The Broadband Futures Forum

The Rise of 5G and the NBN

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Abstract: On 25 May 2021, TelSoc hosted the seventh Broadband Futures Forum, held online, to examine the relationship between 5G and Australia's National Broadband Network (NBN). Two speakers discussed opportunities arising from the 5G core architecture for service creation and delivery via the NBN. Several 5G-related services that could be offered by the NBN to be used by its retail service providers were outlined. Discussion following the speeches included questions about potential service characteristics, possibilities for automation, and deployment scenarios.

Keywords: NBN, 5G, cloud computing

Introduction

The Broadband (formerly NBN) Futures Project (Holmes & Campbell, 2019) has been organizing a series of public forums under the title Broadband Futures to encourage debate, and potentially to build consensus, about the future of Australia's National Broadband Network (NBN) and a national broadband strategy (Holmes *et al.*, 2020) for Australia. The seventh in the series, held on 25 May 2021, was entitled "The Rise of 5G" and provided some insight into ways in which 5G and the NBN could be complementary. Specifically, the forum was designed to address two questions:

1) How does 5G represent an opportunity for the NBN to offer new wholesale services in addition to its existing layer-2 offerings?
2) How can the NBN support the deployment of 5G services in Australia?

The forums are hosted by TelSoc (the Telecommunications Association Inc, publisher of this *Journal*). The first forum was held in July 2019 (Campbell & Milner, 2019), the second in October 2019 (Campbell, 2019), the third in February 2020 (Campbell, 2020a), the fourth in August 2020 (Campbell, Smith & Brooks, 2020), the fifth in November 2020 (Campbell, 2020b) and the sixth in March 2021 (Campbell, 2021).

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The remainder of this paper summarizes the content of the Forum.

The Broadband Futures Forum

The Forum was conducted online via Zoom. There were more than 50 people registered to attend and at least 38 of them were online at one time.

Introduction

Dr Leith Campbell, Secretary of TelSoc and member of the Broadband Futures Group, chaired the Forum. He noted that, while mobile broadband would be a competitor to fixed broadband, the rollout of 5G also provided some opportunities for enhancement of the NBN. This is the approach taken in the Forum.

There were two speakers: Dr Bruce Davie of Systems Approach, LLC (and formerly with VMware and Cisco); and Mr Andrew Hamilton, a member of the Broadband Futures Group and principal author of the annex on 5G in the Group's major report (Holmes *et al.*, 2020).

Bruce Davie: Cloud networks and the NBN

Bruce Davie characterized his presentation as a 'technical tutorial' on the networking transformation through cloud computing that has been taking place over the past dozen years and its reflection in the 5G architecture. This forms an introduction to Andrew Hamilton's following presentation on implications for the NBN.

Bruce Davie described cloud networking as a key component of cloud computing. The introduction of cloud computing has had a profound effect on how computing and networking are done. This is clear in 5G, which introduces an entirely new network architecture, based on cloud computing, from that of earlier generations.

He suggested that growth in cloud computing really accelerated after Amazon Web Services (AWS) was started in 2006. Very quickly (Figure 1), AWS was using more network bandwidth than Amazon's own operations, and 'infrastructure as a service' was born.

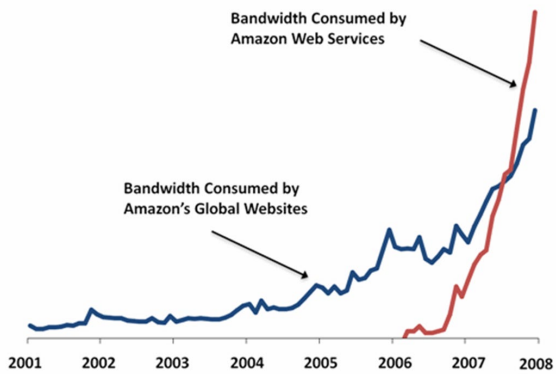

Figure 1: The birth of cloud computing at Amazon (Source: https://aws.amazon.com/blogs/aws/lots-of-bits/)

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With cloud computing, computation and storage has become, he suggested, like a utility. A user only pays for resources needed, without having to pre-provision for the maximum likely capacity; there is no need for in-house computing resources; there is an illusion of infinite capacity, where compute and storage resources can be added or reduced almost instantaneously; and, in most instances, users are heedless of where their computing resources are located.

