IPv6 for decision makers

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Targeted readers and purpose

This report provides IPv6 information for business decision makers (CEOs, CIOs, CTOs, COOs) for Service Providers (SPs) in the Internet industry including Internet transit providers, access network providers, hosting providers, datacentre operators, content distribution networks operators, mobile network operators, and content providers. These professionals are ultimately responsible for making critical business decisions after being briefed on current business and technical issues by organizational staff who are responsible for establishing the SPs business strategy, developing network architecture, product planning, etc.

Deployment of IPv6 networks is not only an urgent issue for access providers but it also affects all SPs whose business model relies on the Internet. Delaying IPv6 deployment in any SP will negatively impact the level of coherence of the currently working Internet ecosystem. We need to achieve robust deployment of IPv6 like we achieved with IPv4 in a holistic manner.

It is important that these decision makers are able to establish their own understanding about the current Internet business environment so that they can make informed and sound decisions for their organization. This webpage has been prepared to provide an overview of the current rapidly evolving business environment within the Internet industry and identifies key issues that have significant implications for these decision makers.

Executive summary

Business developed through the Internet infrastructure has had a significant impact on the world economy. We observed huge growth in the Internet through "fixed" computing networks beginning in mid-1990s through to the early 2000s, but the next wave of Internet growth will have a much larger impact on the fundamental nature of the Internet. As millions and millions of new smart phones are sold annually, "Internet connectivity demand" will increase exponentially. Integrating billions of "mobile" devices on mobile networks that are constantly accessing the Internet via cellular phone networks or Wi-Fi networks is one of our greatest Internet challenges – and opportunities – today.

Ask people with smart phones in cafés if they are using a cellular phone network or a free Wi-Fi network provided by the café. More often, people do not know which network they are using. It's not an issue for them at all. The only issue for end users is whether they are connected to the Internet or not. Smooth, fast, and reliable connectivity is the sole concern of end users.

Smooth, fast, and reliable Internet access has been a fundamental requirement for customers of SPs, and such demand will only increase in intensity. This is even more critical for enterprise customers of SPs that build their business model and/or deliver user-pay services via mobile devices. There may come a day when enterprise customers who are able to choose will shift to that SP that can guarantee smooth, fast, and reliable end-to-end Internet access.

New businesses are constantly emerging and new business models are evolving to leverage smart mobile devices, social networks, cloud computing, and other new Internet developments. SPs play an essential role in this dynamic environment by providing Internet connectivity via Internet Protocol (IP) addresses.

IP addresses are a critical resource that sustains SP business growth and the exponential economic growth generated via the Internet. While SPs are operating in this dynamic environment, IPv4 address space is deprecating, as no new IPv4 addresses are available. This real shortage of IP addresses can be resolved when an SP chooses to deploy IPv6 networks. As millions and millions more mobile devices are annually connected to the Internet, the prudent SP should ask if their networks are prepared for this evolving Internet – an Internet that will include both IPv4 and IPv6 addresses.

In order to provide seamless transition from IPv4 infrastructure to IPv6 infrastructure, SPs will most likely need to maintain both IPv4 and IPv6 networks for a period of time. Managing two systems and concurrently providing smooth, fast, and reliable services is the real challenge for those SPs that want to prepare for the exponential demand for Internet connectivity being generated through mobile devices.

In this environment SPs will need to continue to extend limited IPv4 address availability while also deploying IPv6. Such decisions have to contribute to their competitive edge and also make sense financially from a business costs point of view over the short-term and the long-term.

SPs have been able to cope with all this exponential growth in the past and in the present, but there will come a point in time when such growth will overtake SPs that are purely dependent on IPv4. The existing Internet was able to reach the current point of ubiquitous availability because every type of SP has deployed IPv4 networks. Eventually, IPv6 networks will also need to achieve the same level of ubiquitous availability to support the continued growth of the Internet.

SPs that were early IPv6 adopters made a conscious decision not to become dependent on a single network system, as IPv4 address shortage appeared as a real business risk. Such pioneers deployed IPv6 networks in order to build an SP business model on a scalable and sustainable business infrastructure. Companies responding to this exponential growth, by being IPv6 ready, will manage the Internet today and tomorrow.

