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# Assessing the Readiness of Future Network Cyber Infrastructure in Malaysia– Part-2: Challenges, Opportunities and Recommendations

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"Imagine a world where everything that can be connected will be connected - where driverless cars talk to smart transportation networks and where wireless sensors can monitor your health and transmit data to your doctor."

Ajit Pai, Chairman of the United States Federal Communications Commission.

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## 1.INTRODUCTION

Digital transformation is upon us. Industry 4.0/5.0, 4G LTE/5G, Internet of Things, AI, Smart City to Blockchain, are initiatives- though originated from divergent techno-evolution threads and advanced by seemingly very different communities- yet all are phenomena of the same underlying digital transformation. All the threads of this transformations, irrespective of their origin of drive however will require one convergent thing at the core- a capable and robust national cyber-communication infrastructure (NCI).

Are NCIs ready for it? By design 5G will require a radically expanded edge network infrastructure than needed by any previous mobile generations. IoT is expected to suddenly bring estimated 75 billion devices in next 5 years to internet. Every major public infrastructure and every private asset (not only every home but every appliance in them!) will have their pulse in the internet. Smart Communities will emerge as a new set of citizen centric cyber-physical digital services aimed to improve every aspect of community living. In short years, community governments around the world will be active and forceful political driver in the digital eco-system. Artificial Intelligence (AI) driven networked applications will gain autonomous decision power on sensitive aspects of our life from personal safety to societal justice and equity. Industry 4.0/5.0 will digitize manufacturing. Blockchain is poised to disrupt too many business processes in too many sectors from banking & finance, manufacturing supply-chain, medical to voting management. Cloud infrastructure has already bifurcated world internet traffic reshaping global IT systems. Today more private traffic flows between data and computing centers than in public internet.

In this back drop, the NCI in most countries are deeply reflective of past than ready for the future. Except for the very top ones, NCI's are built mostly around past 20$^{th}$ century telecommunication industries network infrastructure, TV and voice telephony dominated radio spectrum, and some infrastructure of internet service providers. The management of old world NCI is guided by old regimen of voice spectrum licensing, and weak or non-existent data usage or citizen's basic data protection policies. The telecommunication regulatory ecosystem has marginal participation by the players of the new economy if any. To take full advantage of the Industry 4.0/5.0 or as a digital nation, a country requires significant drive to update its national communication infrastructure into cyber-communication infrastructure with bold transformations in the management of the new eco-system. We will refer to it a National Cyber Communication Infrastructure (NCCI).

The impending technological tsunami creates very interesting challenges for any NCIs. For Malaysia, the case is compelling. The bold 11th Malaysia Plan explicitly

spells out her national aspiration- to bring her in the rank of the very advanced nations of the world. The yardstick is based on 'rakyat' i.e. the all-round wellbeing of its people and community. It's an ambitious goal for a five year plan. Whether it is achieved in 5 or 20 years, undoubtedly digital transformation will be key to achieve almost any pillar (it has six) of this grand initiative. To zero in further, the success, failure and speed of this journey will necessitate a capable national cyber-communication infrastructure (NCCI) at the heart.

### 1.1. OBJECTIVE

The objective of this study project originally envisioned by colleagues of MCMC's TDC is to determine the current state of communication and multimedia infrastructure in Malaysia and generate recommendation for the future network readiness of the country.

It is envisaged that the study will promote strategic assessment of networks planning, development and monitoring and enhance MCMC's Communications and Digital Ecosystem Sector's opportunities for engagement and collaboration with key stakeholders to provide greater impetus for the movement towards developing a national strategy to balance investments in technology and infrastructure with investments in the skills and knowledge Malaysian need to use ICTs to improve the quality of their lives, increase productivity throughout the private and public sectors and develop innovative products and services.

The outcome from the project is intended to form part of the collective body of knowledge and information resources needed to support MCMC Technology Development Department' s advocacy role on emerging and future networks specifically, as well as MCMC's role in handling the many complex challenges in regulating and managing the ICT impacts of on society.

### 1.2. SCOPE

There are 4 main objectives of the project:

Assess readiness – propose methodology(s) that could assess the future readiness of our current networks platform in supporting the ubiquitous digital and electronics services.

Identify challenges and opportunities – gather information from relevant stakeholders to identify where are the gaps and challenges, and as well as new opportunities, that arises in deploying emerging technologies for the future network.

Establish future network requirements – determine the necessary elements to make Malaysia future ready towards becoming a smart digital nation.

Facilitate stakeholders – analyze how MCMC can assist the stakeholders in achieving the communication and multimedia objectives of the 11th Malaysia Plan as well as our National Policy Objectives.

## 2.STUDY PROCESS

The study was commissioned in the summer of 2017. The study benefits from an extensive on the ground fact finding effort. The author convened a study team formed with officers from MCMC's Technology Development Department (TDD), area specialists from MCMC, and a focus group representing the current NCI eco-system identified my MCMC.

The focus-group included five leading communication provider organizations. These providers are deemed by MCMC as the main players in Malaysia's telecommunication industry. Together these companies represent roughly 80% of Malaysia's current telecommunication industry by revenue and they also manage roughly 80% of commercial radio spectrum. The focus group also included representative national research organizations MIMOS, the University Putra Malaysia's (UPM) next generation telecommunication systems research group, and Malaysia Multimedia Universities (MMU) Smart home group.

