DECISION ISSUED BY

THE INFOCOMM MEDIA DEVELOPMENT AUTHORITY

ON

IMPLEMENTATION OF IP-BASED INTERCONNECTION IN SINGAPORE

6 JANUARY 2023

DECISION ON THE IMPLEMENTATION OF IP-BASED INTERCONNECTION IN SINGAPORE

1. On 1 March 2021, the Infocomm Media Development Authority ("**IMDA**") issued a public consultation to seek comments on IMDA's broad proposals and preliminary views on the implementation of IP-based interconnection in Singapore (the "**Public Consultation**").

2. At the close of the Public Consultation, IMDA received comments from ten respondents, namely:

   (a) Asia Pacific Carriers' Coalition ("**APCC**");
   (b) M1 Limited ("**M1**");
   (c) MyRepublic Limited ("**MyRepublic**");
   (d) Orange Business Services Singapore Pte Ltd ("**Orange**");
   (e) Singapore Telecommunications Limited ("**Singtel**");
   (f) StarHub Ltd ("**StarHub**");
   (g) SuperInternet ACCESS Pte Ltd ("**SuperInternet**");
   (h) TPG Telecom Pte Ltd ("**TPG**");
   (i) Velox Networks ("**Velox**"); and
   (j) Verizon Communications Singapore Pte Ltd ("**Verizon**").

3. To further understand the respondents' comments, IMDA had engaged the respondents (including industry-level discussions) to discuss specific technical-related issues.

4. IMDA thanks all respondents for their views and comments, and has given careful consideration to the issues raised. IMDA sets out below its decision on the issues raised in the Public Consultation ("**Decision**").

SCOPE AND TECHNICAL REQUIREMENTS

5. In the Public Consultation, IMDA recognised that under the current environment/landscape, a full end-to-end deployment of IP-based signalling protocol in the operators' networks might not be feasible in the immediate to near term, in view of legacy network elements and some international voice traffic terminating and/or transiting the operators' networks that might still require SS7 signalling to establish the calls. As such, IMDA proposed to require only the establishment of IP-based signalling protocol at domestic Points-of-Interconnection ("**POIs**") across all operators' networks that are interconnected to provision voice services.

6. Based on the said defined scope, IMDA consulted on its preliminary view that all operators should follow a standardised set of technical requirements to implement IP-based interconnection at domestic POIs. As IMDA had noted in the Public Consultation, a lack of standardisation in technical requirements

when implementing IP-based interconnection might give rise to various issues, including call quality problems.

7. In addition, based on IMDA's studies of the technical standards which are commonly deployed in other jurisdictions, IMDA also consulted on its proposal for operators to adopt the Session Initiation Protocol ("**SIP**") based on IETF[1] and 3GPP[2] specifications at the POIs (the "**Proposed SIP**").

8. Respondents were generally supportive of IMDA's proposal for operators to follow a standardised set of technical requirements to implement IP-based interconnection at domestic POIs across all operators' networks that are interconnected to provision voice services. One respondent submitted that a standardised set of technical requirements would promote seamless, efficient and expeditious interconnection for the operators as well as reduce interoperability issues. In this regard, IMDA will mandate that all operators follow a standardised/baseline set of technical requirements to implement IP-based interconnection at domestic POIs.

9. On the type of SIP to implement at the POIs, IMDA received differing views from the respondents. One respondent recommended adopting SIP-I[3] (ITU-T) as it would facilitate backward compatibility to existing Time Division Multiplexing ("**TDM**")-based networks and a smooth transition to IP-based interconnection. However, another respondent cautioned that adopting SIP-I might incur additional costs across the operators in Singapore as the respondent believed SIP(IETF+3GPP) was likely the existing commonly deployed approach for most operators in their networks. In addition, one of the respondents submitted that implementing SIP-I in Singapore would be a "backward" step, as the feature set in SIP-I would constrain future developments, especially in multimedia services, and might also be limiting to new competition. Another respondent opined that the standards prescribed by SIP(IETF+3GPP) would be the best for wireline and wireless networks. One respondent submitted that SIP(IETF) specifications were widely adopted by the fixed network industry and equipment vendors while 3GPP specifications were primarily related to cellular telecommunication technologies. It would thus be more relevant to implement IP-based interconnection based on SIP(IETF) for fixed networks. This was also supported by another respondent who commented that SIP(IETF) based on the main standard RFC 3261 for interconnection was the industry norm.

