing**

<table>
<thead>
<tr>
<th></th>
<th>Current networks</th>
<th>Slicing-enabled networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>Pre-defined release windows based on regularity</td>
<td>Flexible release windows based on needs</td>
</tr>
<tr>
<td>Timeframe</td>
<td>6 months or more</td>
<td>From hours to months</td>
</tr>
<tr>
<td>Performance specifications</td>
<td>“Best in class”: designed to meet highest standards for most demanding services (eg “five nines” availability)</td>
<td>“Good enough”: designed to meet, but not exceed, the requirements for specific functions or capabilities</td>
</tr>
<tr>
<td>Compliance process</td>
<td>Extensive evaluation, impact analysis, third-party sign off for all releases to ensure compliance</td>
<td>Some slices follow established testing process to ensure compliance; others follow more flexible “live beta” approaches to quickly pilot new features</td>
</tr>
<tr>
<td>Innovation speed</td>
<td>Slow</td>
<td>Fast (multi-track development)</td>
</tr>
<tr>
<td>Development costs</td>
<td>High</td>
<td>Variable, and potentially much lower, depending on requirements</td>
</tr>
</tbody>
</table>

Source: STL Partners
New services from network slicing

Although it is still unclear how (indeed if) slicing will take shape, there is plenty of speculation that NFV/SDN could open up new opportunities for network operators to offer new services. As set out above, one way that slicing might do this is by better-facilitating multiple innovation streams to operate in parallel. Operators should be able to offer many more services at a lower cost. Consumers (and most business customers) would be completely oblivious to slicing per-se: they will simply experience better services at reduced prices.

The other way slicing uncovers new opportunities for operators is by allowing others (customers, including partners) to gain more direct access to the network through what we have termed ‘external slicing’.

However, this raises a number of questions including:

- What are these new services?
- Who are the customers?
- Is there specific demand for a network slice (rather than alternatives)?
- What are the different business models for external slicing and which will be most prominent?
- How will network operators allow customers to take control? What do these platforms look like?
- Will this not compete with and harm operators’ own attempts to offer new solutions?

And these do not include the other non-commercial challenges and considerations, such as those which are technical, operational, regulatory, to name a few.

We will attempt to answer some of the above questions in the following sections and provide clarity around the question of what these new services might look like.

Evidence of the demand for slicing

A (network) slice would be made up of a range of assets and capabilities, which a partner may want to access to improve their process and services. Due to the end-to-end nature of a slice, slices could contain more than just assets and capabilities tied to connectivity or transport, but also others which add value on top of connectivity. Customers would want to be able to control and manage some of these resources to provide for a better service, particularly if connectivity and the network are crucial to the customer’s service.
Figure 13: How might (operator) assets translate into demand for slices?

### Assets and capabilities

Some of these assets and capabilities, which could be accessed by a third party via a dedicated (or specialised) slice could include the following:

- **Connectivity-related**
  - VNFs
  - Bandwidth
  - Latency
  - Speed
  - Mobility
  - Coverage
  - Access (multiple types)

- **Security**
  - Network security
  - Firewalls
  - VPNs

- **Storage**
  - Cloud
  - Network
  - Caching

- **Compute**
  - Processing
  - Distributed compute/edge compute

- **Identity**
  - Access to terminals, SIMs

- **Data and information**
  - Network

- **Location**
  - IoT (sensors)

- **SLAs**

- **Billing and payments**

- **Management and orchestration**
  - Policy
  - Managed network
  - API for network segment control (SDN)
  - MVNO capability
  - Wide Area and cloud connect (Amazon, Microsoft, Google, etc.)

The customers of slicing who use these assets may not be the ‘traditional’ customers of network operators today. We define ‘customers’ as those who may benefit from a slice; this could be an external organisation, but it could also be a unit within the service provider’s organisation. External customers of slices would include wholesale customers (MVNEs, MVNOs), enterprises, industry players, innovators, application providers and other service providers. It would also include partners, such as system integrators and commercial partners, who would be able to work with the network operator and its network in a more integrated way. Internally, the customers of slicing within the network operator could be different product and development teams, or different units managing different parts of the network.

The next questions would be, so why would a customer of slicing want access to a particular slice and why couldn’t they simply access these resources through a single API platform? There are a variety of potential...
benefits from greater access and control of the network’s assets: which is most relevant to the customer will vary from case to case, but these benefits will be the foundation for recognising the demand for slicing.

Benefits of slicing for the customer

- **Managing complexity**
  The mammoth task of creating a more flexible network through NFV/SDN is challenging enough, without the additional burden of opening this up to external parties. Slicing should make this task more manageable, particularly when it comes to making new capabilities available as quickly as possible, in response to market requirements (e.g. new hardware). Clearly, this applies for those customers who want this, not for the vast majority of consumers.

- **Enhancing the performance of applications and services through greater network integration**
  Customers could integrate the network more easily with existing applications (e.g. video streaming, unified communications applications), as well as their (other) networks (e.g. Wi-Fi). This greater level of network integration could allow the customer to build better applications and services by customizing the network to meet their needs, or making their services more network-aware.