The study team took a three pronged approach. The first instrument is the discussion and knowledge exchange. Half day meetings were conducted with the focus group organizations. More than 50 Malaysia experts- including executives, planners and engineers, from the regulatory experts, academics, and researchers made presentations, provided both issue specific presentations, and participated in intensive discussion sessions. Each group provided their insight into the issues through discussion on topics including the a) current state of telecommunication infrastructure, b) about their vision, plan and activities on 5G, b) services for smart community, c) Internet of Things (IoT), d) network virtualization, and e) data centers and cloud services. Secondly, a national seminar on Future Network for Smart Digital Malaysia was conducted. It was participated by 200+ experts from all the stakeholder organizations from industry, academia, and government. Thirdly, a written survey was conducted with the focus group organizations. The focus group were asked to answer 25 questions regarding all aspects of this study. The result is based on the finding and the input from these activities.

> "The best way to predict the future is to create it."
>
> -Abraham Lincoln, The 16th President of USA

This document is second of the two documents produced. The first document provides the result of the survey. This document identifies the challenges and

opportunities and finally generates the recommendations for Malaysia to be better prepared for FN but does not establish the requirements.

The recommendations and suggestions are not to be taken as concrete roadmap. Each of the issues identified requires daunting ground-work and meticulous planning. It is only intended to provide a preliminary guidance where such work might begin as Malaysia's aims for a FN capable NCCI.

## 3.FINDINGS AND RECOMMENDATIONS

Future network is a rapidly evolving technology participated by many diverse players. Unlike 4G where mobile communication and broad-band companies played the key roles- the Future Network ecosystem will see expanded eco-system with major players including CKD (content-knowledge-and-data) organization, as well as public-entities-as-service-and-infrastructure-providers.

### 3.1. GLOBAL PERSPECTIVE

Overall Malaysia telecommunication industry has consistently and robustly ranked in the top third tiers[1] or better in the decade in many surveys. As per the late 2018 surveys, Malaysia's mobile smartphone coverage is reported as around 66.4% of her total population (ranked in top 25) [1]. For reference UAE leads the world (with 84%), while Japan (51%) and Thailand (51%) in the region.

An increasingly important issue is internet infrastructure's quality and health. Though there is not good comparative data sets, Pinger data was evaluated as measures of Internet health. It is a live, collecting wide range of statistics 24/7 over a decade. These Pinger indicators also point to a relatively healthy Malaysian's (low communication delay, packet loss, and good overall availability of Malaysian IP sites. Its ranks are around top 20-33% among all the countries around the world). [2].

However, it is the trajectory of the indicators where Malaysia need to work on. Countries traditionally trailing are also catching up fast adopting the best practices from their advanced peers. As a result, in last few years Malaysia's, smart phone ranking has fallen off from 10th to 21st. Similarly the current Internet Penetration Rank (IPR) for Malaysia is around 84%. The number is strong but the rank is around 80th based on latest 2017 data.

While fundamentals are right, it also indicates there are potent areas for Malaysia to rethink and improve its national NCI strategy- with understanding what it achieved, what it could not, and where it need to be in the next decade. The

[1] There are many organizations which track global standing of telecommunication service indicator such as Internet End-to-end Performance Measurement (IEPM), Federal Communications Commission (FCC), International Telecommunication Union (ITU), etc.

remaining gaps are hard to crack and very likely cannot be amended simply by prevailing strategies. I will discuss the avenues soon.

More than that, Future Network (FN) would require a quantitative change in old telecommunication management plan. The change will be well beyond the deployment of spectrum i.e. 5G. The game changers are i) skyrocketing demand for cloud services, ii) emergence of data driven smart communities, iii) one by one flourishing of Industry sectors that embrace Industry 4.0 and 5.0 principles; iv) deployment of billions of networked Internet-of-Things. These change agents are not independent- rather will have complex synergistic interplay.

Demand for responsiveness, emergence of massive data intelligence based applications requires a highly capable and reliable cyber infrastructure where data storage and processing are increasingly deeply embedded into conventional telecommunication network making way for a new generation of digital applications beyond voice and video.

Pioneering countries to look at include US, China, Japan, Taiwan, South Korea, Singapore, Netherlands, India, Sweden, Australia, etc. There are multi-tier plans to enter into the future network fray announcing very interesting pilot programs to take the leadership in various FN areas. Many are deploying testbeds in the FN areas; there are model initiatives for smart city and smart community programs, plans for massive IoT service deployment; planning of Industry 4.0 zones. As evident in the responses in the 2017 survey Malaysia seems to be relatively inactive in these new frontiers areas in comparison.

## 4.CHALLENGES AND OPPORTUNITIES FOR MALAYSIA

### 4.1. GEOGRAPHIC COVERAGE

As Malaysia strides to make its transition into NCI Future Network ready, for creating an ecosystem of next generation transforming IoT services, a national road block Malaysia will be facing, like few of its peer nations, is the poor national geographical coverage. Malaysia does not have public communication coverage over a vast swath of its national territories with major void even in central Malaysian peninsula. For a longtime the investment focus was on covering the population centers along the peninsular coastlines. The survey did not get responses back on the exact status of geographical coverage[2].

Rough inspection seems to indicate astoundingly over ~72% Malaysian national ground territory seemingly has near zero coverage. The presentations by the research groups revealed the difficulty poor geo-coverage created. Researchers

[2] All companies were found shy of reporting their geo-coverage numbers.

pursing scientific projects (coastal plantations, are soil erosion containment, environment monitoring, etc.) reported lack of radio connectivity in interior areas.

