Broadband Traffic Report: COVID's 3rd Year Brings Lull in Traffic

1.1 Overview

In this report, we analyze traffic over the broadband access services operated by IIJ and present the results each year[*1*2*3*4*5]. Here, we again report on changes in traffic trends over the past year, based on daily user traffic and usage by port. Now in the third year of the COVID-19 pandemic, the solid increase in traffic we reported on last year has continued, albeit with the growth rate slowing slightly, and so far we see no noticeable changes in that overall trend.

Figure 1 plots the overall average monthly traffic trends for IIJ's fixed broadband services and mobile services. IN/OUT indicates the direction from the ISP perspective. IN represents uploads from users, and OUT represents user downloads. Because we cannot disclose specific traffic numbers, we have normalized the data, setting the OUT observations for January 2020, just before the pandemic, for both services to 1.

Broadband services traffic fell a little from autumn last year when Japan's COVID-19 case numbers settled down, and after rising in January–February when case numbers picked up again, traffic has been hovering roughly around the same level. Over the past year, broadband IN traffic increased 13% and OUT traffic increased 17%. These growth figures are down a little from the year-earlier figures of 20% and 23%.

The broadband figures include IPv6 IPoE traffic. IPv6 traffic on IIJ's broadband services comprises both IPoE and PPPoE traffic. As of June 2022, IPoE accounted for roughly 40% of all traffic, at 39% of IN and 41% of OUT broadband traffic overall, year-on-year increases of 8 and 11 percentage points, respectively. With PPPoE congestion having become quite noticeable amid COVID-19, users are increasingly shifting to IPoE, and use of IPoE thus continues to rise.

Mobile services traffic had remained range-bound amid COVID-19 up until we reported last year, but it subsequently began rising from summer. It fell a little when case numbers increased again in January–February, but it has been rising since. Over the past year, mobile IN traffic increased 23% and OUT traffic increased 8%.

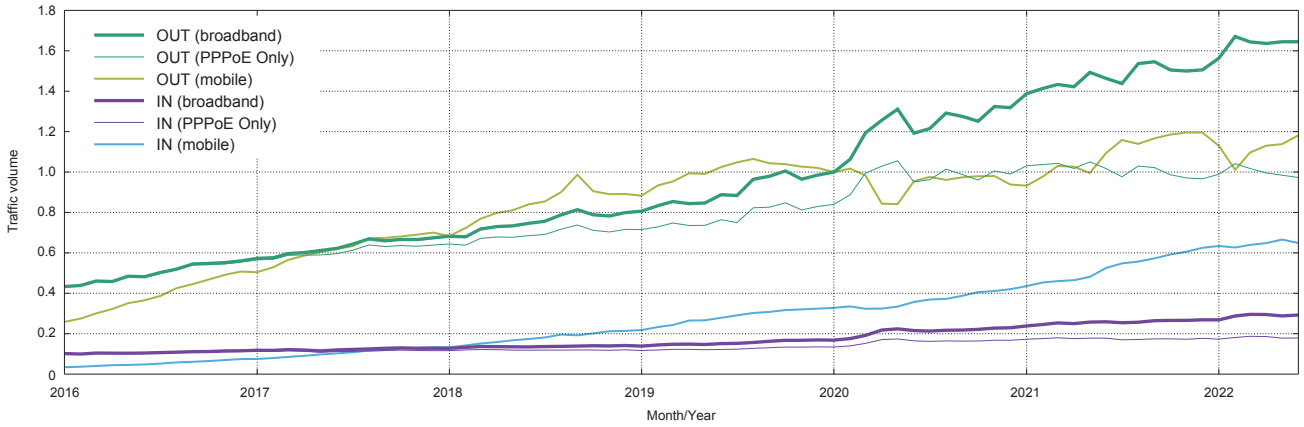

Figure 1: Monthly Broadband and Mobile Traffic

*1 Kenjiro Cho. Broadband Traffic Report: Broadband Traffic Report: COVID-19's Impact in its 2nd Year. Vol. 52. pp4-11. September 2021.
*2 Kenjiro Cho. Broadband Traffic Report: The Impact of COVID-19. Vol. 48. pp4-9. September 2020.
*3 Kenjiro Cho. Broadband Traffic Report: Moderate Growth in Traffic Volume Ongoing. Vol. 44. pp4-9. September 2019.
*4 Kenjiro Cho. Broadband Traffic Report: Download Growth Slows for a Second Year Running. Vol. 40. pp4-9. September 2018.
*5 Kenjiro Cho. Broadband Traffic Report: Traffic Growth Slows to a Degree. Internet Infrastructure Review. Vol. 36. pp4-9. September 2017.

