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Editorial

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Abstract: The Telecommunications Association is hosting a two-day forum in Melbourne in mid-November 2017 on telecommunications and security. With the Parliament passing legislation in support of the government's telecommunications sector security reforms agenda there is a timely need to explore the legislation and to identify what the immediate outcomes will be for the telecommunications sector. With only 12 months to prepare before the new regime kicks in the TelSoc forum provides an opportunity for discussion on this key topic. Papers in this issue of the Journal cover a range of topics that cover historical events, book reviews and international telecommunications markets including a unique look at the development of the telecommunications market in Indonesia.

In This Issue

In this issue, the *Journal* includes topical articles that cover international telecommunications, historical events and a book review on the potential future direction of technology innovation.

SafetyNet - A New Approach to Rural and Remote Communications highlights the need for a more radical approach to update the Universal Service Obligation, public safety network options and mobile roaming.

Implications of Open Source Blockchain for increasing efficiency and transparency of the Digital Content Supply Chain in the Australian Telecommunications and Media Industry identifies the use of hyperledger, an open source blockchain technology for shared ledgers, as an opportunity for industry to collaborate to improve content lifecycle transparency, trust and efficiency while protecting consumer privacy.

The Silicon Valley We Don't Want to Have: A review of Antonio García Martínez, Chaos Monkeys: Inside the Silicon Valley Money Machine is a book review that describes the warts-and-all account of the many undesirable aspects of "Silicon Valley culture". While the book is

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overly self-indulgent, it could valuably be read by policy makers interested in start-ups and business culture.

Hong Kong's Fibre Broadband Market - Busting the Myth of Residential Fibre Broadband always being a Natural Monopoly discusses the rise of Hong Kong as a leading global city when it comes to fixed broadband performance. Unlike many other leading broadband markets, this has occurred without any financial support from the Hong Kong government. The removal, rather than an increase, of regulation of the privately owned broadband network operators has been the overwhelming main driver of this outcome. However, the lack of a universal service obligation for broadband does also mean that households and businesses in areas where competition is neither technically nor economically feasible has resulted in approximately 10% to 15% of Hong Kong households not benefiting from this policy.

Information and Communication Technology Service Industry Development in Indonesia reviews the development of ICT service Industries in Indonesia, the history of how the industries was developed, both the policy as well as the development itself. This is followed by the description of the current situation. The future plan of ICT development will be also included. A more in-depth explanation is given for the Telecommunication sector.

New Zealand Telecommunications: The actual situation – legislation and regulations provides discussion on telecommunications legislation and regulations in New Zealand focusing on key sector and market developments.

The Radio Australia Aerial Matrix Switch provides a historical review of two papers from 1963 that describe the design and construction of the new aerial matrix switch at Radio Australia Shepparton and the ingenuity required to conceive and deploy a world-first solution.

Telecommunications and security

The Telecommunications Association, publisher of this Journal, is holding a forum in Melbourne in mid-November 2017 on telecommunications and security. The Australian Government's telecommunication sector security reforms program has resulted in legislation passing through the Parliament that provides a new focus for the telecommunications industry.

By identifying the telecommunications industry responsibility for infrastructure and system security, the government is seeking to increase awareness of security and to jump start increased information sharing between the telecommunications industry and government security agencies. For the telecommunications industry to prepare for the new regime there will be a 12-month delay before the legislated changes take effect.

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The government's security agenda has implications for business and industry and it is likely that the telecommunications sector security reforms could extend to large enterprises that maintain and operate telecommunications assets in coming years.

For telecommunications professionals, the telecommunications market is entering into a very busy phase with significant growth in demand for broadband in the residential and business markets, the onset of 5G mobile cellular and increasing demand for a third satellite to be launched by NBN Co.

Security is now a key element of telecommunications and market growth will place new burdens on the engineering workforce over coming years.

Looking Forward

The *International Telecommunications Legislation and Regulations* and *International Mobile Cellular Regulation and Competition* themes are set to continue for some time as the opportunity to attract papers from around the globe continues. We encourage papers that reflect on where the telecommunications market is now, how it got to where it is and what is going to happen next.

Papers are invited for upcoming issues and with your contributions the Journal will continue to provide the readership with exciting and informative papers covering a range of local and international topics. The Editorial Board values input from our readership so please let us know what themes you would like to see in the coming year.

All papers related to telecommunications and the digital economy are welcome and will be considered for publication after a peer-review process.

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SafetyNet

A New Approach to Rural and Remote Communications

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Abstract: This paper proposes a new vehicle, dubbed SafetyNet here, for improving communications in rural and remote Australia. It would be led by the Commonwealth replacing its disparate programmes for the bush with a public-private partnership combining the resources of various operators and governments. Part of the proposed solution is a wholesale mobile network using LTE in the 450 MHz spectrum band. SafetyNet would address any updated Universal Service Obligation, public safety network options and mobile roaming.

Keywords: Rural, mobile, black spots, satellite, SafetyNet

Introduction

Rural and remote areas will continue to struggle to keep up with urban telecommunications despite the progress that has been made with initiatives such as the Mobile Black Spot Program (MBSP) and the NBN fixed wireless and satellite. A new approach is needed as we consider updating the Universal Service Obligation, public safety network options and mobile roaming. Instead of seeking more expensive small gains at the margin, or counterproductive roaming arrangements, we should take a large step forward by having the Commonwealth, States and mobile network operators (MNOs) work together to build *SafetyNet*, a collaborative model using shared infrastructure.

The SafetyNet model proposed here would:

1. Resolve the conflict between coverage and competition which is prominent in all rural and remote communications programmes and discussions.
2. Expand the current, narrow view of what 'communications' means for rural and remote customers. In additional to conventional mobile network services, the SafetyNet solution will contribute to making land more productive, providing public benefits (e.g. in education and health) and improving public safety .
3. Reduce the inefficient use of public and private resources to meet the needs of rural and remote customers by taking a cooperative portfolio approach across

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governments and private operators.

4. Improve the affordability of rural communications and provide more retail choices for end users by using open access where it is uneconomic for any MNO to venture without a significant public subsidy.
5. Alleviate the issue that up to 90,000 satellite users, as estimated in the Productivity Commission's June 2017 final report on the USO, will have worse quality voice services and no adequate mobile coverage once the existing copper network is decommissioned.
6. Alleviate concerns about the future capacity of the Long Term Satellite Service (LTSS) by providing better broadband service over LTE.

The Commonwealth may baulk at the prospect of supporting a mobile wholesale operator on the grounds that the mobiles market works well. But in fact it doesn't: not in rural and remote Australia. Such areas account for a large part of our land area and support valuable socio-economic activity. To obtain coverage the economically sensible approach is to address gaps with a natural monopoly. This calls for public intervention. The MBSP programme is worthy. But it is not enough.

The Commonwealth may have no appetite to consider new programmes until the NBN roll-out is complete. Initiatives like the one outlined here will take time to bring to fruition. Australia needs to start planning for it now.

Achievements and Remaining Frontiers

A significant improvement in broadband communications for rural and remote Australia is underway with deployment of the NBN. Most rural and remote residences and businesses will be able to get better fixed broadband – albeit at a price.

The Universal Service Obligation has successfully delivered a uniformly satisfactory voice service over the copper network. But migration from the existing copper network to the NBN will pose a challenge for customers in the satellite footprint who have no alternative mobile voice service.

Mobile service availability has also improved at the margins with blackspot investment, and more people will be adequately served for mobile access – even if only when near population centres. But there is a danger that relying only on this approach for improving coverage will come at a significant and growing cost.

Police, fire, ambulance and other public safety agencies (PSAs) currently use their own networks to deliver voice and some data services, such as text messaging. They are reliable,

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resilient and secure, but they do not support high-speed data and often they are not interoperable across agencies (Productivity Commission, 2015). Public safety mobile broadband (PSMB) would allow frontline officers to access high-speed video, images, location tracking and much more. In November 2016, the Government accepted the Productivity Commission's position that commercial mobile networks are the most efficient, effective and economical way of delivering a public safety mobile broadband capability.

Also, new demands for improved communications arise with the IOT (Internet of Things) in rural and remote areas which are needed to make machines and land more productive.

These needs underpin the next profound shift in technology. After moving from voice to data and then from fixed to mobile, we need networks that support not only calls, texts or browsing but also the fundamental infrastructure that feeds us, transports us, provides power and water, and keeps us safe. It is foreseeable that these capabilities will be seen as foundational rather than add-ons in the near future, and fundamental to all Australians' way of life.

It is Time to Reassess Our National Needs

The NBN may satisfy many requirements including health and education. While its fixed wire and fixed wireless networks will cover 97% of premises (with satellites covering the rest), it will not meet connectivity requirements on the roads or in the paddocks.

Many needs could of course be met by the mobile operators or, in truly rural and remote areas, by just one mobile operator. There are also other technologies (like LoRa – see LoRa Alliance, 2017) that have a role to play, but they are unlikely to obviate the need for wired or (where more practical) wireless interfaces to the wider Internet.

This might indeed look like the inevitable end game given the difficult economics of each new network. But 2017 is a good time to step back and look at how best to meet the complete set of needs for rural and remote Australia. A quite different end game might emerge if the States and Commonwealth looked at the overall portfolio of needs and networks that are being funded in rural and remote areas rather than continuing with the current ad-hoc, uncoordinated and piecemeal approach (e.g. NBN fixed wireless and satellite, USO, MBSP and Public Safety). States and Commonwealth must manage a portfolio of investments as an operator would – not as a collection of disparate policies overtaken by rapidly evolving requirements.

In both the 2012 and 2015 Regional Telecommunications Independent Reviews, mobile coverage was raised as the dominant issue – with access to the full range of competition enjoyed by those in urban areas barely rating a mention. Country customers want improved mobile coverage more than they want competition[1]. Because of rural economics, it is difficult to have both – unless policy makers consider more radical alternatives than the ACCC is able to consider.

A more holistic approach integrating various requirements and pooling resources would work with the demanding economics of the bush and allow retail competition despite coverage challenges.

Mobile Coverage – the State of Play

The ACCC reported (October 2016) that retail mobile services in Australia are currently supplied by three MNOs: Telstra, Optus and VHA. On 12 April 2017, TPG acquired 2x10 MHz in the 700 MHz spectrum, and announced that it would build a mobile network that would cover 80 % of the population within three years. TPG's planned market entry is unlikely to help country areas much.

There are more than 60 mobile virtual network operators (MVNOs) that use one or more of the MNOs. The three existing MNOs each operate national mobile networks and hold a collective market share of 90 percent of the retail market for mobile handset services, with MVNOs accounting for the rest.

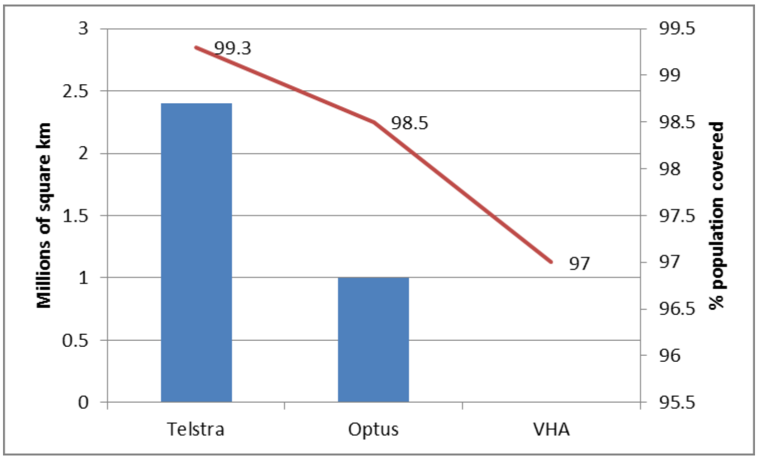

Fig 1 Mobile coverage by carrier by population and geography

Source: ACCC Discussion Paper, October 2016

Each of the three mobile networks covers over 97 % of the places where people live (with VHA's population coverage including that provided through roaming agreements with Optus). But customers want coverage even when they are not at home, and Australia is a very big place.

The total area of Australia is 7.7 million km². About one third is now covered by commercial mobile operators. While it would be foolish to aim for 100 % geographical coverage by terrestrial means, there are undoubtedly many benefits to be gained by extending mobile coverage beyond what any MNO would do for commercial reasons.

Between 1998 and 2016, Telstra more than doubled the size of its network, but increased population coverage by only 6 percentage points. Telstra's mobile network now covers a considerably larger geographic area than those of Optus or VHA, such that for over 1 million km^2 Telstra is the only MNO with mobile coverage. Only 0.8 % of the population (approx. 200,000) lives in areas where Telstra is the only MNO with coverage.

Telstra's superior geographical coverage is rewarded by its market share in regional Australia, which is significantly higher than in the national market. A survey of over 500 farmers across Victoria conducted by the Victorian Farmers Federation found that 88 % used Telstra as their mobile service provider.

Natural Monopoly at the Edges?

Head to head infrastructure competition in the more remote areas is neither likely nor efficient, because once the first network is built in a location previously having no coverage there is not sufficient demand to justify a competitor building a rival mobile network.

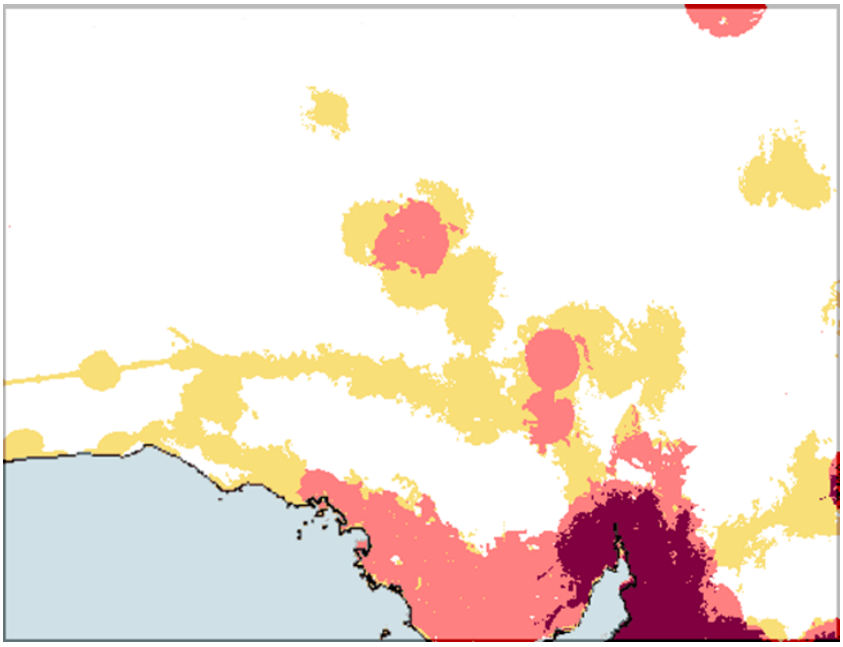

Figure 2 Presence of multiple carrier coverage in South Australia
Source: Robin Eckermann

As one moves away from the densely populated areas, the return on investment for MNOs becomes marginal; and the number of networks drops from three to two, then from two to one (mostly Telstra) and finally – for over 65% of Australia's landmass – from one to zero. This pattern is very clear if the coverage maps of the three operators are "massaged" graphically and amalgamated in a way that highlights the 3-2-1-0 coverage pattern – as shown here for South Australia (the darker the shading, the more mobile networks that provide coverage)[2].

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The ACCC agrees:

> "*the economics of building mobile networks in Australia suggest that in many regional areas, it is likely that a mobile network exhibits natural monopoly characteristics. This means that once there is a mobile network, it may not be efficient for a second MNO to duplicate mobile infrastructure in those areas*" (ACCC, 2016; p. 30).

The quote immediately above comes from a discussion paper exploring whether regulated mobile roaming is the answer to the natural monopoly. Mobile roaming services are offered in some places on a commercial basis. Neither Telstra nor Optus offers coverage across the entirety of their networks. Optus provides roaming services to VHA in some areas where both Telstra and Optus have coverage. Telstra provides wholesale services to 11 MVNOs which cover 98.8 % of the population, 0.3 % more than Optus (ACCC, 2017; p 37).

The ACCC has considered the declaration of a mobile roaming service on two previous occasions: 1998 and 2005. In the earlier cases, it concluded that no regulatory intervention was required, as services would be offered through commercial negotiations. Its draft decision in May 2017 is not to declare the service:

> *The ACCC's preliminary view is that economic regulation, in the form of declaring a domestic mobile roaming service, will not address the concerns regarding the level of mobile coverage and network quality available in regional areas*" (ACCC, 2017; p. 76).

It remains to be seen whether the draft decision will become final. Declaration would almost certainly chill further private investment by a second or third network operator in marginal areas – why overbuild the incumbent if you can access its infrastructure or roam over it? It is unlikely that any declaration would help in addressing the real problem – that is, extending coverage into areas where it is fundamentally uneconomic for any operator to venture.

How Effective is the Mobile Black Spots Programme?

The Coalition Government is subsidising the extension of mobile coverage through the Mobile Black Spots Programme. $220 million in Commonwealth funds has been allocated across three funding rounds ($100 million for Round 1, $60 million for each of Rounds 2 and 3).

The first round was completed in June 2015, with 499 base stations covering 3,000 blackspots (see Figure 3).

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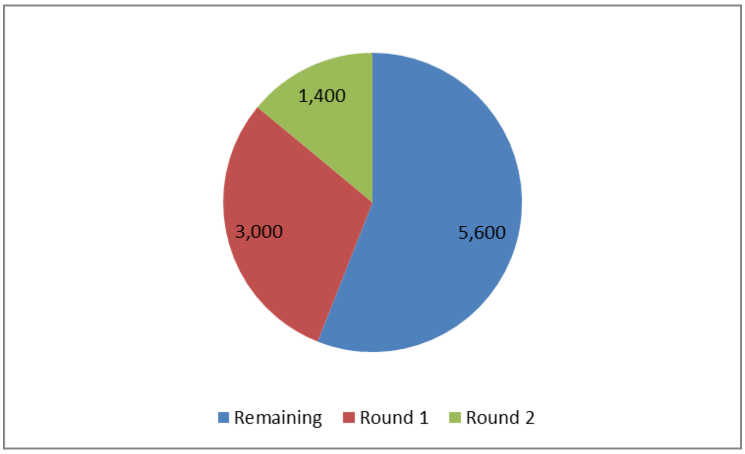

Figure 3 Number of Mobile Black Spots funded

Source: Prime Minister's Press Release, December 2016

Round 2, announced in December 2016, will deliver another 266 new and upgraded mobile base stations in regional Australia, covering some 1,400 black spots across 17,700 square kilometres, as well as 1,900 kilometres of major transport routes, and cover some 6,300 homes and businesses. The $60 million investment under Round 2 leveraged a total investment of $213 million, including funding from state and local governments, mobile network operators (Telstra, Optus, VHA), businesses and community organisations.

Rounds 1 and 2 cover 4,400 of the 10,000 black spots nominated by the public. Round 3 commenced in early 2017. It should be emphasised that the 10,000 nominated blackspots include overlaps and by no means represent the entirety of underserved areas when a broader view of needs and opportunities is taken.

The programme has issues. It has been accused of cementing Telstra's monopoly with public funding and creating islands of alternative mobile operator coverage that require dual SIMs to straddle areas covered by, say, Telstra and Vodafone .

Also, the Auditor General (ANAO) found, that one in five of the mobile phone towers funded in the first round of the programme provided little to no new coverage for consumers:

> "*public funding has resulted in substantial consolidation of existing coverage provided by grant applicants, as opposed to extending coverage in new areas—a key objective for the programme*" (ANAO, 2016).

The auditor found 89 base stations received $28 million in funding despite providing minimal benefits to consumers in areas without any coverage. It also found that 39 of the 499 base stations would have been built anyway by private operators without needing public funding:

> "*The department did not assess whether an applicant's proposed base station location was listed on the work plan of another applicant…the department should review*

applicant proposals against the network expansion plans of other operators as an indicator of whether the programme is funding additional outcomes to normal commercial investment." (ANAO, 2016).

As the programme continues and pushes into even more marginal areas, carrier returns will become more and more elusive. As a result, the MNOs' own appetite for contributing will progressively diminish and the level of community and public subsidy will have to increase.

While small incremental benefits have been achieved at the margins, it is proposed that the money could be better spent on a more comprehensive solution. SafetyNet could eliminate more blackspots cost effectively (especially if 450 MHz is used).

Public Safety Needs and Opportunities

The network options for public safety remain controversial despite the ACMA allocating 800MHz spectrum and the Productivity Commission coming down on the side of commercial operator networks. The main issues are the poor coverage relative to existing (mostly voice) legacy networks and a lack of trust that the commercial networks would deliver.

SafetyNet could deliver a very effective solution for the truly rural and remote areas if existing mobile coverage could be augmented with the 450MHz desired by police and emergency services. The low frequency of 450MHz is well suited to vast areas where base stations are few and far apart. As shown below, one 450MHz base station can cover twice the area of an 800MHz base station, and 20 times that of a single 2.6GHz node.

Table 1: Spectrum Efficiencies for Coverage

Frequency (MHz)	Cell radius (km)	Cell area (km^2)	Relative cell count
450	48.9	7512	1
850	29.4	2712	2.8
950	26.9	2269	3.3
1800	14.0	618	12.2
1900	13.3	553	13.6
2500	10.0	312	24.1

Source: Bright, Julian at OVUM (Bright, 2014)
Notes: Theoretical comparison of base station coverage at different spectrum bands. This performance is based on flat terrain, tower mounted amplifier with radio 60 metres above ground and no interference.

The 450 MHz band was chosen in Finland in 2014. With a relatively low population of 5.4 million, Finland, which spans about 1,000 kilometres from south to north and a total of 340,000 square kilometres, is certainly an ideal kind of country for this sort of technology (*telecoms.com*, 2014).

In Australia, some States may build their own urban core LTE networks for public safety needs, perhaps leveraging transport LTE networks. Operators could then support the surrounding annulus on normal commercial networks and be benchmarked against both SafetyNet and the urban core safety networks.

What is to be done?

What rural and remote Australia needs is open access together with improved mobile coverage. This requires a coordinated response across Federal, State and Local Governments who each manage important pieces of the puzzle for various purposes.

Since the Commonwealth is spending more on rural and remote communications than Telstra and the other MNOs combined, it should take the lead in developing the concept. With a coherent portfolio approach, millions of dollars could be saved.

The cross-government portfolio of telecommunications resources could include:

- Public Safety Mobile Broadband – with Land Mobile Radio for safety already very extensive in regional areas, we could replace existing 450MHz radio systems with national LTE infrastructure – ideally 450-470MHz, (subject to ACMA 400MHz band plan and LTE terminal availability), add 700 or 800MHz Public Safety spectrum managed by State public safety entities, but with an expectation of high availability of this spectrum for non-Public Safety applications.
- Spectrum – the 450MHz LTE available to current Land Mobile Radio footprint plus any available lower band, wider reach 700 or 800MHz spectrum.
- Black Spot funding – where a SafetyNet can have more regard to public interest requirements in improving land productivity through the internet of things, public safety and communications access and affordability.
- USO and payphones funding.
- Remote Indigenous Telecommunications programmes
- Wholesale network infrastructure for rural and remote areas:
    - NBN Fixed Wireless which is inherently a mobile technology, currently adapted to support fixed connections only. With appropriate engineering, the same base station electronics may be able to support both fixed and mobile connectivity. At worst, a separate set of base station electronics could be deployed on NBN Co FW sites – sharing access, tower, power and backhaul. Integrating FW and mobile coverage would thus boost the return on

investment of the nbn's FW sites, and/or

- Inviting MNOs to provide NBN Fixed Wireless over their LTE infrastructure on an open access basis through the NBN for profit.

- NBN Satellite – Traffic quotas are being imposed to stretch the life of limited satellite capacity, but if satellite users were liberated to use the network as freely as their urban cousins, the long term satellite service (LTSS) would very quickly become as saturated as the interim service. Expanding the mobile and/or FW footprint in the underserved area would provide an alternative for displaced satellite users (giving them improved performance as a bonus) and avoid or at least defer the need to invest in additional satellite capacity.

Taken together, a common LTE wireless infrastructure could be used to meet a range of needs that individually have a poor business case. This solution needs the Commonwealth and States to manage their communications portfolios as a pooled resource and possibly add them to relevant commercial infrastructure.

Let us call the common infrastructure Australia's SafetyNet: a single fit-for-purpose LTE network for rural and remote areas. A single, open access network has better economics and would go a long way to meeting the aspirations of rural customers with greater coverage, capacity and scope. Just as the creation of NBN recognised that the fixed network broadband network is a natural monopoly outside metro areas, the pooling of resources in SafetyNet would recognise that in rural and remote areas fixed broadband networks are not viable and an LTE network is a natural monopoly.

Precedents

In 2013 the Rwanda Government together with Korea Telecom established a 4G LTE wholesale operator, Kt Rwanda, aiming to cover 95% of the population of 11.5m. By June 2016, it covered just 29%, compared with over 90% on the incumbent's mobile networks (see Rwanda regulator's annual report, 2016; Table 11). Kt Rwanda's customers are the three mobile operators (MTN, Tigo and Airtel) and a dozen ISPs. In April 2016, it launched 4G LTE Advanced Carrier Aggregation providing data speeds up to 250Mbps.

In Mexico, two universal access projects are under way – a shared mobile network (Red Compartida) and a fixed network program (Mexico Conectado, improving connectivity in schools, hospitals and other public areas on a municipal, provincial and federal level).

Mexico is the largest country in Central America, with a population of about 120 million people, of whom 22% are living in rural areas. The three major players are AT&T, Telefónica and Telcel. Telcel has more than 70% of the MNO market and belongs to America Móviles, which also owns the incumbent fixed line operator Telmex. Since 2007, fourteen MVNOs have entered into the market but have a combined market share under 1% (Detecon, 2016).

Red Compartida (RC) will create a wholesale-only operator providing services that are unbundled and non-discriminatory because "*Doing business as usual, mobile services will not reach unprofitable markets. RC's model will allow coverage in otherwise unserved or underserved areas*" (Minister of Transport and Communications, cited in Detecon, 2016).

RC will be implemented as a Private Public Partnership (PPP) with the State represented by Telecomm and a new entity OPRITEL which obtained cheap spectrum. The selection in November 2016 of a private consortium called Altán, backed by the Morgan Stanley Investment Bank and the World Bank and supported by a number of Mexican cable and telecoms companies, is being contested by Rivada Networks, an Irish company (Capacity Media, 2017).

Although RC will have a monopoly in one spectrum area (unencumbered contiguous spectrum on the 700 MHz band), all other MNOs are able to compete in the LTE wholesale markets using other spectrum.

Governance

An obvious candidate to operate SafetyNet is the nbn, given its role as the existing government owned, wholesale communications supplier. But to this point it has not shown much inclination to sub-contract greenfield infrastructure where it was also subject to complaints about unfair competition (Productivity Commission, 2011) and some of its choices have been questionable (witness the choice of frequency given the high cost and bias towards capacity rather than coverage for Fixed Wireless[3]) .

Another complication which needs to be considered is the possible future privatisation of nbn's fixed wireless and/or satellite assets. This sale might be an opportunity to establish the nucleus of a commercially operated SafetyNet.

A possible alternative is to franchise the operation of a wholesale SafetyNet to an existing MNO or consortium of MNOs. In the area of public safety, capabilities such as Telstra's LANES technology have growing potential to support existing and emerging new needs of public safety agencies on the same infrastructure as provides mobile coverage.

It is in the interests of the MNOs to cooperate regardless of who runs SafetyNet, because cooperation would be a condition of access to unique, additional coverage.

To respect the MNOs' investments and to ensure that public investment in SafetyNet does not stifle private investment, the mobile operators should be given the opportunity to put

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forward in confidence their committed plans for expanding coverage over, say, the next three years[4]. Based on these plans, identify the residual area (let's call it "the underserved area") that has no prospect of achieving coverage through the operation of free market forces. This area is fair game for public investment and SafetyNet. If the MNO plans for expanding coverage do not materialise within the specified period, the boundaries of the underserved area could be expanded accordingly.

Governments and operators could become equity partners in SafetyNet based on the MNOs' contributions of infrastructure and the Commonwealth's contributions around the USO and/or public safety assets.

Conclusion

Australia's SafetyNet would provide network infrastructure for the rural and remote areas of Australia that would otherwise miss out on the availability of competitive mobile communications infrastructure and up-to-date public safety infrastructure. It would provide additional support for the Internet of Things in rural and remote areas to ensure the optimum use of Australia's natural resources. SafetyNet would reduce the costs to the Commonwealth, the States and customers through building just one coherent infrastructure capable of providing for diverse applications.

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Endnotes

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[1] One of the authors, Robin Eckermann, was on the 2012 and 2015 Regional Telecommunications Reviews and has heard these sentiments expressed many times. Also, "*Many agricultural representative groups emphasised the importance of mobile coverage in regional Australia and submitted that the promotion of competition should not be sought at the expense of investment in mobile coverage or networks in regional areas*" (ACCC Draft Decision, May 2017; p. 67).

[2] This diagram was prepared in mid-2015 using published coverage maps by the three MNOs. It does not necessarily reflect coverage at the present time, nor does it attempt to take into consideration differences between coverage using a superior antenna, 2G/3G/4G differences etc. Despite these limitations, the reality it highlights is clear.