These are early indicators of more potential problems to come. With IoT devices will come a wave of applications among which a major class will be in IoT remote-sensing. Green Growth is one of the four strategies cited for the implementation of the 11th National Plan [5]. Astounding lack of radio connectivity over its vast national territory will appear as a road block when the movers will try to implement it.

As the country NCI has reached nearly 90% marks on population coverage, expansion of the geo-coverage is the worthy next frontier for Malaysia. Malaysia's hard to reach places include the vast uncovered zones of Malaysian forested highlands, coastal archipelago areas and inland waterways, and economic zones extended in sea. These areas, have low population density but are extremely rich in natural resources, economic, industrial, climactic, and geo-strategic importance.

Expansion of geo-coverage will require a distinct approach. The geo-application tends to require low-power communication, and not that much bandwidth. Ground infrastructure is expensive to reach and maintain. Four technology positions can be explored.

> "We're already a cyborg. You have a digital version of yourself or partial version of yourself online in the form of your e-mails and your social media and all the things that you do. And you have, basically, superpowers with your computer and your phone and the applications that are there. You have more power than the president of the United States had 20 years ago. You can answer any question; you can video conference with anyone anywhere; you can send a message to millions of people instantly. You just do incredible things."
>
> - Elon Musk

Lower frequencies can reach relatively longer distances with lower power. MCMC may want to accelerate the reallocation (or even better adopt newer technology enabling dual-use) of lower frequency spectrums vacating older technology in favor of IoT capable communication technologies. The vacating effort should be prioritized in hard-to-reach zones. The low density 1G and 2G subscribers in small town/village enclaves can be moved in other frequencies (with 4G LTE) with relatively low investment.

Some military and non-commercial low frequency spectrum can also be eased up for national geo-territory asset protection and monitoring applications and for national university research projects that would support similar goals.

There are promising sky based technology near commercialization. MCMC, in cooperation with universities may setup testbeds in each of these zones for

technology. One such is Alphabet Inc.'s Loon (by Google). It is already experimenting with several countries to provide mobile connectivity from the sky with no ground infrastructure.

Finally, there are also new technologies in the horizon based on ultra-low frequency (ULF) communication that can reach continental-scale long distances. MCMC can pioneer technology testbeds with collaboration with the universities for national interest. The expansion of geo-coverage if addressed will also mitigate the age old rural telecommunication access problem.

### 4.2. NETWORK INFRASTRUCTURE

The FN will require investment in new infrastructure which can be quite daunting. NCI and 4G will need expansion and modernization of underlying radio infrastructure in the cities and localities around the country.

The additional cause at hand is the 5G. 5G proponents envision that new and short wavelength spectrum to be opened up to support the huge data need by the increasing internet users and devices in range 30GHz to 300GHz (where as the wavelengths are in mm range)- a key feature of 5G. However, the issue is more complex. Such mm waves can't easily travel through buildings or obstacles and it is almost always absorbed by foliage and rain. It cannot travel long distances in too many scenarios. Thus almost obviously it will require the densely placed deployment of miniature radio cell like elements in service areas of today's macro base station (MBS). Though the final architecture and functionalities will evolve but it will require combination of smaller cell structures including femtocell (10-20m), Picocell (200m) and today's Microcell (2km). Small cells are easier to stick on poles and atop buildings. Yet 5G generation will require deployment of 4-100 times more radio access points than required by all previous mobile generations together.

Many of these radio access points will also need back haul fibers. These fibers will need ducts to get access through buildings, localities, local, rural and national alleys, roads and highways, private and public lands. These also needs walls, towers, lands for tower, rooftops of building, small and medium structures to keep the equipment, heating, cooling systems, power for them as well as equipment. These will also need manpower for maintenance and safety.

It is going to be very expensive if every 5G company has to have such infrastructure on their own- the way is has been done until now. Thus regulatory bodies such as MCMC need innovative policy orchestration. The way to go is to encourage extreme infrastructure sharing and manage expensive redundancy in steering national investment in distribution infrastructure to cover more grounds avoiding monopoly. This is quite new game.

Fortunately, there is already a forward looking regulatory impetus in Malaysia for encouraging infrastructure sharing. However, the survey revealed there are practical problems in the ground. Survey respondents noted some of the road blocks for rolling out 5G are high regulatory cost of site acquisition, fiber trenching, fiber leasing, spectrum acquisition, monopoly by state-backed company, slow land approval and high approval fees by state authorities. Focus group meetings also revealed that though many infrastructure components are share ready, there is still a lack of interest in leasing. The related information such as existence, location, ownership, pricing etc. are often hidden. Deployment of 5G will benefit from new leasing and colocation models to accommodate estimated 2-3 times more new radio access points in interior spaces.

Oddly, the Future Network is almost certain to bring new players and even morph the roles of the various parties in infrastructure marketplace over the next decade. Digital transformation of communities may turn townships, municipalities or even large property owners into digital service providers themselves. Notably they already hold the rights to substantial part of civil infrastructure. Explosion of IoT and asset management applications will make them more affianced customers of FN services. Is it possible that large property owners will maintain much sophisticated communication infrastructure units themselves and may make new use-case for short range (such as 5G) spectrum ownership?

MCMC should engage these new players of FN (such as property owners, land grant universities, state governments, public schools, power facilities, communities, new property developers and owners, and city planners) in next generation spectrum allocation, ownership and use model discussion. It also need to review current practices and develop a much comprehensive resource sharing models with governmental weight for encouraging sharing of civil infrastructure (duct, access rights, rooftops, real-estate, towers), so FN companies can avail them with less administrative overhead.