We now look at broadband traffic by time of day on weekdays amid COVID-19. Traffic volume here is the sum of PPPoE and IPoE. Figure 2 shows traffic for the following seven weeks. To illuminate the initial changes taking place under COVID-19 in 2020, we show the week of February 25, 2020, before Japan's school closures, the week of April 20, 2020, corresponding to Japan's first state of emergency, and the week of June 22, 2020, after the state of emergency was lifted. And to illuminate changes that occurred later on, we then jump forward about half a year to the week of January 18, 2021, and then to the weeks of July 5, 2021, January 17, 2022, and July 4, 2022. We plot hourly average traffic volume figures for Monday–Friday for each of these weeks. The lines in the lower part of each plot represent uploads, but we again focus on download volume.

Comparing February and April 2020 to see the impact of the first state of emergency, we see that traffic was up substantially in the daytime and that it also increased during evening peak hours. When the state of emergency was lifted in June, the additional daytime traffic fell to less than half what it had been, but peak hours saw almost no decline. Over the last two years, traffic during the peak hours of 20:00–22:00 has seen a fairly consistent increase. Meanwhile, in both 2021 and 2022, daytime traffic was up significantly in January but not much in July. This probably reflects that in January of both years, people spent more time at home amid increases in COVID-19 case numbers, whereas the COVID-19 situation was relatively calm at the start of both Julys. So over the past two years, traffic has seen a solid increase during the nighttime peak hours, while increases during daytime hours have been influenced by the rates of people staying at home in response to COVID-19.

1.2 About the Data

As with previous reports, for broadband traffic, our analysis uses data sampled using Sampled NetFlow from the routers that accommodate the fiber-optic and DSL broadband customers of our personal and enterprise broadband access services. For mobile traffic, we use access gateway billing information to determine usage volumes for personal and enterprise mobile services, and we use Sampled NetFlow data from the routers used to accommodate these services to determine the ports used.

Because traffic trends differ between weekdays and weekends, we analyze traffic in one-week chunks. In this report, we look at data for the week of May 30 – June 5, 2022, and compare those data with data for the week of May 31 – June 6, 2021, which we analyzed in the previous edition of this report.

Results are aggregated by subscription for broadband traffic, and by phone number for mobile traffic as some subscriptions cover multiple phone numbers. The usage volume for each broadband user was obtained by matching the IP address assigned to users with the IP addresses observed. We gathered statistical information by sampling packets using NetFlow. The sampling rate was set to around 1/8,192, taking into account router performance and load. We estimated overall usage volumes by multiplying observed volumes by the reciprocal of the sampling rate. Note that IPoE traffic is not included in the analysis of traffic by port, as detailed data is not available because we use Internet Multifeed Co.'s transix service for IPoE.

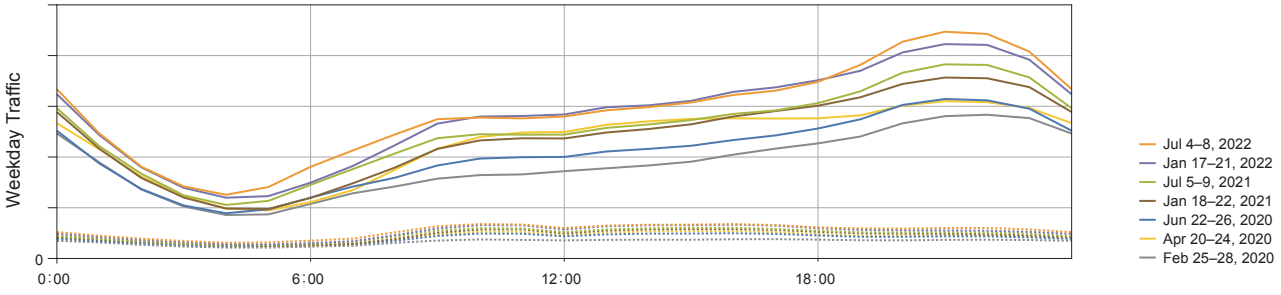

Figure 2: Hourly Average Broadband Traffic on Weekdays

1.3 Users' Daily Usage

First, we examine daily usage volumes for broadband and mobile users from several angles. Daily usage indicates the average daily usage calculated from a week's worth of data for each user.