- **Ability to provide network-resilient services**
  As slices are virtual, they could be locally autonomous and resilient to any disruptions to centralised physical infrastructure, as well as disruptions in the backhaul network. For example, local authorities may require transport management systems to be able to function locally in "safe mode" in the event of a major disaster.

- **Addressing interference-related requirements**
  Certain environments (e.g. manufacturing or mining) may benefit from localized control of networking services for safety or to overcome interference issues. This is particularly interesting if a slice has some form of local ring-fencing.

- **Ensuring compliance with (evolving) industry-specific regulations**
  Due to strict regulations in certain industries (e.g. finance, healthcare, security), companies need to be able to ensure they are able to achieve specific requirements (e.g. security, reporting, recording), especially as communications becomes a more prominent part of their business. In some industries (e.g. government, finance, car manufacturers), security is paramount and customers might want their own slice if this is perceived to better guarantee end-to-end security. Slicing could make it easier to address these specific requirements as and when they emerge – in a far more focused, fast and cost-effective way - thereby making it easier for such companies to meet their requirements and ensure ever-increasing compliance.

- **Insights from data**
  Slicing customers should have more access to control-plane data from the slice, which could include network data, location data, etc., They might be able to use the data to enhance their own products, services and applications.

- **Agility, flexibility, scalability**
  The cloud-like infrastructure that underpins slicing benefits customers who use it, particularly if it is integrated into their core service, as they will be able to scale up (and down) their own services more easily. For example, another carrier from an adjacent geography (carrier A) could potentially have their own network slice from carrier B and effectively expand their network (largely with their own functions). This, admittedly is not a benefit that is specific to slicing.
More relevant (lower TCO) pricing models
By slicing end-to-end, operators could adapt revenue models and therefore tailor pricing models to make them more aligned to the economics of customers. For example, operators could offer a one-off, up-front, “life-time” connectivity cost per device allowing an IoT player to treat connectivity as any other component. Operators could share risk and reward with customers. Slicing could also help to “ring-fence” services into closed-user-group plans a way that addresses net neutrality concerns.

Examples of new services
Taking the above demand factors into consideration, STL Partners has identified a number of potential new services which could be offered using slicing. However, it should be noted that many of these services can be readily achieved without slicing: either on dedicated networks or as configuration options on a single multi-purpose (and potentially virtualised) network and distributed cloud.

This begs the question “why bother with slicing?”. We conclude that it is not that slicing uniquely enables operators to (technically or economically) launch these services, but rather that slicing will allow operators to do so faster, more cheaply and competitively over time; develop, launch, continuously innovate, adapt and evolve services in response to emerging needs and technology. In some cases, the level of effort required to do this today means that operators are unable to provide services to meet market needs. Slicing and services supported will therefore offer operators and their partners the opportunity to stay ahead of competition.

These examples aim to address the following questions:

- **What is the service?**
  Description of the service, selecting a use case for a specific customer.

- **What is the problem today?**
  This may be in terms of the problem the customer is facing within their industry, or in particular related to communications and network services.

- **How could slicing help to address problems?**
  The benefits of slicing for this particular customer as a result of the service.

- **Where is the money?**
  The potential revenue and business models that will release new revenues for the operator.

- **Where did the money come from?**
  In order for customers to pay for a new service, this new revenue stream for the operator needs to come from somewhere. From the customer point of view, this will be either because it enables them to grow revenues in turn, or reduce their costs.
**Figure 14: Example 1 – Emergency Services VMNO**

<table>
<thead>
<tr>
<th>Emergency Services VMNO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>
| **What is the problem today?** | • Existing emergency service networks (e.g. Tetra) are managed by the emergency services organisation themselves.  
• They require dedicated infrastructure that needs to be maintained and updated continuously, and dedicated communications devices.  
• They are therefore expensive, slow to evolve and application-inflexible, and capabilities typically lag those of public networks by a decade or more.  
• Data transfer is slow by modern standards. |
| **How could slicing help to address problems?** | • Enables mobile operators to offer some of the capabilities and performance specifications as current emergency service networks over their existing network infrastructure, reducing the need for dedicated equipment and expensive maintenance programmes.  
• Emergency services would be able to operate more secure, state-of-the-art networks, with full end-to-end control, without the need to invest in expanding their network.  
• By using network slicing to enable network sharing, mobile operators could work together to provide greater resiliency and the best possible coverage. |
| **Where is the money?** | • Offering a new service (for the operator) at very low cost |
| **Where did the money come from?** | • Lower set up costs (no need to pay for dedicated infrastructure or devices)  
• Lower maintenance and upgrade costs (infrastructure upkeep paid for by operator as part of wider network upgrade commitment)  
• Spectrum previously used for emergency service networks could be freed up and made available to commercial operators, generating income for the public purse. |