MCMC should also foster trading of excess telecommunication capacity generated from capital intensive assets (dark fiber strands, co-location facilities, spectrum, lambda, storage, bulk-bandwidth, etc.). Even telecommunication equipment (such as radio equipment, expensive edge switch and routers, core equipment, firewalls) are being shared in matured markets. New FN technology like NFV and SDR are coming to make the sharing easier.

Malaysian companies have begun sharing of tower infrastructure and even radio equipment (at limited scale) with encouragement from MCMC– but from the survey, it seems the trading is quite limited and its mostly a back alley market. With regulatory weight and modern technology, MCMC can bring transparency and efficiency into the infrastructure market by encouraging timely and accurate

exchange of product information (what, when, who to contact, etc.) to accelerate excess asset/capacity trading between the current companies.

Notably, this transparency in infrastructure sharing is more important for the new comers and specifically for the new Future Network constituencies. MCMC should clear the ground for a new generation of FN startup companies to enter into eco-system who will rely on the bulk telecommunication services of older players.

### 4.3. QUALITY AND CONSISTENCY OF NETWORK AND SERVICES

Malaysia has done an admirably providing a cell phone in the hand of every Malaysian. It is also a leading country is Asia in terms to internet and broadband penetration. While the services are reaching a point of saturation, the real new frontier is the quality and consistency of the services and that of the network. Product quality information is more important to consumers who have moved beyond basic scarcity. There is much less preparedness to capture and monitor the quality parameters of interest at many regulatory bodies.

Bandwidth, network delay, connection establishment time are few classical parameters for measuring the quality of network. However, these are not static quantities. These fluctuates over time. A particular dark area in network telemetry is mobility adjusted quality. Humans are mobile by nature, a person moves between their home and office in hourly and daily patterns. Then moves between their home, workplace and market places in daily and weekly patterns. People also move between urban home and rural home in weekly, monthly and seasonal patterns. Though services may be adequate in specific commercial, residential and office zones, it often falls off with individual mobility. Disconnection during hand-over, end-to-end fluctuation of bandwidth, uniformity of coverage during mobility across are the indictors of problem. The dead-zones, tower-to-tower handover, and potential lack of technical (2G/3G/4G switchover)/ business synchronization between provider's networks, opportunistic over subscription, makes user experience quite poor.

This not only matters to end-users, but also to service developers as well. Normally, cyber application developers consider the capability and consistency of the network and asses up to what level network can sustain the data need of the application. They eventually optimize for wider market. If the quality and consistency of the underlying telecommunication service is of high quality only in limited places such as urban center, but spotty in most zones- high performance applications market stalls. Thus quality and consistency of the network will be increasingly critical for FN applications to flourish.

In the absence of any meaningful data (during this survey), anecdotal experience seems to reinforce that end-to-end user experience is not great in Malaysia even in the best places such as Putrajaya in 2017. There is no good data collection effort on

the mobility adjusted population coverage. In Malaysia, there are frequent dead-zones is national highways. Too many times the handover fails even during city travels. Both during 2017 and 2018 bandwidth reports suggests worsening quality even for 4G LTE traffic, which are being rolled out.

The problem is not unique to Malaysia. Indeed in many countries there is no real regulatory demand for consistent network. Poor user experience is endemic, many experts opine that quality and consistency of NCI is now a bigger problem than speed. Regulatory bodies, national planners need to focus on quality of their network infrastructure rather than upgrade to 5G for speed. The industry is well equipped to handle the later and much less on the former.

Malaysia can also lead in consistent networking for Future Network. As MCMC aims at creating a new NCI for FN, it should focus more on the understanding and monitoring quality and consistency of the services and the health of the network. Given the current state of monitoring, it will require a comprehensive three stage approach. First, MCMC should commission study of the current state of network consistency including user-experience measurement. Secondly, it should suggest a set of effective quality metric to track networks health, work with industry for instituting the measurement framework and making such data more available to consumers. Finally, it should encourage national providers to implement subsequent technical and business measures to increase the quality and consistency of the NCI guided by such parameters for significantly improving the user experience in Malaysia.

### 4.4. EXPLOSION OF CLOUD SERVICES

One of the observations from the survey and the focus groups meetings was that Malaysian telecomm and related companies have tapped very little into public Cloud and Content Data networking (CDN) services industry. The survey reveals that although a few companies have started building sizable data centers, they are only being used for their internal data needs.

Cloud will play a big role in the flourishing of digital transformation of the country. A country must provide access to a healthy and modern cloud infrastructure for businesses. This is an essential component in their journey towards digital transformation. Industry 4.0 aims to digitize manufacturing. This will move many business processes into Cloud. Without national services many will migrate to transnational providers.

Further, down the road, the advances in Blockchain technology promises improved efficiency of almost every conceivable industry by replacing tedious and costly middle men/experts (ledger-workforce) used in maintaining, verifying, correcting paper based ledgers and contracts with machine-verifiable trust network and non-temper able smart contracts. The Blockchain will also facilitate business

to business digital transactions for various sectors across supply chain, hugely requiring the Cloud.

In the international arena, Cloud traffic has already surpassed classical internet traffic. In the coming years, the cloud service related traffic is expected to exponentially grown signifying the importance of cloud services.

MCMC should look for means to encourage and invigorate indigenous public Cloud industry. It is a key enabler for digitization of all other business and commerce sectors. Businesses around the world are embracing deeper cloud services. While many started with older CDN and IAAS (storage), models, more are increasingly opting for deeper SAAS (storage and software), and PAAS (processing, software, and storage) models.