10. To determine the most appropriate SIP standards to be implemented in Singapore, IMDA further engaged the respondents to understand their views. From the industry discussions, IMDA understands SIP-I maximises interoperability with legacy network elements while SIP(IETF), as a baseline

[1] IETF: Internet Engineering Task Force
[2] 3GPP: 3rd Generation Partnership Project
[3] SIP-I (ITU-T): SIP which is defined by IETF, but used in a specific way defined by ITU-T. SIP-I is a hybrid signalling protocol where TDM-based signalling protocol (ISUP) is transported within the IP-based signalling protocol (SIP).

standard, offers the flexibility to add on other standards and specifications. Compared to SIP-I and SIP(IETF), SIP(IETF+3GPP) is more forward-looking and holistic with richer feature sets for a more complete SIP implementation. In addition, implementing SIP(IETF+3GPP) would pave the path forward to support common infrastructure (e.g., IP Multimedia Subsystem) for fixed and mobile voice services. Operators continue to hold different preferences and views about the technical specifications to adopt for interconnection at the domestic POIs, and there is no consensus.

11. To address this issue in a transparent and effective manner, IMDA agrees with a suggestion from one respondent to establish an industry working group to contribute to the development of the SIP specifications and technical standards that would best suit the Singapore context.

12. In this regard, IMDA has convened a SIP study group/task force under the Telecommunications Standards Advisory Committee[4] ("**TSAC**") to study the above, which will include the SIP standards and specifications to be implemented at the domestic POIs for IP-based interconnection, as well as possibly other SIP standards-related work/areas as required by the industry for end-to-end network communication[5]. IMDA intends to make the standards to be developed by TSAC mandatory for industry adoption.

*SINGTEL'S REFERENCE INTERCONNECTION OFFER ("**RIO**") FOR IP-BASED INTERCONNECTION*

13. In the Public Consultation, IMDA invited views and comments on its proposed approach to finalise the offerings of the RIO services related to IP-based interconnection, before commencing the migration to IP-based interconnection. This was in view that operators might have differing readiness levels to implement IP-based interconnection at all the POIs established with the other domestic operators. As such, a transition period might be inevitable whereby operators might have to support and cater for both Signalling System No. 7 ("**SS7**") and the SIP signalling at the POIs ("**Transition Period**"). Given that Singtel is the Dominant Licensee regulated under its RIO for TDM-based interconnection, IMDA had considered that providing clarity to the industry on the specific details of any IP-based interconnection arrangement with Singtel would facilitate the migration planning and preparation of industry players who were currently directly interconnected with Singtel via Singtel's RIO. With both sets (TDM-based and IP-based) of interconnection arrangements ready/in place, IMDA believed the Transition Period would be smoother and more manageable for the industry.

[4] TSAC is formed by industry members to advise IMDA on the setting of Information and Communication Technology standards.
[5] IMDA has invited respondents to appoint representatives to this study group/task force.

14. IMDA notes that majority of the respondents were supportive of IMDA's proposal to finalise the RIO offers for IP-based interconnection before proceeding with migration. However, one respondent raised its objection to allow Singtel to define the technical standards for IP-based interconnection through its RIO as this could lead to outcomes that were especially favourable to Singtel. As such, the operator proposed that IMDA should convene and chair a working group of industry experts to define the technical requirements for IP-based interconnection.

15. IMDA notes the respondent's concern and as put forth in preceding paragraphs, that IMDA has convened the TSAC task force to work on the set of mandated standards and specifications to be implemented at the domestic POIs for IP-based interconnection. Once finalised by the TSAC task force, IMDA will direct Singtel to incorporate the said set of mandated standards and specifications in its proposed RIO offers for IP-based interconnection.

16. Notwithstanding, IMDA will clarify that because the RIO agreement is a bilateral contractual agreement between Singtel and each of the operators, and that Singtel (being the Dominant Licensee) has the additional regulatory obligation to publish offers for regulated services, it would be appropriate contractually and regulatory-wise, to allow Singtel to propose other requirements relevant to the RIO services to enable IP-based interconnection. IMDA continues to retain regulatory oversight and will consult the industry on any Singtel's proposed RIO requirement before IMDA approves the RIO IP-based interconnection offers.

