Broadband Traffic Report
Traffic in a Stable Uptrend Post-COVID

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. Traffic has continued to grow steadily since the COVID-19 pandemic fell into the rearview mirror, and at present 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.

Over the past year, broadband IN traffic increased 11% and broadband OUT traffic increased 18%. The corresponding year-earlier figures were 13% and 17%.

The broadband figures include IPv6 IPoE traffic. IPv6 traffic on IIJ's broadband services comprises both IPoE and PPPoE traffic. As of June 2023, IPoE accounted for over 40% of all traffic, at 42% of IN and 44% of OUT broadband traffic overall, year-on-year increases of 3 percentage points each. 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 has been in an uptrend since 2021. Over the past year, mobile IN traffic increased 27% and mobile OUT traffic increased 31%.

We now look at broadband traffic by time of day on weekdays over the past year. Figure 2 plots hourly average traffic volume for Monday–Friday for four one-week blocks selected at intervals of roughly four months since May 2022. Weekday daytime traffic volumes have increased during school holiday periods in recent years, so we selected school weeks. Traffic volume here is the sum of PPPoE and IPoE. The dotted lines in the lower part of the plot

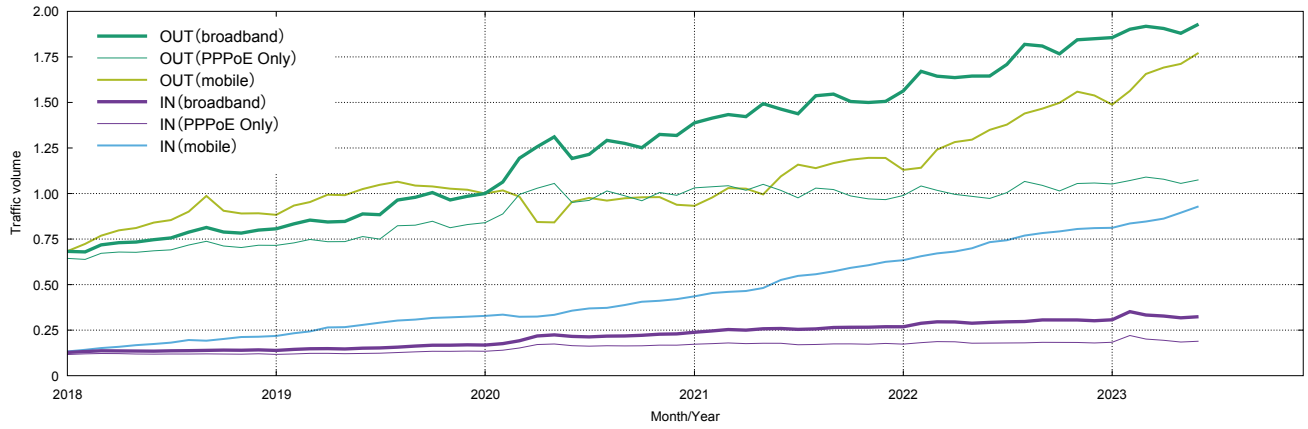

Figure 1: Monthly Broadband and Mobile Traffic

*1 Kenjiro Cho. Broadband Traffic Report: Broadband Traffic Report: COVID's 3rd Year Brings Lull in Traffic. Vol. 56. pp4-11. September 2022.
*2 Kenjiro Cho. Broadband Traffic Report: Broadband Traffic Report: COVID-19's Impact in its 2nd Year. Vol. 52. pp4-11. September 2021.
*3 Kenjiro Cho. Broadband Traffic Report: The Impact of COVID-19. Vol. 48. pp4-9. September 2020.
*4 Kenjiro Cho. Broadband Traffic Report: Moderate Growth in Traffic Volume Ongoing. Vol. 44. pp4-9. September 2019.
*5 Kenjiro Cho. Broadband Traffic Report: Download Growth Slows for a Second Year Running. Vol. 40. pp4-9. September 2018.

represent uploads for each week, but focusing again on download volumes in this edition, we see that traffic volumes were up across all times of the day. The size of the increase during the middle of the day and during the nighttime peak are around the same in absolute terms, so the proportional increase is higher for daytime traffic.

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 29 – June 4, 2023, and compare those data with data for the week of May 30 – June 5, 2022, 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 addresses 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.

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. 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. Note also that we have included IPoE user data in the broadband figures since 2021. In the previous edition of this report, we showed PPPoE and IPoE separately, but starting with this edition, we roll both sets of figures into a single broadband data set[*6].