The strength of Cloud will be essential for Industry 4.0/5.0 sectors, as companies will seek lowering the IT capital expenditure for their data intensive business processes and will require fast, responsive, and reliable IT platform to deliver their own services to their customers.

MCMC may start by a) assessing the current the current cloud market and usage by the Malaysian companies; b) and encourage establishment of an indigenous public cloud infrastructure. c) In the meantime it should work for commissioning National Cloud Exchange and related protocols into its NCI to ensure seamless high performance interconnect to cloud and fog systems worldwide for its businesses.

### 4.5. MODERNIZATION OF ASSESSMENT MECHANISM

MCMC has an active arm to collect extensive data from telecommunication service providers and also an online portal system with many visualization tools. There are reporting on traditional 1G, 2G, 3G and 4G maps, and locations of radio equipment/towers, etc. very specific to voice telephony. The survey revealed indeed there is serious room for modernization.

The industry is already undergoing a paradigm shift from classical voice/video services to data and computing services. Future Network (FN) is about even more radically new set of data network services. There will be drastically new other modalities such as machine-to-machine IoT services. There are new group of customers such as smart community or Industry 4.0 customers. The core infrastructure is morphing with data and computing cloud infrastructure assets being added, with core, edge and fog. MCMC have to address new issues encompassing infrastructure sharing, data security and consistent networking. In recent years there is also many innovations in network telemetry.

To improve the policy and regulatory efficacy MCMC will benefit by redesigning its overall assessment strategy and expand its metrics in the light of each of the FN services. At least the five monitoring areas will need immediate

attention; a) network quality, b) consistency or end-to-end service, c) data networking, and d) infrastructure sharing e) data protection and security. The 2017 Fulbright/MCMC Survey can be used as a starting model (but it is inadequate as it was designed for exposing sharing status with limited expectation).

The paper based batch reporting of quality assessment and annual book styled reporting may not be scalable. MCMC should build up additional live and continuous online assessment reporting system. Many data elements such as bandwidth, delay link health etc. from providers NOCs can automatically and continuously steams into this national platform. Administrative measures should be there to ensure interchangeable format, authenticity and accuracy of reporting.

Further in parallel, MCMC can also deploy a live measurement platform demonstrated. It can setup permanent MCMC measurement points in all over Malaysia's communities and at the critical service points inside the providers and deploy live telemetric tools.

MCMC should add intelligent analytical and visualization tools to make sense from the data. Suggested automation will significantly reduce the cost and overhead of reporting and monitoring and increase transparency both for MCMC and the providers.

### 4.6. CITIZEN DIRECT CONSUMER AWARENESS

Although MCMC and Malaysian telecommunications companies collect and share data, and maintains web-sites to disseminate some data, however, it is not clear these are promoted to be used directly by consumers as being envisioned by more recent initiatives such as Open Government initiatives pursued in other advanced countries.

Just collection of data is not enough- it must be actively disseminated. There are many benefits of data sharing. With time-appropriate modernization, these can be made much more useful all the way for individual consumers, citizen to inform them about the quality of service they are actually receiving. There is significant amount of information haze. To create a healthy ecosystem at a national scale in the age of Industry 5.0, it is important to create more robust mechanism for consumer awareness on the quality. Consumer education is a multifaceted complex process.

How Malaysia can lead? A potential flagship project for MCMC is to lead an initiative to have a Live Label on electronic service quality for major telecommunication services (much like food labels) so end-subscribers are informed about the type, quality and health of the communication service provided to them. Create a small but clear standardized set of indexes covering key items such as technology (4G/5G LTE? Advanced?), speed (end-to-end

delay/bandwidth/speed to major destination hubs), consistency (packet loss drop rates, linkage down time, geo-coverage), green power rating (2G services can drain batteries significantly over 4G), privacy & security (end-to-end encryption, authentication, etc.). The labels can start a market transparency and provide everyone in the co-system a national direction.

Not only for citizens, institutional data is essential for effective policy making in all levels. There are huge number of policymakers, community leaders, who are outside of MCMC, who will directly benefit from the telecommunication data. Specialized/live dashboard can be provided to help policy making at many levels beyond MCMC as a part of open governance effort.

### 4.7. INCLUSION IN SPECTRUM ROADMAP

The providers expressed great uncertainty about the future spectrum allocation. Uncertainty creates resistance for attracting new investment for newer technology. So what type of spectrum roadmap is needed for FN? Unfortunately, a major paradigm shift is now expected as FN will be liberating from voice based blocking that has dictated spectrum architecture for decades. Both 4G and 5G technology enable spectrum band aggregation. Rapid facilitation of Software-Defined-Radio (SDR) will also allow equipment to be versatile and flexible. However, there are more issues at hand than another auction cycle for spectrum block.

The emergence of 5G, IoT and smart communities calls for a much nimble spectrum usage and licensing policy quite unlike the old large provider focuses commercial spectrum licensing paradigm. Smart city, combined with 5G projects will require extensive research and development of systems are testing ground at the millimeter-wave bands between 20 GHz and 200 GHz, with a target of 100 Gbps in data rates for small-cell networks that cover a few city blocks, for the city to deploy.

There is also case for advancing dynamic spectrum technology focusing on the spectral bands that are sub-6GHz (thus has long reachability required by the cities), and aim to identify spectral opportunities in existing networks and establish usage models for novel spectrum-driven applications to be used by smart communities while also studying co-existence and protection issues.