17. In addition, IMDA believes that to provide sufficient clarity to the industry for IP-based interconnection with Singtel's network, it will be necessary for Singtel to include in the RIO offers its proposed technical and operational details such as routing and testing procedures, architecture for interconnection, sizing of the interconnect links, locations of Singtel's POIs, signalling protocol used for interconnection, and handshaking protocol. These technical and operational details as proposed by Singtel, will be issued by IMDA in a separate RIO consultation for industry's review and comments when ready.

18. Once the SIP standards and specifications are finalised by the TSAC task force, IMDA will proceed to finalise the RIO IP-based interconnection offers, before mandating and commencing the migration to IP-based interconnection. For the avoidance of doubt, once finalised, the effective date of these RIO offers will depend on the transition timeline to IP-based interconnection in Singapore, which IMDA will determine separately.

INTERCONNECTION CONFIGURATION AMONGST OTHER LICENSEES

19. On how Non-Dominant Licensees' networks should be interconnected under an IP-based interconnection environment, IMDA had proposed in the Public Consultation to continue the current interconnection regime and leave it to the

industry to discuss the appropriate and mutually agreed arrangements in good faith.

20. Respondents were supportive of IMDA's proposal. In this regard, for Non-Dominant Licensees' bilateral interconnection agreements to establish IP-based interconnection, IMDA will retain the current interconnection regime where operators mutually agree on the most appropriate interconnection configurations and arrangements that best fit their network deployments. However, Licensees must have regard to the standards to be developed by TSAC for industry adoption.

21. As for the RIO IP-based interconnection offers where interconnection configuration details with Singtel (as the Dominant Licensee) are regulated and to be finalised through the aforementioned RIO consultation, IMDA had sought some operators' preliminary views on a few proposed key details during the industry discussions. These proposed details for IP-based interconnection under the RIO are:

(a) Retain current RIO arrangement of dedicated, direct point-to-point physical links with POIs at Singtel's exchanges;
(b) Retain current RIO arrangement where operators have the flexibility to procure the links from Singtel, or any third party, or self-deploy;
(c) Point-to-point interconnect link to be sized at 1 Gbps; and
(d) Singtel's POI exchanges to be reduced from the current four locations to two locations (currently proposed at Paya Lebar and Jurong East, which are new locations).

22. From the discussions, IMDA notes that some operators prefer to implement IP-based interconnection with Singtel at designated neutral data centre(s), instead of at Singtel's exchanges. For these operators, IP-based interconnection at designated neutral data centre(s) is more cost effective and offers flexibility, catering to the operators' specific needs. IMDA also notes some operators' preference to establish IP-based interconnection with Singtel at two of the existing four POI exchanges under RIO, instead of changing to the two new locations. These operators submitted that the change in locations would be costly to them.

23. In addition, for the interconnect links to establish IP-based interconnection under RIO, IMDA also notes two operators' comments not to limit the size to only 1 Gbps, but to also allow other sizing such as 10 Gbps. One operator opined that it might not be efficient to use multiple 1 Gbps interfaces to manage interconnect traffic significantly larger than 1 Gbps.

24. While IMDA understands the operators' concerns, IMDA also notes that Singtel (as the Dominant Licensee with the regulatory obligations under RIO to interconnect with any operator in Singapore) may have to consider factors such as certainty of long-term lease and space availability of its exchanges when proposing the POI locations for IP-based interconnection under RIO. IMDA

further notes that Singtel needs to ensure it has sufficient control and access at the POI locations to avoid impacting Singtel's ability to offer the RIO on a long-term basis and to fulfil its regulatory obligations to IMDA.

25. At this juncture where the SIP standards and specifications are pending finalisation by the TSAC task force, IMDA will hold off issuance of the Direction to direct Singtel to submit its proposed RIO IP-based interconnection offers for consultation with industry. IMDA will address the abovementioned RIO interconnection configuration details as well as other proposed RIO details during the RIO consultation with the industry, and will continue to engage relevant parties to address any operator specific concerns in the meantime.