Cloud computing has enabled a range of service options, from a basic 'infrastructure as a service', through 'platform as a service', which includes higher level functions like messaging, to 'software as a service', which provides a full range of end-user services including, for example, databases.

He noted that a core technology to enable cloud computing has been virtualization. Originally, starting from the early 2000s, this permitted decoupling of applications from the physical systems hosting them: an application or operating system could be implemented in a virtual machine, which could share, completely independently of other applications, a set of physical resources. Many virtual machines can run on a single physical machine, leading to the concept of 'slicing', where an application has a 'slice' of physical resources without being in any way aware of the presence of other applications running on the same resource.

The same ideas apply to network virtualization. This began with large technology companies, like Amazon and Google, but is now common in large enterprise data centres. With network virtualization, network characteristics such as firewalls, switching and routing can be created quickly and in complete isolation from other network instances. This has become central to networking today. There is no longer the need to allocate a physical resource, such as a router, to a single user or application; rather, the physical resource is shared by applications, each of which has the illusion, created in software, of having a dedicated physical resource.

For a new Retail Service Provider, he suggested, network virtualization means that it could create its service on the NBN without the need to install any of its own physical equipment.

Dr Davie then introduced the term 'Software-Defined Networking' (SDN), coined in 2009. SDN refers to a set of software services that enable the creation and management of virtual networks. SDN is in widespread use in cloud networks and large enterprise networks. It has enabled a high level of automation, avoiding manual configuration of networks, and has led to software-defined Wide Area Networks (WANs), which are used in multi-site corporate networks.

Cloud computing, network virtualization and SDN are then applied to mobile networking to create the 5G architecture (Figure 2). It looks much more like a modern cloud data centre, with many commodity servers running software to deliver services in a much more automated and

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flexible way than was possible in 4G. The architecture consists of a collection of clouds, including a 'telco cloud', in which services and networks are configured, and 'edge clouds', which sit much closer to the radio resources and end users and can run latency-sensitive services. New services, especially third-party over-the-top (OTT) services, can be easily provisioned in edge clouds or other cloud locations. This means that many third parties can potentially be involved in creating new services in the 5G architecture.