Operating in exponential growth time

Research on Internet economics says "The Internet accounted for 21% of the GDP growth in mature economies over the past five years" (McKinsey Global Institute, 2011). Another study estimated that the Internet penetration has grown 25% per year for the past five years in the 30 aspiring economies, comparing with 5% per year in developing economies (McKinsey&Company, 2012). Some of the APNIC economies are included in these 30 aspiring economies, which are defined by this report as "those with the economic size and dynamism to be significant players on the global stage in the near future and achieve levels of prosperity approaching those of the advanced economies".

This report also mentioned following set of statistics (as of 2010):

- 1.9% average Internet contribution to GDP in 30 aspiring economies
  vs
- 3.4% in developed economies

- 2.3% average Internet contribution to GDP growth in 30 aspiring economies over the past five years
  vs
- 21% in developed economies during 2004 – 2009

- 25% average growth per year in Internet penetration in 30 aspiring economies during the past 5 years
  vs
- 5% per year in the developed economies

These statistics suggest that potential exponential growth of the Internet-based economy can be anticipated among many aspiring economies that have not achieved potential growth yet. Decision makers of SPs and their competitors in the APNIC region are operating in such an exponential growth period. This is a starting point when thinking about future business direction.

Growth paths of the Internet

Internet growth is also taking place at a tremendous rate in aspiring economies, but with distinctly different growth paths from those seen in developed economies. So where is the growth coming from? Reviewing subscription data of fixed and mobile networks provided by Asia Pacific Economic Cooperation (APEC) Statistics will help to answer this question (see the detailed analysis in the Appendix).

Data suggests that developing economies are leap-frogging traditional connectivity methods straight into mobile networks. Given the recent robust increase of mobile devices such as smart phones and tablets, it is quite obvious that many Internet users in currently growing economies are accessing the Internet through mobile devices, and most likely solely via mobile devices when compared with Internet users of developed economies. Mobile devices are much cheaper than personal computers, and cellular networks are free from the high cost of cable installation on land.

While fixed network broadband still provides an important base for Internet users in developed economies, mobile network access to the Internet has became a major foundation both for currently growing economies and for developed economies. In particular, the role mobile networks play in currently growing economies is phenomenal. Such dynamic changes in the nature of telecommunication subscription produced by rapid evolution of the infrastructure will bring many new Internet users into the market. According to a research outcome, in 2010, 310 million mobile devices were used to access the Internet in 30 aspiring economies out of 800 million devices worldwide (McKinsey&Company, 2012). It's almost 40% of the total, and it is easy to imagine this trend will continue in the foreseeable future.

What Internet user growth means for the SP

From the Internet infrastructure point of view, the implication of the previously discussed significant growth in Internet users simply means a matching parallel growth in demand of IP addresses. In addition to meeting the demands for IP addresses from the existing fixed networks, SPs need to cope with demand for IP addresses coming from wireless networks and mobile cellular phone networks.

It is widely known that IPv4 address space in the APNIC region reached to the final /8 (about 16 million IPv4 addresses) in April 2011. The RIPE NCC region reached its final /8 in September 2012. Prior to reaching the final /8 IPv4 address block, the APNIC region Internet technical community defined an IPv4 address management policy called the "final /8 policy" in order to sustain fair and equitable final IPv4 address distributions in the region (the RIPE NCC region adopted a similar policy). According to this policy, each organization that requires IP addresses for Internet connectivity for end users can receive a one-off delegation of up to a /22, or 1024 IPv4 addresses, from APNIC.

If IP addresses are fundamental to the SP's business model, what does this restriction mean to them? While demand for IP addresses are increasing dramatically, no more unlimited IPv4 address pool is available; there are plenty of IPv6 addresses available though. This is the current environment that SPs in the Internet industry are now operating.

Fundamental ingredients to capture customers

What are the fundamental ingredients for SPs in the Internet industry to capture customers during the times of exponential growth? If SPs have been operating their businesses in the Internet industry during the past few years, they will be familiar with their customers' needs. Customers want to have **cost effective and high quality Internet access.** SPs need to achieve these goals during the time of IPv4 address exhaustion, rapidly growing mobile network subscription, and increasing competition.

The core business competency of mobile network operators is shifting from being a traditional voice and messaging provider to a mobile broadband service provider supplying services on voice, messaging, and data. It is important to note that all these are IP based services. **Scalable deployment of mobile broadband networks and Wi-Fi offload networks** secures sustainable growth of the mobile Internet and associated businesses. The priority is making sure that Wi-Fi offloading from cellular phone networks will be smooth and seamless for a better user experience.