**Figure 15: Example 2 – Low Power IoT Service**

<table>
<thead>
<tr>
<th>Low Power IoT Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>
| **What is the problem today?** | • WAN-connected devices need subscription and/or regular top-up, e.g. wearables, remote sensors  
• Adoption barrier for potential end users (hassle, cost, trust in supplier)  
• Increases cost of managing service (account set up, collection, suspension)  
• Makes WAN less attractive option for all parties |
| **How could slicing help to address problems?** | • Connectivity becomes just another component (such as the battery or display) that is included in manufacturing bill of goods and production process.  
• Slice designed to meet (limited) characteristics in a highly automated, unique manner. Not competing with other services.  
• Operator can limit potential liability by setting lifetime limits just as for other components (e.g. 1GB/device, 10 years in service).  
• Upside for operators from breakage, under-use and limits being met (simple bulk renewals) |
| **Where is the money?** | • Simplify and make more secure application areas currently being served by unlicensed networks such as SigFox or LoRA  
• Enable new application areas / business models with “launch and forget”  
• Enable temporary use / emergency use / back-up use / single-use services that are complementary to main connectivity service |
| **Where did the money come from?** | • Varies by IoT business model  
• End customers’ productivity, maintenance and yields |
**Figure 16: Example 3 – Pop-up Network**

<table>
<thead>
<tr>
<th>Pop-up network</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Enterprises may have the need for temporary, location-specific networks. For example, companies running large events (e.g., music festivals, sports games) traditionally use PTT radios to communicate. Using mobile telephones is costly and often difficult as high demand clogs the network. The company could ‘book’ a slice of the 5G network to run its internal comms – guaranteeing availability and enabling a better feature set.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is the problem today?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Large events bring together large numbers of people and generate high network traffic, meaning communication is unreliable.</td>
</tr>
<tr>
<td>• Event organisers are forced to use inflexible outdated PTT radios to communicate.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How could slicing help to address problems?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A dedicated slice for event organisers would guarantee them uptime and negate the need to hire dedicated radios.</td>
</tr>
<tr>
<td>• There is potential to do more, e.g., use wireless network to transmit event media streams in real-time without need for temporary cabling.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where is the money?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Event organisers pay the operator per connected device, at an agreed rate for the time and land area required for the network.</td>
</tr>
<tr>
<td>• Network requirements and feature-set can be tailored to customer’s needs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where did the money come from?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bring Your Own Device: all employees already have smartphones, so no training required.</td>
</tr>
</tbody>
</table>

**Figure 17: Example 4 – Global Streaming Service**

<table>
<thead>
<tr>
<th>Global network for live video stream</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Using slicing to roam allows operators to expand reach globally. An example of a customer of this could be a broadcaster with a (VR) streaming application. It both wants to offer its customers a high-quality streaming service, regardless of the viewer’s location, and has specific requirements (e.g., bandwidth, latency) for its service. Concept can expand to a range of different customers, for example:</td>
</tr>
<tr>
<td>• Enterprises with employees in multiple locations, or who travel</td>
</tr>
<tr>
<td>• Augmented reality industrial applications working outside home country</td>
</tr>
<tr>
<td>• MVNO</td>
</tr>
<tr>
<td>• IoT application provider</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is the problem today?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• An increasing number of organisations have operations globally and demand global connectivity.</td>
</tr>
<tr>
<td>• Currently, these organisations require agreements with a number of individual operators to ensure global connectivity for their customers/users.</td>
</tr>
<tr>
<td>• Operators are in danger of losing role as service providers – aggregators will become main point of contact for customers looking for connectivity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How could slicing help to address problems?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Through ‘federated network slicing’ i.e., operators using network slices to roam on each other’s networks.</td>
</tr>
<tr>
<td>• Customers would have guaranteed connectivity regardless of their service provider’s ‘home network’.</td>
</tr>
<tr>
<td>• Slice could be unique, tailored for customer needs, or customer could simply have access to a broad slice which meets its requirements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where is the money?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Offer global service.</td>
</tr>
<tr>
<td>• Tailor service to customer’s needs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where did the money come from?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cost-saving from unified agreement, rather than multiple individual agreements.</td>
</tr>
<tr>
<td>• Better, unified service → revenues.</td>
</tr>
<tr>
<td>• Global expansion → revenues.</td>
</tr>
</tbody>
</table>
Figure 18: Example 5 – Smart Meters

**Smart Meters**

**Description**
Current gas and electricity meters were designed decades ago. Switching to smart meters enables a better understanding of how individual households use energy.

For example, the UK government wants energy suppliers to install smart meters in every home in England, Wales and Scotland. There are more than 26 million homes for the energy suppliers to get to, with the goal of every home having a smart meter by 2020. For coverage and reliability, operators can team up and create a common offering. Potentially, this could be a single logical slice.