[3] We acknowledge that by using higher frequencies necessitating smaller cells, the nbn achieves more capacity per cell (useful in the context of delivering fixed broadband), and the shorter reach facilitates spectrum re-use in nearby cells. Also, requirements (and the suitability of spectrum) will vary depending on location - with higher frequencies and smaller cell sizes suited to some of the nbn's deployment scenarios on urban fringes, and lower frequencies and longer reach ideal for the more remote areas. Ideally, nbn should conscript other frequencies if and when it targets the more remote areas.

[4] The ACCC sought such information for its mobile domestic roaming inquiry from all three MNOs on their historical investments and planned investments and found their focus is on improved quality, not improved coverage: "*Based on current information, the ACCC's preliminary view is that there is evidence that coverage-based competition may continue. Such competition is not focused on the size of geographic coverage, but rather on improving the quality of networks in areas where coverage exists*" (ACCC Draft Decision, 2017; p. 46).

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Implications of Open Source Blockchain for increasing efficiency and transparency of the Digital Content Supply Chain in the Australian Telecommunications and Media Industry

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Abstract:

While digital content is key to the Australian Telecommunications and Media industry, there is little industry cooperation to improve the content lifecycle across industry segments including production, distribution and advertising. With the emergence of hyperledger, a Linux Foundation open source program for blockchain shared ledger technology, there is opportunity for the industry to collaborate to improve content lifecycle transparency, trust and efficiency while protecting consumer privacy. Individual business networks and supply chains within the industry can tactically deploy hyperledger as a shadow ledger as a starting point, and, over time, widespread, consistent industry adoption is more likely to be achieved through government regulatory guidelines and a wholesale digital content infrastructure service provider taking a leading role.

Keywords: media and content distribution and protection, industry and regulatory framework for using blockchain, advertising, piracy

Introduction

Creation, distribution and consumption of digital content in its various forms are the core of the Australian Telecommunications and Media industry. While visibility and control of the content across the supply chain is key to the business models of many in the Australian Telecommunications and Media industry, there is no common industry approach to transparency and control of content provenance throughout the content lifecycle.

Provenance is the record of ownership over time, and in the context of content it includes a record of rights, protection, location, distribution and consumption. Content itself takes many shapes including music, movies, news, sports and advertisements, and across the content lifecycle there are multiple parties interested in creating content, controlling distribution and monitoring consumption in order to monetise the content; the content producer wants to minimise piracy, the content rights owner wants to confirm the music or video was accessed, the advertiser and agency want confirmation the publisher delivered the advertisement, the rating agency wants to confirm the audience.

Instead of a common industry approach to transparency and control of content provenance, today there are disparate approaches to tracking and verifying content distribution and consumption. These approaches are largely opaque, resulting in one party in the supply chain not having clear visibility of what has subsequently happened to the content despite their revenue being directly tied to what happens to that content. Reporting on content publication or delivery is often dependent on disparate systems and standards as well as on manual reporting processes within and across organisations. These factors combine to duplicate function, increase risk of inaccuracy due to human error, decrease trust in the accuracy of the reports and create longer than necessary reporting, reconciliation and settlement periods.

Blockchain is an emerging technology that increases trust and efficiency across business networks. Hyperledger (Hyperledger, nd) was announced in December 2015 as an open source Blockchain program run by the Linux Foundation, "the non-profit organisation enabling mass innovation through open source" (Linux, 2015). With the support of the Linux Foundation and its members, Hyperledger is emerging as an important decentralised ledger platform for streamlining and transparently and accurately measuring the transfer of physical and digital assets across supply chains in different industries. Applied to the business networks associated with content in the Australian market, Hyperledger could increase transparency and control of content provenance, resulting in reduced piracy and timely, accurate and transparent accounting and settlements for content distribution.

The Australian Telecommunications and Media Landscape today

The Australian Telecommunications and Media industry comprises a number of segments including telecommunications, broadcast and internet television and radio, newspaper and magazine publishing, content production, content distribution and advertising, all of which are largely Australian heritage and are subject to government regulation.

The increasing ubiquity of the internet, globally coupled with the decreasing cost and increasing availability of powerful consumer electronic devices for accessing the internet, has created a global addressable market for companies based on the internet. In the last several years the largely Australian-heritage organisations in Australian Telecommunications and Media market have been joined by global internet companies including Apple, Facebook,

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Google and Netflix whose capabilities include communications, content distribution, content retail and advertising. There are arguments in Australia and other countries that government regulations for traditional domestic communications and media companies should also be applied consistently to include the global internet companies.

Poor Australian standing in global rankings of broadband internet penetration prompted the Australian Federal Government in 2009 to establish National Broadband Networks Company (nbn) to deploy high speed wholesale internet access networks connected to every premises in the country. The nbn goal is to provide a platform for the digital economy and close the digital divide; nbn expects Australia will be the "world's most connected continent" within three years (nbn, 2017). With the vast majority of fixed broadband retailers using nbn and many of the cellular operating companies also using or intending to use nbn's networks for backhaul connectivity from their cell towers to the internet, in the near future almost all digital content in Australia will be transported to and from the premise or mobile device on nbn's wholesale access networks.

Current issues with content transparency and trust across the industry

While there is competition within each media industry segment, the content supply chain spans multiple industry segments. Organisations from different segments cooperate to distribute content including music, video, advertising and news, but face issues and risk:

- artists and content producers invest creativity and resource to create new content and are dependent on third parties to distribute their content and make it available through broadcast and online channels. Content producers have significant exposure to the risk of piracy, being unauthorised copying and distribution of their content.
- content rights holders own the rights to long and short form content such as movies and music. Broadcasters and media streaming service providers pay the rights holder when the digital content is broadcast, streamed or downloaded. Rights owners do not have direct access to records from the third-party platforms that deliver their content to consumers yet are compensated by the third-party platform owner based on delivery of their content. Performing rights organisations act on behalf of the rights owners to collect royalties but have no systemic means of identifying where the content is being played across the internet.
- news services have inadvertently relayed misinformation or 'fake news' to their readership, a result of the pressure to publish articles ahead of their competition.

- advertising agencies create advertisements and campaigns on behalf of their clients the advertisers. The ad agencies buy advertising inventory (being time or placement slots) from broadcasters and internet media publishers who in turn display the advertisement to the consumer. Advertisers and agencies want validation the advertisement was displayed yet publishers provide no systemic transparency of how long the advertisement was in view. Some Internet media companies do not provide independent verification of how many ads were served. Advertisers want to protect their brands by verifying their ads were not displayed alongside inappropriate material.
- ratings agencies measure and report on audiences and despite the increasing use of consumer electronic devices for viewing there is no common industry model for accurately measuring all viewing on tablets and smartphones.
- telecommunications companies differentiate their service by bundling third party content such as sports, but there is no industry approach to reporting viewer experience across cellular and fixed networks and different devices. Viewers can receive poor quality of experience for different reasons including inadequate network coverage, network congestion or handset issues without the telecommunications service provider or the content distributor knowing or reporting issues exist, much less openly and systematically addressing the quality issues.
- consumers are able to post content to public internet video platforms or distribute content through internet file sharing sites without confirming they have the rights to the content. While it is entirely appropriate for a user to post personal content to social networking sites, community posting of music videos and songs is an issue because it creates advertising revenue for the social networking site without compensating the artists and right holders or recognising the artist may not want their work used for commercial purposes.

The ACMA (ACMA, 2016) reports that accessing audio, video and news are three of the top ten activities most commonly performed by Australians over the internet, with more than 50 per cent of Australians performing these activities in the six months to June 2016. While the ACMA does not identify what proportion of these activities is access is to Australian content, the ACMA data indicates that a high number of Australians would benefit from an improvement in content services.

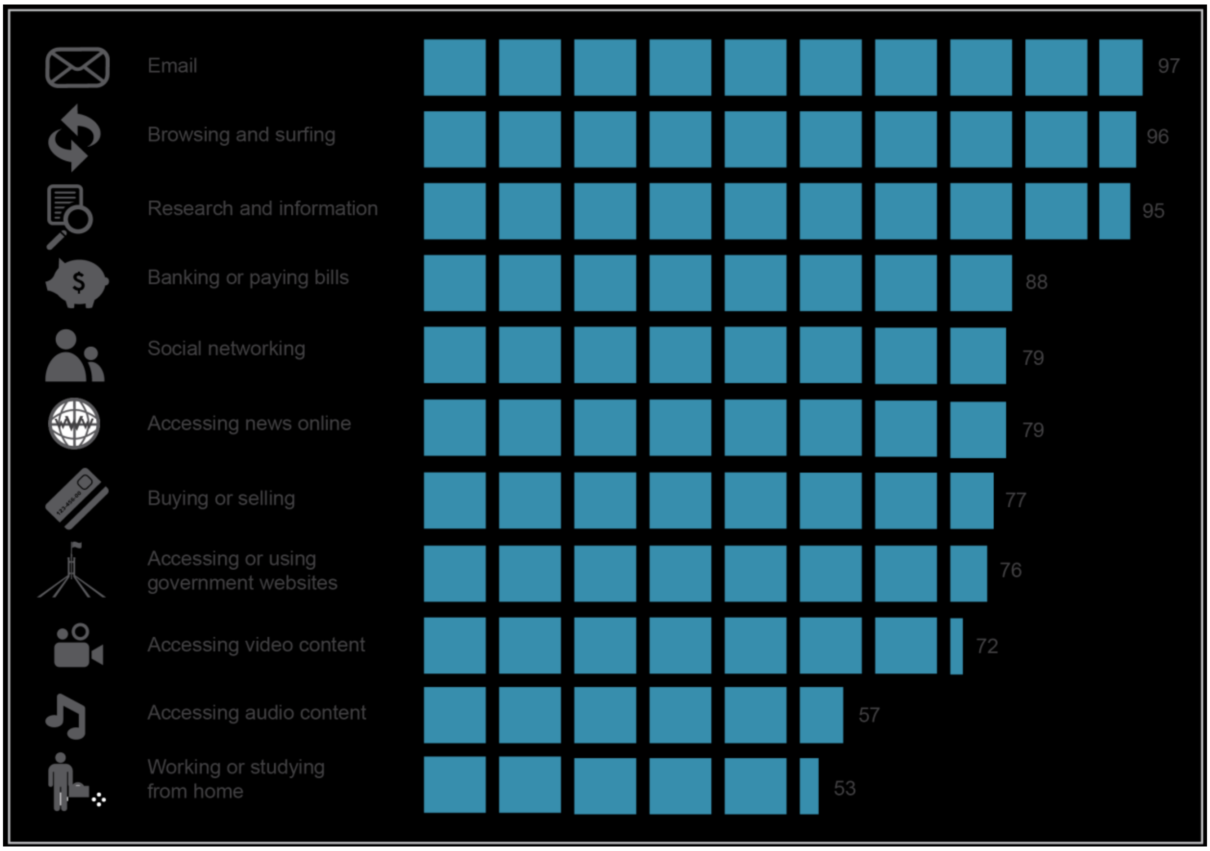

Figure 1- Performing activities online, six months to June 2016 (percentage) Source: ACMA Communications report 2015–16

Current systems and business models are failing many in the industry. An industry-wide collaborative model, not centralised and controlled or monopolised by any one party, for making transparent the content provenance across its lifecycle would address these issues, increasing visibility and control of the content that is key to the business models of most everyone in the Australian Media industry.

Ledgers, Registries and Blockchain as Systems of Record for Assets

A ledger is the system of record for financial transactions and for hundreds of years organisations have maintained ledgers to record their transactions with others and to manage their assets. In this long-established model, each organisation keeps its own ledger and there is no central authority or shared ledger. Maintenance of independent ledgers by each organisation increases the likelihood there will be differences in records across organisations; the ledger of one organisation will show that an account has been settled or goods have been delivered, while the ledger of the other will show that it has not been settled or that there was an issue with all or part of the delivery. Significant time and effort goes into resolving these differences and achieving consensus.

Governments have long used registries to maintain records of entities in their jurisdiction. Entities include assets such as land, and transfer of land requires all interested parties to meet at the same place and time to reach consensus that the records are accurate before land transfer occurs and the land title registry is updated.

Computer systems of the last sixty years have implemented batch then online electronic ledgers and registries, largely perpetuating pre-existing models of responsibility where each organisation has its own independent ledger and the government as central authority maintains registries of assets and entities in which it has an interest.

The long-standing model of each organisation having its own ledger is being disrupted by technology.

In the last several years Blockchain has emerged to increase consensus and reduce friction across business networks. Blockchain is a decentralised shared ledger technology where each party has its own copy of the ledger, identical to the ledgers of others in the network. Blockchain ensures all relevant parties agree on conditions for the decentralised shared ledger to be updated. Updates are immutable, giving each party confidence in the accuracy of the shared record. Blockchain appeared initially as the transaction ledger underpinning the digital currency Bitcoin, described by its inventor Satoshi Nakamoto (Nakamoto, 2008) in October 2008 as "a new electronic cash system that's fully peer-to-peer, with no trusted third party" and in 2014 Gavin Wood (Wood, 2014) provided the first formal specification for blockchain.

CSIRO (2017a) state "Distributed ledgers can store digitised representations of real-world transactions that may be trusted to prove the history of an asset or object. By tracing the transactions, the identity of the asset or object (or the current owner) can also be demonstrated."

Blockchain operates in a decentralised mode, that is, without the control of a central authority and with each party having the same copy of the ledger. Decentralisation is a key distinguishing feature of blockchain, in that the typical datastore or ledger today is centralised within an organisation and not decentralised across a business network. Decentralisation reduces the likelihood of monopolisation of the supply chain.

The Financial Services Sector is leading industry adoption of blockchain in different types of business networks including private equities, funds transfer and consumer lending. The IBM Institute for Business Value (IBM, 2017) cites Walmart, Maersk and Everledger as examples of Blockchain being applied to supply chains for physical assets. Walmart is a retailer starting to use blockchain to increase trust in the food quality by tracking food across the supply chain. Maersk is a global transport and logistics company that is using blockchain to better manage its supply chains to increase the trust each party in the supply chain has in the accuracy of the trade documentation, estimated to be one fifth of transport costs today. Everledger is using blockchain to track diamond provenance across the lifecycle from mining onwards.

SecureKey (Ligaya, 2017) is using blockchain to share customer identity across organisations, reducing the administrative overhead of meeting 'Know Your Customer' regulations. IBM and others have released both OpenHorizon as an open source platform for edge computing and BlueHorizon as an experimental platform, using blockchain to enable discovery and leasing of available third-party compute resource on 'edge of network' platforms outside the data centre.

Recently Hyperledger was established as a Linux Foundation open source program for private and permission-based blockchain. Open Source is an approach to software development where the software is shared across the global community, enabling many thousands of developers to collaborate to inspect and improve the software code. Open source has fundamentally changed the software industry, with development organisations using and building offerings on Open Source and leveraging the global developer community rather than constructing proprietary software using only the resources within their own organisation. Enterprises and government are increasingly using open source to increase the flexibility and speed of development of their key systems while reducing the dependency on commercial off the shelf software packages. This reduces time, effort and skill required to build new software, resulting in higher quality innovation and standardisation occurring more quickly.

While there are alternate open source blockchains, as a program run by the Linux Foundation, Hyperledger has significant membership from technology companies and financial services providers so is likely to continue to gain significant and widespread support.

IBM Research (Cachin, 2016) describe the architecture of Hyperledger as "a permissioned blockchain platform aimed at business use. It is open-source and based on standards, runs user-defined smart contracts, supports strong security and identity features, and uses a modular architecture with pluggable consensus protocols."

As a permissioned blockchain, Hyperledger maintains privacy; while each party in the hyperledger business network has a copy of the Hyperledger decentralised ledger, transactions are only visible to parties who have permission, unlike public blockchains where all parties have visibility of all transactions. This is important in a supply chain where some organisations are competitors; one supplier need not know the customer has given an order to another supplier. This is also important in avoiding the significant energy consumption issue created by the 'proof-of-work' computational workloads of public blockchain.

'Smart contracts' between parties in the business networks are recorded as business rules in each instance of the Hyperledger. As the transaction occurs, for example as the physical asset is transferred from one owner to another, relevant parties verify the transaction has occurred and the business rules in the smart contract in the Hyperledger blockchain are executed. Each Hyperledger is updated to record the transaction with the record being signed and able to be verified.

There is a widespread view that hyperledger will become a technology integral to the internet; in the same way that HTTP is the internet protocol for requesting and transporting web pages, hyperledger is expected to become the internet protocol for transactions across business networks for all industries. Harvard Business Review (Iansiti & Lakhani, 2017) state "TCP/IP unlocked new economic value by dramatically lowering the cost of connections. Similarly, blockchain could dramatically reduce the cost of transactions. It has the potential to become the system of record for all transactions."

Hyperledger to increase transparency and trust across the Media Industry

At time of writing, there were 65 hyperledger use cases (Hyperledger, 2017) published in the hyperledger wiki, 28 covering capital markets and financial services, 19 for government and only 2 directly related to content and media, being 'Sensitive Record Tracking' and 'Music Publishing'.

In much the same way, the Finance Sector and industries with physical supply chains are gaining improvements in trust and efficiencies through blockchain, blockchain could similarly improve benefit to the Australian content marketplace by increasing transparency and trust across the digital content supply chain.

Key examples of how blockchain could improve the digital content supply chain in Australia are listed here:

- **content producers** could reduce the risk of piracy by using blockchain to more tightly control and have visibility of content provenance at each step in the supply chain. In conjunction with content protection technologies, the blockchain would vary the keys and watermarks being applied to the content at each stage in the distribution process, making it easier to more quickly identify and address exactly where in the supply chain piracy is occurring, whether inside the media institutions or at the edge of network by consumers.

  By connecting the content to the blockchain and embedding validation rules and content protection methods supported by all parties into the blockchain, content

distribution occurs only with the agreement and oversight of all parties. Individual items of content could only be played in a certified player that has received from the blockchain approval and keys to play this specific item of content.
Extending this model to allow the blockchain or investigators to access records from Internet Service Providers could identify premises if not individuals in the community that are illegally copying and distributing content.

The scale of the piracy issue is significant; Village Roadshow stating "visits to pirate sites in 2015 were estimated at 78.5 billion worldwide. In Australia a frightening 1.24 billion visits" and "Australians have taken to piracy at a far greater per cap than virtually anywhere else in the world – way ahead of the USA." At risk is the viability of many in the movie industry and the cultural implications associated with reduction or loss of the Australian narrative provided by the movie industry.

- **content creators** such as musicians, content rights holders and performing rights organisations will be privy to service provider delivery transactions, ensuing timely agreement on what was played where and when. As Deloitte (Shelkovnikov, 2016) state, "A common blockchain platform, employing identity management and smart contracts, locks in rules for how revenue flows from consumer to artist every time a piece of content is played or streamed, reducing the costs associated with collecting and managing statistics, maintaining copyright databases and distributing royalty payments."
  Enabling, for example, independent musicians and film makers to assert the rights to their content and be quickly remunerated for community consumption could encourage artists to create and release more material. ACMA (ACMA, 2016) reported that in a recent seven day period, "19 per cent of adult Australians had used a streaming music service such as Spotify, Pandora or iTunes radio," which suggests that improved transparency and accuracy and timeliness of payments would affect a large number of artists and rights holders.
- **Accredited news services** and accredited freelance journalists, having validated new information is accurate, will be able to log the validation of the news, information and source into the blockchain to ensure there is an accurate record of the validation linked to the news content. Syndicated news services, publishers and news consumers will inspect the blockchain in order to be confident the information is accurate regardless of where it is published.
- **advertisers and agencies** sharing a blockchain with publishers including the internet media companies will be able to more quickly and accurately confirm what

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ads were placed where and for how long, significantly decreasing reconciliation efforts. Advertisers could also specify what classes of content the ad should be displayed (or not displayed) alongside. All parties would have consistent visibility of what ads where displayed where and when (including what other content was displayed) regardless of whether the ad was rendered in a browser, injected into a streaming service or presented in the social networking app or web page of an internet media company. ACMA (ACMA, 2016) puts national expenditure for online advertising in 2015 at $6.02 billion, suggesting that increased transparency and efficiency would provide substantial benefit.

- **ratings agencies** participating in the blockchain will have timely and accurate fine grade data on the audience viewing behaviour, down to whether the show was paused and at what point viewing ceased, provided this data is collected from the media player or the delivery platform. Blending data from media players and content platforms with usage data from Internet Service Providers would enable the ratings agencies to analyse the content consumption habits for a household across all content platforms and devices without identifying the individuals.
- **telecommunications companies** measuring quality of experience technology can use blockchain to transparently share viewer quality of experience data with the content distributors, rights holders and advertisers, enabling the all parties to understand and then improve the viewer experience.
- **consumers** posting content to platforms would need to identify themselves assert they have permission, with the record being held in blockchain. Breach of copyright could then be taken up with the known person posting the content; applying the SecureKey example to this scenario, blockchain can provide a trusted and private service for consistently identifying users and consumers across media organisations.

Where file sharing software is used to distribute pirated content, a regulatory regime is needed to enable legal agencies to monitor file sharing activity and user behaviour and to intercept suspicious file sharing traffic, inspecting any associated blockchain as the agreed system of record to determine if the file sharing is authorised, and blocking the traffic it is not.

This is analogous to the Federal Police's authority today to inspect physical goods entering the country through ports and State Police being able to enter a property in their jurisdiction under warrant and undertake searches. The argument here is this model can be applied to protection of digital content, with blockchain being used to provide all authorised parties with a clear record trusted by all parties of identity, commercial transactions and content provenance. Decryption keys for the content and the Virtual Private Networks (being encrypted sessions) in which the content is transported could securely be held in the blockchain, only accessible by approved parties including legal agencies with proper authority.

It is important to acknowledge that while many of these requirements and use cases can be addressed today without blockchain, the distinguishing capability of blockchain that makes these use cases easier to address is decentralisation. This establishes trust across business networks without introducing centralised control.

Importantly, there is no need to displace existing systems when deploying blockchain as a Shadow Ledger. In this model, the blockchain augments existing systems in each enterprise and, is granted read-only access to existing transaction records in those systems. This enables a holistic view of the end-to-end supply chain to be established without the likelihood of taking down the existing systems. A shadow ledger to track content consumption can be initially implemented by only a small number of entities in the business network, an application which meets Harvard Business Review's innovation adoption model by being "relatively high in novelty but need(ing) only a limited number of users to create immediate value" (Iansiti & Lakhani, 2017).

Moving beyond a Shadow Ledger role, the blockchain could progress to providing an active role, such as approving the playing of content as outlined earlier. The barrier to adoption is higher with this application as it requires content distribution systems to be modified.

The design of these blockchain applications would be established over time as stakeholders in the business networks collaborate to solve common problems. The blockchain applications will comprises the decentralised blockchain, interfaces to external systems such as media players and content distribution networks, and end-user interfaces to provide users with services such as logging of new content, visualisation and reporting.

As with any system, non-functional requirements including latency, availability and access control need to be factored into the design and implementation. While blockchain is not a low-latency or high volume technology today, significant efforts are being made to address these points, and like any technology the success of blockchain services will be dependent on identification and good design of applications with non-functional requirements that fall within the current limits of non-functional capability.

The argument here is not for a single blockchain to bind all organisations together, but instead for archipelagos where blockchains operate in different areas, doing so with consistent frameworks, standards and intent. The value lies not only in improved efficiencies and quality, but also in the data aggregated from multiple industry blockchains. Subject to privacy laws, data on content viewing habits for the country could be shared with those who contribute to the blockchains. Anonymised blockchain data could also be sold to third parties for analysis in the same way that weather and credit card data is sold today.

The timeframe for experiment, implementation within small business networks, subsequent linking of business networks followed by widespread adoption is not clear and could take a decade or more. Drawing an analogy with TCP/IP, a technology which transformed communication but took decades to become mainstream, Harvard Business Review (Iansiti & Lakhani, 2017) view blockchain as a similar foundational technology; "True blockchain-led transformation of business and government, we believe, is still many years away … while the impact will be enormous, it will take decades for blockchain to seep into our economic and social infrastructure. The process of adoption will be gradual and steady. " (Iansiti & Lakhani, 2017). A survey by the IBM Institute of Business Value indicates a majority of respondents intend to implement a blockchain by 2020.

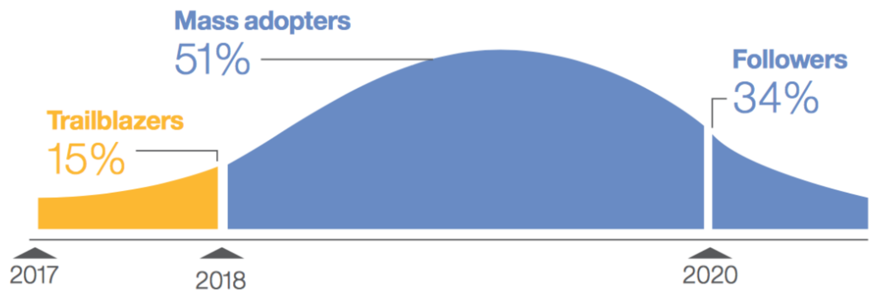

Figure 2: Intended Adoption of Blockchain over time (Source: IBM Institute of Business Value)

Deloitte (Shelkovnikov, 2016) relay the view that the World Economic Forum, "doesn't expect the tipping point for the technology (blockchain) to occur until around 2027," with a survey showing the "majority of experts and executives in the information and communications technology sector expected at least ten per cent of global GDP to be stored on blockchain platforms by 2025".

Potential Role of Government

The Australian Communications and Media Authority (ACMA) is the Australian statutory authority charged with ensuring affective and efficient operations of the legislation and regulation that governs the Australian Telecommunications and Media industry. ACMA could facilitate industry exploration of blockchain in order to stimulate representative industry discussion and confirm likely commercial and community benefits measured as improved efficiency balanced with maintenance of viewer privacy.

A number of government regulatory framework considerations exist for blockchain: thse include protection of end-user privacy; the ability for an independent musician to easily assert and maintain their rights to the content they have created and track usage and be compensated for use; the ability to compel global internet companies to tear down material which has been posted to their sites without the permission of or compensation to the rights holder; the ability for legal entities to proactively investigate and reduce piracy; and Government access to industry blockchain records in order to facilitate introduction of taxation of digital goods and services in the transforming economy.

While there is nothing stopping different businesses collaborating to construct a mutually beneficial blockchain today, widespread industry adoption of blockchain could be accelerated by a trusted service provider intermediary to manage the technical program of work and provide the capability to the market as a service. The intermediary could be a consortium or single entity but would act as a wholesaler or service provider requiring a wide spectrum of skills including design, construction and operation of software and extensive knowledge of business networks and telecommunications and content distribution networks.

With nbn's goal (NBN, 2016) of being a platform for the digital economy and almost all content traversing nbn networks in a few years, and nbn having many of the required capabilities and operating in a wholesale model, nbn is in a unique position to play a key role in deploying industrial-grade blockchain applications and infrastructure for the telecommunications and media industry and amortising the cost over an appropriate term while recovering the investment over time by charging as a service provider.

The wholesale content infrastructure could include content distribution networks, hosting of hyperledger and quality of experience measurement in nbn physical infrastructure at the edge of the network. Given their extensive footprint of technical infrastructure across the Australian continent, this wholesale content infrastructure could be deployed at the edge of the nbn networks, close to premises, thereby reducing latency and improving service quality. nbn also has the Operational and Business Support Systems and expertise to enable monitoring of the infrastructure and assurance, availability of and charging for these wholesale services.

Conclusion

While Australian Telecommunications and Media organisations strive to improve internal efficiencies and compete within their segments, blockchain appears to offer a novel, trusted approach to solving a range of media industry issues. There is opportunity to increase transparency, trust and efficiencies across industry segments through using Hyperledger, the open source blockchain decentralised ledger platform. Individual business networks within the industry can tactically deploy Hyperledger as a shadow ledger as a starting point, and beneficial industry adoption is more consistently and easily facilitated through government and a wholesale digital content infrastructure provider taking a leading role. Sustained cross-industry collaboration over several years will be needed to realise benefits for the industry and the community.

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The Silicon Valley We Don't Want to Have

A review of Antonio García Martínez, *Chaos Monkeys: Inside the Silicon Valley Money Machine*

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Abstract: This article is a review of Antonio García Martínez's book, *Chaos Monkeys: Inside the Silicon Valley Money Machine*, published in 2016, which tells the story of the author's time in Silicon Valley. An area of major interest is his time at Facebook, where he helped develop an online advertising exchange. The book is a warts-and-all account that describes many undesirable aspects of "Silicon Valley culture". While the book is overly self-indulgent, it could valuably be read by policy makers interested in start-ups and business culture.

Keywords: Book review, Silicon Valley, start-up culture

Introduction

With the continuing rise of the FAANG (Facebook, Apple, Amazon, Netflix, Google), we hear a lot these days about developing the digital economy. Much of the talk is about instilling a "Silicon Valley culture" in Australian business. The Prime Minister wants us to be "innovative and agile". Most of the talk is overwhelmingly positive.

But perhaps you've seen *Four Corners* have a go at Facebook (Greste *et al.*, 2017), or you've tut-tutted about Uber after its founding CEO was forced to resign (ABC, 2017), or perhaps you've been shocked by revelations of sexual harassment in "Silicon Valley" by the *New York Times* (Benner, 2017), and you may be wondering just how deep into the "culture" all this bad stuff goes. This book, *Chaos Monkeys* (García Martínez, 2016), by "Silicon Valley insider", Antonio García Martínez, may help you to understand. And the conclusion: it goes very deep – root-and-branch deep – and we should be cautious about what parts of "Silicon Valley culture" we really want in Australia.