MANDATING A SET OF BASELINE NETWORK SECURITY REQUIREMENTS

26. In the Public Consultation, IMDA emphasised the importance of operators securing their IP-based networks to address cyber security risks and vulnerabilities. IMDA proposed for operators to adopt a baseline set of network security requirements that would be aligned with industry best practices. These baseline requirements would be in addition to other security measures and protection that operators should undertake to protect their own IP-based networks, and/or avoid technical harm to the telecommunication network and/or system of another operator. Such baseline requirements could include the following:

    (a) Monitor and analyse signalling messages to detect malicious traffic[6];
    (b) Adopt signalling firewalling to filter malicious traffic;
    (c) Harden interconnect infrastructure such as Signalling Transfer Points ("**STP**") and Diameter Signalling Controllers ("**DSC**"); and
    (d) Perform external network security assessments and penetration tests periodically, if domestic exchange points are used.

27. On IMDA's proposal for operators to adopt a baseline set of network security requirements, IMDA notes that respondents are generally supportive. One respondent commented that the baseline requirements would ensure safe and secure networks interconnected in Singapore. Another respondent submitted that the responsibility to have security measures in place should be on both the sender and the recipient networks. However, IMDA also notes another respondent's view that interconnection between operators would typically be based on a point-to-point connection which was dedicated for voice traffic, thus this would allow a safe and trusted exchange of traffic which would already have minimised security issues.

28. As indicated within paragraph 9 above, concerns regarding the adoption of requirements related to mobile networks were raised by respondents as they are less relevant for fixed networks.

[6] Malicious traffic includes those used to perform unauthorised interception, service disruption, data theft, etc.

29. Considering the above, IMDA will revise the requirements to scope them for SIP on the Session Border Controller ("**SBC**") infrastructure only. The SBC is the active equipment for SIP voice services at the edge of interconnection between operators and presents the highest exposure risk. The set of revised baseline network security requirements to be mandated are:

(a) Monitor and analyse SIP messages to detect malicious traffic;
(b) Filter malicious traffic on the SBC;
(c) Harden SBC with standards or guidelines that are aligned in principle with industry standards and best practices; and
(d) Perform external network security assessments and penetration tests periodically,

(collectively, the "**Mandated Baseline Network Security Requirements**").

30. In addition, IMDA will require the Mandated Baseline Network Security Requirements to be stated in all bilateral interconnection agreements (i.e., interconnection agreement executed between two Non-Dominant Licensees, as well as the RIO agreement executed between Singtel and a Licensee).

31. Notwithstanding paragraph 30, IMDA will also effect the above network security requirements via appropriate regulations (e.g., either through licence conditions or Codes of Practice) when the industry is ready to migrate to the IP-based interconnection regime.

INTERCONNECTION USING PUBLIC INTERNET

32. In addition, IMDA notes one respondent's observation of the trend that IP-based interconnection could be implemented using public Internet rather than physical interconnection and it did not appear that there would be Quality of Service ("**QoS**") degradation issues. Another respondent opined that by following the current interconnection arrangement to adopt physical interconnect links for IP-based interconnection, the operators providing the interconnect links might continue to benefit from its ability to arbitrarily charge for these interconnect links. As such, the same respondent suggested to make available the option for operators to establish IP-based interconnection via public Internet with encrypted tunnel, particularly under the RIO.

33. On the use of public Internet for interconnection purpose, IMDA had engaged some operators subsequently and noted there were divergent views. One operator was supportive and submitted that by requiring SIP signalling messages to be encrypted with IPSec tunnels for security reasons, calls could be safely terminated via tunnels over the public Internet, instead of via costly interconnect links between operators. Another operator opined that the public Internet would have redundancy built in and whichever VPN point-to-point solution the operator used would automatically be re-established if a link was to be broken, unlike physical interconnect links.

34. IMDA also notes one operator's comments that using public Internet for interconnection would be less secured and operators would not be able to troubleshoot and resolve service difficulties or outages in a speedy manner, given the nature of the Internet. Another operator opined that security could be maintained through isolation of facilities from the public Internet and suitable perimeter controls. While one operator agreed that the public Internet should not be used as a prime interconnection arrangement, it suggested that public Internet could instead be used as a "back-up" service in case of disruption to the interconnect links.

35. Considering the above, IMDA is of the view that using public Internet backbone as a transport mode for voice traffic presents exposure risks, where the voice traffic may be subject to Internet-based attacks such as BGP route hijacking, DNS related risks, DDoS, man-in-the-middle to eavesdrop and manipulate traffic which can present a spectrum of cybersecurity concerns on service availability, confidentiality and integrity. The countermeasures needed will be costly as well. As such, IMDA is of the view that generally, interconnection should be implemented using direct point-to-point private links, especially for interconnection that involves Critical Information Infrastructure ("**CII**"). In this regard, IMDA will mandate that interconnection with any CII owner is required to be direct point-to-point private links.