<table>
<thead>
<tr>
<th>What is the problem today?</th>
<th>How could slicing help to address problems?</th>
<th>Where is the money?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Still in a foundational stage - systems and networks are being built and tested, the infrastructure needed to start installation is still being planned</td>
<td>• Provides an infrastructure for networks in the current foundational stage</td>
<td>• Customised connectivity based on the needs of the customer</td>
</tr>
<tr>
<td>• Smart meter data needs to be handled and the right information e.g. regarding bills, needs to be sent</td>
<td>• Stable, consistent, reliable transfer of data</td>
<td>• Helping in the foundational stages → revenue from governments like the UK</td>
</tr>
<tr>
<td>• Requires connectivity, highly available and reliable data transfer, and security</td>
<td>• Different slices mean that secure connections can be established with different levels of security</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Connectivity that can be customised</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where did the money come from?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Customisation → revenue</td>
</tr>
<tr>
<td>• Government projects → revenue</td>
</tr>
</tbody>
</table>

Figure 19: Example 6 – Renewable Energy

**Renewable energy**

**Description**
Energy generation, supply and management is undergoing a quiet revolution, new technologies, new methods and old systems require integration as well as network connectivity to enable successful management.

<table>
<thead>
<tr>
<th>What is the problem today?</th>
<th>How could slicing help to address problems?</th>
<th>Where is the money?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Monolithic supply and delivery systems, alternative energy sources and new storage systems all need to be integrated and managed</td>
<td>• Provide a private wireless channel for wind/remote solar and consumer control systems</td>
<td>• Use telco networks and compute rather than ad-hoc systems</td>
</tr>
<tr>
<td>• Requires expensive and disparate communications services</td>
<td>• IaaS/Edge Compute for management of consumer dashboards/energy bartering</td>
<td>• Provide a managed service with QoS guarantees</td>
</tr>
<tr>
<td>• Expensive over engineered CPE that needs to be maintained / replaced (or becomes out of date, incompatible) with a widespread geographic spread</td>
<td>• Fibre/Fixed for land based generation systems and mega batteries</td>
<td>• Provide consumer connect / install capability (Like Hive / Homecharge / Moixa)</td>
</tr>
<tr>
<td>• Technically challenging to integrate different systems, suppliers, smart meters and consumers</td>
<td>• A slice can be orchestrated and managed as a single virtual network/data centre rather than a collection of different networks/compute capability</td>
<td>• Telcos better able to offer services “on-top” of connectivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete network ecosystems with orchestration of different network/compute elements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Network interconnect/integration via slice</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where did the money come from?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Disruptors, reduced network an data centre costs, new services offered to generators and consumers</td>
</tr>
</tbody>
</table>

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EXECUTIVE BRIEFING
Figure 20: Example 7 – Mining

<table>
<thead>
<tr>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>New technologies in mining like GPS, telemetry systems, sensors, automation mean that people, equipment and vehicles need to be connected across large distances. This connection needs to be consistent and reliable. The exchange of vast amounts of data between field sites and control centres, for example of new real-time video content, require a connection that can support the exchange of large amounts of data at high and consistent speeds. Slicing supports these needs for reliability, consistency and speed. For example, Telstra LANES provides a single delivery platform which allows the monitoring of data and overseeing of staff, facilities and assets. It gives dedicated lanes for exclusive use with capacity that can be extended by the Telstra public mobile network. This traffic can also be given priority, including when using bandwidth intensive applications.</td>
</tr>
<tr>
<td><strong>What is the problem today?</strong></td>
</tr>
<tr>
<td>• Mining corporations need visible supply chains with control systems being monitored from far away, for example knowing when equipment needs updating. This connection needs to be reliable.</td>
</tr>
<tr>
<td>• Real time video is now used to oversee field sites which can help with safety issues. This connection needs to be reliable.</td>
</tr>
<tr>
<td>• Need reliable 24/7, real-time communication mechanisms.</td>
</tr>
<tr>
<td>• Vast amounts of vital data are exchanged between mines and control centres. The network thus needs to scale as automation increases but older sites have legacy wireless networks which can be costly to update and cause performance issues</td>
</tr>
<tr>
<td><strong>How could slicing help to address problems?</strong></td>
</tr>
<tr>
<td>• Allows for large amounts of data to be easily exchanged, which can be with priority</td>
</tr>
<tr>
<td>• Dedicated slices for consistent connections across vast distances which are reliable</td>
</tr>
<tr>
<td>• Enables customisation to specific mining corporations</td>
</tr>
<tr>
<td><strong>Where is the money?</strong></td>
</tr>
<tr>
<td>Create bespoke plans based on different service levels</td>
</tr>
<tr>
<td><strong>Where did the money come from?</strong></td>
</tr>
<tr>
<td>Bespoke plans → new revenue</td>
</tr>
</tbody>
</table>

The slicing business models

As the above examples show, there are use cases and demand for slicing-enabled services (albeit in competition with existing alternatives). However, there is still uncertainty within the industry around the business models that would support these services. Below we have presented five potential models which might emerge; it is likely there could be more than one business model, as the requirements and expectations of the customer would differ. Similar to cloud computing where there is Software-as-a-Service, Platform-as-a-Service and Infrastructure-as-a-Service to reflect different customers’ needs and capabilities, slicing models will need to take into account the same.
Figure 21: Slicing Business Models