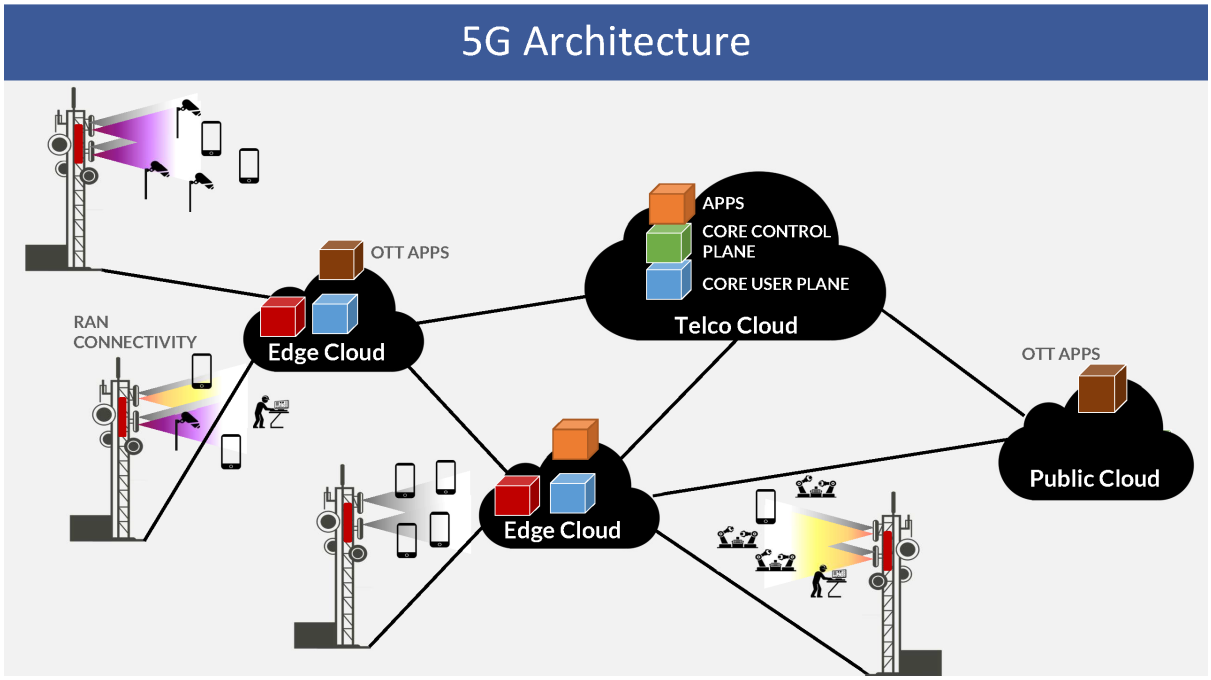

Figure 2: 5G architecture (Source: Bruce Davie)

Figure 3 shows an example of a managed edge cloud in 5G, where a network is delivered to an enterprise but managed by a service provider. In the edge cloud there are many enterprise services that need to run, for example, for the Internet of Things, that are provisioned in the edge cloud but are centrally managed by the service provider. A single service provider could provide these features to many different enterprises.

In summing up, Dr Davie described 5G as the first mobile generation to leverage cloud computing, benefiting from the advances in virtualization of computing and networking over the past 20 years. The 5G architecture will enable a revolution in the provision of new services, enabling them to be implemented much faster with their own isolated 'slice' of networking resources, while sharing the radio resources, computing resources, backhaul and other network capabilities.

In answer to a question posed in the chat about cyber-crime, Dr Davie described some of the security approaches, such as zero-trust, being implemented by cloud service providers and claimed that these implementations were the best available defences against cyber-crime. (For a survey of security aspects in 5G, see Cao *et al.*, 2020.)

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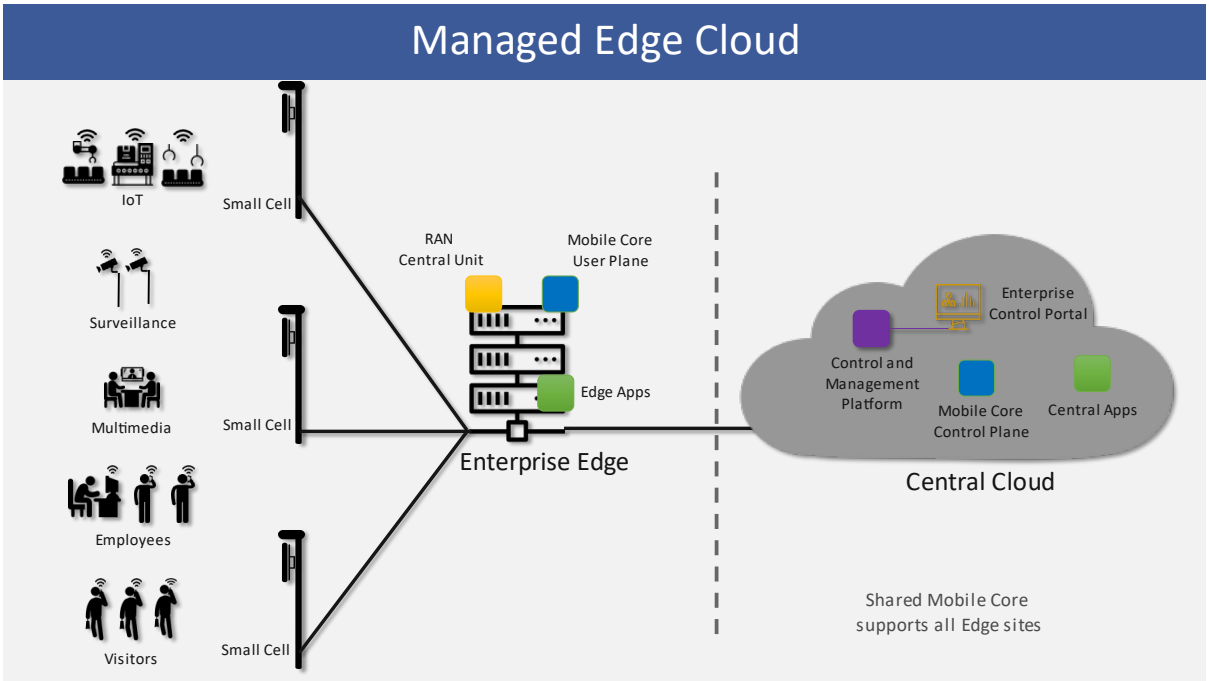