While we are witnessing new growth of Internet users, the Internet technologies for distributing Internet content are also constantly evolving. Content providers must be familiar with the ever-increasing trend towards rich content such as higher definition media, movies, video streaming, online games, etc. End users are simply expecting **faster and reliable retrieval of content**. If the content provider's rich media content comes into the end users' mobile phones or laptop computers in erratic fragments, these users will have little patience to wait for them to arrive in one piece. These users will simply move onto "better" content sites. Sustaining customers on content sites longer than competitors improves the possibilities of enhancing online advertisement revenue. Content providers need to carefully monitor the service level of their hosting providers, datacentres, content distribution, networks etc.

So how can SPs achieve these goals?

SP business continuity and growth plan

During the period of exponential growth in demand of IP addresses and IPv4 address exhaustion, SPs need to make sure their networks do not rely solely on the deprecating IPv4 addresses. Their networks and content should be ready on IPv6. Particularly, access network providers need to make sure their edge networks are ready to provide better user experiences.

SPs need to consult their technical team about how to manage these challenges. The technical team should come back with some options with detailed technical explanations for each. Basically these options can be categorized into the following three major groups:

1. Do nothing
2. Just extending IPv4 address lifetime
3. Deploy IPv6 while extending IPv4 address lifetime.

Each option comes with advantages and disadvantages as the following chart outlines. Please note this is a simplified explanation so if the reader is interested in learning more details, please see the additional resources listed in the section entitled, “More detailed reference information”.

Option	Advantage	Disadvantage
Do nothing	None	SPs cannot sustain business growth, and the fundamental business competency supported by IPv4 addresses will become irrelevant. Customers have no access to IPv6 networks.
Just extending IPv4 address lifetime	Technology called Network Address Translator (NAT) 444 Carrier Grade NAT (CGN) enables the extension of existing IPv4 stock in the SP network for a short time by sharing one globally unique IPv4 address among multiple customers.	As NAT444/CGN may degrade quality of data traffic, customers may experience lowered and fragmented services with poorer user experience. Some services may experience erratic availability, and performance of some applications may be degraded. The cost of NAT444/CGN may remain much higher over the coming few years time when compared with deploying IPv6 + other types of CGN. See more details on Impact of CGN and CGN economics in the following “More detailed reference information” section.
Deploy IPv6 while extending IPv4 address lifetime	This option provides current and future business sustainability. Maintain possibility to develop new IP-based businesses. Lower cost than the NAT444/CGN-only option in a few years’ time.	There are various technical solutions to choose to achieve this option and selection of solutions require in-depth technical competency. Requires internal resources and careful consideration on planning

		and execution of IPv6 deployment. Need to maintain both IPv4 and IPv6 networks. Need to identify a workable business model to enable Customer Premises Equipment (CPE) (e.g., home gateway routers)

Review of indicative business costs

The above listed three options will have business costs. Doing nothing today obviously incurs no additional cost, but may incur substantial costs in the future. The other two options such as deploying CGN only versus deploying both CGN and IPv6 come with business costs. Actual business costs such as CAPEX and OPEX will vary depending on SP size, customer base size, the specific business model, geographic region of operation and economy of operation, and so forth. Therefore "one size does not fit all."

However, we are beginning to see some interesting research comparing costs associated with deploying CGN only versus deployment of both CGN and IPv6. Deploying only CGN is a strategy that simply extends IPv4 address lifetime. Deploying CGN and IPv6 is more holistic, as it prepares for the evolving Internet while extending IPv4 address lifetime.

An IDC report sponsored by Cisco in 2012 said that fixed network operators can expect up to 69% in savings over five years by deploying IPv6 for new subscribers instead of merely relying on the deprecating IPv4 address space by deploying NAT444/CGN (Chander, 2012). Another IDC report sponsored by Cisco in 2013 said that relying on IPv4 addresses only by deploying CGN in mobile networks is the most costly way to manage deprecating IPv4 addresses over a five-year period (Chander, 2013). According to this research, cumulative business costs in relying on IPv4 addresses by deploying CGN, without deployment of IPv6 in mobile networks over a five-year period, will increase business cost by 40%. Compared to this, cumulative business costs of deploying IPv6 transition technologies in addition to deploying IPv4 CGN in mobile networks over a five-year period increases business costs by 8.5% (Chander, 2013).