<table>
<thead>
<tr>
<th>Domain slice</th>
<th>Customer managed slice</th>
<th>Slice-as-a-platform</th>
<th>VxNO</th>
<th>Network sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Operator has slices for multiple partners, because they have similar requirements. Telcos can offer customised services to those partners, as they can parameterise and configure their services as needed.</td>
<td>Operator creates a slice for a single customer/partner based on a set of requirements. This could use pre-defined, standard or tailored functions. The partner may want a slice for a specific reason (e.g. security) but not want to have to manage the licensing or operations.</td>
<td>Operator has a platform which interfaces with partners, offering a pre-defined set of APIs to connect to virtual resources. The partner can change features of its network, but only from this 'menu' provided by the operator.</td>
<td>The customer has its own slice and can build its own logical network, including using external virtual resources. Some virtual and physical resources would still be managed by operator, but the customer has considerable access and freedom to swap out elements.</td>
</tr>
<tr>
<td>Customer sophistication</td>
<td>Limited application and/or networking knowledge. They are looking for customisable solutions that work... with others already.</td>
<td>Limited application and/or networking knowledge. They are looking for tailored solutions that meet very specific (unique) needs. Big but awkward.</td>
<td>High application knowledge, low networking knowledge.</td>
<td>High application, high networking knowledge. Could be an operator in another geography.</td>
</tr>
</tbody>
</table>

Taking the examples presented previously, multiple business models could still be used for a particular use case or customer. For instance, for the global streaming service case, the customer (a broadcaster or video content provider) might wish to have their own slice, which is either managed by the operator, the customer managed slice model, or having more control via slicing-as-a-platform model or running as an VxNO if they have the networking knowledge and skills internally. Alternatively, the customer may not need their own slice and would rather have the benefits of a broader domain slice that is a standard slice provided by the operator to similar customers, i.e. all video content providers.

The business models a telco chooses for its slicing-enabled services, and for its business in general, will be a question that will likely be addressed case-by-case and will not be unanimous across all. In the next section, we look at what the implications of these services and business models will be on telcos once slicing is commercialised to define three possible scenarios for the telco of the future.
So, where is the money?

Scenarios for the telco of the future

To understand how telco business models might evolve through slicing, STL Partners defined and modelled three potential scenarios for how slicing could affect an operator’s future business model.

Scenario 1 – Slicing for internal efficiency only

Under this scenario, the operator uses slicing purely for internal efficiency. It continues to focus on delivering better network services at a lower cost, but does not seek to grow revenues from new services areas beyond connectivity. Slicing is largely invisible to consumers, enterprise customers and partners. They enjoy the benefits (better performance communications, tailored to their applications, at lower costs) and may also enjoy greater control over their services. However, slicing is internal to the operator.

- Small number (5-10) of purely internal slices
- Continued focus on communications services delivered through traditional business model and distribution channels
- Industry manages continued revenue decline, potentially stable margins as operators continue to cut costs in line with revenues
- Proportion of revenue from traditional core of “connectivity and coms” remains high at over 90%
- Where permitted industry consolidation through M&A accelerates this strategy

Scenario 2 – Connectivity hypermarket

Similar to scenario 1, but more disruptive. Under this scenario, the operator achieves very high levels of automation and efficiency through network slicing. The operator's ambition is to become the “AWS of networking”; essentially adopting a “zero-touch” sales and operations model. It creates and enables many slices, some dedicated to single customers, many of whom are competing with it and other telcos. Its customers can also access distributed compute capabilities to run their network functions or enhance application performance. It may seek to partner with a hyperscale cloud provider such as Azure or AWS.

- Dozens (possibly hundreds) of slices (including many dedicated to single IoT applications) for many types of customers (including other operators, and companies formerly thought of as OTT)
- Focus on efficient infrastructure and a few connectivity-related services (e.g. security)
- Revenues per terabyte (TB) transmitted are under constant pressure and a tiny fraction of those achieve today
- Total traffic volumes continue to multiply
- Operator revenues may grow initially but these will be under constant pressure as other operators respond
- Assuming potentially improved margins, slight shift in CAPEX to OPEX
- Logic is that challenger operators will force market down this route
Scenario 3 – Platforms-central

Under this scenario, the operator pursues more of a (multi-)platform strategy. Its aim is to support application and solution providers globally. Its commitment is to having the most compelling and up-to-date set of capabilities and services for the ecosystems that it aims to serve (and dominate). For example, it seeks to be first-to-market in supporting new hardware capabilities. It is very active in many standards bodies, particularly open source. It has a vast Beta programme which is the envy of many others. The operator strongly believes in the “winner-takes-all” logic of platforms. Slicing is key to ensuring that it stays ahead and an integral part of its strategy. Distributed compute is available on the platform (for network functions or applications) is very much part of what makes its platforms different.

As well as building slices on its own infrastructure, it works with other operators to secure global coverage (either by expanding its slices on their infrastructure, or enabling them to run their own versions of the slices).