36. Notwithstanding, taking into consideration the evolution of voice technologies and services, IMDA agrees to allow the use of public Internet for interconnection between two Non-CII owners, as long as both parties meet the requirements stated in paragraph 37 below. For the avoidance of doubt, Non-CII owners need not seek IMDA's prior approval before using public Internet for interconnection purpose.

37. IMDA will require Non-CII owners to secure their use of the public Internet with the following minimal set of requirements:

    (a) VPN/IPSec to secure the connection;
    (b) Network firewalls;
    (c) DDoS mitigation;
    (d) Logging of security events;
    (e) 24x7 security monitoring and analysis (including BGP and DNS activities); and
    (f) Cybersecurity incident response team,

    (collectively, the "**Minimal Requirements to Secure Use of Public Internet**").

38. Where public Internet is used for interconnection purpose, IMDA will also require the two Non-CII owners to state the Minimal Requirements to Secure Use of Public Internet in their bilateral interconnection agreement.

39. Similarly, IMDA will also effect the above network security requirements via appropriate regulations (e.g., either through licence conditions or Codes of

Practice) when the industry is ready to migrate to the IP-based interconnection regime.

IMPACT TO NUMBER PORTABILITY

40. In the Public Consultation, IMDA highlighted that the migration to IP-based interconnection might require changes to the technical solutions currently implemented for the Fixed Number Portability ("**FNP**") service. As such, IMDA proposed the following options and sought comments from all FNP operators:

    (a) The FNP operators could review whether there would be a similar "Release" message with a specific cause value under SIP signalling, or a similar signalling function under SIP signalling, which all FNP operators could agree to use as an indication to the originating network that the dialled number had been ported out; or

    (b) The FNP operators could consider adopting an All-Call-Query ("**ACQ**") method, given that all FNP operators would have their own database.

41. Respondents agreed with IMDA's view that the migration to IP-based interconnection would affect the technical implementation of the current FNP service. Some respondents recommended adopting "SIP 410 GONE" as the "Release" message for the FNP solution to be implemented after the migration to IP-based interconnection, while another respondent suggested for IMDA to review the use of the Query-on-Release ("**QoR**") method for the FNP solution as it might not be fit-for-purpose for efficient IP-based interconnection. However, IMDA notes one respondent's disagreement with adopting an ACQ method for FNP as the respondent believed that it would involve significant changes and disruptions to the operators' networks. In addition, one respondent commented that IMDA and the FNP operators could consider reviewing the existing requirement of using two level 6 numbers in the FNP solution so as to preserve Singapore's numbering resources.

42. As the current FNP arrangement is industry led, IMDA held further discussions with FNP operators on the appropriate FNP solution that should be adopted when IP-based interconnection is mandated in Singapore (the "**FNP SIP Solution**"). From the discussions and preliminary assessment by the FNP operators, IMDA notes that some operators could face constraints commercially and/or technically to implement certain optimisation arrangements for the FNP SIP Solution. More in-depth discussion among the FNP operators and also engagement with the operators' respective system/solution vendors will be required to assess the feasibility of the FNP SIP Solution. In this regard, IMDA will require the FNP operators to finalise the details of the FNP SIP Solution based on "SIP 410 GONE" as the "Release" message to indicate port out number, as well as incorporating any optimisation in the solution where mutually agreeable and feasible technically and commercially.

43. Once the FNP SIP Solution is finalised, IMDA will also require the FNP operators to revise the current published guidelines on the technical approach for FNP, and to submit to IMDA the FNP commercial agreement to be implemented under an IP-based interconnection environment. The objective is to avoid/minimise any number porting issues and adverse impact to end-users arising from the migration to IP-based interconnection.

44. To effect the above, IMDA will convene the FNP working group to work on and finalise the various aspects of the FNP service to be implemented under an IP-based interconnection environment. IMDA clarifies that the migration to and implementation of the FNP SIP Solution will be made either together or after the establishment and implementation of IP-based interconnection amongst the FNP operators. IMDA will finalise the timeline together with the industry.