Figure 3: Managed edge cloud (Source: Bruce Davie)

Andrew Hamilton: The implications of 5G for the NBN

When introducing Andrew Hamilton, Dr Campbell noted that he was a published author in the *Telecommunication Journal of Australia* (Kitchen & Hamilton, 1998).

Andrew Hamilton began by quoting Andy Penn, CEO of Telstra, on the importance and significance of 5G mobile. He noted that 5G is already being rolled out by Telstra, Optus and Vodafone (TPG) as fast as possible. He suggested that, while the benefits of 5G may be being oversold, it will provide new broadband benefits and should be taken into account in planning the NBN.

Mr Hamilton was of the view that 5G, and the technologies on which it is based, can enhance the NBN, providing benefits to users, retail service providers, and NBN Co itself. In this context, he suggested two potential new wholesale products that NBN Co could provide:

1) Network as a service, a variation on infrastructure as a service described by Bruce Davie;
2) 5G hotspots, short-range *fixed* 5G interfaces, similar to a Wi-Fi hotspot.

He indicated that these services were not being advocated by the Broadband Futures Group but had been discussed, and were examples of concepts that should be taken into account in planning the broadband future for the NBN and Australia.

The network-as-a-service product would be supported by two technologies: one or more virtual servers ('in the cloud'); and a 'transport slice' to connect them. The virtual servers in the NBN could be located at fibre access nodes (at the metro-network edge of the fibre

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footprint) and the NBN Points of Interconnect (PoIs) (where retail service providers connect to the NBN). The transport slice is an allocation of network resources dedicated, via software control, for transmission between the virtual servers. (In relation to the earlier discussion of cyber-crime, he noted that the use of a network slice would mean that there is no sharing of traffic as occurs in the general Internet.)

Mr Hamilton wished to emphasize the economics of the network-as-a-service product. By virtualizing the network resources, the user (a retail service provider in the context of the NBN) would only pay for the resources it needs, rather than having to make an initial investment in physical infrastructure, thereby lowering the barriers to entry.

He noted that location of the servers close to end users would be important for low-latency services. There are developing standards for this purpose, including ETSI's multi-service edge computing (MEC) initiatives (Giust, Costa-Perez & Reznik, 2017). MEC integrates virtual servers with the network, particularly at the edge. The MEC standards are separate from the 5G standards but are compatible with them. MEC can thus be used in 5G and non-5G worlds, including the NBN.

NBN Co could implement MEC servers at its fibre access nodes and offer MEC-based services to retail service providers. The retail service providers, or their customers, could then implement low-latency services.

Mr Hamilton suggested, however, that a more intriguing use would be to provide network function virtualization, in which network equipment functions are implemented as software, making them 'cloud native'. The 5G core network, as described by Bruce Davie, is also cloud native and is implemented with network function virtualization and software-defined networking. For an end-user, network function virtualization would lower the cost of entry and convert capital cost for equipment to ongoing operational cost. Transport slices would also be required between virtual servers and to the PoI.

The second potential wholesale service for the NBN is a 5G hotspot, a short-range, fixed radio interface at customers' premises, similar to a Wi-Fi hotspot. The customer premises equipment would be a 5G femtocell, the 5G equivalent of a Wi-Fi access point. The access point could use radio spectrum in the 3.4 GHz band but would better use millimetre wave spectrum, which is currently available in Australia. In December 2020, the ACMA issued a class licence variation (ACMA, 2020) making 850 MHz of mmWave spectrum available to anyone who wished to run a private 5G network, subject to low-interference operation.