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Living the Life

In this book, Mr García presents himself as a self-centred, greedy, sexist, vaguely racist operator, who will lie to and cheat his closest colleagues, and generally exploit anyone who comes into his orbit. In his view, this personality perfectly matches most of the people with whom he has dealings. He does encounter some people who seem to be motivated by something other than money, but they are just grist for the exploitation mill.

He begins his story with a brief account of his experiences at Goldman Sachs in New York, after an unhappy (and relatively impoverished) period as a graduate student in California. He describes some appalling behaviour in the workplace that is encouraged, or at least not discouraged, by the management. At Goldman Sachs, he has some useful skills as a "quant" (a quantitative analyst) but that will only carry him so far and he will always be just a small cog in a big wheel. So, he decides to jump ship to "Silicon Valley" when the opportunity arises.

Mr García was recruited by Adchemy, a start-up company developing software for digital marketing campaigns. Although he finds that he despises almost everyone there, especially the founder and CEO, Murthy Nukala, Mr García is introduced to the world of online advertising and gains knowledge that will later stand him in good stead. Adchemy, it turns out, had recruited a strong team: it was later acquired by Walmart (Perez, 2014) for its talent (not including Mr Nukala).

Now, Mr García is not a large company man. His attitude is summed up in the following quote:

> *I would always prefer … being subject to the rigors of the market, the fickleness of luck, and the whims of users than to navigate the popularity-contest politics of a large company, surrounded by the mediocre duffers who've succeeded in life through nothing more than guile and appearances.* (García Martínez, 2016; pp. 30-31)

In short, Mr García wished to be in the start-up game, and so he entered it with two colleagues from Adchemy, playing somewhat loosely with Adchemy's resources and intellectual property, and with the luck of being accepted by "Y Combinator", a successful incubator of start-ups. He details the machinations involved in creating, supporting and eventually "selling" his company, a three-person start-up. By this stage, the reader will not be surprised that honesty, integrity and transparency do not figure often in this story. Mr García's attitude wavers between admiring his own performance and noting the lack of an ethical basis. This account, however, which takes up about 40% of the book, is quite instructive about the start-up "culture" and is well worth reading by anyone contemplating such a move. It could also be of interest to any company regulator who might seek to tame this new Wild West.

The "selling" of the company is especially instructive. It is acquired by Twitter but Mr García, in a move that undercuts his colleagues, sells himself separately to Facebook. He makes the case that he did not do well, or did not do as well as he should have, out of this deal, but it certainly displayed a depleted level of trustworthiness.

Mr García's time at Facebook, which is described in the second half of the book, has been a selling point, because he was there at an important time, when Facebook was preparing for its IPO, and he was in the heart of the money-making part, the online advertising. He tells an interesting story. Of course, it was not going to end well, given Mr García's attitude to large companies quoted above (but, to be fair, he may not have developed his dislike before he went to Facebook). He survived two years, from April 2011 to April 2013. Then he was fired, mostly, it seems, for not being a team player.

You may want to read this book to find out how Facebook organises itself. In many ways, it is quite impressive: Mr García reports several instances when the company could move quickly to concentrate resources on a project; and it appears to react positively to ideas percolating up from the workers. Mr García, of course, dislikes all the meetings associated with his job as a product manager, but he develops a grudging (and somewhat surprising) respect for Sheryl Sandberg, the chief operating officer of Facebook, and her ability to manage in a complex, technical environment.

You may also want to read this book to find out how online advertising works to produce such rivers of gold for Facebook and Google. In this, Mr García is quite instructive. He worked on an open advertising exchange, to permit potential advertisers to bid in real time for Facebook advertising space, so he knows all the details and writes about them clearly. He also describes what user privacy means in this context: no direct identity information is revealed but a lot of potentially defining characteristics can be mined for value. You may be left wondering if it is at all satisfactory.

It's Not Just Sexism

All this is set firmly in the context of "Silicon Valley culture" and the murky underpinnings of this "culture" are well on show. Let us start with sexism. Mr García's contempt for "most women" is telling:

> *Most women in the Bay Area are soft and weak, cosseted and naïve despite their claims of worldliness, and generally full of shit. They have their self-*

> *regarding entitlement feminism, and ceaselessly vaunt their independence, but the reality is, come the epidemic plague or foreign invasion, they'd become precisely the sort of useless baggage you'd trade for a box of shotgun shells or a jerry can of diesel.* (García Martínez, 2016; p. 57).

His sexism runs quite deep and extends to most of the professional women around him (with the notable exception of Ms Sandberg). He is also a binge drinker and a dangerous driver. He thinks of himself as more streetwise than most ordinary folk. None of these attributes will likely endear him to the reader.

While we now hear about sexist attitudes in "Silicon Valley", it is not just sexism that is the problem. Mr García could also be accused of racism. At least, although he comes into contact with several Indian or Indian-American managers, he seems to find none of them competent in their positions. He rightly points out parallels between the US visa system and the slave trade, but he exhibits little sympathy for those caught up in it. This is all despite his recognition that his own Cuban-American background restricts his own opportunities.

But perhaps the worst of it is the business "culture" around funding and operating start-up companies that Mr García describes. It involves misrepresentation, if not downright lying, cheating one's colleagues and potential business partners, and generally carrying on in ways that would cause great distress in a more regulated business environment. It is significant that the review of the book in the *Australian Financial Review* (Shapiro, 2016) praises Mr García as having "the smarts and the hustle to thrive at the centre of the new economy" and notes the "fantastic and colourful insights into the greed and politics at play", while only mildly condemning the surrounding environment as "making us feel a little less envious" of "the centre of the universe". It is to be hoped that this "start-up culture" has not now become so normalised that it passes without comment.

In using this book to condemn "Silicon Valley culture", one must ask just how much of an insider Mr García really was. He certainly worked in a start-up and founded one himself, he worked for Facebook and negotiated with other businesses that are household names, and he exercised his "smarts" and "hustle" in Palo Alto, Menlo Park and surrounds. In all that, he was a consummate insider. But he shows little comprehension of any motivation other than greed, he has little compassion for foreign workers trapped in an alien environment, and he is contemptuous of those who attempt to build a traditional career. In all those ways, he is sitting outside and observing his fellow participants in the "culture". Perhaps there are redeeming features in the behaviour of others that he does not see.

Conclusion

Antonio García Martínez writes well and has done us all a service by describing the real "Silicon Valley" as he sees it. He has an intelligent eye for an illuminating historical parallel, so he can paint a well-rounded picture for the attentive reader.

There are lessons to be learnt from this story and it would be good if it were widely read by policy makers and those in a position to influence business culture. It is to be earnestly hoped that these US "start-up culture" practices are not adopted holus-bolus in Australia in our zeal to emulate our American cousins. Getting the balance right between free-ranging entrepreneurialism and business regulation will need to be finely judged.

At the same time, Mr García is self-absorbed and there are regular self-indulgent passages in the book. The reader may well be put off by some of Mr García's wilder excesses. The story would have benefitted from a stronger editor to tighten the focus. Nevertheless, it is a rollicking read and a compelling insight into an interesting time for our technology industries.

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Hong Kong's Fibre Broadband Market

Busting the Myth of Residential Fibre Broadband always being a Natural Monopoly

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Abstract: Hong Kong has been long recognised as a leading global city when it comes to fixed broadband performance. Unlike many other leading broadband markets, this has occurred without any financial support from the Hong Kong government. The removal, rather than an increase, of regulation of the privately-owned broadband network operators has been the overwhelming main driver of this outcome. The key factors driving this outcome have been an open market with low barriers to entry, aggressive competition between network operators, low network build costs and innovative marketing to stimulate demand for higher-speed broadband service. The successful rollout of profitable competing Fibre to the Premises (FTTP) across the city demonstrates that fibre networks are not always and everywhere utility-style natural monopolies. However, the lack of a universal service obligation for broadband does also mean that in areas where competition is neither technically nor economically feasible approximately 10% to 15% of Hong Kong households are not benefiting from this policy.

Keywords: Broadband, Fibre to the Premises, Hong Kong, Infrastructure competition, Natural Monopoly, Universal Service Obligation

Introduction

Hong Kong has consistently been a top performer in the global rankings for broadband download speeds. According to Akamai's State of the Internet report (Akamai, 2017) for Q1 2017, Hong Kong was ranked 4th globally with an Average Peak Connection Speed of 129.5 Mbps. This ranking has been consistent for over five years, with Hong Kong ranking alongside the other top performers such as Singapore and South Korea.

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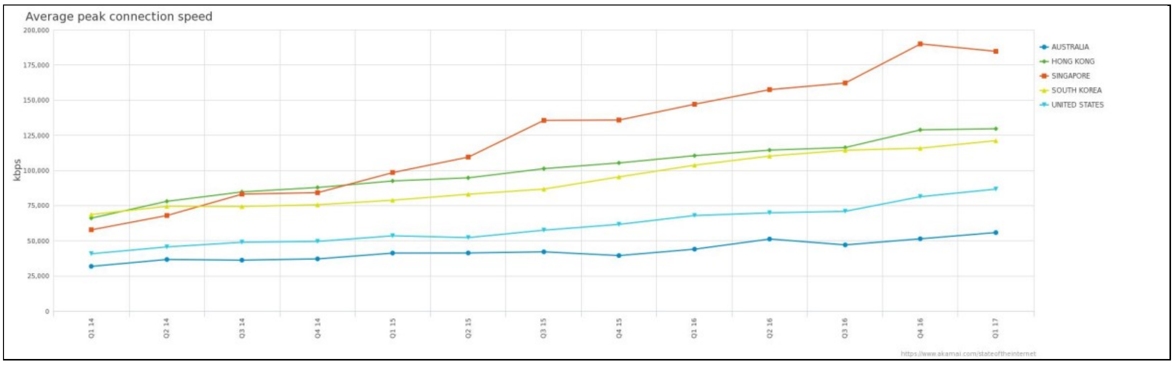

Figure 1 Akamai Average Peak Connection Speeds 2014 - 2017

On the broader measure of overall Average Connection Speed, which is impacted by factors other than the local access connection, the average speed in Hong Kong is 21.9Mbps, again with a ranking of 4th globally behind South Korea, Norway and Sweden.

Hong Kong is the only market ranking in the top four globally for both of these measures.

These high rankings are consistent with the wide deployment of optical fibre infrastructure in the access network of these countries. The deployment of deep fibre optical fibre networks in these countries have enabled peak download speeds of up to 1 Gbps for residential users.

However, Hong Kong is unique in that this investment has not resulted from an active government policy framework: rather it has resulted from the withdrawal of government from regulation of the telecommunications sector. While other markets have had pro-active government policies and investments to encourage higher speed broadband (eg. Singapore, South Korea), Hong Kong is distinguishable by the almost complete lack of government support provided to the telecommunications sector.

This paper examines the factors that have enabled Hong Kong to achieve this outcome.

Initial Market Liberalisation (1995-2003)

The Hong Kong telecommunications market, like many other markets, was originally dominated by an incumbent monopoly provider of the telephony network, namely the Hong Kong Telephone Company (HKTC), which was acquired by Cable & Wireless in 1984.

In 1995, the Hong Kong local fixed market was partly liberalised by the granting of three additional Fixed Telecommunication Network Services (FTNS) licences which allowed new companies to build and operate full-service fixed networks with separate outside cable plant and exchange-based facilities. The three new additional operators were New T&T (subsequently Wharf T&T), Hutchison and New World.

From 1995 to 2003, these four operators focussed on building optical fibre networks throughout Hong Kong for the connection of enterprise and wholesale customers. Some sharing of network build activity was achieved (ie. sharing of trenches, ducts etc) however, the majority of the optical fibre networks involved separate cable plant and exchange facilities. Investment was driven by competition in the enterprise market between these four operators. This focus on optical fibre build out for enterprise market services was similar to many other large cities after the removal of monopoly protection for the incumbent telecommunications operator.

Residential broadband services were launched in Hong Kong during the early 2000s, a similar timeframe to other markets. By the end of 2002, Hong Kong ranked second out of some of the global market leaders with takeup rates at 42% of Hong Kong households.

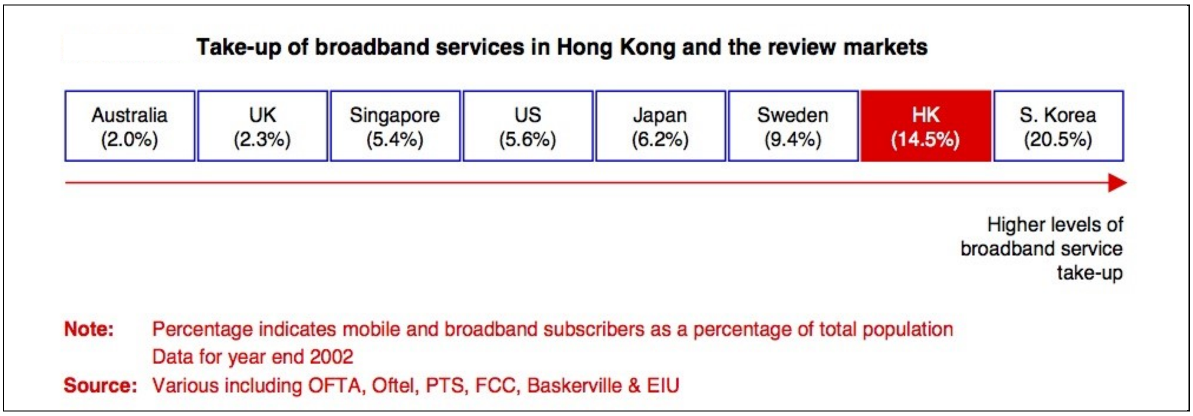

Figure 2 Hong Kong broadband rankings 2002 (Spectrum Strategy Consultants, 2003)

Three technologies were used during this initial residential deployment phase.

Firstly, ADSL over existing copper telephone cabling was used by PCCW-HKT to provide services from its network of telephone exchanges. Competition was facilitated by unbundled local loop (ULL) regulations that required PCCW-HKT to lease exchange-based copper loops to other licensed operators and for in-building sub-loops between all licensed operators (as some new operators were owners of in-building sub-loops via their real estate interests).

Secondly, using DOCSIS on existing cable TV infrastructure, Hong Kong Cable Television (HKCTV) was able to provide broadband services after being granted a telecommunication licence in 2000.

Lastly, using Ethernet over newly-installed Category-5 cabling (normally used in enterprise networks) by Hong Kong Broadband Network (HKBN), which had been granted a fixed wireless licence in 1999. HKBN was a 100% owned subsidiary of City Telecom which had commenced business in Hong Kong in 1992 by providing international calling card services. HKBN initially used a combination of Local Multipoint Distribution Services (LMDS), wireless backhaul and leased lines to connect residential households to its core network infrastructure with the in-building Ethernet cabling before deploying its own fibre from 2002 after being granted a full FTNS licence. By the end of 2002 HKBN had installed its own Ethernet in over 3000 residential apartment buildings covering approximately 30% of Hong Kong's households, (OFTA, 2003a) covering over 1,000,000 households.

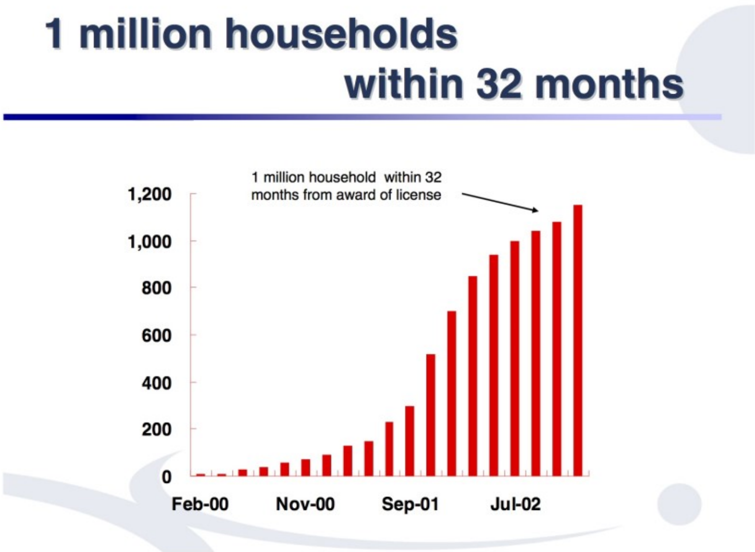

Figure 3 Hong Kong Broadband rollout of Ethernet cabled households (HKBN, 2008)

At the end of 2002 the broadband market was effectively split as follows based on the different technologies:

Broadband Market (as at end of December 2002)

	LMDS and leased circuits	xDSL	FTTB	HFC	Total no. of lines	Market share
HGC	-	-	√	-	452 342	44.7%
HKBN	√	-	-	-		
HKCTV	-	-	-	√		
NWT	-	√	-	-		
Wharf T&T	-	√	√	-		
Others	-	√	-	-		
PCCW-HKTC	-	√	√	-	559 422	55.3%
Total	*>100 000*	*473 697*	*155 539*	*>200 000*	*1 011 764*	*100%*

Figure 4 Hong Kong Broadband Market by Technology at Dec 2002 (OFTA, 2003a)

In 2003, most of the restrictions on licensing of new fixed operators were removed in order to fully liberalise the Hong Kong fixed telecommunications market.

Withdrawal of Unbundled Local Loop regulation (2003 – 2008)

Immediately after full liberalisation of the market in 2003, the Hong Kong regulator for telecommunications (Office of the Telecommunications Authority or OFTA) commenced a review of the ULL regime. The review was framed in terms of the overall policy objective of "promoting an environment conducive to investment in network and facilitating effective facilities-based competition" (OFTA, 2003a).

This review was occurring eight years after the initial opening up of the market and the corresponding investments by the four new entrants (including HKBN) and the incumbent cable TV provider. The question at issue was whether further regulation was needed to facilitate competition in the broadband market or whether continuing regulation of the market would actually hinder investment and hence restrict competition outcomes.

At the time of the review concluding, in July 2004, approximately 53% of Hong Kong households already accessed one or more alternative self-built customer access networks (from Hutchison, Wharf, NWT or HKBN). (OFTA, 2004).

The technology deployed in these alternative access networks was primarily xDSL using existing building copper plant or new Ethernet Cat-5 cabling. Fibre infrastructure was built to the common telecoms equipment rooms of apartment buildings and not to each individual apartment (i.e. a Fibre to the Building architecture).

This large build of alternative customer access networks in parallel with the regulated ULL regime was a positive sign that an investment appetite existed in the Hong Kong market. The regulator was keen to keep this momentum going.

The responses of the five competitors to PCCW-HKT was crucial in determining whether there was sufficient appetite for investment in new network infrastructure existed.

In the end the result was as follows:

	Pro-Investment	Pro-Regulation	Undecided
Hutchison	✓		
HKBN	✓		
HKCTV			✓
New World		✓	
Wharf		✓	

Figure 5 Summary of responses from Hong Kong alternative operators (OFTA, 2003b)

As can be seen from the above table there was a split between the "pro-investment" and the "pro-regulation" cases. Interestingly, both the largest and the smallest competitors to PCCW-

HKT were aligned, pushing for infrastructure competition. The companies that had benefited in the enterprise market by infrastructure competition (New World and Wharf) since 1995, but were not actively pursuing residential market share, were pro-regulation. The cable TV infrastructure player was undecided, mainly due to technology concerns regarding possible access to its hybrid fibre coax plants under the regulatory scheme at the time.

Given a strong response from the largest and smallest competitor to PCCW-HKT to pursue a 'pro-investment' withdrawal of the ULL, the regulator decided to move in this direction on an apartment building-by-building basis. The key determinant for each building would be the existence of at least one competitive self-built fixed access infrastructure network capable of telephony and broadband services in addition to the incumbent copper network of PCCW-HKT.

HKCTV's cable TV network, however, was deemed not to be a self-built network for the purposes of this building classification for two reasons. Firstly, the lack of a "conventional" telephony service, secondly the limited bandwidth of HFC services compared to fibre-based services and thirdly the lack of wholesale service on the HFC network were the reasons stated.

The regulator was looking to promote fibre-based infrastructure competition – not competition between HFC and DSL networks.

A transitional period of two years was also put in place to ensure ULL based operators had the option of investing, but with an overall sunset data of 30 June 2008 (ie. four years after announcement of the withdrawal).

This 'pro investment' regulatory decision by the regulator, knowing that it had strong signals of investment by both a new entrant (HKBN) and an established operator (Hutchison), was the key to Hong Kong's successful rollout of competing fibre-based networks.

From 2004 to 2008 the regulator managed the transition from ULL regulation to self-build customer access network rollout by providing regular information to consumers and industry on a building-by-building basis.

In July 2008, at the end of the transition period, the regulator published a statement highlighting the extent of the rollout of competing customer access networks. In this statement the regulator proudly advised the following:

> *"We are pleased to report that out of the total of 2.5 million households in Hong Kong, 2.03 million, or 81% of, households are provided with at least two customer access networks while 1.46 million, or 58% of, households are provided with at least three customer access networks.," the spokesperson of OFTA said.* (OFTA, 2008a)

The increase in infrastructure over the four year implementation period of the ULL withdrawal was as follows:

Households covered by New Fixed Network Operators (2004 - 2008)

	No. of Households	% of Total Households
July 2004	1,252,532	53%
Sept 2004	1,450,103	61.2%
June 2005	1,736,592	71.4%
July 2006	1,882,061	76.0%
July 2007	1,979,553	79.1%
March 2008	**2,032,382**	**81.2%**

Figure 6 Growth in Hong Kong households with choice of Fixed Network Operator (OFTA, 2008b)

A key factor in the successful transition from a ULL competition regime to infrastructure competition was the entry of an aggressive, disruptive competitor – namely HKBN.

In 2005, HKBN launched 1000Mbps (or 1Gbps) symmetric services using its Ethernet-based Category-5 Fibre to the Building (FTTB) network. This service was initially available to one-third of Hong Kong's households.

The push to higher speeds (ie. 100Mbps and 1Gbps) using Ethernet technology was a key differentiator against the xDSL-based incumbent and other competitors. By focussing exclusively on Ethernet and VoIP telephony services (rather than legacy xDSL and PSTN) HKBN was able to minimise costs and price aggressively to grow market share.

In 2008, HKBN reported broadband connections of 316,000 (City Telecom, 2011). This compared with HKCTV's (now called i-Cable) reporting broadband connections of 280,000 (Telegeography, 2008) and Hutchison reporting 161,000 residential broadband connections for 2008 (Hutchison Telecom, 2009).

HKBN, the last competitor to enter the market against PCCW-HKT in 1999, had become the clear second largest provider of residential broadband 10 years later.

The Fibre Investment Era

After the full withdrawal of regulated ULL services, the stage was set for Hong Kong's market to shift to competition based on full end-to end-fibre services.

In October 2007, HKBN announced it would offer Fibre to the Home (FTTH) services in approximately 100 housing estates with a focus on marketing of 1Gbps services. The technology would be expanded to all residential users during 2008 (SCMP, 2007).

PCCW-HKT announced the availability of 'direct fibre' to two-thirds of Hong Kong homes on 27 November 2007 (Telegeography, 2007)

The response from PCCW-HKT was prompted by the growing market share of HKBN and the heavy marketing campaigns that were being used to promote 100 Mbps and 1Gbps broadband services which PCCW-HKT could not deliver on its xDSL based copper network.

In August 2010, Hutchison launched its residential 1Gbps service using an FTTP GPON architecture (Hutchison Telecom, 2010).

Strong growth in fibre broadband services resulted in approximately 90% of Hong Kong's broadband services being at speeds equal to or greater than 100Mbps by 2016.

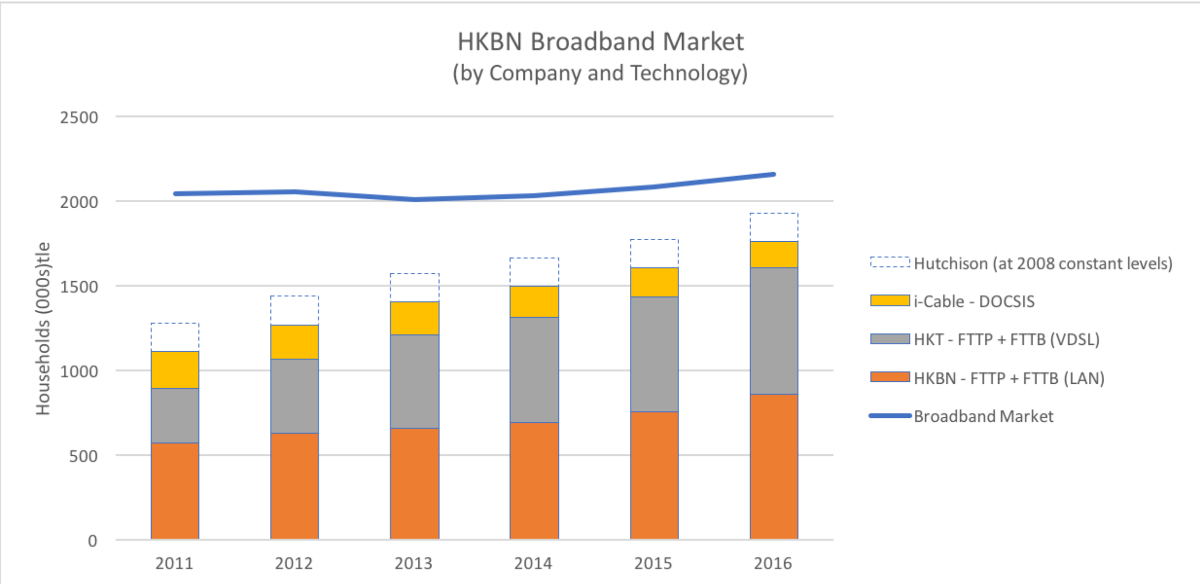

Figure 7 Hong Kong Broadband Fibre Broadband Service Growth 2011-2016

Furthermore, as reported by PCCW-HKT and HKBN, in 2017 approximately 80-85% of Hong Kong's households are able to obtain an FTTH GPON service capable of 1Gbps with a choice of at least two service providers.

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No Natural Monopoly for Fibre Network

The investment and profitability of three separate GPON FTTH networks in Hong Kong dispels the myth that fibre networks are everywhere and always natural monopolies.

Natural monopolies occur where the revenues available in a market can only support the cost (capital and operating costs) of one supplier. Utilities such as electricity, gas and water networks have been typically understood to be natural monopolies. The legacy copper telephone system was also a natural monopoly until mobile and broadband technologies created competing network infrastructure and new services that increased revenues.

Hong Kong demonstrates clearly that broadband residential networks can generate revenues high enough to sustain multiple suppliers with parallel infrastructure networks that compete for business. Hong Kong's consumer broadband prices are some of the cheapest in the world, yet the revenues have supported the build and operation of multiple networks rather than being used to increase monopoly rents to shareholders. Over-regulation which retards investment in new technologies has also been avoided, providing Hong Kong with a key asset to support its social and economic well-being for the 21st century.

Of course this is not possible in all broadband markets. Hong Kong has a number of key advantages that have enabled this competitive industry structure:

1. High population density driving down unit costs of fibre network construction.
2. Good incomes that enable consumers to afford higher value services.
3. Open information economy that has ensured high value attributed to fast broadband services.
4. Competitive, entrepreneurial spirit that has driven risk taking and investment.
5. A regulator that is able to operate independently of other government departments and politics in general.

All of these advantages are important. If one is missing then it is likely that competition will not deliver profitable outcomes, with monopolies and/or subsidised networks being the result.

Hong Kong, with its successful, market-based city economy has significant advantages that are not available in all markets. Many cities have these characteristics in Asia, North America and Europe; however the cities are parts of larger national fixed telecommunications markets that do not universally exhibit all these advantages.

Deployment of fibre-based broadband infrastructure across large national markets is undoubtedly more difficult than in Hong Kong. Some areas (eg. vibrant, densely populated cities) will exhibit the necessary characteristics for competition at the infrastructure level to be successful, other areas will be natural monopolies or uneconomic for any fibre deployment.

If these national markets were considered as an aggregation of a range of sub-markets involving major cities, regional and remote areas rather than one homogenous market (which they certainly are not from an infrastructure perspective) then it may be possible to bring more competition at the network level to the major cities rather than delivering lowest-common-denominator broadband for all.

The deployment of mobile networks over the last 20 years has followed this approach. New investment decisions for mobile networks were also guided by a similar range of factors as listed above. Deployments were prioritised into areas where economic returns were greatest in major cities. Competing networks successfully grew customer bases on the back of new and innovative service models that generated increasing funds for further investment into wider geographic areas.

The successful rollout of competing mobile networks in most markets demonstrates the greater efficiencies and innovation stemming from competition rather than the high costs of monopoly rents and regulation that have plagued many fixed networks in their transition from basic telephony to broadband.

The efficiencies that competition brings to the telecommunication infrastructure rollout in major cities, along with the extra economic output from the digital economy that results, is the best source of funding the development of telecommunications infrastructure in areas that lack the advantages of the major cities (eg. regional and rural areas). These efficiencies and extra economic output need to be taxed in ways that provide sufficient funds to support the rollout of infrastructure in areas where these key advantages are lacking. In locations where competition does not drive investment, government has a role to regulate monopolies and fund infrastructure development (both fixed and mobile) where it is uneconomic otherwise.