Since our 2019 report, we have used daily usage data only on services provided to individuals. The distribution is heavily distorted if we include enterprise services, where usage patterns are highly varied. So to form a picture of overall usage trends, we determined that using only the personal user data would yield more generally applicable, easily interpretable conclusions. Starting with this report, we also include IPoE user data. Note that the analysis of usage by port in the next section does include enterprise data because of the difficulty of distinguishing between individual and enterprise usage.

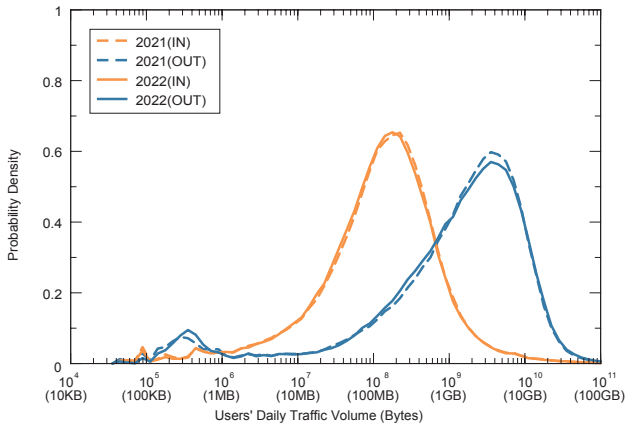

Figure 3: Daily Broadband (PPPoE) User Traffic Volume Distribution Comparison of 2021 and 2022

Figures 3 and 4 show the average daily usage distributions (probability density functions) for broadband (PPPoE and IPoE) and mobile users. Each compares data for 2021 and 2022 split into IN (upload) and OUT (download), with user traffic volume plotted along the X-axis and user frequency along the Y-axis. The X-axis shows volumes between 10KB (10^4) and 100GB (10^{11}) using a logarithmic scale. Most users fall within the 100GB (10^{11}) range, with a few exceptions.

The IN and OUT traffic distributions in the figures are close to a log-normal distribution, which looks like a normal distribution on a semi-log plot. A linear plot would show a long-tailed distribution, with the peak close to the left and a slow gradual decrease toward the right. The OUT distribution is further to the right than the IN distribution, indicating that download volume is more than an order of magnitude larger than upload volume.

First, we look at the broadband PPPoE distributions in Figure 3. Both the IN and OUT distributions have barely changed between 2021 and 2022. A close look reveals that the 2022 OUT distribution peak is ever so slightly lower while the midrange of the left side of the distribution is commensurately a little higher, indicating that the proportion of relatively low-usage users has risen a bit.

The broadband IPoE distributions in Figure 4 are shifted further to the right than the PPPoE distributions, and overall usage is much higher than for PPPoE. The distributions are also narrower than for PPPoE and almost symmetrical.

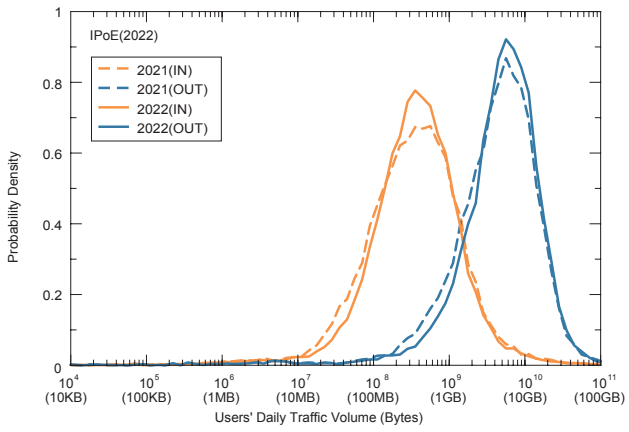

Figure 4: Daily Broadband (IPoE) User Traffic Volume Distribution Comparison of 2021 and 2022