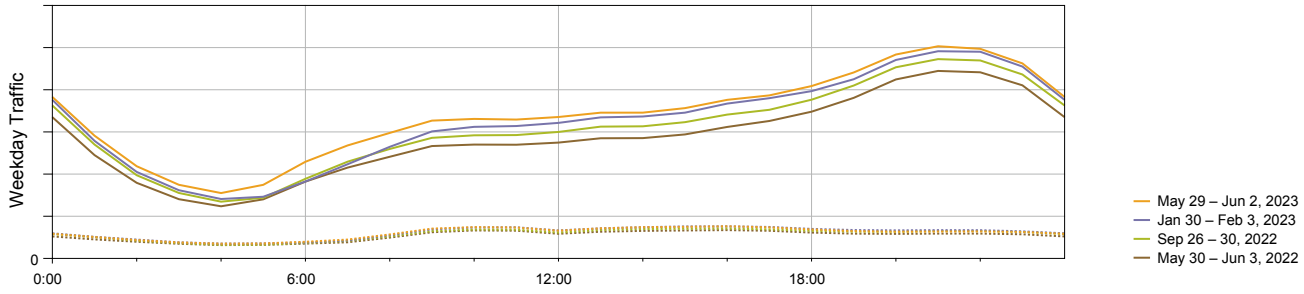

Figure 2: Hourly Average Broadband Traffic on Weekdays in the Past Year

*6 The PPPoE and IPoE usage figures of users who use both protocols are treated as coming from separate users.

Figures 3 and 4 show the average daily usage distributions (probability density functions) for broadband and mobile users. Each compares data for 2022 and 2023 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 distributions in Figure 3. Comparing 2022 and 2023, both the IN and OUT distributions have moved just slightly to the right, indicating that overall traffic has increased. The peaks of the mobile distributions in Figure 4 have also moved a little to the right since last year, again 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 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

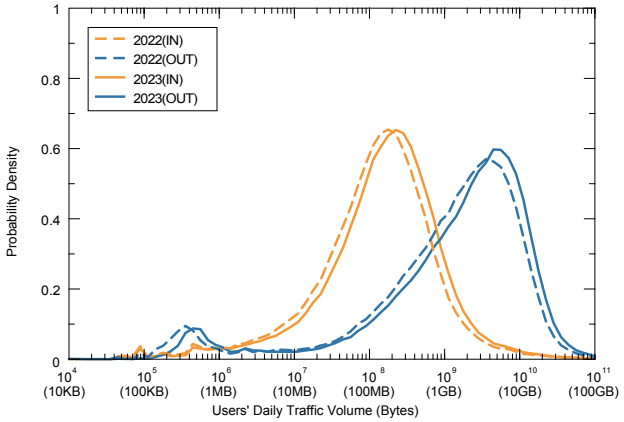

Figure 3: Daily Broadband User Traffic Volume Distribution Comparison of 2022 and 2023

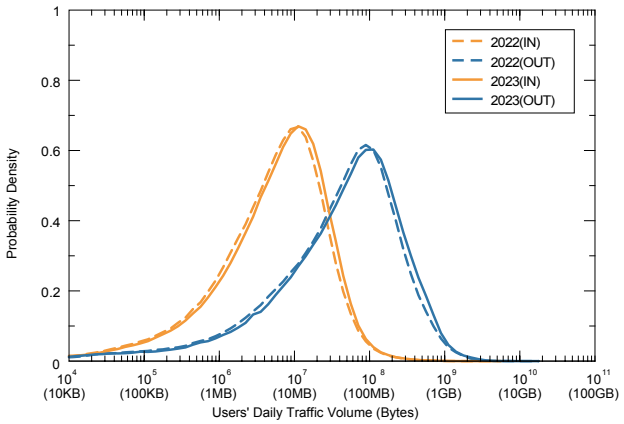

Figure 4: Daily Mobile User Traffic Volume Distribution Comparison of 2022 and 2023

Table 1: Trends in Mean and Mode of Broadband 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	714	143	200	4432	2004	3981
2022	727	142	178	4610	2010	3981
2023	804	166	224	5456	2369	5012

toward the center. Comparing 2022 and 2023, the IN mode rose from 178MB to 224MB and the OUT mode rose from 3,981MB to 5,012MB, translating into growth factors of 1.26 for IN and 1.26 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 804MB and the OUT mean at 5,456MB in 2023. The 2022 means were 727MB and 4,610MB, respectively. As mentioned, up to 2020 the data covered only PPPoE users, and since 2021 the data have covered both PPPoE and IPoE users.

Table 2 shows the mobile traffic metrics. In 2023, the IN mode was 11MB and the OUT mode was 100MB, while the means were IN 14MB and OUT 129MB. The 2022 modes were IN 10MB and OUT 89MB, and the means were IN 13MB and OUT 114MB.