The alternative approach, of relying on national monopolies to internally cross-subsidise from the highly profitable city areas (where competition is viable) to the high cost regional areas, will result in lagging broadband investment all round as the monopoly seeks to maximise profits by minimising investments and reducing obligations imposed by regulators or governments

Hong Kong also has valuable lessons in this regard as even this city economy has remoter villages and islands that have not benefited from the competition to rollout fibre based networks.

No Broadband Universal Service Obligation

Hong Kong's fibre coverage is not universal. Approximately 10 to 15% of the region does not have access to fibre networks from any operators.

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While both HKBN and PCCW-HKT are continuing to build fibre networks into various local villages and remote areas in Hong Kong (HKBN, 2015), there is a limit to the financial returns available so that this is unlikely to achieve 100% universal fibre coverage.

As mentioned above, the regulator decided to implement a sunset date of 30 June 2008for all regulated ULL services across the entire Hong Kong market. This was done in order to ensure that all buildings where alternative customer access networks were “technically feasible and economically viable” would see infrastructure investment. A hard cutoff date was needed to “reinforce the above arrangements with greater clarity and certainty” (Hong Kong Legislative Council, 2004).

After the sunset date, buildings that were not technically feasible and not economically viable would fall back to being supplied on terms determined by PCCW-HKT. Furthermore, there would be no incentive for PCCW-HKT to rollout fibre infrastructure to these buildings given the high costs and the lack of competition. As a result these areas would be left to be serviced primarily by ADSL or wireless broadband technologies.

This has resulted in households in areas without competition complaining about being left behind the vast majority of Hong Kong when it comes to broadband services (SCMP, 2015a; 2015b; 2015c). Some households have banded together and paid the substantial sums required by PCCW-HKT to bring fibre infrastructure to particular areas. However, this is clearly restricted to those areas where the households are relatively well-off in economic terms.

The regulator decided to leave any future competition issues with these non-economical buildings to be covered by an “essential facilities” criterion using “established competition law principles” (Hong Kong Legislative Council, 2004) established in the USA during the 1980s (OECD, 1996).

It is difficult to see how reliance on this *ex-post* type of regulation will assist households in these areas. The small market size means the incentive for competitors to PCCW-HKT to initiate a competition case are extremely low. The regulator may have the power to initiate such action but is unlikely to without support of competitors to PCCW-HKT.

As a result it is likely the situation for many of these areas will remain unchanged unless the Hong Kong government intervenes with an appropriately funded broadband universal service policy that drives fibre investment. A universal service obligation does exist for basic fixed telephony services and public payphones; however the regulator has not indicated any plans to extend this to broadband or mobile services (OFCA, 2017).

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Conclusion

Hong Kong's successful transition from a regulated incumbent-run monopoly telephony market before 1995 to a vibrant, competitive fibre-based broadband market within 20 years is a model for many cities. The factors that contributed to this success are not necessarily unique to Hong Kong.

Hong Kong has also shown that success in fibre broadband in densely populated areas does not automatically translate to regional and rural areas. In fact it has shown that without government support these areas are left behind with a monopoly that will not invest due to a lack of return on investment.

Hong Kong is an example of what does work and what doesn't work in ensuring broadband infrastructure is upgraded for the benefit of social and economic development. The lessons learned can be used by many other markets to find better ways to a brighter broadband future.

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Development of the Information and Communication Technology Service Industry in Indonesia

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Abstract:

The Indonesian government is committed to achieve the Millennium Development Goals which are mainly aimed to improve quality of life. One of the most significant ways is by empowering Information and Communication Technology (ICT). Due to this fact, ICT developments in Indonesia have been growing rapidly.

The developments of ICT Infrastructure have gone through several stages. At the beginning, the ICT backbones were developed with the support from the Government. Then the liberalisation of the ICT Service Industries was implemented in order to encourage private companies to develop ICT businesses. This was further followed by subsidising ICT services in selected areas where these services are not financially feasible. In addition, along with the growth of democracy in Indonesia, application and content are also liberalised, resulting in the fast growth of application and content providers. These factors have made contributions to the development of ICT Infrastructures set up by private companies.

This paper lays out the development of ICT service Industries in Indonesia. It contains the history of the development, the policies, and the description of the current situation and the future plan of ICT development. A more in-depth explanation is dedicated to the telecommunications sector.

Keywords: Indonesian ICT Governance, Telecommunications Governance, Internet Governance, Broadcasting Governance, Palapa Ring.

Introduction

In Indonesia the terminology ICT covers Telecommunications, Internet, Application and Content which includes the Radio and Television sectors. This paper reviews the development of the ICT sectors in Indonesia with special emphasis on the telecommunications sector.

This paper starts with a brief description of the history of the development of ICT in Indonesia, starting from the transition from analogue fixed line telecommunications system to the digital system. This transition to the digital system gave rise to the development of ICT industries such as digital switching, transmission systems and other related industries, by using one particular technology: the EWSD of Siemens, Germany. Next is the description of the development of domestic satellite Palapa used for telecommunications and TV transmssion, and the industrial development to produce local TV transmitters, satellite receivers and others. This is followed by the development of wireless systems using almost all available technologies, such as AMPS, PHS, CDMA, GSM and other technologies. This is popularly known as the neutral technology policy. It is shown that during this period, since there was no policy which commands the use of one selected technology to be used throughout Indonesia, telecommunications industries that previously had already had strong capabilities to produce ICT, including telecommunications products, were diminishing. At the same time, the policy to enable telecommunications service industries to carry out managed service operations was issued. Subsequently WiMax technology was introduced.

Along with the development of Wimax technology, a policy for standardising WiMax products for Indonesia was selected and this had a direct impact on the strengthening of local ICT industries. This policy however was terminated and all operators were allowed to use any technologies available. As mentioned above, this was referred to as the neutral technology policy.

A similar policy to adopt neutral technology was also used when GSM was making a rapid global progress. The ICT service industries were free to use any systems and products for their licensed operations areas.

While considerable developments of ICT are taking place across Indonesia, it is shown that several less developed areas in the country, such as remote islands and some isolated places in the eastern parts of Indonesia, which are considered to be not profitable, are given priorities. Next is a discussion on the problems facing the ICT activities in Indonesia especially those related to content. It has to be emphasised that currently, a national effort is being carried out to reduce false information that has caused a lot of social problems and is even considered endangering the country. Finally, the near future plan of ICT development in Indonesia is briefly described.

It is expected that this paper may provide information on the development of Indonesian ICT services, and the most likely development that will take place in the near future. It is obvious that although ICT service industries and markets have enjoyed a progressive development, the ICT industries have not developed at similar rates. This results in the scarcity of some ICT, and therefore Indonesia has resorted to importing more and more ICT products. In light of the revision of *Act Number 36 Year 1999* on Telecommunications and *Act Number 32 Year 2002* on Broadcasting, it is expected that this paper will serve as one of the main sources for CIT and the stakeholders to benefit from, in order that they could focus on the efforts to develop the telecommunications sector.

A Brief History

Organisations and Regulations

The emergence of ICT service industries started on 27 September 1945, when the 'Post and Telecommunication Youth Organisation' took over the Post and Telecommunication Government operator from the Japanese government. This was followed by the establishment of the new 'Post and Telecommunication Institution' to operate the Postal and Telecommunication infrastructure and services in Indonesia.

From 1945 to 1966, the 'Post and Telecommunication Institution' experienced several changes. The operational activities of the institution were separated. The institution was renamed 'Directorate General of Post and Telecommunication' (DG Postel) and placed under the Ministry of Transport. With all the changes, the legal entity of the Telecommunication Government Operator was changed to 'State-Owned Telecommunication Service Industry' (Telkom) and the DG Postel, which is the regulator.

Since 1961, telecommunications services in Indonesia have been carried out by Telkom (Soewandi & Soedarmadi, 1976 ; Telkom, 2009). As is the case in other developing countries, the development and modernisation of telecommunications infrastructure play an important role in the development of the national economy in general. Furthermore, the large population and rapid economic growth have driven a high demand for telecommunications services.

The government regulates the telecommunications sector, particularly through the DG Postel. It has given Telkom the monopoly over telecommunications services in Indonesia. The telecommunications reform in 1999 has created a regulatory framework that encourages competition and accelerates the development of telecommunications services and infrastructure. The next regulatory reform in September 2000, was intended

- to increase competition by removing monopolies,
- to increase transparency and certainty for the regulatory framework in order to create opportunities for strategic alliances with foreign partners and
- to facilitate the entry of new players in the telecommunications service industry.

It has to be noted that Telkom, under several telecommunications Acts, operates a type of monopoly for telecommunications services.

In 1999, a new *Telecommunications Act Number 36 Year 1999* was issued to replace the previous *Telecommunications Act Number 3 Year 1989* (Telecommunications Act, 1999). Although the previous Act gave Telkom the authority to monopolise, the new Act, which took effect in September 2000, had caused big changes. It liberalised the telecommunications sector in Indonesia. This Act has been implemented through several government decrees (Government Decree, 2000).

Firstly, the fixed line service is also given to two other companies that operate fixed wireless telephone. Wireless communications based on several technologies were introduced and operated by several private companies as well as by Telkom (Telkom, 2009). Another big change took place on the regulatory side. The *Act Number 36 Year 1999* requires the setting up of an independent Indonesian Regulation Telecommunications Agency (BRTI – Badan Regulasi Telekomunikasi Indonesia) (MCIT, 2008). The Agency was manned by government officers as well as officers from the public, including business players and academicians. The Minister of Transport selects the members of the Agency and in turn the Agency reports to the Minister of Transport.

To regulate the fast development of internet, the DG Postel issued licences to Internet operators based on several government decrees, which were derived from the *Telecommunications Act Number 36 Year 1999*. In the broadcasting sector, Radio and TV service industries were regulated by the Directorate General of Radio, TV and Films (DG RTF) under the Ministry of Information. The DG RTF, however, only regulated the businesses and the contents, while the frequencies used for Radio and TV were still regulated by DG Postel. Several changes were made to the regulation of Radio and TV Broadcasting and it was finally regulated by *Act Number 32 Year 2002* on Broadcasting. This law not only provided liberalisation to the broadcasting service industries, but also facilitated the establishment of a new independent regulator, called the Indonesian Broadcasting Agency (KPI – Komite Penyiaran Indonesia). The members of the agency were selected by the

Parliament. However, the agency's responsibility was only to control the content, while the business licence was still regulated by the Government.

To accommodate the rapid development of ICT in Indonesia, in 2001 a new Ministry was formed to regulate the ICT sector (Presidential Decree, 2001). In 2004 the Ministry was empowered and named Ministry of ICT. The Ministry then integrated DG Postel and DG for Radio and TV, excluding Films, into one Ministry. The DG that regulated Radio and TV was named DG SKDI (Sistem Komunikasi dan Diseminasi Informasi-Communication and Information Dissemination). The Government also set up a new DG to control Internet Application and Content; the DG for Informatics Application (DG Aplikasi Telematika was renamed DG Aplikasi Informatika in 2010), abbreviated as DG Aptika.

In 2008 a new Act on Internet application and content was promulgated namely *Act Number 11 Year 2008* on Electronic Information and Transaction (EIT Law, 2008). This law was later revised in *Act Number 19 Year 2016*. In order to ensure security in the operations of telecommunications and internet infrastructure in Indonesia, the Government formed the Indonesia Security Incident Response Team on Internet Infrastructure (Id-SIRTII) based on Ministerial Decree Number 26 Year 2007 on Security Telecommunications Network Utilisation-Based Internet Protocol. This was later revised through Ministerial Decree Number 29 Year 2010. It is a team assigned to the Minister of ICT, to help monitor the security of internet protocol based telecommunications networks (Setiawan & Sastrosubroto, 2016).

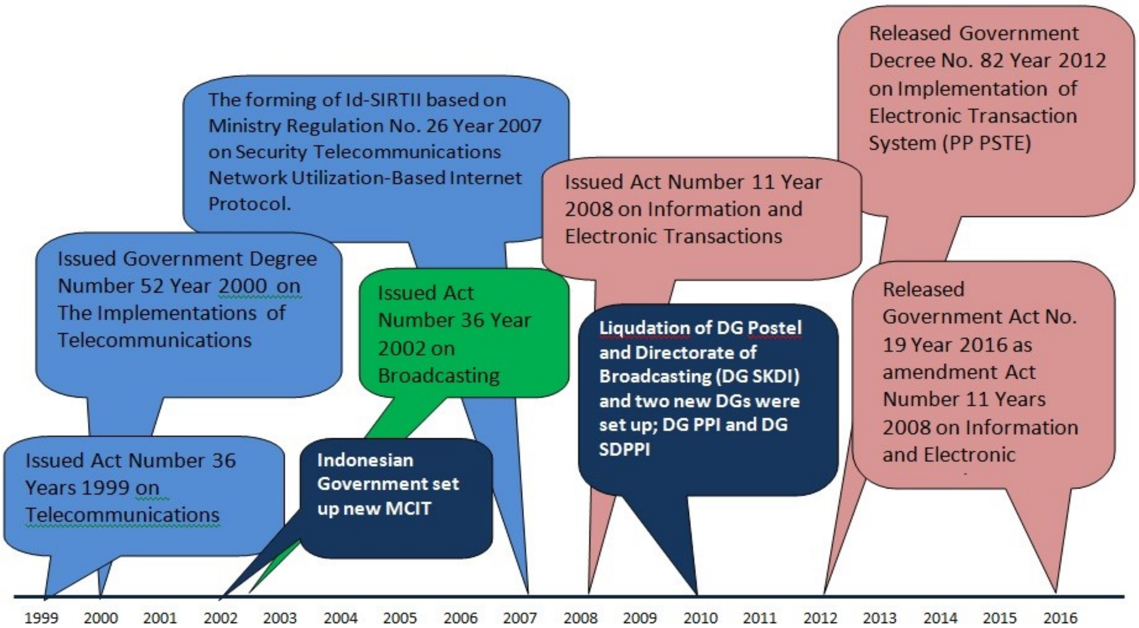

Figure 1: Time Line of the Brief History of ICT Regulations.
(Setiawan & Sastrosubroto, 2016)

Figure 1 shows a brief history of ICT regulations, depicting developments from 1999 to 2016. Due to these changes, the ICT sectors in Indonesia have been rearranged as follows:

- Telecommunication sector: Regulated by DG Postel and BRTI, and operated by several companies. This sector also includes Internet Operators.
- Broadcasting sector: Regulated by DG SKDI; content is controlled by KPI, and operated by many companies.
- Internet Application and Content sector: Regulated by DG Aptika, and operated by numerous companies.

It should be noted that the Internet Numbering such as IP and AS Numbers is operated by Indonesian Internet Operators Association (APJII – Asosiasi Pengusaha Jasa Internet Indonesia) while the DNS for [.id] is operated by a non-profit organisation, the Indonesian Domain Name Organiser (PANDI - Pengelola Nama Domain Indonesia). They basically act as partners of ICANN (the Internet Corporation for Assigned Names and Numbers) to distribute internet resources. As regulated in *Act Number 11 Year 2008*, internet resources are allowed to be operated by a non-Government Organisation (EIT Law, 2008).

In 2009, DG Postel and DG SKDI were liquidated, and two new DGs were set up. The DG of Post and Informatics Operation (PPI – Penyelenggaraan Pos dan Informatika) regulates all licences for Telecommunications, Internet and Broadcasting Operators. The DG of Post and Informatics Infrastructures and Resources (SDPPI – Sumber Daya dan Perangkat Pos dan Informatika) controls all resources, such as Frequency, Standard and other resources.

BRTI and KPI however, still hold the same functions. With the latest developments on illegal content in the internet, where content has become more and more important for the whole nation of Indonesia, the Ministry has set up an independent team to review Application and Content in the Internet, to make a decision on whether an item has to be blocked. The team was established based on the Ministerial Decree Number 19 Year 2014. It has to be emphasised that as stipulated in *Act Number 11 Year 2008* and other Acts such as *Pornography Act Number 44 Year 2008*, illegal content must be blocked. Recently, *Act Number 11 Year 2008* has been revised in *Act Number 19 Year 2016* which gives a firm legal basis for the government to block illegal contents including false contents that have caused serious social conflicts.

It must be emphasised that the Indonesian Government strongly supports the UN summit in promoting Milennium Development Goals (MDGs). In addition, the setting up of the World Summit on the Information Society (WSIS) demonstrates that ICT is promoted to support most of the actions to achieve the MDGs. It goes without saying; that Indonesia also supports the WSIS action plans. The Minister of ICT represented Indonesia in the WSIS (MCIT, 2005) and also in the International Telecommunication Union (ITU), where Indonesia was elected as a member of the ITU Council. Hence, it is obvious that the Ministry fully supports the development of ICT in Indonesia to achieve the WSIS goals. The President even issued instructions to Ministers and local governments to develop e-Government (Presidential Instruction, 2003) followed by indexation of e-Government for Ministries and regional governments (MCIT, 2011). It should be noted here that Indonesia consists of many autonomous regional governments (Indonesian Act, 2004). The participation of Indonesia in supporting WSIS is evident when Indonesia hosted the 8th Internet Governance Forum (IGF) in Bali, including the High Level Leaders meeting, the theme of which was to enhance global cooperations for Cybersecurity based on Cyberethics (MCIT, 2013; Sastrosubroto, 2014).

In line with the ITU system, Indonesia also set up the Universal Service Obligation (USO) system for promoting ICT in areas where, from the business point of view, ICT services were not feasible. Under the USO scheme, based on Presidential Decree Number 45 Year 2012, all telecommunications operators have to provide a fund of 1.25% of their revenues. The fund is then utilised by the government to provide ICT services in the above mentioned areas. The Ministry also represented Indonesia in the ASEAN Telecommunications Ministerial meeting and is the Indonesian focal point in the development of the ASEAN ICT Masterplan (AIM). The Indonesian ICT master plan – a five-year development plan – is a compulsory reference for the Ministry in developing ICT in Indonesia. Also it has to be in line with AIM.

The government has just established a new agency for strengthening cyber security. It is called the National Cyber and Cryptographic Agency (BSSN, which stands for Badan Siber dan Sandi Nasional) and is the integration of the National Cryptographic Institution (Lembaga Sandi Negara abbreviated as LSN) and cyber security units in the MCIT. BSSN was formed through Presidential Decree Number 53 Year 2017 on the National Cyber and Cryptographic Agency, in the context of achieving national security, since the field of cyber security is one of the areas of the government that needs to be encouraged and strengthened (Presidential Decree, 2017). The arrangement of LSN to be BSSN was done to ensure the implementation of government policies and programs in the field of cyber security.

Infrastructure Development

The Telecommunications infrastructure acquired from the Japanese government on 27 September 1945 was only the fixed-line telephone infrastructure. At that time, this fixed line telephone was already available in the main cities in Indonesia. However, recognising the huge area of Indonesia, in 1976 Indonesia launched its first Domestic Communication

Satellite called Palapa. This satellite was mainly used for telephone connection and TV Broadcast transmission. During that period of time, Telkom, which still held the monopoly in Indonesia, changed from analogue switching to digital switching. With these two main programs, almost all areas in Indonesia were therefore covered by telephone service. In addition, TV broadcasts could also be received in most parts of Indonesia. This infrastructure development was integrated with a program to develop village telephone and TV so that most of the villages in Indonesia are connected. It has to be underlined that in 1976, TV broadcasting was still monopolised by the state TV station (TVRI).

During this time, the program to launch domestic satellites, which was operated by an appointed company Satelindo, and the program to transform analogue to digital telecommunications, carried out by Telkom, were also used to develop local ICT industrial capabilities. Several state-owned and private enterprises were appointed to carry out this development of technology. To enable these capabilities to develop, several particular technologies from international companies were selected. INTI was appointed to produce digital switching in cooperation with Siemens Germany while LEN was appointed to produce the transmission product as well as TV transmitters. INTI, LEN and several other private companies were also appointed to produce hundreds of satellite receivers throughout Indonesia. The combination of all these have enabled the local industries which produce telecommunications products to cover almost all areas in Indonesia. The appointed industries were also asked to develop their own products, normally smaller products with a simpler technology.

Satellite-based communications flourished after the liberalisation, and today there is a large number of satellite communication operators. To facilitate the technology development in this field, optical communication was established as the new system of telecommunications. The government started the program with the Fibre Optic (FO) backbone development program called Nusantara 21, which was launched in 1997. Nusantara is the cultural name of Indonesia, hence the program is to connect the whole Nusantara, that is, all the main islands of Indonesia with FO which is then integrated with the satellite backbone.

Since the cost to develop this FO backbone is extremely high, the government invited private sectors to jointly develop the backbone. However, only Telkom took part in the venture. The Nusantara 21 program has undergone several changes and is currently known as the Palapa Ring Program. The technical program however is similar: that is, to connect all main islands of Indonesia with FO (TARHRD, 2013). Figures 2 and 3 show the Indonesian archipelago with the satellite coverage and FO ring. It can be seen that due to the vastness of the archipelago, the FO Palapa Ring program and the domestic satellite are an absolute necessity.

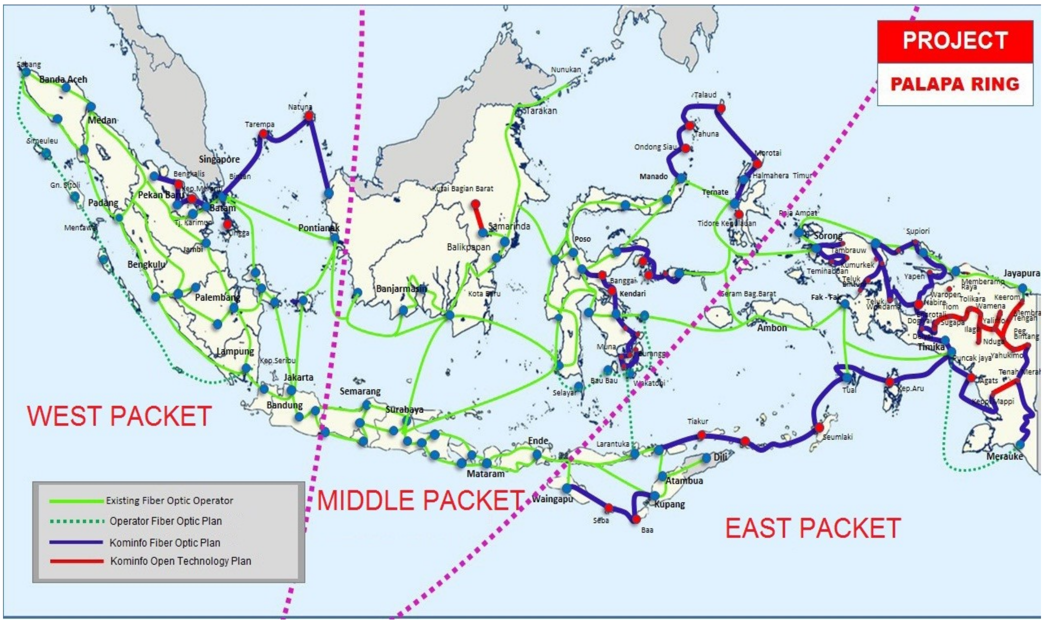

Figure 2: FO Backbone Program
(TARHRD, 2013)

Figure 3 : Satellite Coverage(TARHRD, 2013)

As discussed previously, with the enactment of the *Telecommunications Act 36/1999*, the telecommunications sector was liberalised. This liberalisation happened only about one year after a significant political change in Indonesia in 1998: President Soeharto, who had been in power for 32 years, stepped down, followed by a national general election.

The liberalisation has had a very significant effect on the Indonesian telecommunications infrastructrure development. Two other fixed wireless operators were appointed: Indosat (a new name for Satelindo after the share was transfered to the government). The liberalisation also covered the technology aspect. Instead of implementing selected technologies, now all kinds of technologies can be used. As a result, several new private companies offering wireless communication services using various technologies were formed. Almost all wireless technologies were implemented in Indonesia such as AMPS, CDMA, PHS, GSM and others which are operated by various companies. At almost the same time, the Government Decrees Numbers 52 and 53 Year 2000 were issued to support the liberalisation.

Telecommunication service industries may also assign managed service of the operations of their licence to other companies, generally to foreign ICT industries. Under this scheme, ICT product producers are given the opportunity to be partners in operating a particular area. This policy enables global ICT producers to operate as telecommunications services industries on behalf of the local ones. It has to be emphasised that this liberalisation had caused local industries which previously produced telecommunication products for Telkom to stop their activities, since the industries which obtained managed service contract used their own products.

The GSM system was later proved to be the most competitive technology in Indonesia, and a new restructuring of industries was carried out. Telkom set up a new company operating GSM called Telkomsel. Several other companies were established and they all operated GSM wireless telecommunications. Similar to the previous policy of neutral technology, GSM operators are allowed to use any suppliers as their partners to operate their GSM licences.

To facilitate the development of internet technology, Indonesia has developed the internet infrastructure. Basically, the main program consists of developing the Indonesian Internet Gateways as well as arranging the Internet Resources management. The main development is to legalise and support the development of Voice over Internet Protocol (VoIP) services followed by other Internet-based additional infrastructures such as Government Data Centers and others.

The Palapa Ring program facilitates access to telecommunication services in the eastern part of Indonesia (MCIT, 2015). The government has been developing a huge FO network, thousands of kilometers long, called the East Package Palapa Ring project. The FO will stretch from East Nusa Tenggara, Maluku and Papua. The Palapa Ring Project is targeting four provinces in the eastern region of Papua, West Papua, Maluku and East Nusa Tenggara. This network will be built in 35 new districts and will be connected with the 11 districts that already had a FO network. The inauguration of the construction of this package was carried out on February 23, 2017 by the ICT Minister. The total length of the FO that will be installed is around 8454 kilometres with an investment of 5.1 trillion Rupiahs, from the total construction cost of 20 trillion Rupiahs (1 USD is about 14000 Rupiahs). In the West Papua province, FO networks will be built in seven districts, which will be connected with two districts that already have networks.

The Palapa Ring network would eventually become the foundation of all operators and users of telecommunication services in Indonesia. This network will also be integrated with existing network-owned by telecommunications operators. This project will open up access to the internet at a speed up to 10 megabytes per second, and if used positively will increase Indonesia's competitiveness in world affairs. The huge development of FO in the eastern part of Indonesia also clearly demonstrates the Government’s commitment to prioritise the development in the eastern part of Indonesia.

Another program to develop local industrial capability using a selected technology was carried out again during 2006-2007. To facilitate the development of WiMax technology, a particular standard was selected and this has a direct impact on the strengthening of local ICT Industries. With the expectation that ICT industries capable of producing WiMax based products will be able to increase their market shares, a research fund was provided to universities which cooperate with local ICT Industries to produce local WiMax products. Despite the fact that local WiMax products have been produced and used by some industries, this effort was terminated due to the change from the policy of requiring the use of one selected technology to the policy of allowing the use of any technologies available.

With all the above mentioned developments, Indonesia now has several GSM operators in addition to Telkom as the fixed line operators.

Regulation of the Industries

As previously mentioned, the telecommunications, broadcasting and internet sectors were integrated in one Ministry, the MCIT, in 2005. The Ministry then introduced regulations to cover those sectors. Based on previous Acts, the Ministry set up a new Act in 2008 covering application and content. In addition, several government decrees were issued and/or modified in order to integrate these sectors. Figure 4 below shows the concept of the integration of those regulations.