A network engineer at a major US ISP made another indicative estimate of the CGN business costs (Howard, 2012). This analysis concluded that deploying CGN costs USD 2 million for every 10,000 users over a five-year period. In other words, CGN costs USD 40.00 per user per year, although this estimate was made based on a common US business model by applying various assumptions of associated USD costs for implementing CGN. CGN costs may not be exactly the same for an SP in another country. However, the important message is that CGN does come with additional costs that go on top of SPs' conventional IPv4 network business costs. Such costs will continue as the SP's customer base grows.

Deploying IPv6 in the network operator's core network can occur as part of their regular network equipment upgrade cycle, although such deployment does require additional planning and training for their network engineers. In order to enable IPv6 services to their customers, some SPs will need to develop and adopt a technical and business plan on how to upgrade their access networks and CPEs with IPv6.

Successful IPv6 adopters often apply IPv6 services as a default to new subscribers and upgrade existing IPv4 customers with IPv6 services later when they conduct service upgrades. In this way, CPE costs can be absorbed into business upgrading costs. IPv6 deployment comes with some costs, but it appears to be a one-off capital cost unlike CGN's ongoing operational costs.

Conclusion

Managing IPv4 and IPv6 networks while providing smooth, fast, and reliable service today and tomorrow is the real challenge for those SPs who want to prepare for the exponential growth of Internet connectivity demand due to mobile devices. Millions and millions of new mobile devices connecting annually to the

Internet are likely to impact the current business model for some SPs and their enterprise customers. Some SPs may want to establish a new set of goals to respond to this new business environment. Responding to this challenge requires technical and business planning.

Regular network equipment upgrade cycles of SPs can provide an opportunity to deploy IPv6 into core networks although additional planning and technical training of key technical staff is required prior to such deployment. Then to enable IPv6 customer service, some SPs will need to adopt a technical and business plan on how to upgrade their access networks and CPEs with IPv6.

Making efforts to extend IPv4 address lifetime by using technology such as NAT444/CGN may come with accompanying negative consequences. Studies demonstrate that ongoing annual business costs continue when implementing such strategies, while such solutions may negatively impact end user experiences due to the overall likely degraded quality of Internet experience. On the other hand, upgrading to IPv6 technologies appears to be a one-off business cost for SPs, which allows SPs to evolve with the exponential growth in Internet connectivity demand, although strategies for upgrading CPEs still need to be considered.

SPs are at a critical turning point and some may be left behind if their organizations do not learn how to provide both IPv4 and IPv6 services. Obviously, choosing technologies that support the current business model, while establishing a foundation for a future business model is no simple task – there is no one strategy that fits all. SPs should begin by seeking input from their own technical and business development units about their analysis and recommendations. These would include actual ongoing annual costs and one-off costs for each option. They would also need to examine competitors' behaviours as part of the process of making an informed decision. Business planning needs to consider current and future Internet connectivity demand in arriving at a business model that makes sense today and tomorrow.

More detailed reference information

Information on impact of CGN-NAT

- NAT444 (CGN/LSN) and What it Breaks by Chris Grundemann (Feb 2011)
- Is NAT444 a realistic fix for IPv4? (Youtube video) By Spirent (June 2011)
- Assessing the Impact of Carrier-Grade NAT on Network Applications IETF draft (Nov 2011)
- Carrier Grade NAT – Observations and Recommendations by CableLabs (April 2012)
- A Royal Opinion on Carrier Grade NATs by Geoff Huston (May 2013)

Information on CGN-NAT economics

- White Paper: The Business Case for Delivering IPv6 Service Now (May 2012)
- Internet Access Pricing in a Post-IPv4 Runout World by Lee Howard (Time Warner Cable)

Information for CTOs – IPv6 transition technologies: advantages and disadvantages