Table 2: Trends in Mean and Mode of Mobile Users' Daily Traffic Volume

	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
2023	14.1	6.8	11.2	129.2	56.0	100.0

Figures 5 and 6 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. Variability between users in terms of usage levels and IN/OUT ratios is wide, indicating that there is a diverse range of usage styles. 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 2022.

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 49% of total OUT and 76% of total IN traffic, while the top 1% of users account for 16% of OUT and 49% of IN traffic. On mobile, the top 10% of users account for 49% of total OUT and 47% of total IN traffic, while the top 1% of users account for 15% of OUT and 15% of IN traffic.

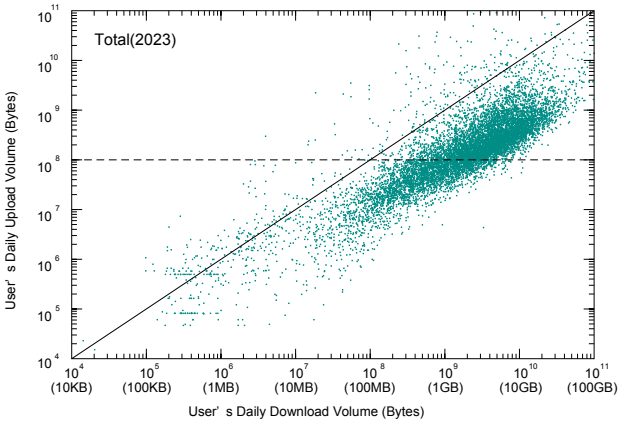

Figure 5: IN/OUT Usage for Each Broadband User

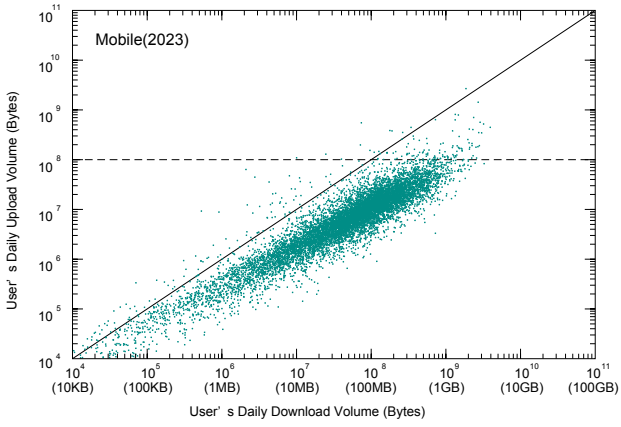

Figure 6: IN/OUT Usage for Each Mobile User

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 HTTP ports like port 80 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 3 shows the percentage breakdown of broadband users' usage by port over the past five years. In 2023, 71% of all traffic was over TCP connections, down 1 point from 2022. The proportion of traffic over port 443 (HTTPS) was 57%, a 1-point increase from last year. The proportion of traffic over port 80 (HTTP) fell from 9% to 7%. The figure for UDP port 443, which is used by the QUIC protocol, was up 2 points to 18%.

TCP dynamic port traffic fell ever so slightly to below 6%. Individual dynamic port numbers account for only a tiny portion, with the most commonly used port 31000 only making up 1.1%.

Table 4 shows the percentage breakdown by port for mobile users. The figures are close to those for broadband on the whole. This is possibly 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.

The broadband port 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 3: Broadband Users' Usage by Port

year	2019	2020	2021	2022	2023
protocol port	(%)	(%)	(%)	(%)	(%)
TCP	**81.2**	**77.2**	**71.9**	**71.6**	**70.5**
(< 1024)	73.3	70.5	65.8	65.4	64.8
443(https)	51.9	52.4	53.5	55.7	56.9
80(http)	20.4	17.2	11.6	8.9	7.2
183	0.0	0.0	0.1	0.2	0.2
993(imaps)	0.3	0.2	0.1	0.1	0.1
22(ssh)	0.2	0.2	0.2	0.1	0.1
(>= 1024)	7.9	6.7	6.1	6.2	5.7
31000	0.2	0.4	0.6	0.9	1.1
8080	0.5	0.4	0.4	0.3	0.4
1935(rtmp)	0.3	0.4	0.2	0.2	0.2
UDP	**14.1**	**19.4**	**24.5**	**24.3**	**25.4**
443(https)	7.8	10.5	15.9	16.3	18.2
4500(nat-t)	0.3	0.6	0.8	0.8	1.0
8801	0.0	1.1	0.9	0.6	0.4
ESP	**4.4**	**3.2**	**3.3**	**3.8**	**3.8**
GRE	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**
IP-ENCAP	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**
ICMP	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 4: Mobile Users' Usage by Port