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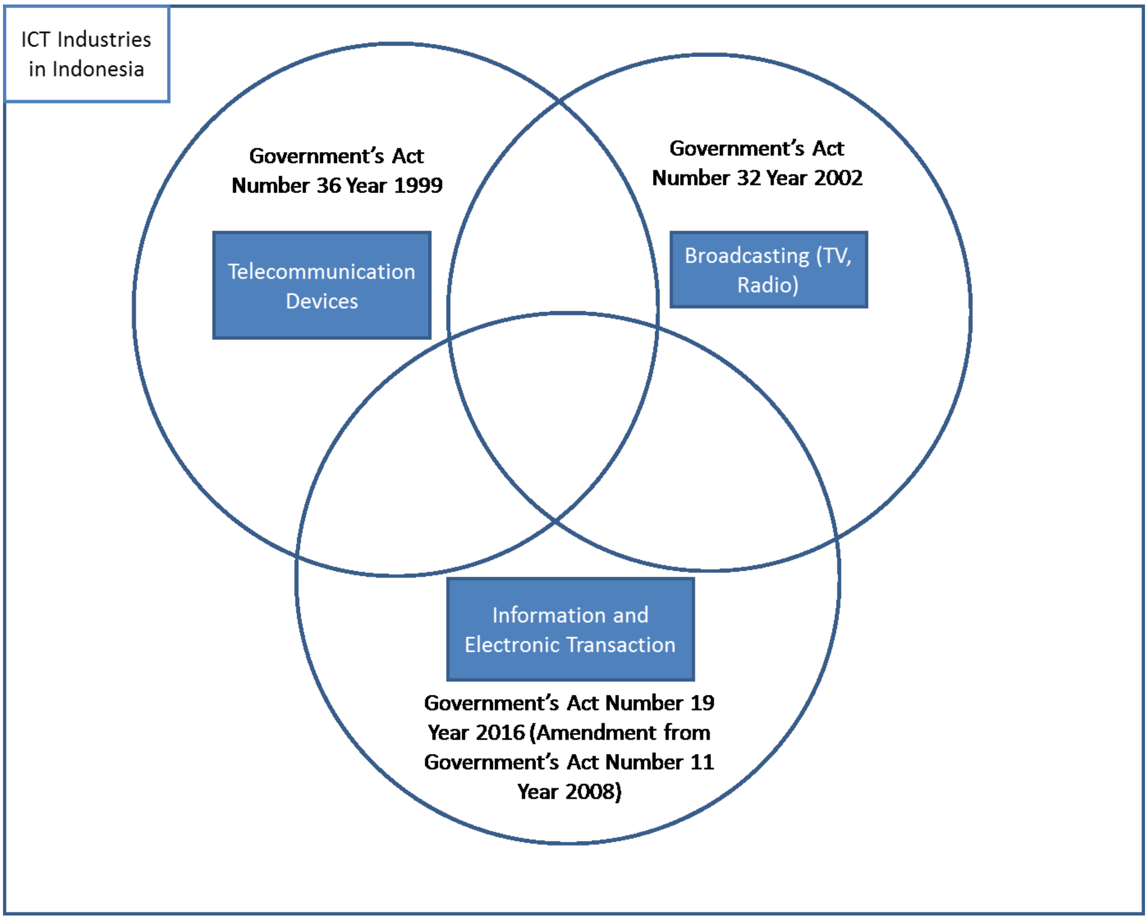

Figure 4: Regulations of ICT Industries in Indonesia
(TARHRD, 2013)

Telecommunications Act Number 36 Year 1999

The development of telecommunications in Indonesia experienced significant changes as a result of the enactment of *Act Number 36 Year 1999* on Telecommunications on September 8, 2000. This Act can be regarded as an attempt to synergise the agreement contained in the General Agreement on Trade in Services (GATS) and the Annex of Telecommunications. The Act was a key guideline for reform in the telecommunications industry, including the liberalisation of the industry, the requirement for new organisers and the effort to increase the competitive structure of the industry (Nababan & Darwanto, 2015). There are substantial differences between the *Telecommunications Act Number 3 Year 1989* and the *Telecommunications Act Number 36 Year 1999* as shown in Table 1 below.

Table 1 : Comparison of Material Content between the Telecommunications Acts 3/1989 and 36/ 1999

(Budhijanto, 2010)

Telecommunications Act Number 36 Year 1999	Telecommunications Act Number 3 Year 1989	Material Content
State-owned enterprises; Regional owned enterprises; private and cooperative	The government through the Agency Operator	Telecommunications Providers
Telecommunications Network; Telecommunications Services; Specific Telecommunications	Basic Telecommunications Services, Telecommunications Services Non-Primary and Specific Telecommunications	Telecommunications Services Category
The mechanisms of the common business	Joint Venture, Operation and Contract Management	Forms of Cooperation
Based on the ability of the business	Through the cooperation with the Agency Operator/Telkom	Venture Capital
Exclusive rights are retained according to the schedule. Acceleration is possible with the termination of the payment of compensation by the government	Exclusive rights are owned by the Operating Body /Telkom	Exclusive rights of the telecommunications
Determined by providers based on a formula set by the government per the recommendation fromBRTI	Determined by the government	Tariff
The government together with BRTI	Government	Regulator

Telecommunications Act Number 36 Year 1999 declared that Telecommunications is defined as an organisation engaged in activities of transmitting and receiving information in the forms of signs, signals, writings, images, sounds and sounds by wire, optical, radio or/and other electromagnetic systems. Based on the Act, the government set up two main government decrees. The first is Government Decree Number 52 Year 2000 on telecommunications operations including licensing system, and the second is Government Decree Number 53 Year 2000 on the Use of Radio Frequency Spectrum and Satellite Orbit.

First, all telecommunications operations in Indonesia can only operate after obtaining permission from the Minister by completing a simple procedure. It is a transparent, fair, non-discriminatory and fast process. The Government sets the composition of the network tariff and telecommunication services, including the structure and types of tariff. The tariff is set using a formula based on a market mechanism and the cost of investment which is determined by the types of cost, operations and maintenance, network development, factors of inflation, purchasing power and efficiency. The tariff structure of the telecommunications network consists of access fees, usage fees and the cost of universal service contribution.

Telecommunications equipments which are traded, manufactured, assembled, imported or used in the territory of the Republic of Indonesia shall take into account the technical requirements and must be based on the licence in accordance with the legislation in force. In addition, all equipments should also bear government licences.

In accordance with the procedure in the two decrees, permission must be obtained for the use of radio frequency spectrum and satellite orbit in order to make sure that there is no frequency interference. Planning includes the use of radio frequency spectrum band plan and channelling plan. A permit is also compulsory for the use of radio frequency spectrum for telecommunications operations. The permit specifies the use of radio frequency spectrum in each frequency band or channel. Permission to use a particular radio frequency spectrum is granted based on radio frequency allocation and determination of the use of radio frequencies.

All users of the radio frequency spectrum for telecommunications operations are required to pay the fee for radio frequency spectrum, which is determined by a formula that takes into account various components, such as the type of radio frequency bandwidth or radio frequency channels, broad scope, location as well as market interests.

Broadcasting Act Number 32 Year 2002

As mentioned before, broadcasting is part of ICT. Previously, broadcasting was regulated by Government Decree Number 55 Year 1970 on Non Government Radio Broadcasting and Minister of Information Decree Number 111 Year 1990 on Television Broadcasting. These decrees were replaced by the *Broadcasting Act Number 24 Year 1997* which was considered to be highly repressive and was viewed as an implication that the government does not have any other implementing regulations. This situation was abused by the public to develop illegal private radio and TV broadcastings. The Indonesian political reform in 1998 called for press freedom including freedom of content in broadcasting. A new law was passed and a new *Act Number 32 Year 2002* was promulgated in December 28, 2002. The new Act basically guarantees the freedom of Broadcasting content for all broadcasters, irrespective of the status of the operator, whether it is government, private or community. The content is controlled only by the independent KPI.

Figure 4 above shows several Acts that regulate the ICT sector in Indonesia. It has to be taken into account that due to the use of ICT in almost all sectors, *Act Number 11 Year 2008* and its amendment in *Act Number 19 Year 2016* are also used as the basis for many other regulations in those sectors. This Act, for example, also regulates Information, Documents, and Electronic Signature that can be used as legal evidence. This also means that electronic information, document and signature have been legally acknowledged as evidence and hence should be used properly. This includes e-Commerce transactions which is a fast growing business in Indonesia.

The Current Situation and Recent Developments

Telecommunications Sector

Prior to the development of the Internet legal structure, Indonesia used *Act Number 36 Year 1999* on Telecommunications as the legal basis. In that law, any activity running on the telecommunications network was defined as telecommunications services; this is detailed in Government Decree Number 52 Year 2000 on Telecommunications Operation.

To ensure transparency in the regulatory process, under the *Telecommunications Act* in July 2003, BRTI was established as an independent body to set up regulations, monitor and control the telecommunications industry. Previously, BRTI was chaired by the Director General of the DG Postel. After the reorganisation of the Ministry took place, BRTI is currently chaired by Director General of PPI and Director General of SDPPI as the Vice Chair.

The above regulations direct the requirements for issuing a licence for each category of telecommunications service as shown briefly below. A telecommunications network provider is licensed to provide and/or operate a telecommunications network.

A telecommunications service provider is licensed to provide services by leasing network capacity from other network providers. Special telecommunications licences are required for private telecommunications service providers to carry out broadcasting content.

To regulate the licences, several Ministerial decrees were issued.

- Ministerial Decree Number 1 Year 2010 on the Licensing of Telecommunications Network.
- Ministerial Decree Number 21 Year 2001, later replaced by Ministerial Decree 31 Year 2008 on Telecommunications service industries.
- Ministerial Decrees Numbers 7 and 31 Year 2008, to implement the *Telecommunications Act* regarding the new categories of telecommunications network and service operations.

The growth in the number and users of telecommunications services is an indicator which shows the state of progress of access to ICT in the society. Indonesia is a developing country with a population of about 250 million spread over five major islands and thousands of small islands. One of the challenges in the implementation of ICT Indonesia is the geographical conditions that contribute to the uneven development of ICT infrastructure.

Users of telecommunications services in Indonesia are divided into users of mobile cellular and fixed telephone users. Customer-specific fixed telephone services are also divided into two areas: Fixed Wireless Access (FWA) and the Public Switched Telephone Network (PSTN). The number of cellular subscribers in Indonesia tends to increase every year. This is due to the availability of wide selection of mobile devices at an affordable price combined with related infrastructure development and regulations that provide healthy competion among all players. In 2010 the number of cellular mobile users was around 211.3 million and it continued to rise. In 2014, the number of mobile subscribers was recorded at around 325 million, as shown in Figure 6. This number exceeded the total population in Indonesia and this was caused by dual ownership, where there were many people who had more than one telephone number.

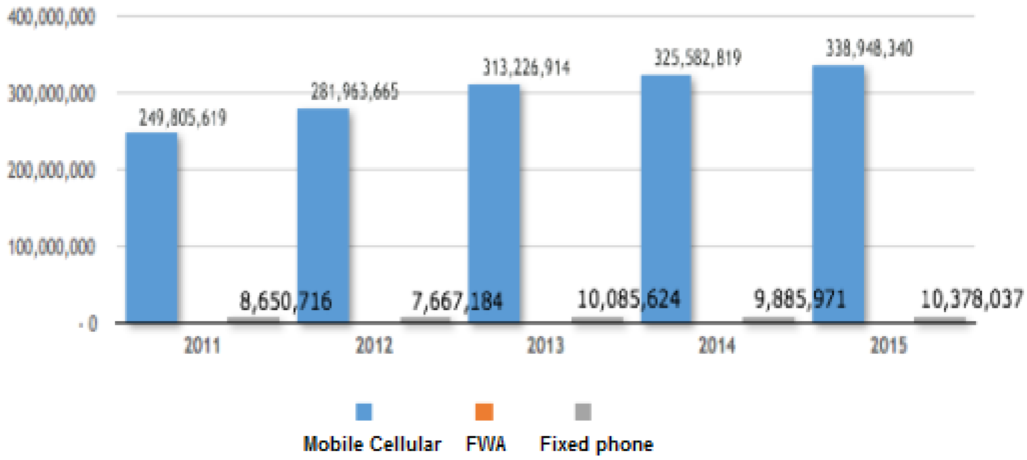

Figure 5: The Number of Telephone Subscribers in Indonesia
(TARHRD, 2015)

The number of PSTN subscribers in Indonesia did not change significantly from 2013 to 2014, while the number of FWA subscribers had decreased since 2012. In 2010 the number of FWA subscribers was 32 million; it continued to decline and in 2014 the number fell to 16 million. Due to the limited area of coverage and the decrease in the number of subscribers, the popularity of FWA CDMA technology adopted by the FWA operator had lessened in Indonesia. As a consequence, the government decided to stop the entire FWA services through Ministerial Decree Number 30 Year 2014 on the Settlement of Radio Frequency

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Band of 800 MHz for the Purpose of Mobile Cellular Network. This is implemented by asserting FWA licence revocation on the spectrum (ATSI, 2015; TARHRD, 2014).

Another important aspect is the types of payments for different mobile phone services, including prepaid and postpaid services.

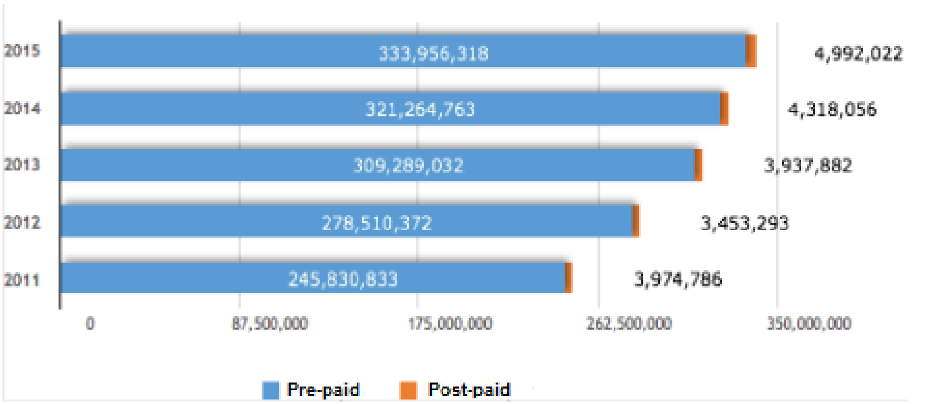

Figure 6: The Growth of the Number of Mobile Cellular Subscribers Based on Types of Services (TARHRD, 2015)

Figure 6 above demonstrates that from 2011 to 2015, the number of cellular subscribers in Indonesia experienced growth every year, with the highest percentage rise recorded in 2012 amounting to 12.87%. This increase also applied to the number of prepaid and postpaid subscribers. The postpaid customers increased since 2012 after having previously decreased to around 13.12%. In Indonesia, the number of prepaid subscribers is always much higher than that of postpaid customers. It is evident that the customers prefer the prepaid type since the telephone cost is easier to control.

Internet Sector

The increase in the number of mobile phone users has also boosted the growth of the number of internet users. The borderless internet connection has now almost become an integral part of community activities in all sectors. These conditions also drive the growth of the Internet Service Providers (ISP), which can be either an ISP only or Telecommunications operator that extends their services from SMS and Voice to ISP.

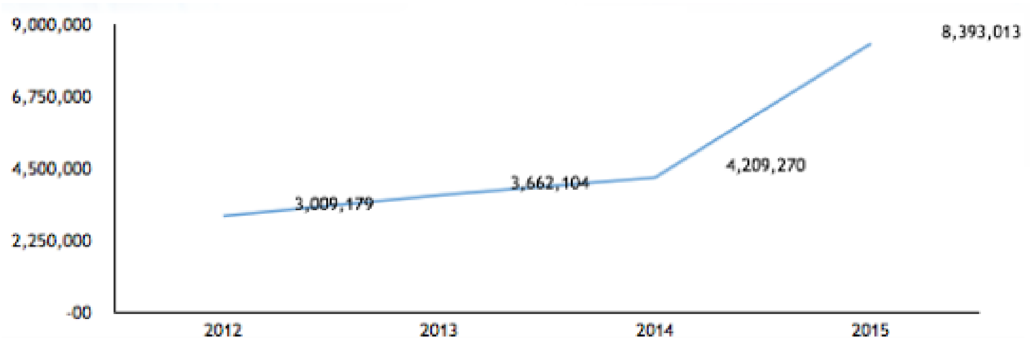

Figure 7: The Growth in the Number of ISP Subscribers
(TARHRD, 2015)

Figure 7 above shows that from 2012 to 2015 the number of Internet subscibers grew consistently, although in 2012 and 2013 the growth was not too significant. The highest increase was in 2015 amounting to 99.39%. With this increase, the number of subscribers in 2015 was almost double the number in 2014. The number of ISP subscribers by the end of 2015 reached more than 8 million subscribers. It has to be understood that the number of Internet users was certainly much higher, since many internet users could use similar ISP subscriptions, using dynamic IP addresses. Since all smart phones can be used to get Internet Access, the Number of Internet Users should be close to the number of Cellular users. It is noteworthy that Internet kiosks are spread acrross Indonesia and this enables people who do not have smart mobiles to be internet users, causing a higher number of users of the internet (TARHRD, 2015). The Indonesian Association of Internet Service Providers survey in 2016 predicted that the number of Internet users in Indonesia would reach 132.7 million people. The same survey in 2014 shows the number to be around 88 million people.

Along with the growth of internet penetration, the number of social media users is also growing. Through social media, anyone can easily socialise and interact with other users by means such as sharing photos, videos and messages over the Internet. The penetration of social media users in Indonesia in 2015 amounted to 31%, an increase of 6% from the previous year, making Indonesia the country with the highest number of users in ASEAN, which may be due to the high population. However, by percentage Indonesia is still below several ASEAN countries (TARHRD, 2016). This is shown in Figure 8.

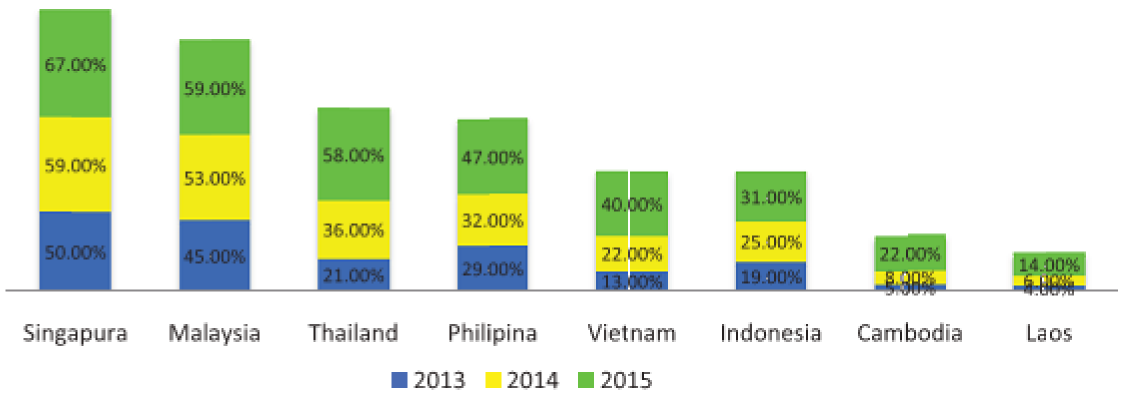

Figure 8: Comparison of Social Media Users in Indonesia and ASEAN Countries
(TARHRD, 2016)

Facebook is the social medium most widely used in countries in Southeast Asia. Based on the number of users of Facebook by the count of active accounts (sign in) over the past three years, Indonesia was the country with the highest number of Facebook users, amounting to 79 million active users. Meanwhile, the Philippines ranked second with 48 million active accounts and Thailand was in the third place, with 38 million users. It is worth noting that in Singapore, the country with the highest teledensity, Facebook users were 67% of the population, amounting to 3.7 million as shown in Figure 9.

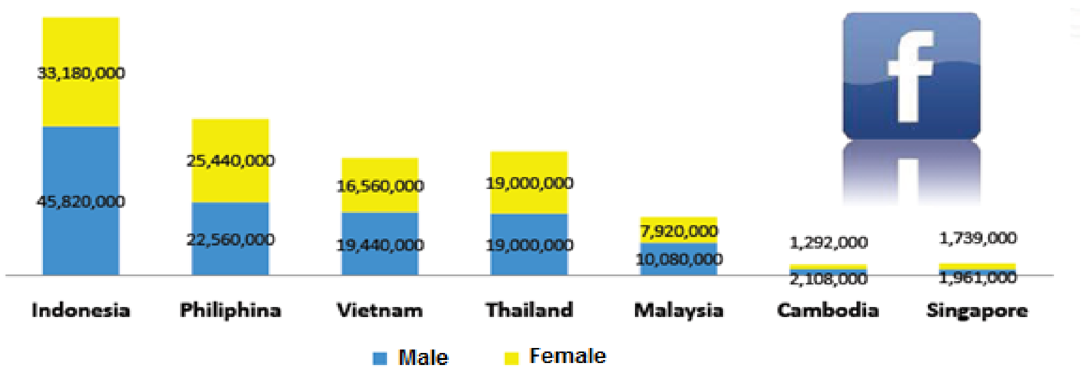

Figure 9: Comparison of Facebook Users in Indonesia and ASEAN Countries
(TARHRD, 2016)

From the gender point of view, in 2016 Facebook users in the Southeast Asian region were dominated by males rather than females, with the exception of the Philippines where more Facebook users were female (53%). The percentage of male Facebook users in Indonesia is 56% (45.82 million accounts), while the percentage of female users is 44%, equivalent to 33.18 million active accounts (TARHRD, 2016).

This high number of social media users in Indonesia has caused politicians, political parties, NGOs and even Government organisations to use the media to spread information. At the same time, false information, hate speech, and misleading statements among others are also spread in social media, causing the Indonesian Government to set up a movement against these negative waves of content.

Broadcasting Sector

The Indonesian TV broadcasting market is characterised by a large number of national public, commercial and non-commercial TV services and a wide range of choices of TV platforms such as analogue terrestrial TV, digital satellite TV, analogue and digital cable. The TV market in Indonesia is mainly Free-To-Air (FTA) terrestrial with 419 broadcasters currently in operation. The 419 TV broadcasters comprise one nationwide public TV broadcaster, 297 commercial TV broadcasters, 8 local public TV broadcasters and 113 community TV broadcasters (ITU, 2013). It is estimated that there were 50 million TV households in 2012.

Currently, Indonesia's Gross Domestic Product (GDP) per capita was in the range of USD 2500 - 2900. This relatively low GDP figure and the very competitive TV market is one of the greatest challenges for the digital switch-over (DSO) process. DSO can only be successful if the costs for the government, the broadcasters and the viewers are kept low. The government can achieve more efficient use of the frequency spectrum and may allocate part of the broadcasting band to other communication services.

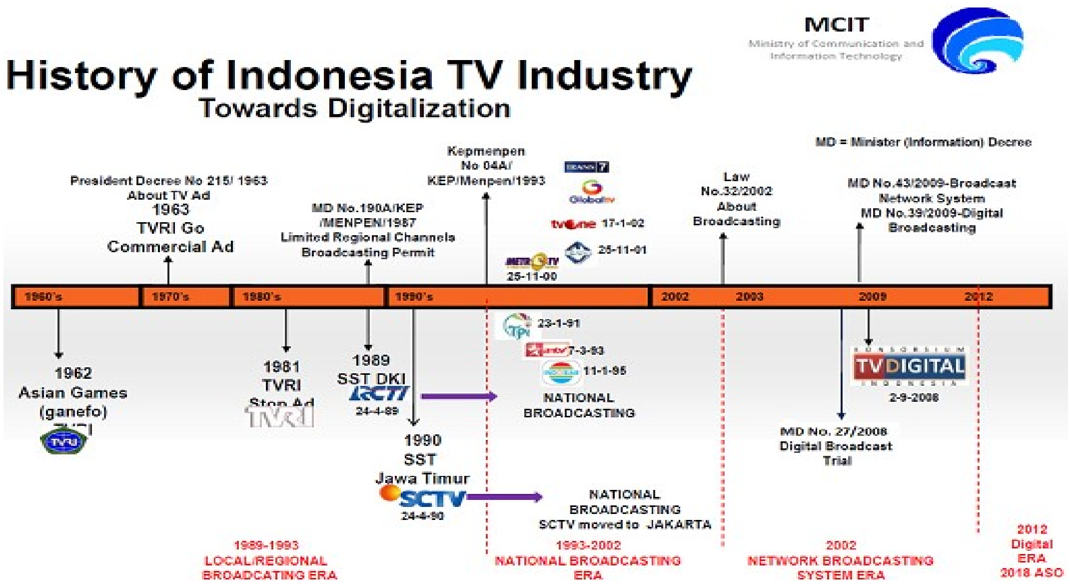

Figure 10 : The History of the Indonesian TV Industry
(ITU, 2013)

The duration of the transition process from analogue to digital television is specified in the Ministerial Decree Number 2 Year 2011, which covers the implementation of digital terrestrial TV broadcasting and implementation of simulcast.

In August 2009, MCIT issued Ministerial Decree Number 30 Year 2009 regarding the implementation of Service-Based Internet Protocol Television (IPTV) in Indonesia. It imposes the requirements for providing IPTV service: an operator should have Telecommunication, Internet and Broadcasting licences. The clear regulations boosted the growth of IPTV services in Indonesia, both at the National level and even the local IPTV operator.

This number of IPTV users in Indonesia added to the previous number of free broadcast TV users, obviously increased the total number of TV users in Indonesia significantly.

Recent Significant Telecommunication Developments

Telecommunications Business Competition

Although the monopoly of Telkom has been terminated, the government does not prohibit or prevent any operator from maintaining a dominant position in the business telecommunications services. However, the government will ban an operator found abusing its dominant position. In March 2004, the Ministry of Transportation (formerly the institution that regulated DG Postel) issued a Ministerial Decree Number 33 Year 2004 which is the implementation of *Act Number 5 Year 1999* on antitrust and unfair competition. The decree imposed restrictions on the abuse of a dominant position for network and service providers. Dominant providers are determined based on a number of factors such as business scope, coverage area of services and market control.

The decree specifically prohibits a dominant provider from practices such as price dumping (highly reduced price), arbitrary pricing and especially cross-subsidy. Cross subsidy happens when the cost for mobile phone calls between different operators is arranged to be much higher than when it is done within a single operator, forcing customers to use the other services of the provider and therefore hampering mandatory interconnection (including discrimination against certain service providers).

The enactment of BRTI Regulation Number 1 Year 2009 on Early Notification Regarding Merger, Consolidation and Acquisition, is expected to provide more legal certainty in the business environment in Indonesia, especially for those companies which have the intention to undertake Mergers and Acquisitions (M & A).

The regulation is intended to control M & A activities and thus the regulation can be viewed as anti-competitive. To overcome the problem, BRTI imposes their "notice-early" and "later notice" to them. Notification-early is voluntary and can be submitted prior to the merger, while the notice-after is mandatory and must be submitted after the merger is done (PT Telkom Indonesia, 2009).

BRTI also has the authority to supervise foreign transactions that can give an unfavorable result to the Indonesian market, as stipulated by *Act Number 5 Year 1999*. This includes

a) a merger of foreign companies operating in Indonesia,

b) a merger between domestic companies and foreign companies (both operating in Indonesia), or

c) any other form of mergers involving foreign parties.

The success story of the merger between two Telecommunications Operators – namely XL and Axis – demonstrates the implementation of the above regulation (Tim PPM Manajemen, 2016). While XL already has LTE (Long Term Evolution) networks operating in more then 35 main cities, Axis has sufficient frequency spectrum. The merger of the two resources will enable the merged company to develop data services faster and more efficiently using 4G technology than other telecommunication companies.

Telecommunication Consumer Protection

Based on the *Telecommunications Act Number 36 Year 1999*, each operator must provide guarantees for the protection of consumers in terms of quality of service, usage or service fees, compensation and other matters. Customers harmed by the negligence of the operator can claim their loss from the operators. As a great number of advances are taking place in telecommunications services, the operators should pay more attention to the quality of service. Such being the case, Consumer Protection Regulations in the field of telecommunications provide quality standards for telecommunications networks required for operators.

ICT Convergence

Digital technology is growing rapidly, resulting in convergence or integration of telecommunications services, data, information and broadcasting. This led to the issuing of several regulations that specifically incorporate some aspects of the convergence:

1. *Act Number 11 Year 2008* on Information and Electronic Transactions which also regulates financial transaction. This is followed by the issuance of *Act Number 3 Year 2011* on Fund Transfer and *Act Number 7 Year 2014* on Trading that includes e-commerce. These Acts definitely support the convergence of ICT and e-Commerce and e-Payment.

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2. Ministerial Decree Number 30 Year 2009 on IPTV, as has been briefly described above, integrates Telecommunications Broadcasting and Internet services.

The convergence policies in the above sectors have been followed by almost all sectors such as Transportation that enable application-based Transportation, Accommodation that enables on line room bookings and many other kinds of applications. This had resulted in the necessity of more and more requirements for creative applications on ICT. Therefore in 2015 the government set up a new Agency to boost the development of Creative Industries including ICT, called The Indonesian Creative Economics Agency (Bekraf – Badan Ekonomi Kreatif Indonesia).

Some Significant Ongoing New Programs

National Internet Exchange

The interconnection of Internet networks in Indonesia is currently still concentrated in Java Island and the big cities, especially Jakarta. This means that other regions, especially in central and east Indonesia, are required to route their networks to Jakarta. This definitely causes high connection fees for these areas. The disparity in rates of internet service has become one of the problems that can hamper the growth of the national economy. On the other hand, in the era of the Internet of Things, content as well as an all-electronic system has become more important. This has driven the rise in demand for interconnected networks as well as data centres across Indonesia. It has to be emphasised that in accordance with Government Decree Number 82 Year 2012, Public Data must be stored in data centres located in Indonesia (Bhaskoro, 2013; OEIT, 2012 ; Silaban, 2014).

To accommodate this need, the government issued Ministerial Decree Number 21 Year 2010, which commands universal service NIX to be built in all regions throughout Indonesia (TARHRD, 2010). The MCIT then built Nusantara Internet Exchange (NIX) in 33 provincial capitals. NIX is the infrastructure aimed at providing a more equitable distribution of national Internet traffic across Indonesia. Moreover, this development is expected to promote local content. By the end of 2015, 27 NIX were completely developed. This program was continued as part of the Indonesian Broadband Plan Program.

Indonesia Broadband Plan

The implementation of national communication and information technology entered a new phase in the year 2000 where there was a shift in the pattern of telecommunications operations from monopoly to competition. In the same year the government executed the elimination of operating functions. Although the construction of telecommunications infrastructure is dominated by enterprises, the government ensures fulfillment of the right of communication and access to information for everyone.

In 2014, due to the increasing internet content development, a Presidential decree Number 96 Year 2014 was issued. This decree arranged the plan to develop brodband access across Indonesia including enormous infrastructures and also raised several flagship pograms as shown in Figure 12. This arrangement was expected to overcome the problem of fixed access. The access had been developed for many years across Indonesia and the spread was considered to be more or less equally distributed in big cities and remote regions. However the actuality seemed to fall short of the expectation.