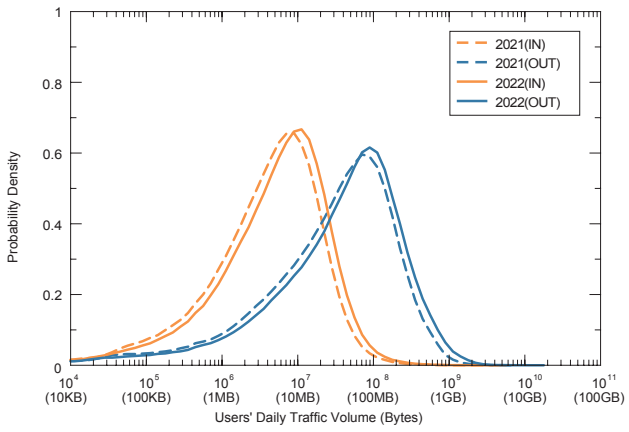

Figure 5: Daily Mobile User Traffic Volume Distribution Comparison of 2021 and 2022

While the proportion of low-usage users on the left side of the distributions is smaller, there is not much difference for high-usage users on the right of the distributions. The IPoE distributions do not look much different from last year, but the peaks are slightly higher, and in contrast to PPPoE, the proportion of observations near the mode increased.

So the overall broadband distributions for both PPPoE and IPoE have hardly changed. Meanwhile, with the migration from PPPoE to IPoE progressing, the proportion accounted for by IPoE is rising, so overall traffic volume is increasing.

The peaks of the mobile distributions in Figure 5 have moved a little to the right since last year, indicating that overall traffic has increased. Mobile usage volumes are significantly lower than for broadband, and limits on mobile data usage mean that heavy users, which fall on the right-hand side of the distribution, account for only a small proportion of the total. There are also no extremely heavy users. The variability in each user's daily usage volume is higher for mobile than for broadband owing to there being users who only use mobile data when out of the home/office as well as limits on mobile data.

Table 1 shows trends in the mean and median daily traffic values for broadband PPPoE users as well as the mode (the most frequent value, which represents the peak of the distribution). When the peak is slightly off the center of the distribution, the distribution is adjusted to bring the mode toward the center. Comparing 2021 and 2022, the IN mode fell from 200MB to 178MB and the OUT mode was unchanged at 3,981MB, translating into growth factors of 0.9 for IN and 1 for OUT. Meanwhile, because the means are influenced by heavy users (on the right-hand side of the distribution), they are significantly higher than the corresponding modes, with the IN mean at 698MB and the OUT mean at 4,291MB in 2022. The 2021 means were 684MB and 4,225MB, respectively.

As Table 2 shows, IPoE usage is much higher than PPPoE usage. This is probably because relatively high-usage users are moving to IPoE first, or in other words, because many of the low-usage users still linger on PPPoE. In 2022, the IN mode was 398MB and the OUT mode was 6,310MB, while the means were IN 1,007MB and OUT 7,700MB. The 2021 modes were IN 447MB and OUT 6,310MB, and the means were IN 1,110MB and OUT 7,169MB.

Table 1: Trends in Mean and Mode of Broadband (PPPoE) Users' Daily Traffic Volume

	IN(MB/day)			OUT(MB/day)		
Year	Mean	Median	Mode	Mean	Median	Mode
2007	436	5	5	718	59	56
2008	490	6	6	807	75	79
2009	561	6	6	973	91	100
2010	442	7	7	878	111	126
2011	398	9	9	931	144	200
2012	364	11	13	945	176	251
2013	320	13	16	928	208	355
2014	348	21	28	1124	311	501
2015	351	32	45	1399	443	708
2016	361	48	63	1808	726	1000
2017	391	63	79	2285	900	1259
2018	428	66	79	2664	1083	1585
2019	479	75	89	2986	1187	1995
2020	609	122	158	3810	1638	3162
2021	684	136	200	4225	1875	3981
2022	698	130	178	4291	1778	3981

Table 2: Trends in Mean and Mode of Broadband (IPoE) Users' Daily Traffic Volume

	IN(MB/day)			OUT(MB/day)		
Year	Mean	Median	Mode	Mean	Median	Mode
2021	1110	312	447	7169	4285	6310
2022	1007	336	398	7700	4935	6310

All of the mobile traffic metrics were up, as Table 3 shows. In 2022, the IN mode was 10MB and the OUT mode was 89MB, while the means were IN 13MB and OUT 114MB. The 2021 modes were IN 8MB and OUT 71MB, and the means were IN 10MB and OUT 86MB.

Figures 6, 7, and 8 plot per-user IN/OUT usage volumes for random samples of 5,000 users. The X-axis shows OUT (download volume) and the Y-axis shows IN (upload volume), with both using a logarithmic scale. Users with identical IN/OUT values fall on the diagonal.