- Many slices: mostly domain specialised
- Rich, well-developed partnership programmes, tools, branding and associated environments
- Revenue growth mainly from new services / value add, higher margins, shift in CAPEX to OPEX
- Logic is that of platform economics and the view that operators need to build platform beyond the geographic confines of their physical networks to succeed

Scenario 4 – Telco goes vertical

Under this scenario, the operator continues to focus on serving customers with end-to-end solutions. In doing so, they are replacing the lost revenues from voice and messaging (the previous “killer” applications). “Customers” will be consumers, enterprises and ecosystems. Operators will aim to build strong solution capabilities in selected verticals. IoT figures highly in this. For example, healthcare (see report XYZ). These solutions will aim to exploit the operator’s unique infrastructure and analytics assets to create and sustain differentiation. Distributed compute (for network functions or applications) is very much part of this differentiation.

- Modest number (20-30) mainly internal slices: internal because the telco is providing the applications and needs these to perform appropriately. It also needs to ensure reliability and performance through direct control of all the services running over its infrastructure.
- Expansion into sector solutions for industry verticals (including content for consumers and the associated 2-sided business models)
- Industry sees revenue growth, potentially stable margins, bigger shift in CAPEX to OPEX
- Proportion of revenue from traditional core of “connectivity and coms” falls to under 50%
- Logic is that slicing and related distributed computing can create valued differentiation
- M&A (solutions) accelerates this strategy

Scenario 5 – Slicing fails

Under this scenario, the operator is unable to adopt slicing or simply decides against it. Not strictly-speaking a slicing scenario, we have included it here for completeness as it is of course a real possibility.
The scenarios imply different business models and ways of making money…

These scenarios all assume the adoption of slicing to build profitable growth but with different business models. This is set out in Figure 22 below.

**Figure 22: Mapping out the scenarios**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of external slices</th>
<th>% Revenue from “pure connectivity”</th>
<th>Inspiration</th>
<th>Where is the money in slicing?</th>
<th>Type of operator who might pursue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slicing for internal efficiency only</td>
<td>None</td>
<td>&gt;90%</td>
<td>Existing telecoms model</td>
<td>Cost savings only</td>
<td>Any operator</td>
</tr>
<tr>
<td>Connectivity hypermarket</td>
<td>Hundreds</td>
<td>&gt;90%</td>
<td>Amazon Web Services</td>
<td>Cost savings and winning share through automation and cost leadership for everyone’s slices.</td>
<td>Challenger entrant</td>
</tr>
<tr>
<td>Platforms central</td>
<td>Dozens</td>
<td>~60%</td>
<td>iTunes, eBay</td>
<td>Cost savings and becoming the winning (dominant) platform for key ecosystems. The place where connectivity and application providers meet.</td>
<td>Operator group in many markets</td>
</tr>
<tr>
<td>Telco goes vertical</td>
<td>Few (mainly internal)</td>
<td>&lt;50%</td>
<td>Accenture, Schlumberger</td>
<td>Delivering integrated solutions with end-to-end control and differentiated experiences.</td>
<td>Incumbent in a large market</td>
</tr>
<tr>
<td>Slicing fails</td>
<td>None</td>
<td>&gt;90%</td>
<td>Existing telecoms model</td>
<td>There is no money</td>
<td>Any operator</td>
</tr>
</tbody>
</table>

As this suggests, the revenue mix of these approaches is quite different. The figure below maps out how the three scenarios would translate into five “buckets” of revenue:

- Pure connectivity and communications
  - The operator’s own
  - Other operators’ (forms of roaming/resale/termination)

- Distributed cloud (including ability for customers or partners to run their own functions and applications on the telco cloud), this does include edge compute applications provided by the operator but does not include the use of telco cloud for supporting the operator’s own network functions (e.g. virtualised RAN functions)
Other platform capabilities and services that support applications and end-to-end solutions. These include security, payments, device management, billing, identity/authentication/attributes, analytics, development and management tools.

Applications, solutions and content provided to enterprises and consumers. This could be operators’ own, resale or operator “orchestrated” combinations.

Figure 23: Where will revenues come from?

These four scenarios (scenario 5 does not apply) represent quite distinct (and deliberately extreme) views of how slicing could be used by operators to sustain growth. In practice, most operators will pursue a mix of these strategies. Indeed, in order to drive scale, operators will need to combine different elements of these scenarios. Operators nonetheless need to be clear where the “centre of gravity” of their vision resides as this will determine their slicing strategies.

In STL’s research report Telco Cloud: Translating New Capabilities into New Revenue we argued that telecoms operators’ traditional cost structure was ill-suited to an industry facing disruption. We illustrated this by comparing the cost structures of an operator with that of platform and product businesses.
In this earlier report, we argued that virtualisation offered a potential route for operators to move their business model towards that of product or platform business. Applying this to the slicing scenarios illustrates how the different scenarios correspond to shifts in operating model reflected in their cost structures.

Figure 25: Under the slicing scenarios, the cost structures shift accordingly
How slicing might work in practice

We have so far presented a forward-looking vision for network slicing, having yet not taken into consideration the many challenges that must be overcome in order to reach the vision. There are some key dependencies for slicing – not least the need for more advanced forms of virtualisation. At the moment, this is mainly occurring at the core network level; slicing the radio access network is a future concern. Nonetheless, this is only one potential barrier...