In some countries, a similar regulation can still keep the telecommunications density fixed-access to more than 10% and even 20% in the early 1990s, while in Indonesia, the fixed-access current density could only reach about 4%. This low percentage may cause disparity of telecommunications access across the country, especially in some remote areas which were previously connected using fixed access. As a result, despite the current liberalisation policies introduced by *Law Number 36 Year 1999*, Indonesia still faces the issue of equalisation, namely telecommunications network development outside Java and underdeveloped rural areas. This may lead to a national telecommunications access gap between cities and rural areas, as well as between the western and eastern parts of Indonesia (BAPPENAS, 2014).

To overcome this problem, the development of communication and information in the period 2004-2009 brought into focus the following three agendas:

1. The development of information and communication services in the non-commercial areas to improve public accessibility.
2. The creation of equal competition (level playing field) and a supportive business climate.
3. The use and development of ICT to improve the ability of society and industry, as well as to realise the validity, security and legal protection of the use of ICT.

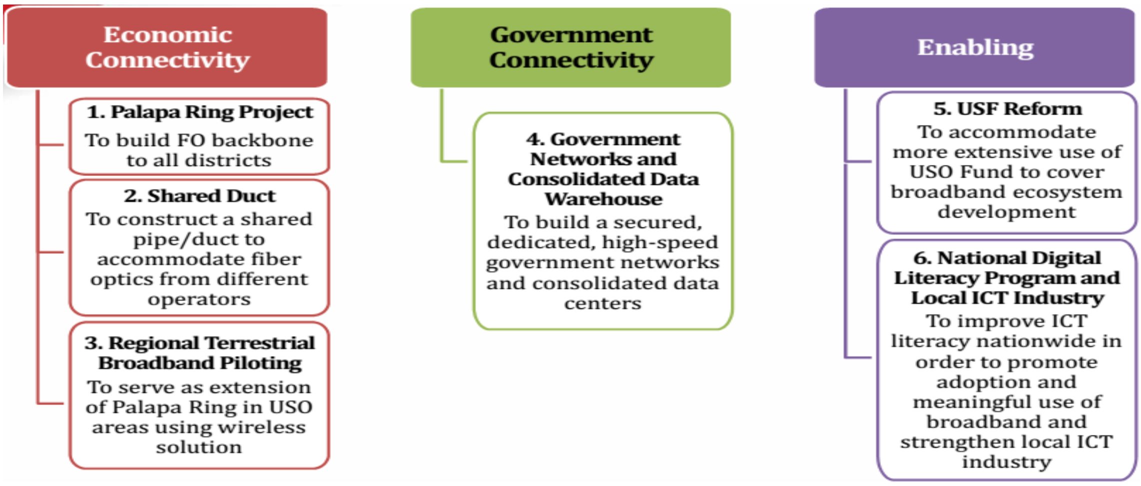

Figure 11 : Indonesia Broadband Plan Flagships (BAPPENAS, 2014)

In continuing the above development agenda of the period 2004-2009, the developments in communication and informatics in the following period of 2010-2014 were more focused on strengthening national connectivity, covering economic connectivity between and within islands, as well as connectivity among government agencies. This program is popularly called 'Indonesia Connected'. The direction of the development is detailed in three agendas, namely:

1. The reduction of the digital divide and areas not accessible by communication services and informatics (blank spot).
2. Increasing the availability of infrastructure and communication services and information that are secure and modern with good quality and reasonable price.
3. Improving the quality of provision and utilisation of information, and the use of ICT effectively and wisely in all aspects of life.

During this period, the Government also encouraged accelerated development of broadband via the Palapa Ring project in 51 districts/cities that are located in the non-commercial areas. The construction started in 2015 and the fund was derived from the USO fund. In addition, using company funds, Telkom carried out development in other 446 counties/cities.

Digital Broadcasting

In 2015, following the development of digital technology in broadcasting and the need to get more frequencies for the broadband plan, the government launched a plan to revise *Act Number 32 Year 2002* to accomodate digital broadcasting. From this program, the government will get a digital dividend – additional spectrum not used by the broadcasting sector, since the frequency required for digital broadcasting is less than for analogue broadcasting. The revised draft of the Act however is still under serious discussion due to the many different views on this program.

For the above implementation, MCIT issued Ministerial Decree Number 5 Year 2016 concerning Telecommunication Testing Technology, Information and Broadcasting. The regulation was carried out in the framework of research and policy direction setting the operations of telecommunications, information and broadcasting (Ministry of Communication and Information Technology, 2016). Several types of technologies were tested, including Open BTS (Base Transceiver Station), Google Loon, PPDR (Public Protection and Disaster Relief), 5G, digital TV method of SFN (Single Frequency Network) and MFN (Multi-Frequency Network).

Following the above digitalisation broadcasting program, a basic agreement was signed on June 9, 2016 between TVRI and more than 35 Content Providers on the trial to broadcast Terestrial Digital Television. This was followed by six months of field testing in 20 locations, monitored closely by the KPI. The successful tests included analysis of various technical aspects such as the set-top box, the various services possible including data services, weather information, financial information, current traffic conditions, early warning information and other related aspects. Non- technical aspects such as possibilities of partnership, business model between content providers and broadcasting operators and others were also under study.

5G System

In 2016, several countries and telecommunications industries started to test the 5G system. MCIT also launched a program to prepare the country to migrate to the 5G system including IoT. The study was carried out by the MCIT Research Agency (TARHRD, 2016a) and the following are some of the significant results:

1. The implementation of this technology in Indonesia should consider various aspects such as business models, impacts, benefits, regulations, and even the ecosystem in order to really provide benefits for the industries and their consumers.

2. To support this migration, Broadband Infrastructure should be the priority to be developed.
3. New policies and regulations should be issued for 5G migration.

Based on the above-mentioned results of study, several scenarios have arisen for 5G implementation:

1. Enhanced Mobile Broadband can contribute to the improvement of performance and give users a better Quality of Experience (QoE). It ensures the coverage of a larger area without neglecting the quality of the connection from medium to high level of mobility.
2. Ultra-reliable and low latency communications to fulfill the requirements of throughput and availability of connectivity, especially for critical applications in the future such as self-driving cars.
3. Massive Machine-Type Communications connecting various kinds of tools and communication devices both in the home, office, or vehicle mounted.

The above scenarios call for the need to fulfil the requirements to achieve IMT-2020 (International Mobile Telecommunications for 2020 and beyond').

Stratosphere Based HAPS

As previously described, despite the development of FO to connect main islands in the Palapa ring program, Indonesia still has many remote islands and places with no telecommunication access. Although satellite technology can overcome this problem, the cost is considered high.

During the Presidential visit to the US in 2015, the President initiated a basic agreement with several US companies to carry out a trial using a High Altitude Platform System (HAPS). HAPS is a vehicle in the form of a flying craft that is located at an altitude of 17 to 22 km above the earth's surface (Chauhan, Agarwal, Purohit, & Kumar, 2013). As a start, the HAPS which was tested was the one developed by Google, the Google Loon. Basically it is a balloon flying at an altitude of around 20 km and directly connected to the mobile devices using LTE technology. Currently, the test is still being carried out by Google and several Indonesian telecommunications operators. MCIT has also reviewed the feasibility of implementing HAPS from the regulatory side by using the Regulatory Impact Analysis from the aspects of frequency governance, information security and airspace. MCIT also gives recommendations for the preparation of new antecedents related to 900 MHz frequency governance for eNodeB LTE HAPS, telecommunications provider security standards for space environments and the formulation of controlled balloon classification as unmanned aircraft (TARHRD, 2016b).

Improving Cyber Security

With the increasing use of internet across Indonesia, the information in the internet is highly used for many activities. To handle information security issues, MCIT introduced Index KAMI as a tool to assess the maturity level of institutions to meet the national information security management standard. A finding from a study in cyber security points out that most organisations were focused on technology, but ignored risk management and framework aspects (Kautsarina & Gautama, 2014). While the government has just launched a program to boost the Digital Economy, at the same time much false information also spreads in the Internet (Setiawan, Syamsudin, & Sastrosubroto, 2015). A number of studies have been conducted to improve the policy and requirements on Cyber Security in Indonesia. One of the studies reveals that the readiness of Cyber Security in Indonesia is at a low level compared to the five pillars of the Global Cybersecurity Agenda (GCA)'s ITU Framework (Nugraha, Brown, & Sastrosubroto, 2015). Moreover, the Indonesian Government's requirements for state self-defence should be formulated and issued in response to the reported secret intelligence collection by the Australian Signals Directorate (ASD) (Brissenden, 2013; Internet Governance Forum, 2014; Lane, 2013; Nugraha & Sastrosubroto, 2014). Strict regulations and requirements are of paramount importance to protect and safeguard our national interests. To ensure the confidentiality of national sensitive data, a reasonable effort is to encrypt all the sensitive data for processing, transmission and storage (Nugraha, Kautsarina, & Sastrosubroto, 2015). A study in cooperation with Oxford University even proposed several recommendations to improve Cybersecurity (Nugraha, Brown, Roberts, & Sastrosubroto, 2016).

To overcome the above problems of cyber security, several actions have been taken. *Act Number 11/2008* on Electronic Transactions and Information has been revised to *Act Number 19 Year 2016* where by the Government is given the power to directly remove all illegal content from the Internet (EIT Law, 2008). For this purpose, all ISPs also support this program by blocking all content upon the request of the government. Mass socialisation against false informaton in the internet is also widely spread. At the same time, all institutions holding public data are requested to improve their security measures by adhering to Ministerial Decree Number 4 Year 2016 on Information Security Management, where Indonesian National Standard, SNI, which is based on the ISO 27001 standard is used as a reference (Badan Standardisasi Nasional, 2014; Direktorat Jenderal Aplikasi dan Informatika, 2011; Ministry of Communication and Information Technology, 2016a). This

EIT Law was ammended in 2016 to take into account several inputs from the public, especially those related to Cybersecurity and sanctions against defamation (EIT Law, 2016).

Conclusions and Recommendations

The ICT infrastructure, consisting of Telecommunications, Internet and Broadcasting, is being rapidly developed, both by the Government and by private companies. Liberalisation in this sector, combined with strong monitoring and control, has resulted in lots of ICT service industries to flourish. This expansion is also supported by new Acts and other regulations.

However, the TV Digitalisation process is still being carried out and so are the frequencies that can be made available by this program which is known as the Digital Dividend. Similarly, the Indonesian broadband plan needs to be implemented at a faster pace.

With the policy to promote the digital economy, there is an urgent need to speed up the development of both the ICT infrastructure and various applications and contents. Of equal importance is ICT security, therefore improvement in this aspect is necessary as well.

It is important to note that while the ICT service industries are rapidly growing, reflecting the fast growing markets in Indonesia, this is not the case with ICT product industries. As described, these industries can only grow when a particular technology is selected so that the products can have initial significant domestic markets. This will ensure that the development and production of the products can be economically feasible.

Acknowledgements

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New Zealand Telecommunications

The actual situation – legislation and regulations

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Abstract

A recent paper (Gul, Sarkar & Gutierrez, 2016) offers recommendations for changes to existing telecommunications legislation and regulations in New Zealand. These recommendations are based on a review of the history of legislation governing the sector and market development since liberalisation in 1989. We have identified key omissions in this review which have prompted us to revisit the analysis and conclusions. We find that the evidence is insufficient to support the paper's recommendations.

Keywords:

History of New Zealand telecommunications legislation, telecommunications market competition, telecommunications regulation, telecommunications policy, market liberalisation.

Introduction

A fundamental goal of New Zealand telecommunications legislation, as stated in the *Telecommunications Act 2001*, is to promote competition for the long-term benefit of end-users. The Act introduced telecommunications-specific legislation, over a decade after the implementation of market liberalisation. During that decade regulation of the telecommunications industry was governed by general competition law, namely the provisions of the *Commerce Act*. This light-handed approach to regulation subsequently proved insufficient to address in a timely manner key issues for new market entrants such as interconnection and discriminatory pricing, and thus the *Telecommunications Act* was introduced. However, a recent paper (Gul *et al*, 2016) claims that competition flourished in the 1990s in New Zealand while also recommending that New Zealand telecommunications legislation should be changed in order to 'create a healthy market competition' and to meet

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'the expectations of customers, industry and administrative bodies' (Gul *et al*, 2016; p187). In reaching these recommendations the paper appears to have misunderstood the development of New Zealand telecommunications legislation and regulation. Following a review of the paper we find that different conclusions and recommendations would have been offered had further analysis been undertaken to address important omissions, and correct factual inaccuracies. In the absence of such analysis the paper offers no substance to support its recommendations.

Competition in New Zealand telecommunications

A 2015 illustration of the history of telecommunications sourced from the Ministry of Business, Innovation and Employment and reproduced in the paper (Gul *et al*, 2016; Figure 1) clearly demonstrates that in the 1990s there was 'some competition, but lengthy litigation on interconnection with Telecom', and also characterises competition as 'increasing, but still limited' in 2001 (Gul *et al*, 2016; Figure 1). However, this illustration is not mentioned in the text of the paper, and it provides a stark contrast to the claim of the paper that competition flourished from 1990 (Gul *et al*, 2016; p185). The illustration also highlights the amendment of the *Telecommunications Act* in 2006. However, this crucial *Amendment Act* is not discussed at all in the text of the paper, and it is not listed in the bibliography or the telecommunications legislation in Appendix A.

The paper states that 'competition in the telecom industry really started to flourish' (*Gul et al* 2016; p185) in 1990 with the privatisation of Telecom New Zealand. A long list of legislative orders is provided as evidence of new operators entering the market 'to overcome the monopoly of the Telecom Corporation Ltd' (Gul *et al*, 2016; p174). The paper then skips past the 1990s, with no commentary or analysis, to the *Telecommunications Act 2001* which 'allowed private companies to access the existing telecommunications network to sell their telecommunications services to the public' (Gul *et al*, 2016; p176). The next identified milestone is the 2006 operational separation of Telecom and local loop unbundling, which the paper asserts was the result of the growth of the telecommunications industry. Without any explanation the paper states (incorrectly) that this involved Telecom committing to provide high speed broadband 'to the whole country by laying an optical fibre infrastructure' (Gul *et al*, 2016; p176).

In fact, as is made clear in the Cabinet policy minute, the *Telecommunications Amendment Act (no. 2) 2006* was formulated in response to public policy concerns about New Zealand's laggard performance in the OECD broadband rankings and a lack of effective competition in the market (Cabinet Policy Committee, 2006), factors identified in the government's comprehensive 2005 Stocktake of the telecommunications sector. Following a lengthy investigation (2002-2003) the telecommunications regulator had recommended the introduction of a regulated limited speed bitstream product, but that full local loop unbundling not be introduced. The regulator's recommendation sought to maintain Telecom's incentives to invest in next generation infrastructure to support high speed broadband. However by 2005 it became apparent to Government that Telecom's rate of investment was relatively slow. At the same time competitors struggled to make market inroads in the absence of safeguards for the terms and conditions of supply of wholesale services from the vertically integrated incumbent supplying essentially the same services to its own retail arm (Cabinet Policy Committee, 2006).

The Amendment Act was highly significant in the history of the development of the telecommunications sector in New Zealand as it encompassed key provisions for improving competition, including equivalence of inputs (EoI), non-discrimination and transparency, as well as additional regulated services (unbundled copper local loop and unbundled bitstream access). It was the requirement to implement EoI which led to the functionally separated network arm of Telecom (rebranded Chorus) deploying FTTN ('cabinetisation') to all cities and towns with over 500 lines – reaching more than 80% of all New Zealanders – by the end of 2011.

The final highlighted milestone in the paper is 2010 when 'Ultra Fibre Broadband came into play' and structural separation of Telecom occurred, the purpose of which, according to the paper, was to deal efficiently with growing customer demand (Gul *et al*, 2016; p176). In fact, had Telecom shareholders failed to agree to structural separation then Chorus would not have participated in the Ultra Fast Broadband (UFB) initiative (Telecom New Zealand, 2011; p36).

The purpose of existing legislation

Prior to the 2001 Act a light-handed regulatory approach had been adopted with reliance only on the non- industry specific competitive safeguards in provisions of the *Commerce Act*. While market entry did occur in the 1990s, new entrants faced considerable obstacles, including discriminatory pricing and interconnection disputes with Telecom involving litigation spanning several years. A key omission in the paper is the fact that telecommunications had no sector-specific governing legislation until the 2001 Act, to the detriment of competition.

Following the Fletcher Inquiry in 2000, telecommunications-specific regulation was introduced with the passing of the *Telecommunications Act 2001*. Importantly the Act provided a process for service regulation (including interconnection) with the stated purpose:

> *...to promote competition in telecommunications markets for the long-term benefit of end-users of telecommunications services within New*

> *Zealand by regulating, and providing for the regulation of, the supply of certain telecommunications services between service providers.* (*Telecommunications Act 2001; Part 2, Section 18*)

Given that the stated purpose of the current Act is the promotion of competition and the long-term benefit of end-users, it is unclear why the paper recommends legislative change to accommodate competition and meeting consumers' expectations.

The New Zealand Government has been engaged in a consultation process since 2015 for the review of the *Telecommunications Act 2001*. The aim of the review is to determine whether regulatory modifications are necessary following significant technological, market and structural change over the last fifteen years, including convergence, the UFB programme and the structural separation of Telecom in 2011.

Although two of the Government consultation documents are listed in the bibliography, the paper is silent on the implications of the review. This is odd, given that the Government review seeks to ensure that the legislation is fit for purpose to address the challenges alluded to in the paper – namely, burgeoning demand for high-quality services that will accommodate data-hungry fixed and mobile applications. Furthermore, the consultation papers are very clear that a key Government objective remains the promotion of competition for the long-term benefit of end-users and where there is no effective competition to promote outcomes consistent with competitive market outcomes (MBIE, 2016; p17).

Market structure

In contrast to the 1990s and early 2000s, the retail market now comprises numerous fixed line Retail Service Providers (RSPs) in addition to Spark and Vodafone, such as Vocus (which includes the CallPlus brand), 2degrees, Trustpower and Compass. The paper lists only three fixed line retailers (Spark, Vodafone and CallPlus) (Gul *et al*, 2016; p178) and claims that 'the Telecom Infrastructure (including optical fibre) is maintained by Chorus, NZ's largest telecommunications network operator together with Crown Fibre Holdings' (Gul *et al*, 2016; p178). While it is true that Chorus owns and maintains the copper access infrastructure, it has an Ultra Fast Broadband (UFB) contract with Crown Fibre Holdings to deploy fibre in 24 of the 33 UFB candidate areas in New Zealand (Crown Fibre Holdings, 2011; p3). Crown Fibre Holdings has only a managerial role in respect to the Government's UFB investment, and fibre is being deployed and maintained in the remaining candidate areas by three Local Fibre Companies (LFCs), encompassing Whangarei (served by Northpower), Waikato (Ultrafast Fibre) and Christchurch (Enable Services). In the LFC areas Chorus competes in the provision of broadband infrastructure with high speed offerings (ADSL2 and VDSL) over its legacy copper network.

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There are a number of approaches to assessing the market's response to key legislative and regulatory milestones. An important source of data for such an analysis is the Commerce Commission's annual telecommunications monitoring reports. However, the paper relies mainly on a secondary source which provides little insight on the trends and characteristics of the New Zealand telecommunications sector. For example, rather than declining as is claimed by the paper (Gul *et al*, 2016; p178), fixed lines have been virtually flat over the past ten years, as is shown in Figure 1 (Commerce Commission, 2017; p4). While the paper shows that there are a number of players in the New Zealand market (Gul *et al*, 2016; pp178-180) and presents evidence of strong growth in fibre uptake (Gul *et al*, 2016; Figure 7) as well as data usage (Gul *et al*, 2016; pp182-184), such information does not demonstrate the existence of any problems, such as lack of competition, that may be due to constraints in the existing legislation or regulation.

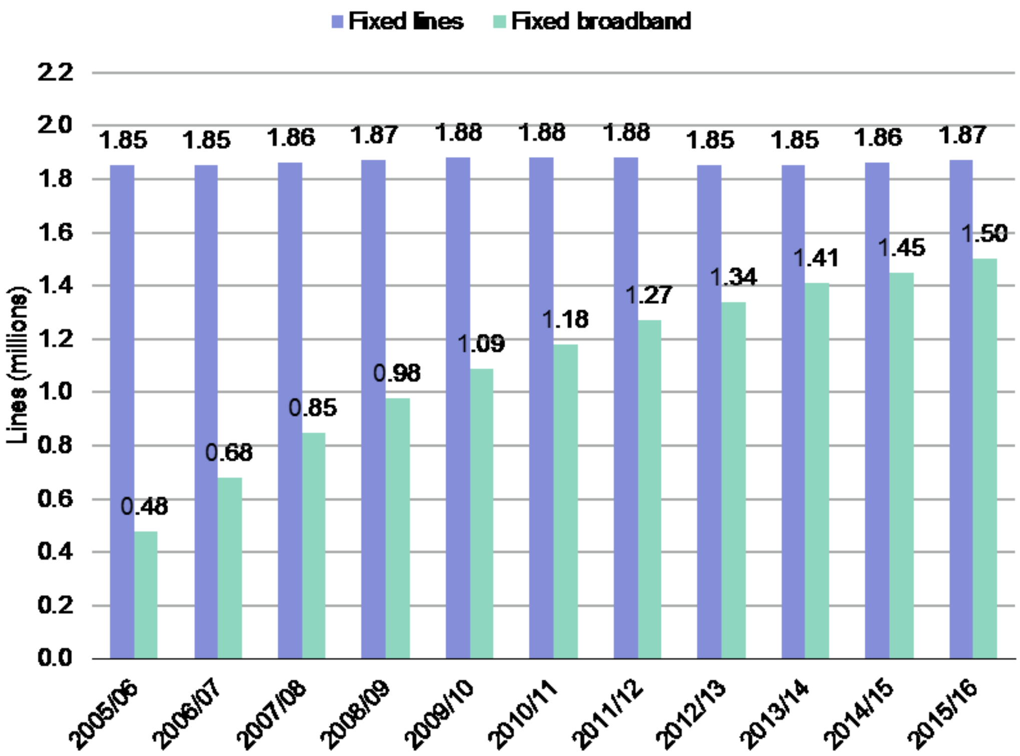

Figure 1: Fixed lines and fixed broadband in New Zealand, 2005/06 to 2015/16 (millions). Source: Commerce Commission, 2017.

Conclusions

Any thorough investigation of the history of legislation governing the telecommunications sector in New Zealand would reveal a plethora of legislative and regulatory measures that have **already** been undertaken to strengthen market competition for the long-term benefit of end-users. Although the paper concludes that 'to address the challenges of the existing telecommunications industry some changes in the existing legislation are essential' (Gul, Sarkar & Gutierrez, 2016; p188) there is insufficient evidence to demonstrate that the current regime fails to meet market expectations, nor is there an explanation for an apparent perception of a lack of competition which contradicts the paper's market characterisation of flourishing competition since 1990. In the absence of such evidence there is nothing to substantiate the claim that the paper's recommendations 'would help telecommunications legislation regime will be strengthened [*sic*] and would be able to address the challenging needs of the telecom industry in NZ' (Gul *et al*, 2016; p188). In fact, maintaining the longstanding objective of promoting competition for the long-term benefit of end-users in the face of rapid technological and market change remains a Government priority, as demonstrated by consultation papers in the recent review of the Telecommunications Act.

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The Radio Australia Aerial Matrix Switch

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Abstract: Two papers from 1963 describing the design and construction of the new aerial matrix switch at Radio Australia Shepparton and the ingenuity required to conceive and deploy a world-first solution.

Key Words: Telecommunications, History, HF Broadcasting, Radio Australia

Introduction

The Radio Australia high frequency (shortwave) transmitting station at Shepparton, Victoria was completed in 1944. The original aerial switching design allowed 3 transmitters to access 19 aerials in group configuration. The station relied on fixed bearing and fixed frequency directional aerials (usually curtain dipole arrays or rhombics) to skip high-frequency signals off the ionosphere to distant audiences in Japan, North America, South Africa and Europe. The selection of transmitter frequency and associated aerial was governed by the anticipated ionospheric propagation conditions and the need to provide reliable communications to the desired destination.

Fast forward to 1963 and the growth in Radio Australia services necessitated 10 transmitters having access to 35 aerials and one dummy load, which was unworkable with the original group configuration. Ideally a 10 by 36 aerial matrix switch was required to give full availability however none were available at that time with a rating of 100kW for each connection.

In typical Postmaster-General's fashion, a specialist engineering team was established to solve the problem and included representatives from Radio Australia Shepparton, Lyndhurst Radio Station, Radio Section and the Workshops.

The historic papers (Cliff, 1963; Gemmell & Fullarton, 1963) describe the development of the switch from concept through prototype development, field trials and ultimately staged implementation. The electrical and mechanical engineering challenges were considerable. How do you connect a 100kW transmitter output, configured as a four-conductor open wire transmission line to any one of 35 aerials and dummy load, whilst minimising crosstalk and reflected power? How do you then control the matrix with a 24 hour, 7 days per week transmission schedule to ensure safety and reliability?

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The switch had to be physically large and strong to accommodate the 36 transmission lines made from four-conductor, 600 lb per mile hard-drawn copper. The aerial terminating frame and switching frame were both semicircular, with a radius of approximately 15 and 8 metres respectively. The switching frame was approximately 7 metres high and had to be straight from end to end to within a few millimetres. Similar exacting tolerances were required on the switch arms, and a surveyor was engaged to layout the site precisely.

The switch arms were designed from the ground up by the project team. The transmission lines transitioned from an open four-conductor configuration through the hub into a balanced two conductor arrangement enclosed in the arms, then back to four-conductor again at the aerial terminating frame. The arms and connections needed to be rated for 100kW amplitude modulated transmissions as well as withstanding a VSWR of up to 5:1. A complex array of hoist and traverse motors were used to remotely control the arms from the transmitter hall.

The first stage of the switch connecting 10 transmitters to 9 aerials was completed in May 1961 and the final stage connecting to 35 aerials and dummy load was completed in September 1962. The outstanding success of the project highlighted the expertise of the personnel involved and the close cooperation between station staff, Radio Section and the Workshops Drafting teams.

Postscript.

The 1963 matrix switch was replaced progressively in 1991 with a Marconi matrix switch. It comprised seven transmitter inputs and eleven aerial outputs and one dummy load, still in-situ today. At its inception, the Marconi switch had 11 field switches thereby doubling the available aerials to 22, plus a 500kW Brown Boveri dummy load. This allowed it to accommodate the aerials for Japanese, American/African, European/Continental and South East Asian transmissions, plus three rhombics and the dummy load.

In 1993, the old American/African, European/Continental and South East Asian aerials, as well as the American and European rhombics were removed. All but two of field switches were retained and relocated to provide connection to high and low band Japanese aerials. The American and Japanese rhombics were rebuilt and a new aerial array comprising five multiband TCI aerials was commissioned in 1993 to cover the Central and Western Pacific.

The ABC ended its shortwave transmission service to international audiences from 31 January 2017, in line with the national broadcaster's commitment to dispense with outdated technology and to expand its digital content offerings. A Senate Committee inquiring into the possibility of restoring ABC shortwave services rejected the proposed legislation on 9 August 2017. (SWLing Post, 2017; Senate Report, 2017). The station at 490 Verney Road, Shepparton is owned by Broadcast Australia International and is currently up for sale according to the local paper and estate agents CBRE (White, 2017; CBRE, 2107).

I worked at Telecom Radio Section in the early 1980's and the 1963 aerial switching matrix at Radio Australia Shepparton was showing signs of wear, given its unbroken service during the 20 or so intervening years. Doug Cliff was the manager of Radio Section at that time and he had a photograph of the switch on the wall behind his desk. Doug was a good manager and created a collegiate work environment in the office at Richmond, and at the depot at Box Hill. Doug was also an accomplished pianist and the Musical Director of the Whitehorse Musical Theatre company. Doug passed away in 1984 after a battle with prostate cancer and is fondly remembered by those who worked with him.

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The historical paper

THE NEW AERIAL SWITCHING SCHEME AT RADIO AUSTRALIA, SHEPPARTON—GENERAL DESIGN AND PERFORMANCE

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INTRODUCTION

One facility of prime importance at the International High Frequency Transmitting Station, Radio Australia, is that of providing flexible switching between transmitters and aerials. At this station, where a limited number of transmitters is required to operate on a number of different frequencies throughout any 24-hour period, the switching system must be capable of providing rapid connection.

When Radio Australia (Ref. 1) was first installed in 1944, access from any of the three transmitters to any of the nineteen aerials was required. The type of switching system installed was of the sequential type (Ref. 2) in which connection was made through a series of switches, these being remotely controlled from within the transmitter building. Monitoring of correct switch operation and transmitter interlock were also provided. Although a sequential switching system is inherently inflexible, the relatively small number of inputs to the system meant that access problems were readily overcome.

With the advent of an increasing number of transmitters and aerials in the expansion programme of 1956-1962, the switching system had to be enlarged. This proved to be possible only to a limited degree, as enlargement of the sequential system to the required degree to provide for the number of additional transmitters and aerial connections and give full availability (that is any transmitter should be capable of being switched to any aerial irrespective of the interconnection of other transmitters with other aerials) would have been very costly and have increased the complexity of the control system to a great extent.