The cluster spread out below and parallel to the diagonal in each of these plots represents typical users with download volumes an order of magnitude higher than upload volumes. For broadband PPPoE traffic, there was previously a clearly recognizable cluster of heavy users spread out thinly about the upper right of the diagonal, but this is now no longer discernible. Variability between users in terms of usage levels and IN/OUT ratios is wide, indicating that there is a diverse range of usage styles. On IPoE, there is less variability between users than with PPPoE, and the proportion of low-usage users is small. For mobile traffic, the pattern of OUT being an order of magnitude larger also applies, but usage volumes are much lower than for broadband. For both broadband and mobile, there is almost no difference between these plots and those for 2021.

Traffic is heavily skewed across users, such that a small proportion of users accounts for the majority of overall traffic volume. For example, the top 10% of broadband users account for 50% of total OUT and 78% of total IN traffic, while the top 1% of users account for 16% of OUT and 53% of IN traffic.

Table 3: Trends in Mean and Mode of Mobile Users' Daily Traffic Volum

	IN(MB/day)			OUT(MB/day)		
Year	Mean	Median	Mode	Mean	Median	Mode
2015	6.2	3.2	4.5	49.2	23.5	44.7
2016	7.6	4.1	7.1	66.5	32.7	63.1
2017	9.3	4.9	7.9	79.9	41.2	79.4
2018	10.5	5.4	8.9	83.8	44.3	79.4
2019	11.2	5.9	8.9	84.9	46.4	79.4
2020	10.4	4.5	7.1	79.4	35.1	63.1
2021	9.9	4.7	7.9	85.9	37.9	70.8
2022	12.8	6.0	10.0	113.7	49.2	89.1