To run a 5G service, a user would also need a 5G core network. Mr Hamilton explained that NBN Co will likely upgrade its fixed-wireless accesses from 4G to 5G and will therefore need

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to implement a standalone 5G core network as well. Consequently, NBN Co will also be able to connect 5G femtocells to its 5G core network.

What are the benefits of 5G hotspots for end users? Mr Hamilton suggested an example of the Internet of Things used for connecting premises security cameras. The cameras would be connected to a 5G hotspot and, via a secure network slice, transmit their data to a cloud-based server. A second benefit would come about by roaming from one 5G hotspot to another; a 5G device could connect to a premises 5G hotspot when it comes within range. This would have the added benefit of offloading traffic from 5G mobile macrocells onto the NBN, providing more reliable service for all users.

Pricing for these services would also be an issue. Mr Hamilton believed that the same AVC/CVC pricing structure as used in the current NBN could be adapted for the new wholesale services, with service features being equivalent to AVCs or CVCs. A network slice, for example, would be equivalent to a CVC. Retail service providers would issue their own SIM cards, permitting users to roam onto NBN-provided 5G hotspots. The price of access between a 5G access point and a PoI would depend on the bandwidth subscribed to, as it does with an AVC.

For connectivity into a service provider's network, the 5G standards provide for two options: local breakout, equivalent to the current NBN network-network interface; and home routed, referring to routing a connection back to its home 5G network. The second option would permit a 5G operator to implement a 5G core but not have any 5G access network: the access network would be provided by another operator. Mr Hamilton explained that such an operator could use the NBN, enhanced with 5G hotspots, to be its 5G access network.

He noted that retail service providers could themselves provide 5G hotspots, that is, 5G access devices, connected to the NBN. He foresaw that some retail service providers would do so. There are, however, two advantages stemming from the NBN providing the 5G hotspots. The first is that NBN Co could also provide edge-cloud services from a fibre access node, a location not accessible to retail service providers. The second is that it would avoid the risk of market fragmentation. Mr Hamilton described an example of a security service provider deploying and managing security cameras on customers' premises. If the 5G connections were provided by a retail service provider, the security provider would either need to subscribe to all retail service providers or would restrict its deployments only to premises served by the retail service providers with which it has subscriptions. This could be to the disadvantage of smaller retail service providers. The alternative of the 5G hotspots provided by NBN Co would mean that the security provider would need only one arrangement, that with NBN Co.

In summary, Mr Hamilton noted that there is an overarching need for a national broadband strategy, as described by the Broadband Futures Group, with the NBN as a central facility. One

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can assume that NBN Co evaluates speculative networking opportunities as part of its planning, but this is not made public. The ACMA provides an annual communications report, which identifies advances in network technology but does not consider their implications for the NBN. Mr Hamilton suggested that, at the least, these two government-supported strands should be brought together in a coordinating document, which could inform more detailed policies such as the allocation of radio spectrum.

To be clear, Mr Hamilton also summarized what he was *not* suggesting:

- He was not suggesting that NBN Co should become a mobile network operator.
- He was not suggesting that NBN Co be compelled to offer a virtual network as a service and 5G hotspot services. The offering would depend on a suitable business case.
- He was not suggesting that NBN Co stop providing its current layer-2 Ethernet services.
- He was not suggesting that retail service providers be prohibited from offering their own 5G hotspot services. In fact, he would expect that they would offer such services.
- He was not suggesting that NBN Co should offer any retail services; it should remain a provider of wholesale services.

Questions and Answers

Question: Why had a cloud-based core infrastructure not been introduced with 4G?

There had been some discussion of this issue in the chat during the presentations. It was noted that there were cloud-based services available 'over the top' in current 4G networks but the full integration of networks and cloud services had been restricted by the technical maturity of the various components and had only become possible with 5G.