LIMITATIONS OF ORIGINAL SWITCHING SCHEME

The system as it existed before this work commenced comprised three distinct groups of switches, of the type shown in Fig. 1. The groups were as follows:

1. A group of switches which allocated the lines from the transmitters to three lines to the "North" switching group and three lines to the "South" switching group.
2. The "North" switching group provided connections between the three incoming lines and the aerials situated in this area.
3. The "South" group provided similar connections for aerials in this area.

There were several undesirable limitations, inherent in this system, which became determining factors in transmission schedule preparation as the required facilities and programmes increased:

(i) Only three transmissions were possible to any one switching group. This meant that it was often not possible to broadcast to required target areas with the desired number of aerials, or that different target areas whose aerials were all in one group could not be served simultaneously.

(ii) A further restriction existed due to the design of the system in that only two of any group of three aerials could be used at any one time, that is the system lacked the desirable "full-availability" feature.

The effect of these limitations could not be foreseen when the station was planned. The system was more than adequate for the required service at the time, and was comparable with contemporary switching systems. The difficulties arose only as the demand for transmissions and facilities increased.

An appraisal of the situation at this stage indicated the need for a complete redesign of the aerial switching system, and the provision of a more suitable and flexible system. In addition to the undesirably complex control of an expanded sequential system, this principle was discarded because a large number of transmission line switches would have been needed if the desired "full availability" feature was to be achieved, or even approached. Each switching point introduces transmission line impedance irregularities which cause standing waves on the transmission line for which correction can only be performed at the point where the line from the aerial connects to the last switch in the group. Lines from that switch back to the transmitter are multi-frequency as they must carry transmissions to different aerials, and cannot conveniently be corrected to improve the standing wave ratio. Further, short lengths of line which would exist between switches when not in use could appear as resonant circuits, and have high voltages induced in them with consequent hazards to personnel and plant.

Several types of switching system were available for study at this time, but the most favoured type was similar to the so-called "crossbar" switch at Radio Lyndhurst, Victoria (Ref. 2) which had been installed for the 1956 Olympic Games and had given satisfactory operation since that time. (The term "crossbar" had arisen in reference to this switching principle, although this is technically incorrect. A more appropriate term is "matrix" which will be used for this paper.)

REQUIREMENTS OF NEW SWITCHING SCHEME

It was considered that a suitable type of switching system should fulfil the following criteria:

1. Give full availability.
2. A minimum number of switching points between transmitter and aerial, and hence a minimum of transmission line impedance irregularities.
3. A minimum degree of R.F. coupling between adjacent circuits.
4. A maximum of safety to personnel.

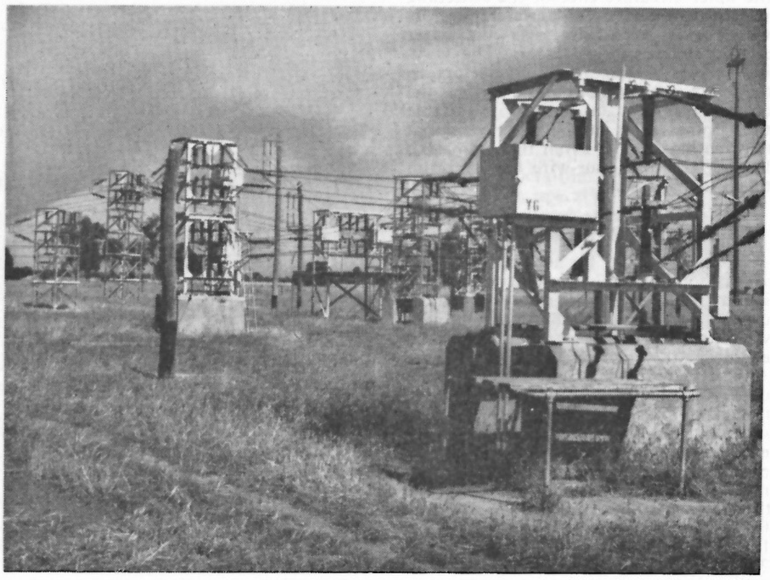

Fig. 1.—Portion of One of the Three Switching Groups in the Original Scheme.

* See Page 81

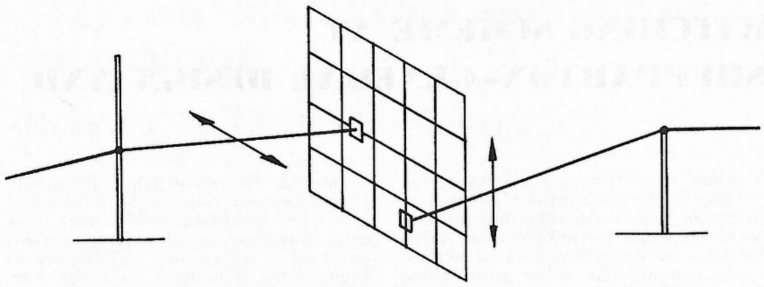

Fig. 2.—Principle of the Shepparton Matrix Aerial Switch.

5. A remotely controlled and monitored operation as the switch would be located away from the transmitter building, due to its physical dimensions.
6. The transmission line impedance should be 300 ohms balanced.
7. The switch capacity should be 10 transmitters and 36 aerials.
8. The switch should be capable of carrying 100kW of fully modulated R.F. power.
9. Operation of normal transmission schedules must not be interrupted during conversion to the new system.

The matrix switch was the most suitable to fulfil these requirements, and in addition, could be designed to meet the local conditions. The principle of the switch may be seen from Fig. 2 and the following brief description.

The four-wire lines from the transmitters terminate on the transmitter terminating frame. At this point they become two-wire and pass to the pivot structure and thence via a pivoting connection to the transmitter connectors. These connectors move horizontally over the inner circumference of the switching structure and mate with aerial connectors which move vertically over the outer circumference of this frame. The varying length of the aerial connectors as they move from bottom to top of the central frame is taken up by suitable telescoping joints at the outer or aerial terminating frame. From this frame the lines revert to a four-wire configuration to go to the aerials.

MATRIX SWITCH DESIGN

As far as could be ascertained, there was no other switch of this type operating at 100kW power levels in use or under development anywhere in the world, so it was necessary to design and engineer the project in its entirety. Although based on the earlier design used at Lyndhurst Radio Station as mentioned earlier, it is much larger in construction, has a greater number of connection points, operates at much higher power levels and is operated under remote control. The detailed design of the switch will be outlined under the following headings:

1. Operating sequence.
2. Control circuits.
3. Switch connectors.
4. Switch connector driving units.
5. Structural layout and design, including foundations.
6. R.F. Fittings.
7. Reliability and Testing of Prototype Switch.

1. Operating Sequence

The sequence of events in the setting up of a connection on the Lyndhurst switch was firstly considered as a possible basis for the Shepparton project. The sequence (see Ref. 2) is as follows:

1. The required aerial connector is raised to a level above that of the required transmitter connector.
2. The transmitter connector is brought round opposite the selected aerial position.
3. The aerial connector is lowered to meet the transmitter connector and is supported by it.

The release of the combination is the reverse of these events.

A relay switching sequence to fulfil these conditions was developed but was excessively complex, due to the required reversal of the aerial carriage motion, and it was considered sufficient for the following sequence to occur:

1. The transmitter connector be driven to a position opposite that of the aerial connector.
2. The aerial connector be raised to make contact with the transmitter connector.

The release is the reverse of these.

This change of sequence had the implication that the aerial connector would need support from the lifting device, and not from the transmitter connector.

2. Control Circuits

Prior to the detailed design of the control for the aerial switch a study was made of the logic required of a matrix control system as compared with the sequential logic of the original switch control system. The sequential logic in which a particular event depends on previous events, differed from the matrix logic found necessary for the new switching system, in which functions of the transmitter ("inlet") and aerial ("outlet") could only be associated in a particular connection. At the completion of this connection and for its subsequent release, information pertaining to the selected transmitter and aerial must remain associated. This association must be to the exclusion of all others, and since ten connections could exist through the switch simultaneously, this exclusion was necessary for each.

The following features were therefore required:

1. The circuit should be as simple and reliable as possible.
2. The essential nature of the matrix switch required that any transmitter should have connection to any aerial.
3. All switch connectors should have a home position from which a selection is made, and to which they return when a selection is released. This was essential if the control circuitry was

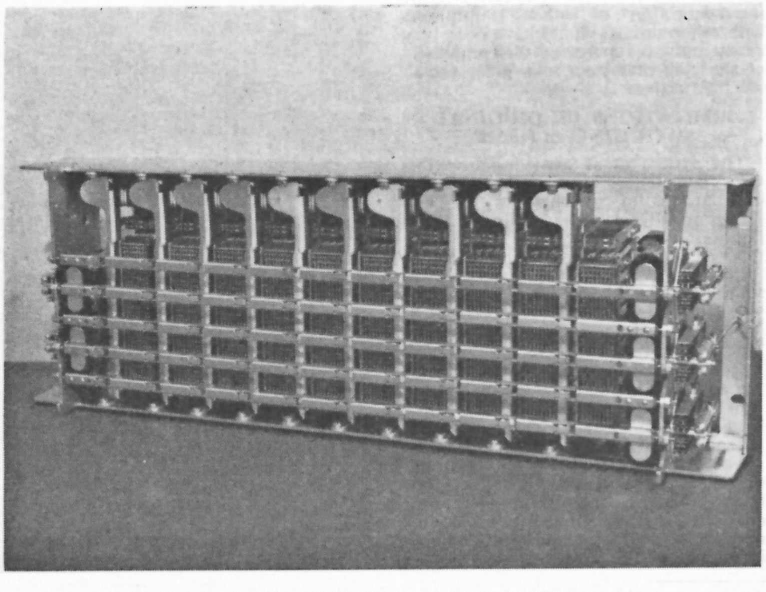

Fig. 3.—Crossbar Switch chosen for the Control System.

not to become excessively complex through catering for a connection with the switch connectors in random locations.

4. Only one combination should be selected or released at any one time.
5. Although individually selected, a maximum of ten connections could exist through the switch.
6. It would be desirable to utilize the existing aerial system control voltage of 50V D.C. to facilitate future cutover procedures.

In the initial stages of the control circuit design, many relays in the remote control desk and a large number of limit switches on the aerial switch structure were needed. It was not possible to achieve a reduction in the number of switches and relays until the possible advantages of some mechanical assistance in the sequence of operations were considered. A feature of the Lyndhurst switch was the use of a control rod at each aerial position, the function of which was to act as a stop for the transmitter connector. It was thought that the use of a similar rod which would act as a marker of the selected aerial and also as a control system element could be useful. The subsequent investigation resulted in the use of control rods which had rotational as well as vertical movements, which together with a number of other mechanical devices gave the required operation. Substantial simplification of the control circuit was then obtained. A diagrammatic explanation of the operation is set out in a companion paper in this issue of the Journal. (Ref. 3). With this electro-mechanical type of operation, only 82 limit switches were found necessary for the basic operation of the full structure, that is for 10 transmitters and 36 aerials. It was, however, necessary to add further switches to the system to provide interlocking facilities of the transmitter, monitoring of the home positions of the connectors, and a number of safety features necessary for the reliable operation of the switch.

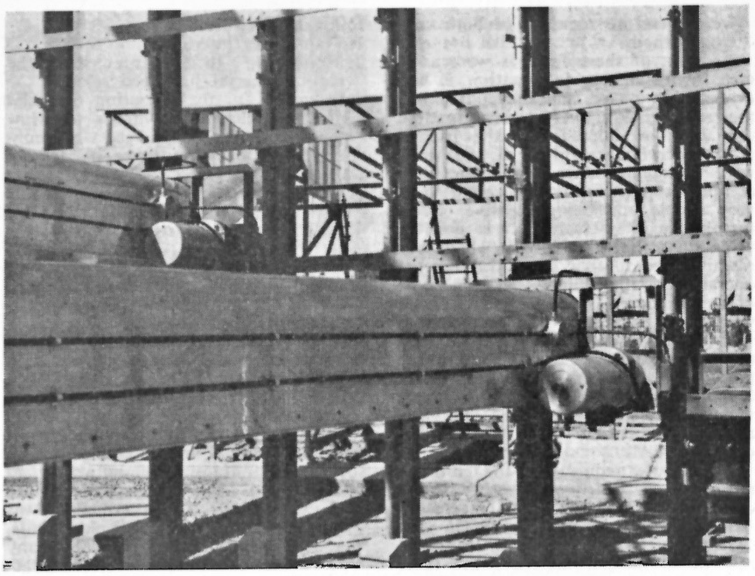

Fig. 5.—Transmitter Arm Drive Units mounted on the Arms.

With the basic electrical and mechanical circuit design complete, the Victorian Postal Workshops Drafting Section was approached with the request to translate these requirements into physical reality, and to proceed with the overall structural design of the switch proper. This Section had previously been responsible for similar work on the Lyndhurst switch, and some details of the work carried out on the matrix switch for Shepparton forms the basis of the companion paper already referred to.

A number of important auxiliary features were necessary in the control system, which affected both the switch structure and the design of the remote control in the transmitting building. These were:

1. The provision of transmitter interlock. This facility ensured that the required transmitter could not be fully switched on until its connection to an aerial was complete.
2. The protection of a transmitter-aerial connection from release while the transmitter was on the air. Protection and indication must also be available should the connection be broken.
3. A reliable method of monitoring the aerial connected to any transmitter at all times.
4. A method of monitoring at the control desk the operation of the automatic sequence of operations.
5. The provision of appropriate alarms to indicate the malfunctioning of faulty parts or sequences.
6. Several of the aerials used are capable of transmitting in a number of directions, the direction required being obtained by the operation of a number of transmission line stub switches. The control of these switches was also to be included in the new switching scheme.
7. The method of motivation applied to the arms should be controlled by 50V D.C. and operated by 415V A.C., 3 phase motors in order that the required reversal of drive could be readily achieved.
8. The control system was to be capable of operating in tandem with the existing system during the period of the cutover. Compatible characteristics

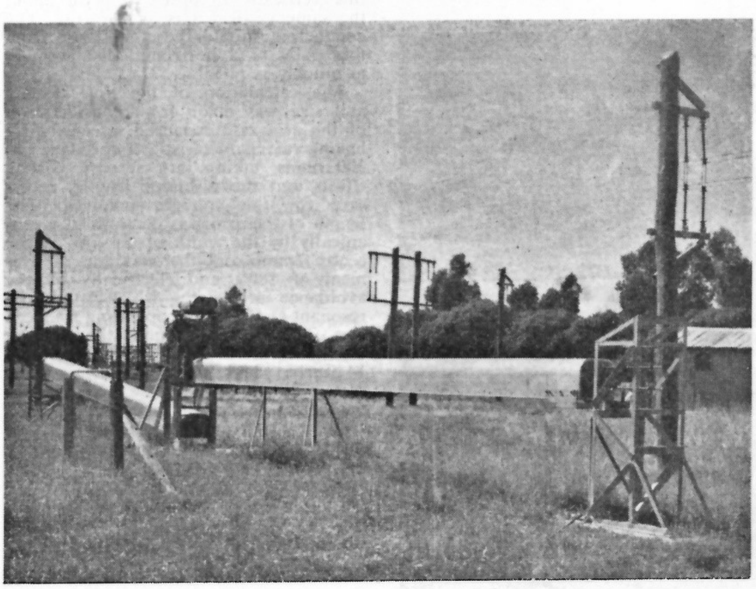

Fig. 4.—General View of "One-by-one" Prototype Switch.

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were therefore required of both control methods.

As most of these features were associated with matrix information it was evident that a slave matrix would satisfy the requirements. After investigation, the solution adopted was the use of crossbar switches which, at the time, were being introduced into telephone equipment practice in this country. A very simple and comprehensive circuit for the auxiliary features was possible using the switches, a circuit which was readily fitted to that developed for the operation of the switch itself. The type of switch chosen is shown in Fig. 3, and was fitted with ten preselect magnets with associated five two-way bars, and ten hold magnets and bars. With the preselect magnets associated with aerial functions and the hold bars associated with transmitter functions, all the required information could be readily obtained.

The features required for the ten transmitters and thirty-six aerials were obtained by the use of four crossbar switches. Each hold magnet in one switch was commoned with the corresponding magnet on the other three and associated with a transmitter. Forty preselect magnets were available of which thirty-six were used, each being associated with an aerial. In operation, the circuit is so arranged that the aerial preselection occurs first. The successful conclusion of the selection operates a limit switch which in turn operates the cross-bar hold magnet associated with the transmitter. The limit switch concerned is mounted on the transmitter connector of the aerial switching structure and is operated when the R.F. contacts are made. At the completion of the selection, the aerial preselect magnet is released.

The circuits through the crossbar switch matrix were used to provide the following facilities:

1. Transmitter interlock.
2. Monitoring to indicate that the required aerial has been selected.
3. Provision for the operation of aerial direction changing switches to allow the direction to be changed while connected to a transmitter. This feature also includes protection to ensure that such operation is not possible while the transmitter is operating.
4. A release guard to ensure that the aerial cannot be released while the transmitter is operating.
5. Monitoring to indicate directly the aerial to which the transmitter is connected.

The display of transmitter — aerial connections needs ready interpretation by the operator. The provision of a grid of 10 x 36 lights as a method of indication, while being relatively simple to obtain, had the disadvantage that it did not readily show the connection, as the particular transmitter and aerial had to be found from designations at the grid extremities. A direct method was employed using digital display units. The display unit selected from the many types available contains twelve characters, each engraved on individual perspex strips which, when end lit, cause the characters to be visible from the front of the units. The aerials at Radio Australia are given local designations such as J15, that is, a 15 Mc/s aerial for transmission to Japan. With the use of three display units and three crossbar switch connections for each transmitter, it was possible to provide direct indication in the local terminology of the connection obtained.

3. Switch Connectors

As the moving connectors of the switch formed part of the transmission line and R.F. coupling between lines was to be kept to a minimum, it was evident at an early stage that the connectors should be hollow, rigid, and made of a shielding material. The conductors could then be mounted inside this "arm", which could be given motivation because of its rigid nature. A suitable material, "Alumply", was suggested by one of the authors of the companion article. This is essentially half-inch bondwood which is sheathed on both sides by aluminium. The resultant product is very stable and is unaffected by weather. It was further indicated that the material could be moulded

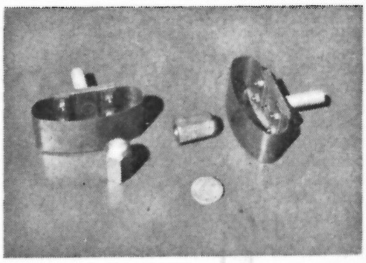

Fig. 7.—R.F. Contacts (The coin is 2/-).

to the required shapes, so that the original idea of a rectangular cross-section arm composed of four flat side sections of Alumply could be discarded, and a more suitable two-piece section designed.

Since the actual contact was to be made by the aerial connector moving vertically to mate with the transmitter connector, the displacement of the contacts would be on a horizontal plane. The conductors would be supported in the arm in the same plane. A variation of this configuration was required at the pivot end of the transmitter arm. At this point, the conductors should be in line vertically in order to pivot about the same vertical axis as the arm. The conductors should therefore twist from this point to a horizontal displacement as quickly as possible.

The calculation of the line spacing and size was made from consideration of the arm as a balanced screened pair having a characteristic impedance of 300 ohms, taking into account corona effects and the insulator lengths necessary for the voltages involved. The length of the arm was determined mechanically by the width of the arm at the centre frame and the maximum movement of 180°, and electrically by the avoidance of lengths which would be resonant at any of the operating frequencies. The resultant shape of the arm was essentially an inverted U, 25 feet long, 14 inches high and 17 inches wide. Across the bottom was attached a flat panel of "Alumply" which was removable for maintenance access to the transmission lines. These passed through the tube and were supported by four sets of insulators mounted from the top of the arm. In its final form the arm was sufficiently light to be carried by two men and can be seen in Fig. 4.

4. Switch Arm Drive Units

A number of points concerning features of the arm driving units had already

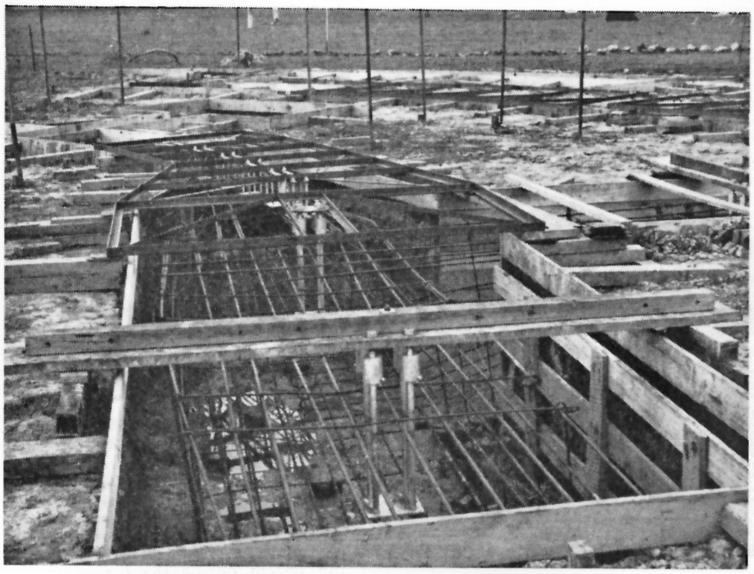

Fig. 6.—Foundation Excavations showing Bolt-holding Jigs.

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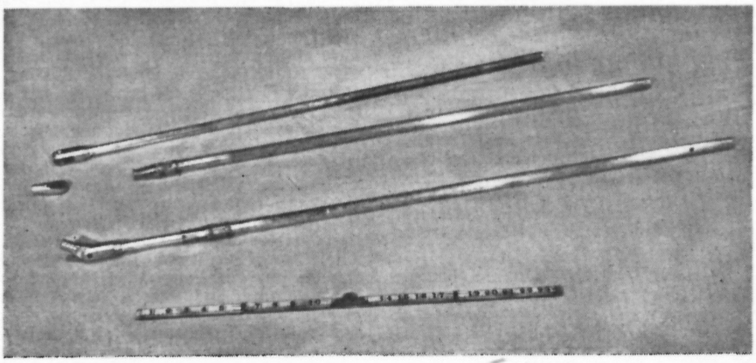

Fig. 8.—Telescoping and Pivot Fittings.

been fixed by the control circuit design, that is, the aerial arm lifting device would require a strong brake to hold the arm in position without slip, and both the aerial and transmitter arm driving units would require three phase motors to conveniently obtain the reverse drive.

One of the authors of the companion article was instrumental in suggesting both types of units. The novel way in which the transmitter arm was driven and a detailed description is given in the article. Fig. 5 shows a transmitter arm drive unit in position.

5. Structural Layout and Design

The design of the structure for the switch was one of the major problems of the project and is also dealt with in the companion paper. It is sufficient to mention here that extremely fine tolerances were necessary. Steel columns, 22 feet long, had to be straight within $\frac{1}{8}$ inch over the full length. Rails to support the transmitter arm required an accuracy for the 25 feet radius of $\pm \frac{1}{8}$ inch. In the foundations for the structure, a similar order of accuracy was required. A surveyor was engaged in order that the relatively complicated foundation was placed accurately, and braced steel jigs were used to position the foundation bolts in the correct positions in the excavation before the concrete was poured, as shown in Fig. 6.

6. R.F. Fittings

A number of specialised fittings were required for the transmission lines. These were:

1. A pivoting joint in the conductors, located at the point where the transmitter arm pivoted.
2. The actual R.F. contacts which meet at the centre structure when a selection is made.
3. Telescoping fittings at the outer structure needed to take up the variations in position of the outer end of the aerial arms, as the inner end moves vertically on the centre structure.
4. Pivot joints to allow for variation in angle from the horizontal at the outer end of the aerial arm as it is raised or lowered. These fittings would be the same as for the transmitter arm pivot point.

The joints designed to provide pivoting were of simple fork and eye configuration, sweated into the ends of the copper tube conductors. It was thought desirable to attach a flexible strap across the joint to ensure proper conductivity in case the contacting surfaces of the joint became tarnished with weathering. This was simply a precautionary measure as the contacting surfaces should be self-cleaning.

The design of the actual switching contacts was influenced by the following considerations:

1. As the operational sequence required that the aerial arm be raised to meet the transmitter arm, the shape of the contact should allow this condition.
2. The contacts must be capable of carrying R.F. currents of the order of 30 amps. and corona must not occur.
3. The contacts should not be excessively large if impedance irregularities were to be minimised.
4. A tolerance of $+ \frac{1}{4}$, -0 inch was required in the mated position.

Experience with the Lyndhurst switch indicated that a point contact, under sufficient pressure, was quite efficient, reliable and capable of carrying the required R.F. current. An advantage of this type over a flat configuration was that the contact was definite and was not prone to small arcs as would occur if flat contacts did not engage correctly. The final form of the contact is shown in Fig. 7.

The principle of telescoping fittings was accepted when initially determining the operation of the aerial arm. Telescoping sections had been successfully used in the 100kW transmitters at Radio Australia for many years and had indicated that the operating currents could be handled adequately. The fittings were carefully designed to ensure that proper contact was made between the sliding surfaces. Because of the nature of the fitting, a single, high pressure contact was not possible, and a number of low pressure points were provided. The final fittings provide a maximum travel of 20 inches, this being the variation at the rear end of the aerial arm. The telescoping fittings are described in detail in the companion paper, and are shown with the pivot fitting in Fig. 8.

7. Switch Reliability and Testing of Prototype Switch

The relatively simple forms of switch driving methods, fittings and control circuits indicated that the reliability that could be expected from the switch would be good. The control system operated on a "fail safe" basis, that is, in the event of a component failure or power failure, the resultant condition would be safe. In addition, protection against spurious earth faults in the control circuit was obtained by placing all relay and contactor coils at the earth end of the circuit. Reliability of the operational sequence and all components was ensured in a thorough testing programme, described later, although the

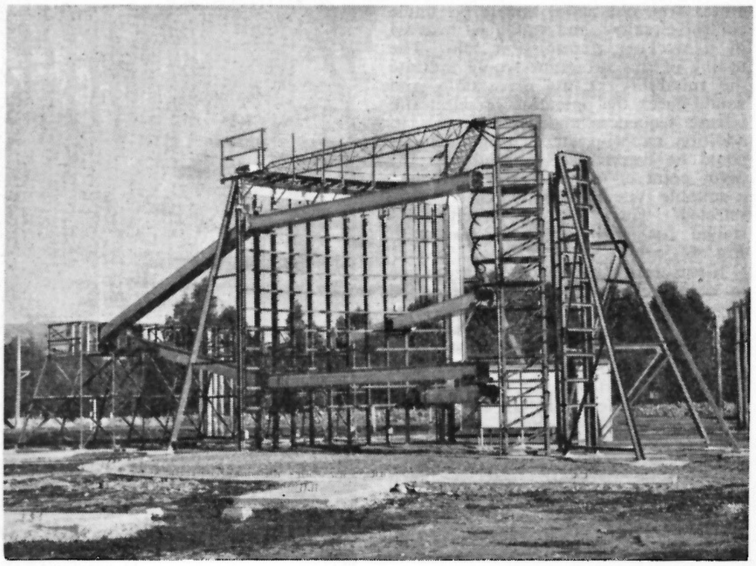

Fig. 9.—Partially Completed Switch Structure equipped for Testing.

tests performed in all cases were carried out during developmental stages.

The first important tests were static in nature and were performed on a sample arm which had been obtained. The tests were:

1. The measurement of the characteristic impedance of the arm with the transmission lines in position. This was to verify the calculated figures.
2. Voltage and power tests to ensure that the insulators would successfully withstand the expected transmission conditions and that the conductor diameter was sufficiently large to ensure corona free conditions.

The determination of characteristic impedance was made by the method of open and short circuit measurements. The measured value agreed with the figure calculated theoretically.

The voltage and power tests were carried out with the arm and its conductors inserted in the transmission line to an aerial. The output of a 100kW transmitter was switched to the line, and the transmitter brought gradually to full power. When this had been successfully achieved, the transmitter was 100% tone modulated, again successfully. Following this, a quarter wavelength short-circuited stub was placed on the line between the arm and the aerial, and was progressively shortened to cause a high standing wave ratio to occur in the arm. The VSWR reached was 5:1 which was not exceeded as damage to the transmitter may have occurred. This process was repeated on another transmitter frequency, and all tests were completely satisfactory. These tests had the effect of producing voltages in the arm considerably greater than would be experienced under normal operation.

In order that more extensive testing could be performed it was decided to build a "one by one" prototype switch. This would be equipped with one transmitter arm, one aerial arm, drive units, control circuitry, and would be inserted in a working transmission line. The testing of this prototype would indicate the suitability of the drive units and would check the operation of select and release sequences under repetition. In addition, appropriate wiring methods could be determined, especially at the pivot point of the transmitter arm and a suitable type of limit switch could be selected. The prototype structure installed for field testing is shown in Fig. 4.

It was not possible with the prototype to obtain confirmation of the expected operation of the switch over the large matrix area of the final structure on which the very fine tolerances were concerned. In order for this to be done, the first quarter of the structure was erected initially, that is 9 positions, and equipped with three hoists, four drive motors and seven arms. This allowed the following tests to be performed:

1. Operation of the arms over the much greater area of the structure.
2. Operation of control rods, which for the large structure were obviously much longer and heavier than for the prototype.
3. Measurement of R.F. coupling between adjacent arms and between arms and switch frame.
4. Measurement of the effect of insertion in transmission lines.