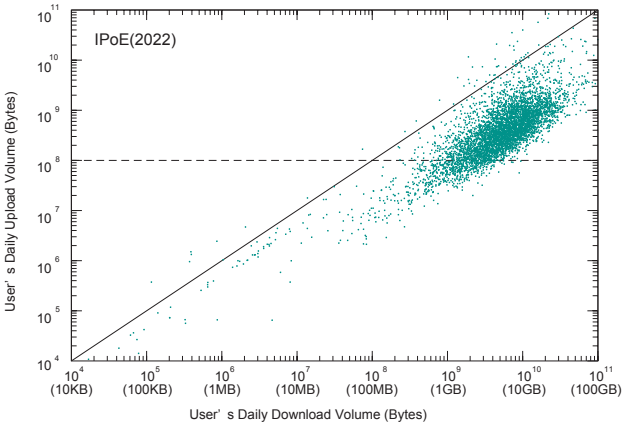

Figure 7: IN/OUT Usage for Each Broadband (IPoE) User

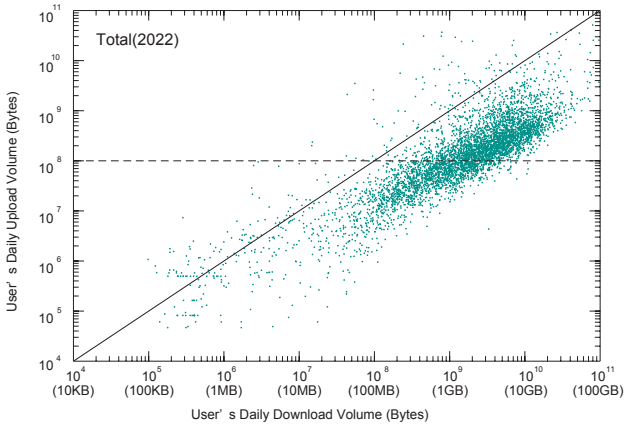

Figure 6: IN/OUT Usage for Each Broadband (PPPoE) User

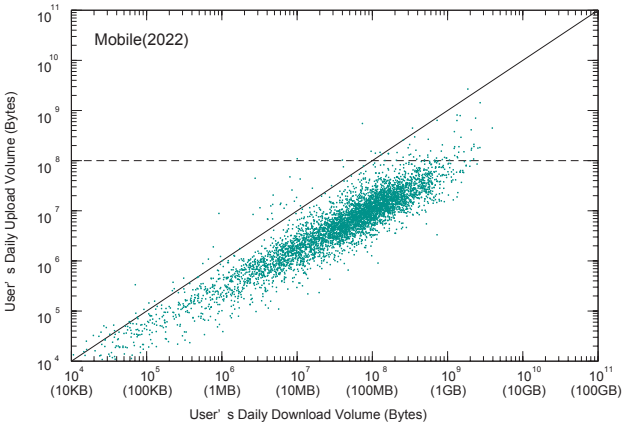

Figure 8: IN/OUT Usage for Each Mobile User

The skew has increased just slightly from last year. On IPoE, the skew is smaller than for PPPoE, with the top 10% of users accounting for 39% of OUT and 64% of IN traffic and the top 1% of users accounting for 11% of OUT and 36% of IN traffic. As for mobile, the top 10% of users account for 50% of OUT and 49% of IN traffic, while the top 1% account for 13% of OUT and 16% of IN traffic. The skew in OUT traffic has increased just slightly from last year.

1.4 Usage by Port

Next, we look at a breakdown of traffic and examine usage levels by port. Recently, it has become difficult to identify applications by port number. Many P2P applications use dynamic ports on both ends, and a large number of client/server applications use port 80, which is assigned to HTTP, to avoid firewalls. Hence, generally speaking, when both parties are using a dynamic port numbered 1024 or higher, the traffic is likely to be from a P2P application, and when one of the parties is using a well-known port lower than 1024, the traffic is likely to be from a client/server application. In light of this, we take the lower of the source and destination port numbers when breaking down TCP and UDP usage volumes by port.

Table 4 shows the percentage breakdown of broadband users' usage by port over the past five years. In 2022, 72% of all traffic was over TCP connections, largely unchanged from 2021. The proportion of traffic over port 443 (HTTPS) was 56%, a 2-point increase from last year. The proportion of traffic over port 80 (HTTP) fell from 12% to 9%. The figure for UDP port 443, which is used by the QUIC protocol, was largely unchanged at 16%.

TCP dynamic port traffic, which had been in decline, looks to have leveled out at 6%. Individual dynamic port numbers account for only a tiny portion, with the most commonly used port 31000 only making up 0.9%. Port 1935, which is used by Flash Player, makes up 0.2%, but almost all other traffic is VPN related.

Table 4: Broadband Users' Usage by Port

year	2018	2019	2020	2021	2022
protocol port	(%)	(%)	(%)	(%)	(%)
TCP	**78.5**	**81.2**	**77.2**	**71.9**	**71.6**
(< 1024)	68.5	73.3	70.5	65.8	65.4
443(https)	40.7	51.9	52.4	53.5	55.7
80(http)	26.5	20.4	17.2	11.6	8.9
183	0.0	0.0	0.0	0.1	0.2
22(ssh)	0.1	0.2	0.2	0.2	0.1
993(imaps)	0.2	0.3	0.2	0.1	0.1
(>= 1024)	10.0	7.9	6.7	6.1	6.2
31000	0.1	0.2	0.4	0.6	0.9
8080	0.3	0.5	0.4	0.4	0.3
1935(rtmp)	0.7	0.3	0.4	0.2	0.2
UDP	**16.4**	**14.1**	**19.4**	**24.5**	**24.3**
443(https)	10.0	7.8	10.5	15.9	16.3
4500(nat-t)	0.2	0.3	0.6	0.8	0.8
8801	0.0	0.0	1.1	0.9	0.6
ESP	**4.8**	**4.4**	**3.2**	**3.3**	**3.8**
GRE	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**
IP-ENCAP	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**
ICMP	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 5 shows the percentage breakdown by port for mobile users. The figures are close to those for broadband on the whole. This is likely because apps similar to those for PC platforms are now also used on smartphones, and because the proportion of broadband usage on smartphones is rising.

Broadband data only include PPPoE, not IPoE, and so do not necessarily reflect the trend in fixed broadband overall. Comparing IPv4 and IPv6 on mobile, port 443 accounts for a higher proportion of both TCP and UDP usage on IPv6, and there is probably a similar trend in the case of IPoE.