Key challenges to achieving slicing

In an interview-based research programme STL Partners recently undertook with a group of select senior telecoms executives, participants highlighted the most difficult challenges for operators to implement and fulfil the benefits of slicing. The uncertainty around business models and the level of transformation effort required to prepare for slicing were the most frequently stated challenges by interviewees. A significant majority also voiced concerns for the business case and whether the network and technology were ready to be able to slice practically.

In order for the concept of slicing to materialise, the following challenges need to be addressed:

- Operationalisation

Operationalisation was one of the most frequently cited challenges by interviewees. With use cases of external network slicing developing, operators are subsequently concerned as to how complex the orchestration of these use cases will be and therefore if they are actually achievable. This linked to concerns surround the business model around external network slicing. If use cases of external network slicing are too
complex to orchestrate, then they are not generating new revenue and may have a negative impact on operators’ businesses.

- **Business case**

The transformative nature of external network slicing, and the subsequent costs involved in developing network slicing from concept to reality and creating a new business model around it, create the challenge of network slicing needing to be justified with a business case proposition. Some operators have questioned where there is a need for network slicing at all, others have said they need a more solid business case to enable their shareholders to approve investment in this area. The inconsistent and somewhat conceptual thinking around network slicing also makes it harder to develop a business case around it.

- **Technology**

The main issue with technology is that because network slicing is transformative in its nature it will be difficult to implement on a technological and network level.

Since network slicing is an evolution of virtualisation and therefore needs virtualisation to become a reality, another frequently highlighted network challenge is the need to extend virtualisation to give network slicing the potential to succeed. Linked to this is the questioning of whether legacy issues prove to be a challenge preventing operators from making the concept of network slicing a reality.

On a related operational level, instilling staff with technical knowledge regarding the physical implementation of network slicing has been raised as another challenge.

- **Standardisation**

Linked to developing an understanding of the technicality of network slicing is the argument that the definition of network slicing has still not been standardised. Different operators are at different stages of developing their understanding of what network slicing actually is – some are in early stages of determining what it is, others are in early stages of practicing it on a very small scale. This lack of a standardised understanding of what network slicing is poses a challenge to its eventual implementation. It also makes it harder to develop a well-defined business case justifying the need to invest in and implement network slicing.

- **Security**

Since slicing is an end to end service that needs to be guaranteed, there has been some concern regarding security issues. Operators have questioned whether problems on one slice, like viruses, would impact other slices. However, our definition of network slicing relies on the network slices being discrete and therefore the events in one slice not impacting another slice. In this sense, by separating slices network slicing overcome security concerns.

- **Regulation**

Some concern exists around the challenge of regulation. Issues surrounding net neutrality prevail in this category. However, there is also some concern that regulators will find it difficult to understand network slicing and therefore it will be difficult for them to appropriately regulate it. When it comes to external slicing, there will be additional regulation concerns regarding the industry which the slicing customer is from, for
example for hospitals looking to ‘own’ a slice, there would be a need to resolve the regulatory conflict between doctor-patient confidentiality and legal intercept.

### Early 5G trials and proofs of concept

Trials and proofs of concept for 5G may offer an indication of where end-to-end slicing may be introduced at scale. Mobile World Congress provided a rich harvest of slicing demos, trials, co-operator announcements and proofs of concepts. We have selected some:

- **Deutsche Telekom**: demonstrated last year what they claim is the world’s first fully functional 5G infrastructure on a small scale in February 2016. In this demonstration a robot arm was trying to catch a magenta and silver ball. The silver ball was missed every time as it was running on a 4G slice and did not act fast enough. The magenta ball was caught every time as this communication occurred via a network slice that was programmed with extremely low latency. The demonstration included two other slices (one for high speed video) running over the same infrastructure.

- **Deutsche Telekom**: Deutsche Telekom’s stand at MWC this year placed much significance on 5G networks and the role of network slicing within 5G. A variety of potential use cases were displayed including: robotics where network slicing guaranteed low, reliable and well managed latency as an end to end network slice – this could later be applied to industry and manufacturing use cases; and a medical services robot which could be controlled by a human remotely via network slicing. There was also a demonstration where a 5G network remotely managed multiple mechanical arms as they co-operated to complete a goods transfer task. Three slices were created which met the low latency requirements of the robotic arms even when the network was congested by heavy traffic. The robotic arms were thus able to be controlled in real-time.

- **Deutsche Telekom and SK Telecom**: on 14 February 2017 SK Telecom and Deutsche Telekom completed a successful proof of concept of network slicing enabling inter-continental 5G network in DT’s corporate R&D centre in Bonn. They showcased how by making network slices available on each other’s network footprint, enabling customers to “roam” between the countries. This was displayed at MWC 2017 through SK Telecom’s connected car which could function and utilise data on networks based in Germany.

- **Vodafone**: demonstrated the benefits of network slicing through the example of machine vision applications where they reduced network latencies to increase the recognition rate of cloud based face detection.

- **NTT DoCoMo**: completed a proof of concept that showed how varying 5G services could use network slicing to allow customisation of specific rates of latency, security and capacity in order to deliver different types of services.