With automatic remote control installed, the operation of the switch was observed over the matrix area. A number of mechanical improvements were indicated which later led to minor changes in some components, and a number of techniques were developed to ensure correct alignment and adjustment procedures.

In order that R.F. coupling between lines through the switch could be measured under the worst possible conditions, two of the aerial arms and two of the transmitter arms had been installed in adjacent positions. Coupling figures were measured by connecting these two transmitter arms to the two aerial arms, thus representing adjacent transmitters connected to adjacent aerials. The values of coupling were measured at frequencies from 6 Mc/s to 26 Mc/s and averaged approximately 57db. A figure better than 50 db is considered satisfactory. In order to observe the behaviour of the steel work and other metal fittings from the point of view of induction effects, three transmission lines were connected through the switch, and normal transmissions operated. Steel members, and especially switch arms, were examined but were found to be free from induction, as was control and power wiring. The effect of continuous transmission on line fittings and contacts was found to be negligible, and only a few degrees rise in temperature was noted on contact faces and telescoping joint fingers.

The effect of the insertion of the switch in the transmission line was determined by the measurement of standing wave ratio on both aerial and transmitter sides of the switch. Adverse effects would appear as a degradation of this

Fig. 10.—Completed Aerial Switch.

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ratio. The results were as shown in Table I.

TABLE I

Frequency Mc/s	VSWR	
	Aerial Side of Switch	Transmitter Side of Switch
7.22	1.7	1.7
9.58	1.43	1.56
11.74	1.14	1.14
15.315	1.45	1.47
17.84	1.3	1.5
21.6	1.49	1.54

The structure equipped for this series of tests is shown in Fig. 9.

Following the conclusion of these tests the first section was fully equipped with arms, hoists, motors and associated wiring, incorporating the modifications found necessary. The three additional sections forming the complete switch were manufactured, installed, and the control desk in the main transmitter hall was wired and tested thoroughly. Fig. 10 shows the completed switch, and Fig. 11 shows the remote control desk.

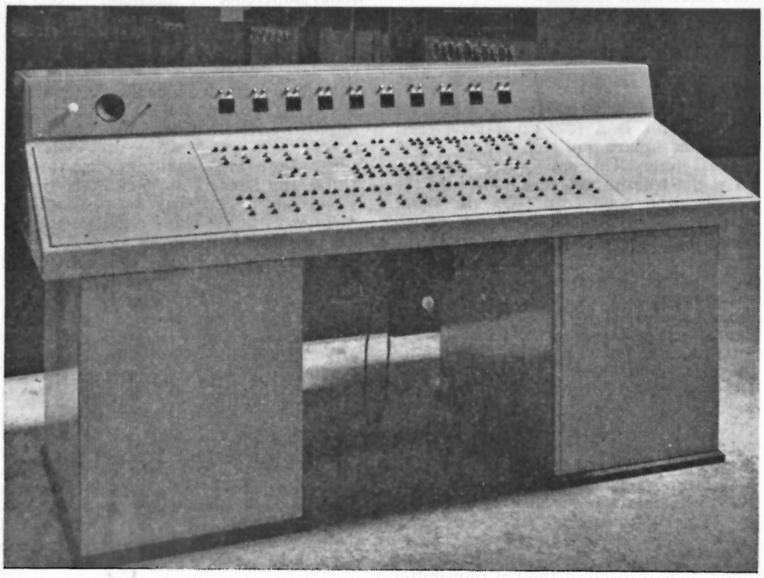

Fig. 11.—Aerial Switch Control Desk in Transmitter Hall. All switching operations are carried out from this location and the final selection is indicated on the panel.

CUTOVER PROCEDURES

The introduction of the switch had to be performed without affecting the normal operation of the station. Careful planning was therefore necessary in the various stages of the cutover to ensure that this requirement was met, and that completely satisfactory, highly reliable service would continue after the point of no return in the cutover was passed. Extensive preliminary re-arrangements of transmission lines were performed and a number of switches in the original system were re-located to give access for the new lines.

The most important part of the cutover and the point of no return was the complete elimination of one of the switching groups, after which individual aerials were connected to the corresponding outlet on the matrix switch.

CONCLUSION

The problem which initiated this project was unique in Australia. There was no precedent available for assistance in the design work with the exception of the smaller switch at Radio Lyndhurst, and the operating sequences, control, structure and all fittings had to be designed by staff of the Postmaster-General's Department. The major items of structure, hoists, motors, arms and limit switches were obtained by contract to P.M.G. specifications.

ACKNOWLEDGMENTS

The author wishes to express his thanks to the Drafting Section for their work on the mechanical design of the switch and to engineering colleagues for their assistance. Special credit is due to the Radio Australia construction and line staffs who were responsible for the difficult installation of the switch and associated line work. This paper is based on material which was delivered to the Institution of Radio Engineers Convention 1962 in Sydney.

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THE NEW AERIAL SWITCHING SCHEME AT RADIO AUSTRALIA, SHEPPARTON— MECHANICAL AND STRUCTURAL DESIGN

L. C. GEMMELL and J. M. FULLARTON†*

INTRODUCTION

A companion paper (Ref. 1) in this issue has detailed the requirements which brought about the development of the switching scheme and dealt with the electrical aspects of the design. In this article, it is intended to outline the mechanical and structural design and highlight some of the problems peculiar to a structure of this nature for which close tolerances are essential. Previous experience had been obtained in the mechanical work associated with a switch operating at lower power and manually operated (Ref. 2). The new switch, however, was to be mechanically operated by electric motors remotely controlled from the transmitter building. The electrical requirements resulted in a much larger and heavier structure, and the mechanical design dictated very close tolerances and a degree of precision seldom required in construction work of this nature.

DESCRIPTION OF THE SWITCH

The new aerial switching system for Radio Australia, Shepparton, was required to provide for the interconnection of any one of ten transmitters to any one of thirty-six aerials. The switch was to be used in an outdoor environment without weather protection and is shown in schematic form in Fig. 1.

The conductors in the switch consist of a pair of $\frac{3}{4}$-inch diameter by 18 s.w.g. copper tubes spaced 7 inches apart. To prevent interference between pairs of conductors, each pair of conductors is carried in a twenty-five feet long screening tube called an arm, made of formed plywood faced inside and out with aluminium. On the transmitter side of the structure there are ten of these arms which move in a horizontal plane. On the aerial side there are thirty-six of these arms which move in a vertical plane.

* See Page 81
† See Page 82

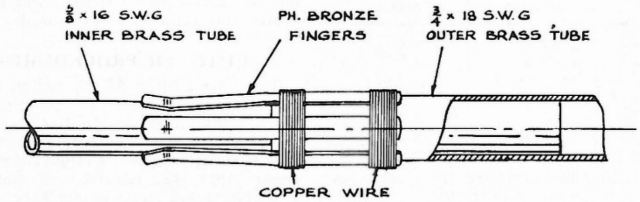

Fig. 2.—Sliding Contacts used in Switch.

The actual structure can be divided into three main sections:

(a) The Transmitter Terminating Frame.
(b) The Switching Structure.
(c) The Aerial Terminating Frame.

A description of the structures is as follows:

(a) **The Transmitter Terminating Frame:** This is a fabricated steel mast 36 inches square and standing 23 feet 8 inches high. On one side, the wires from the transmitters terminate into the copper tube conductors. On the other side are the pivot positions for the horizontal arms. The mast is braced at the top by five struts of a tubular steel construction which connect it to the switching structure. To avoid distortion in the mast due to tension in the 600 lb. copper conductors from the transmitter, a terminating frame is placed just behind the mast. This takes all wire loads and slack connections are made to the mast itself.

(b) **The Switching Structure:** This is a curved grid of steel work standing on a concrete base and braced at each end and at intermediate points by built-up steel structures. The radius of curvature is 25 feet $9\frac{5}{8}$ inches, and the structure stands 28 feet high and spans approximately a full semi-circle. The outer ends of each of the ten transmitter arms are supported on two ball-bearing wheels which run on ten curved rails bolted to the structure, one above the other. The arms are driven by $\frac{1}{2}$ h.p. geared electric motor units. As frictional adherence of the plain wheels on the rails would not be sufficient to overcome resistance in high winds, the drive is by a rack and pinion arrangement. The rack consists of a $\frac{5}{8}$-inch pitch single roller chain fixed alongside the rail and this is engaged by a chain pinion on the output shaft of the motor unit. The motors are fitted with very effective solenoid-operated multiple disc brakes which stop the arm as soon as the power is cut off. This has been found to operate with an error of less than a quarter-inch of travel.

The thirty-six vertical arms are guided by nylon wheels which track in between the flanges of the I beams. They are raised and lowered by wire rope wound on individual hoist motors which are mounted on the top of the switching structure. These motors have solenoid-operated band brakes which operate as soon as the power is cut off.

There are thirty-six control rods mounted to the frame. The control rods are of tube and have flags fixed to them at specified intervals to perform various operations as explained later in accompanying diagrams. The rods are lifted $3\frac{3}{4}$ inches and rotated through 60°. Each rod is hydraulically damped on its return stroke.

A ladder is positioned at the rest position end of the structure and serves to provide access to the ends of the transmitter arms for servicing motors and contacts. It also provides access to the catwalk around the top of the structure which allows for maintenance of the hoists.

When the selected transmitter arm rotates around to its required position and the appropriate aerial arm is brought up to meet it, a pair of contacts come together and the switch is ready for transmission. The actual contacts consist of a pair of silver-tipped brass domes which mate on elliptical phosphor-bronze springs. These springs are wide enough to permit a positional error of approximately $\frac{3}{4}$-inch either vertically or horizontally.

(c) **The Aerial Terminating Frame:** This consists of a series of steel frames 12 feet 7 inches high, joined together in an arc of 48 feet 10 inches radius. The lines from the aerials terminate on this frame and, as each line consists of four 600 lb. copper wires, considerable loads are imposed and substantial concrete

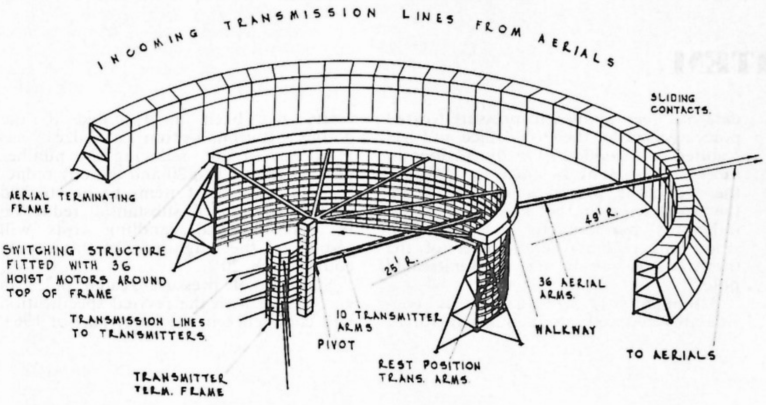

Fig. 1.—Schematic Form of Matrix Aerial Switch.

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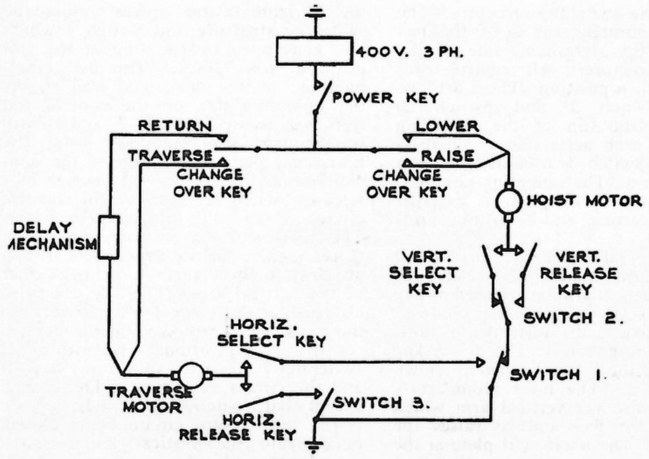


Diagram 1.

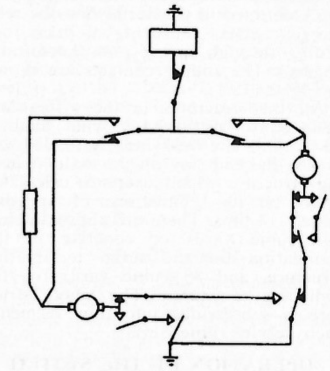
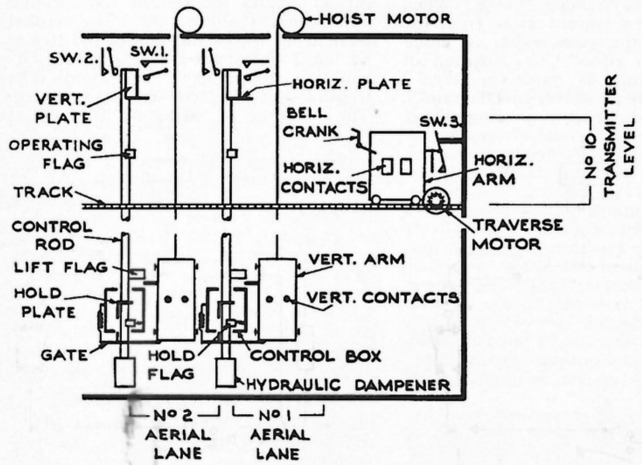


Diagram 2.



Stage 1.

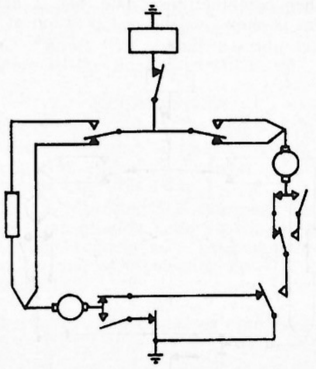
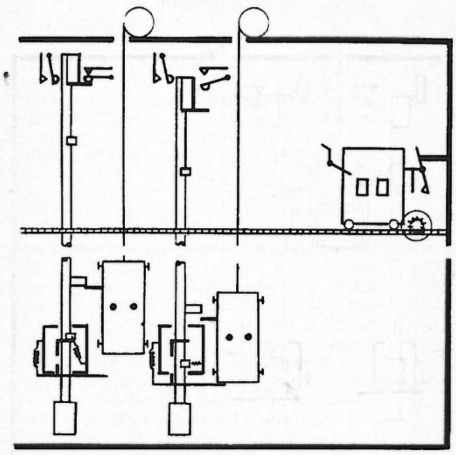
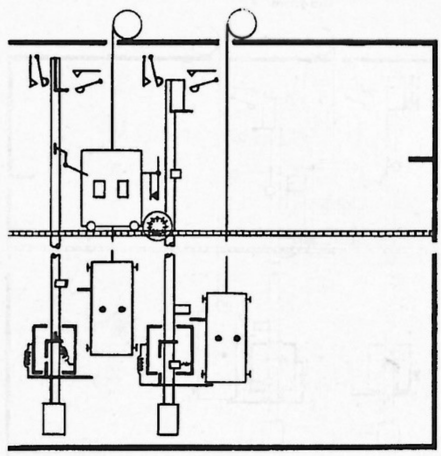


Diagram 3.



Stage 2.



Stage 3.

Fig. 3.

foundations are required. The outer ends of the aerial arms are supported on nylon wheels running on rails, allowing a horizontal movement as the inner end is raised and lowered. The conductors are connected to the aerial lines by telescopic contacts consisting of brass rods sliding through spring phosphor-bronze fingers. The sliding contacts are shown in Fig. 2.

All the structures in the system are designed to withstand a wind load of 80 m.p.h. The most heavily loaded section is the end stay on the main switching structure which exerts a calculated uplift on its foundations of approximately 14 tons. There are approximately 107 cubic yards of concrete in the foundation for the aerial terminating structure, and 85 cubic yards for the switching structure. The whole structure is sub-divided into four segments, each serving nine aerials.

OPERATION OF THE SWITCH

The sequence of events in the operation of the switch can readily be seen from the sketches, Stages 1 to 5 and Diagrams 1 to 6 which comprise Figs. 3 and 4. As an example, these show the switching of No. 10 transmitter to No. 2 aerial. Similar sequences occur for all other combinations. The No. 2 aerial arm is shown at the rest position at the bottom of the switching structure. The No. 10 transmitter arm is at the rest position at the right-hand side of the switching structure. All control rods are in the down position. There are two switches (Switch 1 and Switch 2) mounted at the top of the switching structure in each aerial lane. There is one switch (Switch 3) mounted on each horizontal arm. The operating circuit is then as shown in Diagram 1, and the position of vertical and horizontal arms as in Stage 1.

The horizontal select key for No. 10 transmitter arm and vertical select key for No. 2 aerial arm are closed. The changeover keys are switched so as to raise and traverse the vertical and horizontal arms respectively. The power key is closed and the circuit is then as shown in Diagram 2. The hoist motor commences to raise the vertical arm which strikes the lift flag and so raises the control rod. The horizontal plate at the top of the control rod strikes Switch 1 and opens the hoist motor circuit, thus stopping the motor. The power is now supplied to the traverse motor. When the vertical arm moved away from the control box, the gate which is under spring tension closed. The position of switching is then as shown in Stage 2 and the circuit as shown in Diagram 3.

The traverse circuit now being closed, the horizontal arm moves across the switching structure and Switch 3 which was kept open by the stop at the rest position now closes. The bell crank mounted on the horizontal arm strikes the operating flag on the control rod (this was set up in Stage 2) and rotates it through approximately 30°. The horizontal plate at the top of the control rod having also moved through 30°, releases Switch 1 and opens the traverse circuit which stops the traverse motor. The horizontal arm is now in position to receive the vertical arm. The lift flag attached to the control rod moves clear of the vertical arm. The hold flag also attached to the control rod moves onto the hold plate thus keeping the control rod in the up-position. The position of switching is then as shown in Stage 3 and the circuit as shown in Diagram 2, except that Switch 3 is closed.

The hoist motor circuit being closed, once again the vertical arm restarts, moving upwards. On reaching the horizontal arm, the projection on the vertical arm strikes the bell crank which further rotates the control rod through approximately another 30°. The vertical plate at the top of the control rod strikes Switch 2 and opens the hoist motor circuit thus stopping the hoist motor. The transmission contacts are now mated. The position of switching is then as

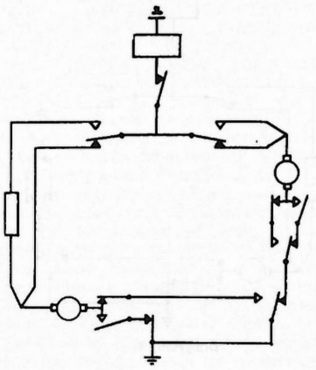


Diagram 4.

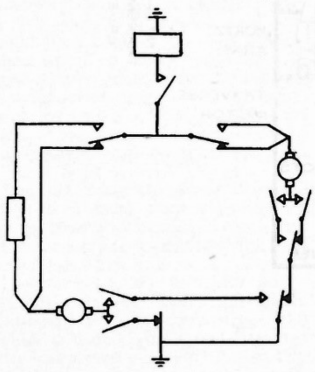


Diagram 5.

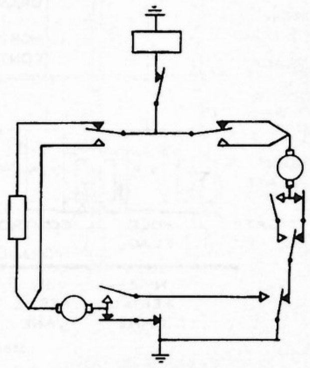
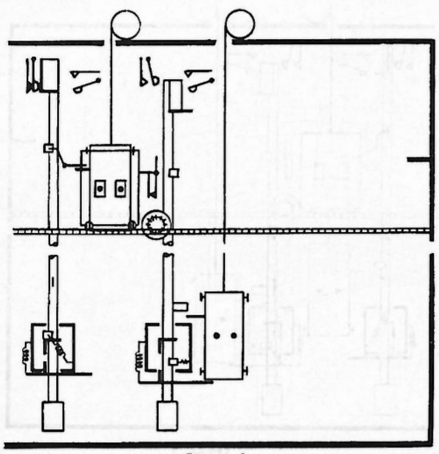
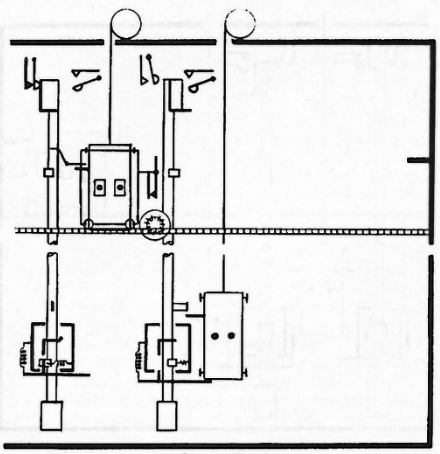


Diagram 6.



Stage 4.



Stage 5.

Fig. 4.

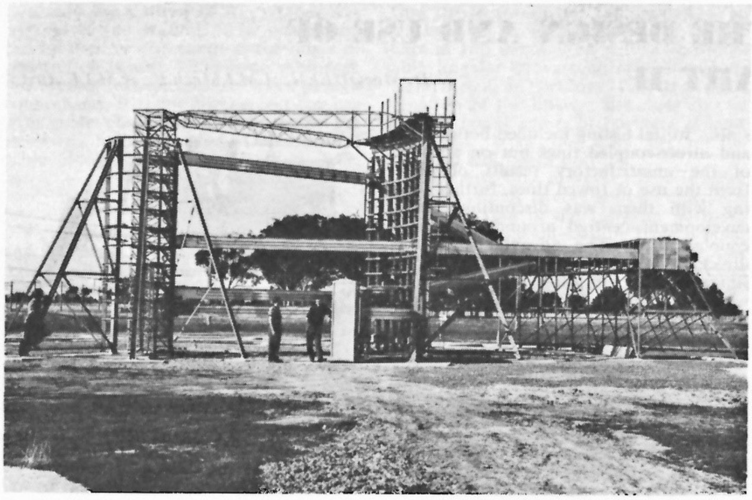


Fig. 5.—View of Partially-built Switch (10 x 9).

shown in Stage 4 and the circuit as shown in Diagram 4. The hold flag having moved through another 30° also now over-rides the hold plate, thus allowing the control rod to drop to the down position. The control rod is held from returning to its original position by the gate and in this position ensures that Switch 2 is kept open. The position of switching is then as shown in Stage 5 and the circuit remaining as shown in Diagram 4.

The power key is opened. The horizontal and vertical select keys are opened. The circuit then is as shown in Diagram 5. All is now ready at the switching structure for the transmission from No. 10 transmitter to No. 2 aerial.

RESTORATION OF SWITCH

The horizontal and vertical release keys are closed by the operator. The changeover keys are switched to lower and return the vertical arm and horizontal arm respectively. The power key is closed and the circuit is then as shown in Diagram 6.

A delay mechanism in the traverse circuit delays power to the traverse motor until the vertical arm has lowered sufficiently to break the electrical transmission contacts. If this were not done damage could result to the contacts. Both vertical and horizontal arms are now moving towards their respective rest positions. The vertical arm on reaching the rest position strikes the gate depressing it, thus opening it and allowing the control which is under spring tension to rotate back home through 60°, opening Switch 2 which stops power to the hoist motor. The vertical arm is now at the rest position. Switch 3 mounted on the horizontal arm strikes the stop at the rest position thus opening the traverse circuit stopping the traverse motor. The horizontal arm is now at the rest position. The power key is opened. The horizontal and vertical release keys are opened. The changeover keys are returned to neutral. The position of switching is then as shown in Stage 1 and the circuit as in Diagram 1.

STRUCTURAL DESIGN

At a preliminary stage of the design it became obvious that extremely small tolerances would be necessary in the complete switch structure, and this would require an accuracy of working which is normally seldom attained in work of this nature. Indeed, the achievement and maintenance of very close tolerances has been one of the major problems of the design of the structure. It was necessary to ensure that steel from commercial suppliers was straight to within a small fraction of an inch over the entire length or was appropriately straightened to the required degree.

The tolerances in position of the completed structure also were required to be very small, and some mention has been made of this in an earlier section of this paper. It might be mentioned also that the curved rails to support the transmitter arms were to be positioned to an accuracy of ± $\frac{1}{8}$-inch at a radius of over 25 feet over the full arc of nearly 80 feet. As the operating structure was located outdoors in an inland location subject to wide variation in ambient temperatures, the effects of such variations on constructional materials had to be fully considered in order that the tolerances would not be exceeded under temperature extremes.

CONCLUSION

The design of the mechanical and structural details was carried out by the drafting personnel at the Workshops Drafting Office while the electrical and transmission details were carried out by the personnel of the Radio Section. The collaboration between the two Sections was excellent, and contributed a good deal to the successful completion of the project.

The first stage of the switch (10 transmitters to 9 aerials) shown in Fig. 5 taken on May 11, 1961, was completed despite considerable operational difficulties. Fig. 6 taken on September 12, 1962, shows the project nearing completion to the final stage (10 x 36).

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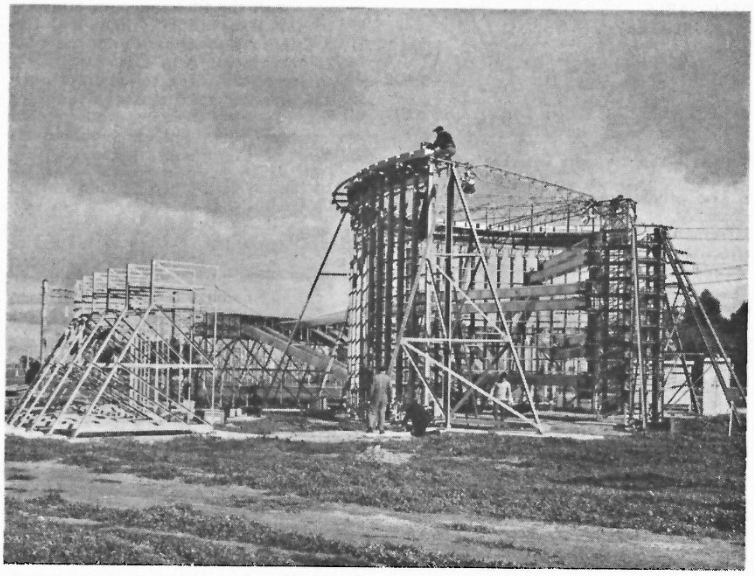

Fig. 6.—Putting Finishing Touches to Complete Switch (10 x 36).

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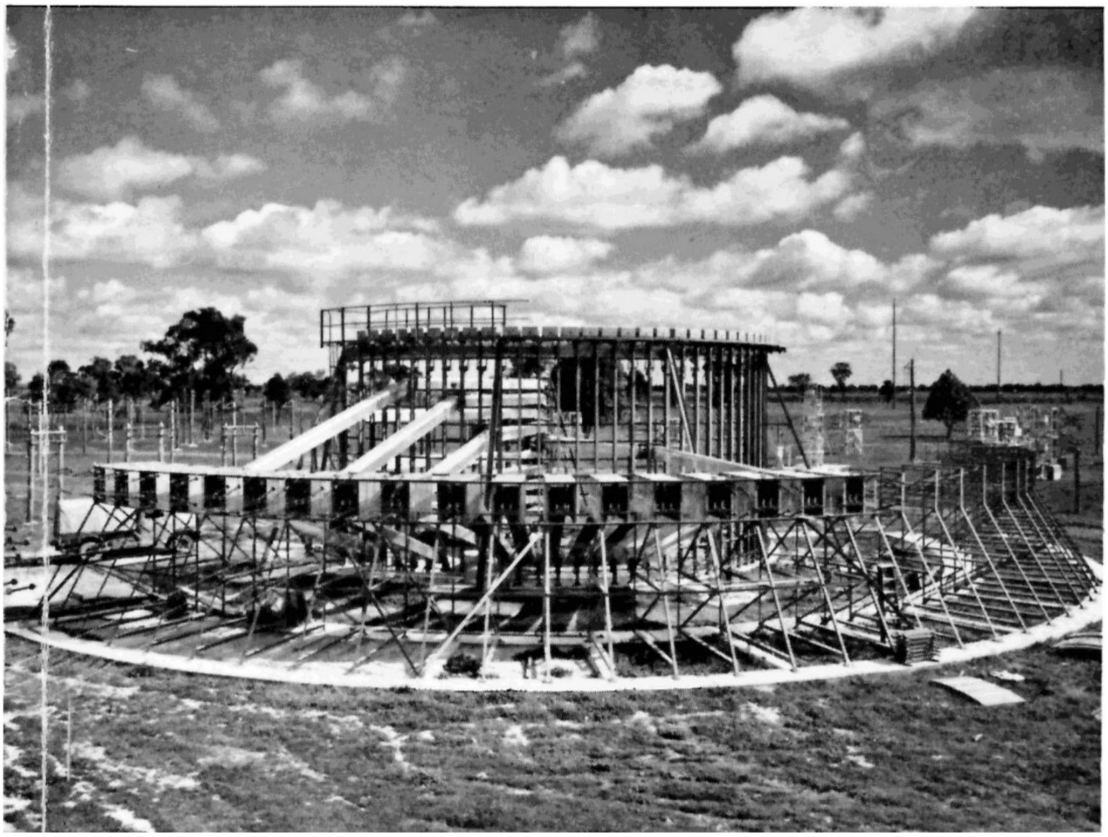

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