Growth Trends in Japanese Broadband Traffic

Kenjiro Cho (IIJ)
Kensuke Fukuda (NII)
Hiroshi Esaki (Univ. of Tokyo)
Akira Kato (Univ. of Tokyo)

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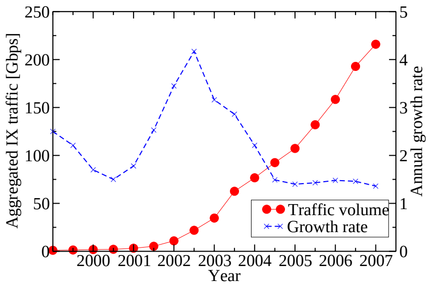
about this talk

- extensive study on residentail broadband (RBB) traffic
  - aggregated traffic data from 7 Japanese ISPs
  - comparison of heavy-hitters/other-users, fiber/DSL users
- results show impact of RBB to Internet usage/backbone traffic
  - networking people should know
  - although each result may not be too surprising to experts

unprecedented traffic increase in backbone

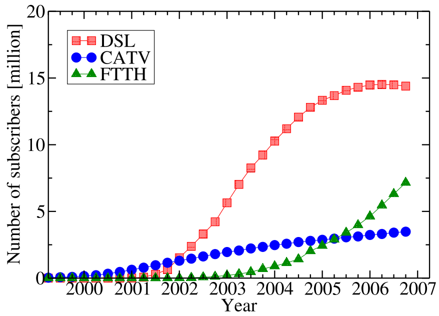
- rapidly growing residential broadband access
  - low-cost high-speed services, especially in Korea and Japan
  - Japan is by far the highest in Fiber-To-The-Home (FTTH)
- traffic growth of the peak rate at major Japanese IXes
  - still keeps growth of 50% per year
  - how much is contributed by residential broadband traffic?



Traffic growth at major Japanese IXes

residential broadband subscribers in Japan

- 25 million broadband subscribers as of September 2006
  - 14.4 million for DSL, 3.5 million for CATV, 7.2 million for FTTH
- exponential increase of FTTH, expected to exceed DSL in 2008
  - 100Mbps bi-directional fiber access costs 40USD/month
  - significant impact to backbones



RBB subscribers in Japan

motivation

- concerns about rapid growth of RBB traffic
  - backbone technologies will not keep up with RBB traffic
  - ISPs cannot invest in backbone simply for low-profit RBB
- ISPs and policy makers need to understand the effects of RBB
  - although most ISPs internally measure their traffic
    - data are seldom made available to others
    - measurement methods and policies differ from ISP to ISP

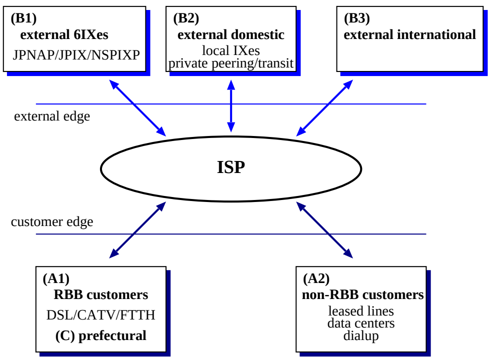
- to identify the macro-level impact of RBB traffic on ISP backbones
  - a study group with 7 major Japanese ISPs and government
- our approach consists of 2 analyses
  - aggregated traffic analysis
    - based on aggregated SNMP data from 7 major ISPs
  - per-customer traffic analysis
    - based on Sampled NetFlow data from one of the ISPs

major findings in aggregated traffic data

- our data is considered to cover 42% of total Japanese traffic
  - total RBB traffic in Japan is estimated to be 637Gbps (2006/11)
- 70% of RBB traffic is constant, peak in the evening hours
- p2p file-sharing was dominant in 2004
  - non-p2p video downloading has increased in 2006
- RBB traffic is much larger than office traffic, so backbone traffic is dominated by RBB traffic
- traffic volume exchanged via private peering is larger than volume exchanged via major IXes
- regional RBB traffic is roughly proportional to regional population

data collection across major ISPs

- focus on traffic crossing ISP boundaries (customer and external)
  - tools were developed to aggregate MRTG/RRDtool traffic logs
- only aggregated results published not to disclose individual ISP share
- challenges: mostly political or social, not technical