The current model of licensing ties spectrum bands to too tightly to applications (such as voice, VOIP). This approach stifles the new applications. The idea is to find ways where new applications from the cities and communities can coexist in the bands and this can be done without destroying the quality of service of legacy applications.

Thus over all, there is a strong case for new licensing paradigms that need to make a) spectrum bands flexible so small to very large data rates can be supported.

There is need for increasing the spectrums width by band aggregation or concatenation capabilities. b) The spectrum license should make bands more sharable (whitespace), more leasable/ sub-leasable, and more inclusion of use-it-or-lose-it models, c) reallocation of extremely valuable low frequency long-range bands should be accelerated. Emerging applications need them more urgently, and most importantly e) new spectrum allocation policy is urgently needed that should create space for smaller but major innovative players (universities, startups, and smart communities, etc.).

### 4.8. CITIZEN'S DATA SAFETY, PRIVACY AND ETHICAL APPLICATIONS FRAMEWORK.

Malaysia is pioneer in adopting a Personal Data Protection Act 2010 (PDPA) with enforcement since 15 February 2014 [2]. It covers communications companies regulated by MCMC. About 120 countries now have comprehensive citizen data privacy law enacted [3,6]. Another 40 countries are still in second category where the laws are in the process (Pakistan, India, Thailand, Indonesia, etc). The third group has no initiative (Bangladesh, China, etc.).

The PDPA confers a set of rights (subject to qualifications) on relation to citizens personal data such as the right to access personal data; the right to correct personal data; the right to withdraw consent to process personal data; the right to prevent processing likely to cause damage and distress; and the right to prevent processing for direct marketing. There is scope of improvement in PDPA in the light of later specifications particularly EU's GDPR. There are two issues MCMC have to deal with as FN emerges.

> "Industry 4.0 & Industrial Internet of Things. Made in Germany – is the fourth industrial revolution and the one that goes hand in hand with the powerful guardian – the cyber security.
> Mysterious mistress, the cyber security is in reality, more spoken about than understood."
>
> — Ludmila Morozova-Buss

First, after the regulation are enacted- the bigger challenge is the **implementation framework**. The real problem for the first group of countries is now how citizens can exercise their digital privacy rights conferred by the act?

This s much more onerous stage. The regulatory and standards bodies need to work with company business processes so the rights can be exercised. For example, a company may collect location data to optimize service. Individuals may have the right to limit archival duration for the specific purpose (say 7 or 30 days) or even retract them. These options can be exercised only if certain data archival and storage practices are in place. The required technical mechanisms do not exist in most telecommunication

companies today. Today the business mechanisms for letting customers change or withdraw their privacy choices; check and correct accuracy; knowing/notifying a client in timely (to minimize damage) if his/her personal data has been illegally breached, etc. are non-existent or very weak at best.

Implementation of the digital rights have significant cost and challenge for businesses. Companies need investment and time to change their technical and business processes. Thus these rights are barely meaningful to customers even in first-tier countries like Malaysia. Yet, to foster FN, government regulatory agencies including MCMC immediately need to start working with all the provider companies on the implementation details and set time frame to create such implementation framework so a new generation of more personalized data intensive services can flourish with appropriate protection for business and citizens.

Secondly, the emergence of IoT, Community Computing, and overarching increased use of Artificial Intelligence (AI) will require revisiting even the digital law framework beyond privacy. One case at hand is IoT. These applications by design will be intensely invasive and collect myriads of very detailed data related to every aspect of dwelling both private and public places. Misuse of infrastructure data can be lethal . Even the latest personal data protection laws do not adequately cover many infrastructure data. For example, operational data of a house (such as power data, security video-, etc.) may not directly contain personal information about the owner of the house; thus may or may not be covered by PDPA; and yet it can have direct implication on the owner's safety- specially in the light of advances in data mining. Thus additional Infrastructure Data Protection (IDP) policies and legal safeguards is imperative to foster safe rollout of these systems. MCMC should work closely with related international and local bodies for **Infrastructure Data Management and Protection** policy and framework to accelerate safe rollout of IoT and machine-to-machine applications.

Yet another case at hand is the emergence of AI in Industry 4.0 or Industry 5.0. The potent systems will make more decisions without human in the loop. These requires vetting of approved application areas and use cases, protection against ethical and unethical use and applications, adherence to purpose, avoid unfair systemic bias, careful safety testing before mass launching, even a new certification paradigm. These calls for a separate national regulatory establishment of ***national AI principles*** or even broader Fair Information Practices principles [6].

### 4.9. 11TH MALAYSIA PLAN

One of the objectives of this study is to find ways to facilitate stakeholders and analyze how MCMC can assist the stakeholders in achieving the communication and multimedia objectives of the 11th Malaysia Plan. The plan originally, launched in 1991 as Vision 2020 envisions Malaysia as a fully developed country

along all dimensions - economically, politically, socially, spiritually, psychologically, and culturally - by the year 2020, and anchored on the prosperity and wellbeing of its citizens that will be building a better Malaysia for all Malaysians.

Its greatest focus is fulfilling the aspirations of 'rakyat' which means people or community. Its objective is to drive capital economy by helping Gross Domestic Product (GDP) growth, big businesses, large investment projects, and financial markets, while the people economy is concerned with what matters most to the people, which includes jobs, small businesses, the cost of living, family wellbeing, and social inclusion. It has six strategic thrusts (and six game changers) that will transform ideas into reality and address.