45. Separately, for Mobile Number Portability ("**MNP**"), IMDA notes that respondents shared IMDA's view that the implementation of IP-based interconnection would not directly impact the current MNP service. Notwithstanding, there could be optimisation to the MNP technical solution following the migration to IP-based interconnection and mobile operators could consider reviewing subsequently.

MIGRATION APPROACH

46. In the Public Consultation, IMDA provided its preliminary views on the broad migration approach. Regardless of whether the migration approach was a co-ordinated single approach or a phased approach, IMDA suggested for industry to conduct a co-ordinated industry-wide trial migration on testing platforms first before actual migration. IMDA would remain involved and facilitate such trial migration as IMDA believed this would avoid/minimise any migration issues.

47. Respondents were generally supportive, and most preferred a phased migration approach, which would take into account the various operators' readiness to migrate to IP-based interconnection. Some respondents also supported IMDA facilitating a coordinated industry-wide trial migration to ensure uninterrupted and seamless customer experience continued to be provided to end-users during the migration. One respondent submitted that significantly more discussion would be needed on the actual technical implementation details.

48. IMDA agrees with the respondent that more in-depth discussion will be needed with the industry to review the migration approach, specific plans and implementation details. IMDA will engage the industry on the detailed migration plans after IMDA finalises the various technical and commercial aspects of the IP-based interconnection framework, particularly the SIP standards and specifications, and the RIO IP-based interconnection offers.

*BILL-AND-KEEP ("**BAK**") REGIME FOR FIXED CALL TERMINATION*

49. On a related note, some operators also sought IMDA's clarification on the BAK regime for fixed call termination which will come into effect once IP-based interconnection is fully implemented by operators in Singapore.

50. As a recap, on 18 April 2022, IMDA published the Closing Note for the public consultation on the review of the Telecom and Media Competition Code (the "**TMCC**"). In the Closing Note, IMDA had finalised and set forth the change in the interconnection charging regime for fixed voice termination from Calling-Party-Pays ("**CPP**") to BAK. This would allow for a harmonised interconnection charging framework for all domestic telephony services, which would be appropriate, given that these services would eventually be provided over IP-based networks. As IMDA had stated in the Closing Note, an operator would not receive any compensation for calls terminating into its networks when it is through another local operator in a BAK regime. IMDA reiterates that the BAK regime will be implemented only between domestically originated and terminated voice traffic.

CONCLUSION

51. IMDA has set out in this document IMDA's decision on the key proposals and approach to take towards finalising the IP-based interconnection regime as consulted in the Public Consultation:

(a) Industry is generally supportive of the proposal to replace SS7 signalling protocol with IP-based signalling protocol at the domestic POIs. IMDA will implement IP-based interconnection in Singapore;

(b) IMDA has convened TSAC to finalise the SIP standards and specifications required to implement IP-based interconnection at the domestic POIs, as part of its review of the SIP standards for end-to-end network communication;

(c) IMDA will conduct a separate RIO consultation with industry to finalise the RIO IP-based interconnection offers for interconnection with Singtel, when the SIP standards and specifications are ready;

(d) IMDA will allow Non-Dominant Licensees to continue with the current interconnection regime where operators mutually agree on the most appropriate interconnection configurations and arrangements that best fit their network deployments;

(e) IMDA will adopt "SIP 410 GONE" as the "Release" message for the FNP SIP Solution. IMDA will convene the FNP working group to finalise the technical details (including any optimisation of the solution) and to submit to IMDA the related technical guidelines and commercial agreement;

(f) IMDA has specified the network security requirements for IP-based interconnection at the domestic POIs as well as for the use of public Internet for interconnection purpose, to be included in the Licensees' bilateral interconnection agreements. IMDA will also effect these requirements via changes to licence conditions or Codes of Practice when the industry is ready to migrate to IP-based interconnection; and

(g) IMDA will engage the industry on the detailed migration plans after IMDA finalises the various technical and commercial aspects of the IP-based interconnection framework (including for RIO and for FNP).

52. IMDA has updated the outline of the steps to implement IP-based interconnection in Singapore with the inclusion of the TSAC task force work to finalise the SIP standards and specifications (see Annex 1A).

Annex 1A

Outline of IMDA's steps on implementation of IP-based interconnection in Singapore (Revised)