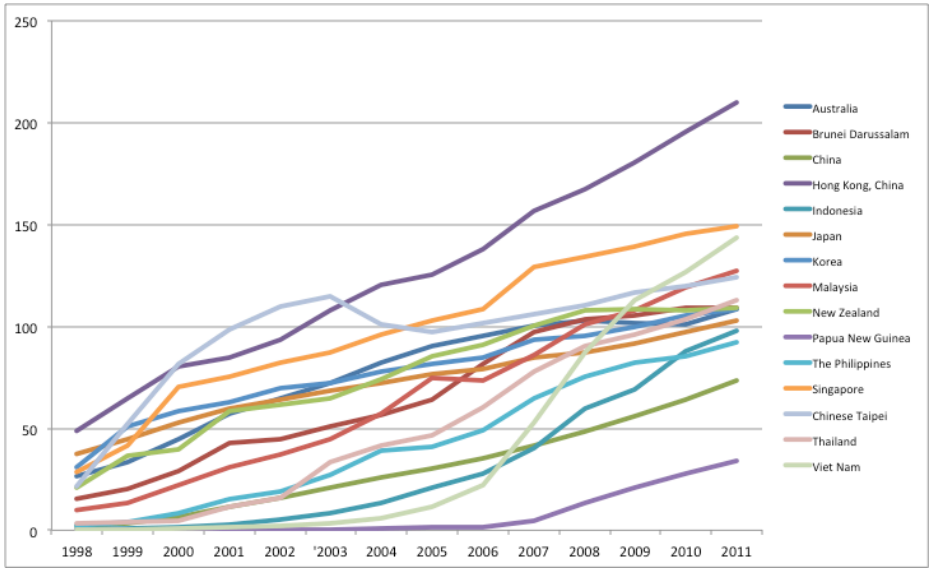
- A decision making tree of IPv6 transition technologies
- IPv4 and IPv6 co-existence, Dr Philip Smith, APNIC (Aug 2012)
- IPv6 Transition Technologies, Alastair Johnson, Alcatel Lucent (Nov 2012)

Appendix

Growth paths of the Internet

Internet growth is also at a tremendous rate in aspiring economies, but with distinctly different growth paths from those seen in developed economies. So from where is the growth is coming? The following charts show part of the answer.

Chart1: Mobile Cellular Subscriptions (per 100 inhabitants) (Source: StatsAPEC, APEC, http://statistics.apec.org/index.php/key_indicator/index)



The above chart is based on APEC's statistics as of 2011, Hong Kong reached 210 cellular subscription per 100 inhabitants (more than two subscription by one person), followed by Singapore 150, and the third highest economy of cellular subscription among member economies of Asian and Oceania of APEC is Vietnam, and they reached about 145 subscriptions per 100 inhabitants. The remaining top five economies are Malaysia (130), Taiwan (125) and Thailand (115). We can assume in terms of types telecommunication subscriptions, developing economies are leap-frogging into mobile networks.

Chart 2: Mobile Cellular Subscriptions (ratio to fixed telephone lines) (Source: Source: StatsAPEC, APEC, http://statistics.apec.org/index.php/key_indicator/index)