Interestingly the document does not specifically mention digital transformation. However, a review of the plan indicates that a robust NCI- and each of the future network elements discussed is likely to be central instrument in achieving every six thrust areas of the plan. The very number one thrust of the plan calls for Government initiative to transform rural areas by creating employment and business opportunities, and enhancing rural-urban linkages. The central piece of number two thrust of the plan is to ensure the well-being of every Malaysian irrespective of geographic location or socio economic background by ensuring equal access to health care, education and make every neighborhood and communities to be safer and peaceful place for citizens to thrive, making available in time in-place and high quality mobile healthcare to all communities.

These goals will be unattainable without expanding the geographic coverage of the NCI infrastructure and requiring placing top-priority in the empowerment of smart community and smart cities initiatives, i.e. regulatory facilitation of their spectrum and communications need.

### 4.10. ECO SYSTEM FOR FUTURE NETWORK INNOVATION

In the current global eco-system in telecommunication, the international inventors, investors, and manufacturers will keep on making the technology, equipment, and software paradigms available to the Malaysian providers even without much local shepherding. A question was asked, how Malaysia enter into the FN innovation eco-system? Unfortunately, the effective participation in this eco-system by countries is disproportionate and is not guaranteed. But the good news is that the FN is a fertile ground of innovation, and its advent will open up unprecedented opportunity worldwide to enter into the fray. Countries like Malaysia should not miss this opportunity to break into this innovation ecosystem. MCMC commendably is already supporting a 5G research center and a digital lifestyle and smart home center in the universities as well as a very active Makers Lab onsite.

What can MCMC do further to help Malaysian entering into the eco-system? A three pronged approach fostering human network with expanding access to physical labs, and angel funding to ensure the rapid entry can be suggested.

MCMC should consider creating a Innovation Forum to connect University researchers, Engineers from Malaysia's Telecommunication Industry's FN related units, Smart Community/Municipalities technology leaders, potential IoT service companies; Provide seed funding to collaborative groups from these constituencies to perform baseline studies on FN services; MCMC should place particular emphasis to engage Smart Community Initiative leaders who are often furthest from the technology and prioritize their voice and needs, particularly to help the 11th Malaysia plan.

In conjunction with proposed specific set of testbeds, MCMC may set up Future Network Innovation Demonstration Center(s) under the auspices of MCMC to gain immersive experience into the newest. Invite international/national companies/vendors to setup product/service demonstration of their newest technology as they plan rollout in Malaysia or in the region, side-by-side demonstrating flagship FN projects from the university and local startups; arrange early exposure to MCMC policy makers, university researchers, local innovators, university researchers to the latest for next step ideation and adoption.

Further MCMC may mobilize a 5 year national FN Innovation Fund for industry-academia (mandatory) collaborative projects for commercialization of innovative service, software and hardware systems specifically solving MCMC goals.

## 5.RECOMMENDATIONS

What can be done to make Malaysia future ready towards becoming a smart digital nation? Based on the assessment of Malaysia and global trends as discussed the following twenty recommendations are made aimed to promote strategic assessment of networks planning, development and monitoring and enhance MCMC's Communications and Digital Ecosystem Sector's opportunities for engagement and collaboration with key stakeholders to provide greater impetus for the movement towards developing a national strategy to balance investments in technology and infrastructure with investments in the skills and knowledge Malaysian need to use ICTs to improve the quality of their lives, increase productivity throughout the private and public sectors and develop innovative products and services.

### 5.1. SET NEW MCMC GOAL 80% GEOGRAPHIC COVERAGE BY 2030

1. Complete the network! MCMC and related organizations should address the real challenge of geo-coverage[3] head-on. This is also the viable way to solve the rural population coverage problem. MCMC should commission a study specifically focusing to map the extent and severity of geo-coverage problem and draw an action plan.

2. Countries including Malaysia will benefit by fitting the best frequencies with best technology. Lower frequencies can reach relatively longer distances with lower power. Accelerate the reallocation of lower frequency spectrums in hard-to-reach neighborhood zones. Vacate older 2G/3G technology for newer IoT capable technologies in these golden spectrums. Migrate low density 1G and 2G subscribers in small town/village/enclaves to newer technology such as 4G LTE.

3. Be a pioneer in exploring non-conventional innovative technologies for widening of geo-coverage. Engage university and innovators and setup testbeds for sky based internet/LTE technology such as Alphabet (Google) Inc's Loon, or software defined radio (SDR) for ultra-low frequency (ULF) communication that can reach country-scale distances.

### 5.2. MARKET PLACE FOR INFRASTRUCTURE AND EXCESS CAPACITY ASSETS

4. MCMC should foster sharing arrangements of civil telecommunication related capital intensive infrastructure assets (public and private buildings, ducts, right of the way in roads and highways, rooftops, public towers, lands) so there is less administrative impediment for telecommunication companies to use them.

5. MCMC should foster a market for sharing capital expensive telecommunication assets/product between the FN companies. Encourage and ease trading of excess capacity and bulk services such as bulk-bandwidth, dark fiber strands, unused spectrum, colocation facilities, etc. Even radio equipment and expensive core switch and routers will be sharable by new technology like NFV and SDR.

6. Setup online marketplace for exchange of timely and accurate product information (what, when, who to contact) to accelerate the above trading. The transparency and ease is profoundly important for the new generation of FN startup companies and service entrepreneurs to enter into market.

[3] The population coverage index is not reflective of the gap.