Table 5: Mobile Users' Usage by Port

year	2018	2019	2020	2021	2022
protocol port	(%)	(%)	(%)	(%)	(%)
TCP	**76.6**	**76.9**	**75.5**	**70.3**	**71.6**
443(https)	52.8	55.6	50.7	44.4	42.3
80(http)	16.7	10.3	7.4	5.0	4.1
993(imaps)	0.3	0.3	0.2	0.2	0.1
1935(rtmp)	0.1	0.1	0.1	0.1	0.1
UDP	**19.4**	**17.3**	**18.0**	**23.8**	**24.4**
443(https)	10.6	8.3	9.3	16.3	17.9
4500(nat-t)	4.5	3.0	1.8	3.7	2.7
1701(12tp)	0.0	0.4	0.9	0.0	0.8
8801	0.0	0.0	1.4	0.7	0.3
3480	0.0	0.0	0.4	0.3	0.1
ESP	**3.9**	**5.8**	**6.4**	**5.8**	**3.9**
GRE	**0.1**	**0.0**	**0.1**	**0.1**	**0.0**
ICMP	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

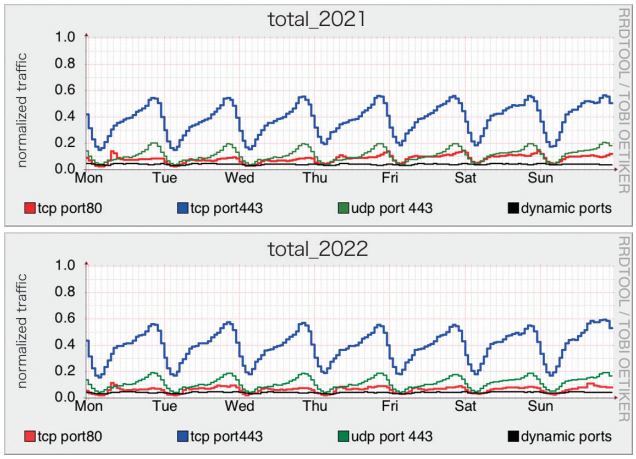

Figure 9: Broadband Users' Port Usage Over a Week
2021 (top) and 2022 (bottom)

Figure 9 compares overall broadband traffic for key port categories across the course of the week from which observations were drawn in 2021 and 2022. We break the data into four port buckets: TCP ports 80 and 443, and dynamic TCP ports (1024 and up), and UDP port 443. The data are normalized so that peak overall traffic volume on the plot is 1. The overall peak is around 19:00–23:00. When compared, there is almost no difference between 2021 and 2022, and it appears that the migration from HTTP to HTTPS has largely run its course for now.

Figure 10 shows the trend for TCP ports 80 and 443 and UDP port 443, which account for the bulk of mobile traffic. Here too, there is almost no change from 2021. When compared with broadband, we note that mobile traffic levels remain high throughout the day, from morning through night. The plot shows that usage times differ from those for broadband, with three separate mobile traffic peaks occurring on weekdays: morning commute, lunch break, and evening around 17:00–22:00.

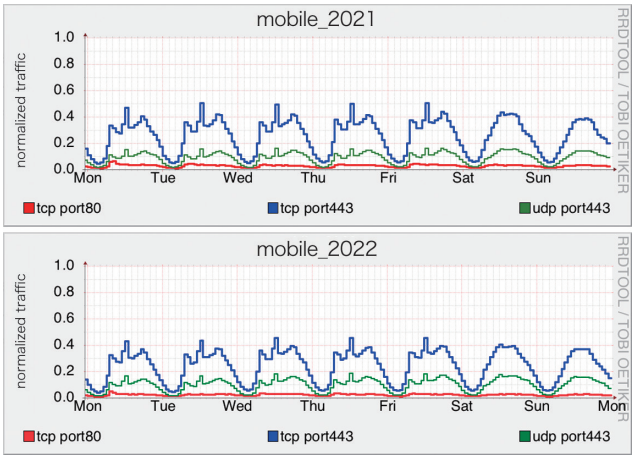

Figure 10: Mobile Users' Port Usage Over a Week
2021 (top) and 2022 (bottom)

1.5 Conclusion

In summary, the trends in traffic we reported on last year have continued to hold over the past twelve months, which marked COVID-19's third year, with no major changes apparent. Daytime broadband traffic does look to have been shaped by the rate at which people stayed home in response to infection case numbers, but it is steadily rising during the peak hours. Growth in overall traffic volume has been solid, driven by the migration to IPoE, but beyond that, there has not been much change in individual users' usage volumes. Hence, while it is evident that online conferencing and video streaming are establishing themselves as the norm, looking at the past year in isolation, we do not really see any major changes in the services users use or how they use them.

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