- **BT**: applied multi-tenanted network slicing to a live music concert scenario where one slice was for general internet access so concert attendees could upload content onto social media, one slice for live video production so videographers could send video data to a video production centre, another slice for 360 video experiences via virtual reality for people unable to attend the concert in person, and yet another slice for safety issues which has reliable bandwidth and communication features. BT also posits that new slices could be created in real-time for example to control drones which could assist with safety control teams should an incident occur.

- **Türk Telekom**: announced on 16 December 2016 that a fully programmable radio access network (RAN) architecture allowing for dynamic RAN slicing had been successfully incorporated into their
commercial LTE-A network. The limited deployment covers an enterprise area in Istanbul’s commercial center, Maslak.

- **Telenor and Tele2**: signed an agreement in December 2016 to build a common nationwide network with 5G technology in Sweden.

- **China Telecom**: completed a network slicing trial where certain services were delivered to specific customers depending on whether they were consumer, enterprise or campus users. In this trial the slices were isolated from each other to ensure security and service reliability. The trial found that network slicing helped lower overall power consumption.

- **China Telecom**: created and displayed their network slicing prototype on 22 February 2016. The prototype creates dynamic 5G application scenario network slices via a visible orchestration environment, including mobile broadband (xMBB), internet of things (IoT) and mobile edge computing (MEC).

**The evolution to slicing**

In terms of technology, network slicing is a progression from simple virtualisation of “as is” functions but, as seen in the previous section, there are clear barriers to making this progression and it will not be achieved overnight. At the most basic level, the technology needs to be ready and implemented in the network to support virtual slices. STL Partners believes this will be an evolution over time, closely tied to the development of NFV, SDN and 5G. It will also need to co-exist with non-virtualised networks. We have identified three key phases in the network transformation to slicing: virtualisation, orchestration and automation (see Figure 29.)

**Figure 27: Phases of network transformation for slicing future**

<table>
<thead>
<tr>
<th>No network slices</th>
<th>Few, internal slices</th>
<th>Many slices, including external</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Virtualisation</strong></td>
<td><strong>Orchestration</strong></td>
<td><strong>Automation</strong></td>
</tr>
<tr>
<td>Data centre cloudification</td>
<td>Decomposition of functions into micro-services</td>
<td>Real-time automation for multiple network slice creation and management</td>
</tr>
<tr>
<td>SDN-controlled data centre</td>
<td>End-to-end orchestration of network and services</td>
<td></td>
</tr>
<tr>
<td>NFV-based services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core network virtualisation (and later, radio network)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The question of if (when and how) operators will offer external slicing will depend on this timeline, as well as to what extent the organisational and business processes are ready to support slicing. In reality, it is likely that there will be a gradual development, starting from few, internal slices to the ideal of many, internal and external slices.

**A tricky transition with major obstacles to address**

There are many challenges that operators face in making the transition set out in this vision. STL Partners will set these out in our forthcoming reports. For now, we will highlight two of the biggest ones.
Hybrid networking: Operators have trillions invested in legacy infrastructure that works reliably and needs to deliver an economic return. Even if they could, they are not about to decommission this and switch to the brave new world overnight. To reach the vision set out above, they will need manage legacy which will need to co-exist with the new virtual infrastructure: legacy fixed and mobile (2G/3G/4G) networks with dedicated infrastructure. They will also face constraints with running virtual and legacy core and edge networks in parallel... essentially “dumbing-down” the new technology to ensure interoperability with the rest of the network.

Coverage: Although slicing applies to existing fixed and LTE networks, some of the new capabilities and services outlined in this report will fulfil their full potential through 5G. This will have limited geographical coverage for many years: indoor coverage (e.g. 5G), national coverage and international coverage.

Because so many of the opportunities outlined in this document relate to a somewhat idealised end-state rather than the messy reality of getting there, operators face a major problem with funding this transition. Namely that with few easy incremental revenue growth cases, it will be difficult to justify (to shareholders) the incremental investments required: in spectrum, licenses, infrastructure, people, IT and general transitional pain. We will address this challenge in our next report.
Conclusion

Slicing is not “the” answer to meeting operators’ aspirations. It is one aspect of the potential new practices and supporting capabilities that operators could pursue to secure a sustainable future. We have made a strong case for slicing in this report, arguing that it could offer a viable mechanism for operators to extract the most potential from NFV/SDN, an opportunity of mind-boggling complexity.

There are very significant challenges and barriers to meeting the vision for slicing set out in this report. Indeed, there is a high probability that slicing will never become as powerful as we set out and not deliver many of the promised benefits. It could even “fail” completely, or evolve beyond recognition, or become superseded by a fundamentally different approaches. We do not claim that slicing is inevitable or that the potential benefits guaranteed.

In this report, we set out a long-term vision which we have been careful not to set a date against. We make no apology for this timeless, arguably idealised picture, as we want this vision to be compelling, precisely because without the vision, it will be difficult for operators to motivate their teams, secure the support from shareholders and build the resolve to get there. Given that, it promises to be a very challenging undertaking.
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