### 5.3. FOCUS ON QUALITY AND CONSISTENCY OF NETWORK

7. Step one, commission a technical study of the current status of network consistency and user-experience, including security and privacy.

8. Step two, encourage national providers to implement subsequent technical and business measures to increase the quality and consistency of the NCI for significantly improving the user experience in Malaysia.

### 5.4. MODERNIZE MONITORING AND ASSESSMENT MECHANISM

9. Redesign and strengthen the reporting and monitoring instrument. Add metrics in following deficient areas[4]. At least the five monitoring areas will need immediate attention: a) network quality, b) consistency of end-to-end service, c) data services, and d) infrastructure sharing, and e) data protection and security.

10. Introduce streaming based reporting. Many data elements such as bandwidth, delay link health etc. from providers' NOCs can automatically and continuously steams into this national platform. Administrative measures should be there to ensure interchangeable format, authenticity and accuracy of reporting.

### 5.5. PROMOTE CLOUD SERVICES

11. Assess the current the current cloud market and usage by the Malaysian companies. MCMC should look for means to encourage and invigorate indigenous Cloud industry.

12. Work for commissioning National Cloud Exchange and related protocols into its NCI to ensure seamless high performance interconnect to cloud and fog systems worldwide for its businesses.

### 5.6. SPECTRUM ROADMAP

13. Reengineer spectrum. There is a need for increasing the spectrums width by band aggregation or concatenation capabilities so small to very large data rates can be flexibly supported.

14. Rethink spectrum allocation policy. Create space for smaller but major innovative players (universities, startups, and smart communities, etc.) for innovatively using raw spectrum.

[4] The current survey can be used as a starting model for sharing dimension- but it is inadequate as it was designed with a very limited resource and participation expectation.

### 5.7. CITIZEN'S DATA SAFETY, PRIVACY AND ETHICAL APPLICATIONS FRAMEWORK.

15. Prioritize implementation of Individual Digital Privacy rights frameworks so citizens can actually and meaningfully exercise their digital privacy rights given to them in PDPA 2010. This will be essential for new generation of a more personalized data intensive FN services to flourish.

16. Work with peer international and local bodies for **Infrastructure Data Management and Protection** policy and framework to accommodate safe rollout of IoT and machine-to-machine applications.

17. Further move towards a regulatory framework for information management and applications such as **National AI Principles**, **Fair Information Practices Principles [6].**

### 5.8. ECO SYSTEM FOR FUTURE NETWORK INNOVATION

18. Create a **MCMC Innovation Forum** to connect university researchers, entrepreneurs, engineering from FN related telco/industry units, smart community technology units, potential new IoT companies; Provide seed funding to collaborative groups from these constituencies to perform ideation studies on various aspects of FN.

19. Setup **TRL-6 Testbed for FN Technologies** which has exceeded TRL-6 or 7 [7], such as 5G, demonstrable Smart Community, IoT Village, Public Cloud Services Center, and flagship AI (education, public health) and Blockchain govt. applications (smart voting). Malaysian University researchers, students and innovators may participate early hands-on experimentation and development on the FN technologies.

20. Set up TRL-8 **Future Network Innovation Demonstration Center(s)** under the direct auspices of MCMC. Invite international/national companies/vendors to showcase their newest product and technology (TRL 8 or 9) as they plan to rollout in Malaysia or in the region; MCMC policy makers, university researchers and local innovators should seek early exposure to newest.

## 6.CONCLUSIONS

The implementation of the 20 recommendations are specific yet substantive when viewed as a whole. Any action plan call for delineating a road-map with substantial ground planning. Implementation of any will involve extensive participation and engagement of many players in the eco-system.

The outcome from the project is only intended to form part of the collective body of knowledge and information resources needed to support the

Technology Development Department' s advocacy role on emerging and future networks specifically, as well as MCMC's role in handling the many complex challenges in regulating and managing the ICT impacts of on society. The recommendations and suggestions are not to be taken as concrete roadmap. Each of the issues identified requires daunting ground-work and meticulous planning. It is only intended to provide a preliminary guidance where such work might begin as Malaysia's aims for a FN capable NCCI.

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## 8.REFERENCES:

[1] "Top Countries by Smartphone Penetration & Users - Newzoo". Retrieved 20 April 2018.

[2] Data protection in Malaysia, Jillian Chia from SKRINE, Malaysia summarises Malaysia's Personal Data Protection Act 2010, https://globaldatahub.taylorwessing.com/article/data-protection-in-malaysia.

[3] Banisar, David, National Comprehensive Data Protection/Privacy Laws and Bills 2018 (September 4, 2018). Available at SSRN: https://ssrn.com/abstract=1951416 or http://dx.doi.org/10.2139/ssrn.1951416.

[4] Javed I. Khan, Assessing the Readiness of Future Network in Malaysia- Survey Analysis, MACEE/MCMC Fulbright Senior Specialist Report, April 2018, Available at: https://ssrn.com/abstract=1951416.

[5] Eleventh Malaysia Plan 2016-2020, http://www.epu.gov.my/en/rmk/eleventh-malaysia-plan-2016-2020.

[6] Data Policy in the Fourth Industrial Revolution: Insights on personal data, November 2018, World Economic Forum Report, Switzerland, [Avaiable at: https://weforum.ent.box.com/s/cd1m02qcx2yihq58b9l1r31nvgmalo48

*[7] Vincent Jamier; Christophe Aucher (April 2018). "Demystifying Technology Readiness Levels for Complex Technologies, Leitat, Barcelona, April 24, 2018"*