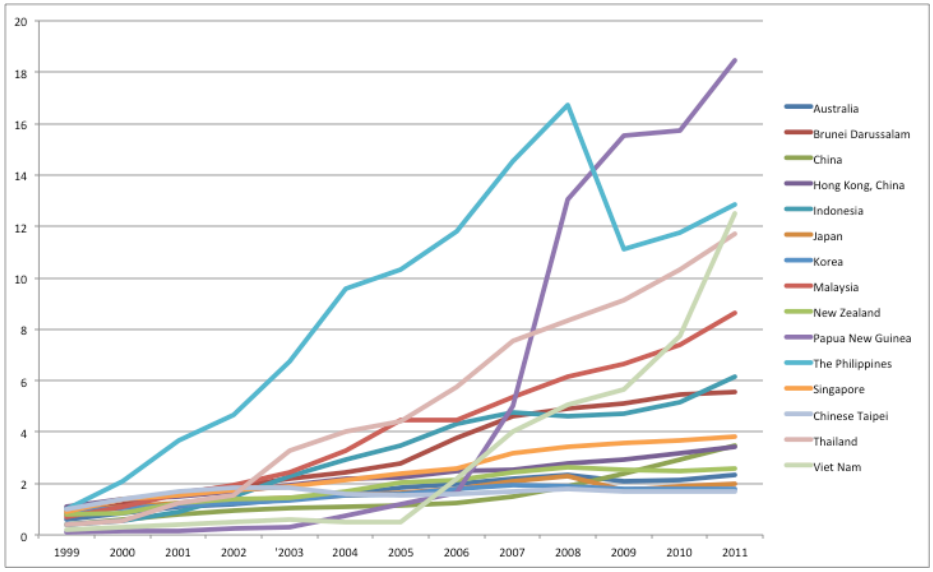


Chart 2 shows the growth trend of mobile cellular subscriptions in ratio to fixed telephone lines among Asian and Oceania member economies of APEC. Papua New Guinea's growth rate since 2006 is phenomenal. It increased eightfold between in the five years between 2006 and 2011. Indonesia, Vietnam and Thailand show similar steep growth curve as well. Compare to these growing trend of developing economies, it is quite interesting to see very moderate growth rate among developed economies such as Singapore, Hong Kong, and Japan.

Given recent robust increase of mobile devices such as smart phones and tablets, it is quite obvious, many Internet users of currently growing economies are accessing to the Internet often through mobile devices, and most likely solely from mobile devices comparing to Internet users of develop economies. Mobile devices are much lower cost to obtain than personal computers and cellular networks are free from high cost of cable installation on land.

Then what is the situation in developed economies with more fixed line infrastructure?

Chart 3: Internet Subscriptions, Broadband (per 100 inhabitants) (Source: StatsAPEC, APEC, http://statistics.apec.org/index.php/key_indicator/index)

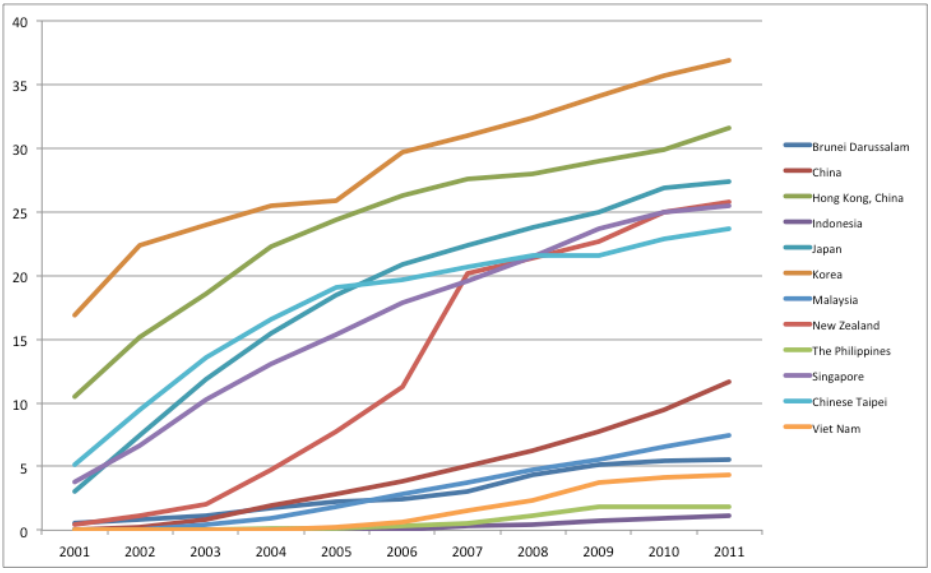


Chart 3 shows a different growth curve from the Chart 1 and 2. Top five economies with higher subscriptions of broadband Internet per 100 inhabitants are Korea, Hong Kong, Japan, New Zealand and Singapore. Interestingly, these economies are simultaneously listed with moderate and rather slower growth rate of mobile cellular subscriptions in ratio to fixed telephone lines (See Chart 2). Internet users in economies with matured fixed network infrastructure obviously use their existing fixed line infrastructure to access the Internet as well as newly available mobile devices thorough mobile networks.

While fixed network broadband still provides an important base for Internet users in developed economies, mobile network access to the Internet has became a major foundation for both currently growing economies and developed economies. Particularity mobile networks' role in currently growing economies is phenomenal. Such dynamic changes in the nature of telecommunication subscription that is educed by rapid evolution by infrastructure will bring in so many new Internet users into the market place. According to the McKinsey&Company's report, in 2010, 310 million mobile devices were used to access the Internet in 30 aspiring economies out of 800 million worldwide. It's almost 40% of the total and it is easy to imagine this trend will continue in the foreseeable future.

Reference

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