Dr Campbell added that there is a security boundary around a mobile operator's core network and the opening up of services through this boundary depends on a business case for the operator and the pressure of user demand.

Question: Are you advocating the 5G approach for NBN Co just for its internal operations or are there end-user applications provided by NBN Co?

Andrew Hamilton replied that virtual machines can be used to benefit the network provider but also can be used to provide services to end-users, as in the security camera example.

Bruce Davie added that it was clear that 5G services could be provided to end-users by the NBN. He noted that, in a fully virtualized 5G core network, a service provider could use the 5G mobile network provider's core resources in the same way as it could gain compute or storage resources from Amazon Web Services. This opens up many new service possibilities. It would

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apply to the NBN if it also implemented a 5G core architecture. Just as the NBN uses 4G for some accesses, so 5G could also be used, but the 5G architecture in addition adds many new capabilities independent of the radio access.

Question: Low-latency services have been mentioned, but what about performance in general? Does network slicing, for example, degrade network performance?

Bruce Davie noted that in all virtualizations there are choices about how resources are shared. Amazon Web Services, for example, offers two types of access to compute cycles: either the cycles are allocated to the one customer and cannot be used by others; or, more cheaply, cycles can be shared with other users and may not always be available. The same options can be applied to network slicing: either dedicated bandwidth is allocated and guaranteed; or the bandwidth is shared with other users.

Question: Can we expect that fixed network providers will also implement a 5G core?

Andrew Hamilton outlined the current work by the Broadband Forum on wireless-wireline convergence to ensure that a 5G core can be used both for wireless networks and for fixed networks. This permits a service to be provided on either network. Mr Hamilton suggested that, in this way, the distinction between mobile and fixed networks was disappearing.

Question: Will the 5G hotspots enable retail service providers to do end-to-end management of services, including the in-premises network?

Both speakers agreed that end-to-end management of services will be possible. Bruce Davie added that end-to-end management of services is in the vision of the 5G operators.

Question: Can the speakers comment on the cost and time to deploy 5G access points within 50-100 m of every premises, compared to in-premises deployments via 5G hotspots?

Andrew Hamilton suggested that the best way to get 5G services in premises is to implement a 5G hotspot connected to the NBN. The alternative is that 5G mobile operators will deploy small 5G base stations along streets, which will be much more costly and take a long time. Wireless signals from street deployments may also not penetrate walls and can suffer other degradations.

Dr Campbell reminded the audience that some of this thinking about deploying 5G via the NBN was triggered by a presentation by Professor John Cioffi to TelSoc in August 2020, which described the concept of 'cellular subscriber lines' (Cioffi *et al.*, 2020).

Conclusion

This was the seventh of a planned series of forums related to the future of the NBN and a broadband strategy for Australia. It was the first to concentrate on technical developments, in

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this instance the deployment and architecture of 5G mobile networks. It addressed some questions around how the NBN and 5G could provide complementary broadband services.

As Bruce Davie described in his speech, the 5G core network is designed to be cloud-native and provides the infrastructure for the rapid definition and deployment of new end-user services. This architecture, which will be implemented, at least partially, to support the 5G extensions of the NBN's Fixed Wireless Access, will open up new opportunities for NBN Co.

Andrew Hamilton outlined two of these possibilities. Clearly, NBN Co can introduce cloud-based features into its own access network to enable its retail service providers to support low-latency services. More interestingly, NBN Co could offer 5G wireless access points at the customer ends of its fixed access network. In this architecture, the NBN would be 'transparent' to a 5G service provider, as if its customers were roaming onto another provider's network. This provides a mechanism for rolling out 5G access into customers' premises at low cost and in a timely manner.

To exploit such opportunities efficiently, Australia needs a technical roadmap based on an overarching broadband strategy to support the development of the digital economy. As Andrew Hamilton pointed out, there are some isolated silos of technical planning within government entities, as in the ACMA and NBN Co, but no apparent coordination between them. This can lead to economically inefficient outcomes, such as market fragmentation or an inability to support greater levels of automation. Modern computing technologies, now tightly integrated with telecommunications through the 5G core architecture, provide opportunities for advancing the digital economy that should not be missed.

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