year	2019	2020	2021	2022	2023
protocol port	(%)	(%)	(%)	(%)	(%)
TCP	**76.9**	**75.5**	**70.3**	**71.6**	**71.0**
443(https)	55.6	50.7	44.4	42.3	42.1
80(http)	10.3	7.4	5.0	4.1	3.5
993(imaps)	0.3	0.2	0.2	0.1	0.1
1935(rtmp)	0.1	0.1	0.1	0.1	0.2
UDP	**17.3**	**18.0**	**23.8**	**24.4**	**26.5**
443(https)	8.3	9.3	16.3	17.9	20.9
4500(nat-t)	3.0	1.8	3.7	2.7	2.5
8801	0.0	1.4	0.7	0.3	0.2
51820	0.0	0.0	0.0	0.1	0.2
53(dns)	0.1	0.1	0.2	0.2	0.2
ESP	**5.8**	**6.4**	**5.8**	**3.9**	**2.4**
GRE	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**
ICMP	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**

Figure 7 compares overall broadband traffic for key port categories across the course of the week from which observations were drawn in 2022 and 2023. We break the data into four port buckets: TCP ports 80 and 443, 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 are no major changes between 2022 and 2023, but traffic on UDP port 443 is up a little, and as previously mentioned in relation to Figure 2, the proportion of traffic accounted for by daytime hours has also increased a bit.

Figure 8 shows the trend for TCP ports 80 and 443 and UDP port 443, which account for the bulk of mobile traffic. As was the case with broadband, mobile traffic on UDP port 443 was up slightly compared with 2022. The lunchtime peak is a little lower compared with 2022 and, accordingly, more spread out. Comparing the plots with those for broadband, usage times evidently differ, with mobile having three separate traffic peaks on weekdays: morning commute, lunch break, and evening.

1.5 Conclusion

With the COVID-19 pandemic behind us, we have finally returned to normal everyday life, and yet the Internet has come to permeate our daily affairs and is now a crucial part of our everyday infrastructure. Video conferencing and remote work are here to stay, and even our children now routinely stream video in the home. And with Japan's performances in the 2022 FIFA World Cup and the March 2023 World Baseball Classic attracting eyeballs, online broadcasting has also broadened the sports viewership base. The proportion of social media accounted for by video content has also increased markedly relative to a few years ago. Meanwhile, although per-user traffic volume on both broadband and mobile jumped in 2020, the first year of the pandemic, it has since eased to relatively stable growth levels. Overall traffic volume also remains in a solid uptrend. Contributing factors here may include the decline in work-from-home rates since 2021 resulting in people spending less time online, a lack of any truly notable new services or use cases, and milder growth in traffic volumes than growth in video content volumes would otherwise suggest owing to technological advancements such as more efficient video compression.

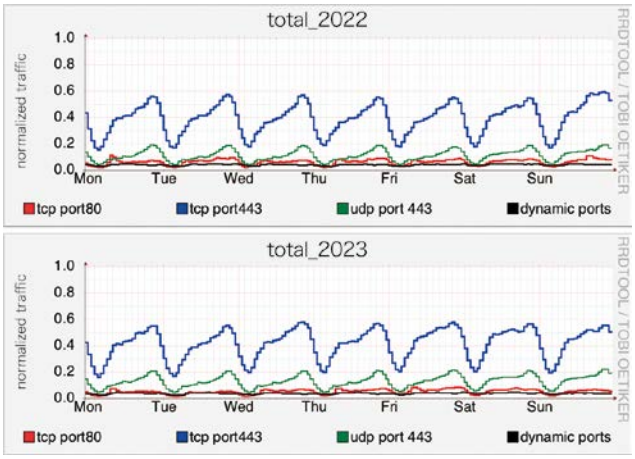

Figure 7: Broadband Users' Port Usage Over a Week
2022 (top) and 2023 (bottom)

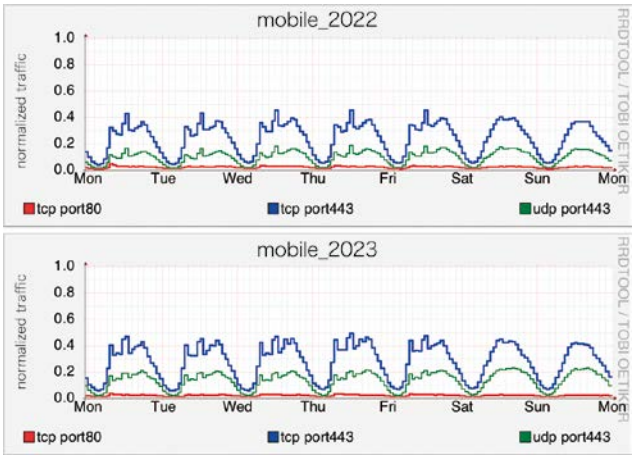

Figure 8: Mobile Users' Port Usage Over a Week
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