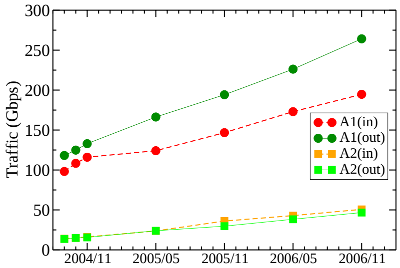
5 traffic groups at ISP cusomer and external boundaries

methodology for aggregated traffic analysis

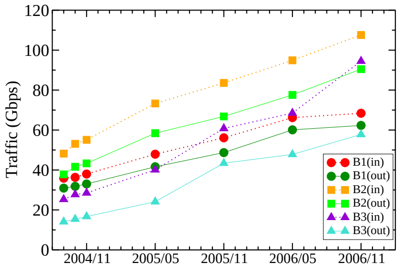
- month-long traffic logs for the 5 traffic groups with 2-hour resolution
  - MRTG's resolution for monthly log
- a script to read and aggregate a list of MRTG/RRDtool logs
  - each ISP creates log lists and makes aggreagated logs by themselves without disclosing details
- biggest workload for ISP
  - creating lists by classifying large number of per-interface logs
    - some ISPs have more than 100,000 logs!
  - maintaining the lists
    - frequent planned and unplanned configuration changes
- data sets
  - 2-hour resolution interface counter logs
    - from Sep/Oct/Nov 2004, May/Nov 2005, May/Nov 2006
    - by re-aggregating logs provided by 7 ISPs
- IN/OUT from ISPs' view

traffic growth

- 26-66% increase in 2006
  - RBB: 33% increase for inbound, 36% increase for outbound
- growth has slowed down from 100% in 2002 to 50% in 2005
  - observed worldwide



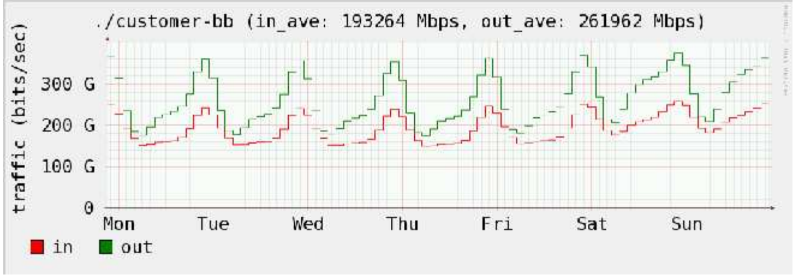
Growth of customer traffic



Growth of external traffic

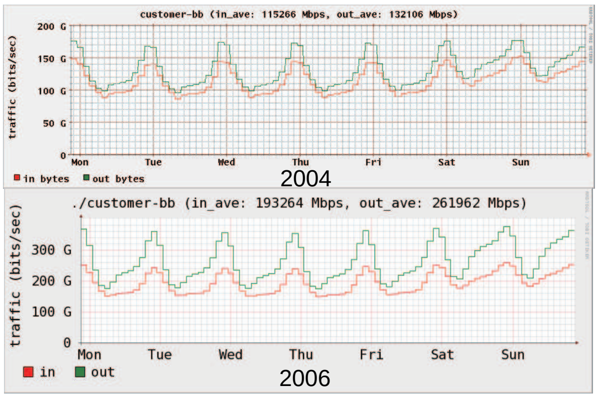
RBB customer weekly traffic
in November 2006

- DSL/CATV/FTTH customer traffic of the 7 ISPs
  - 200Gbps on average!
  - 150Gbps is constant, probably due to automated p2p applications
  - daily fluctuations: peak from 21:00 to 23:00



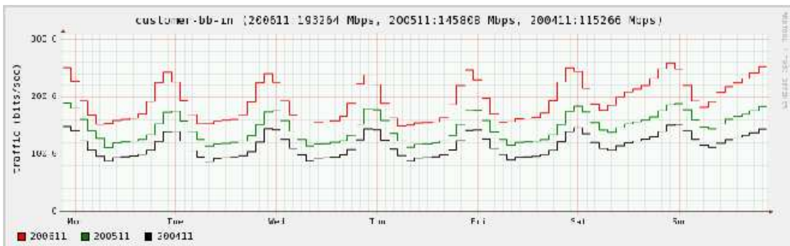
changes in RBB weekly traffic

- in 2004, inbound and outbound was almost equal
- in 2006, outbound (downloading to users) became larger



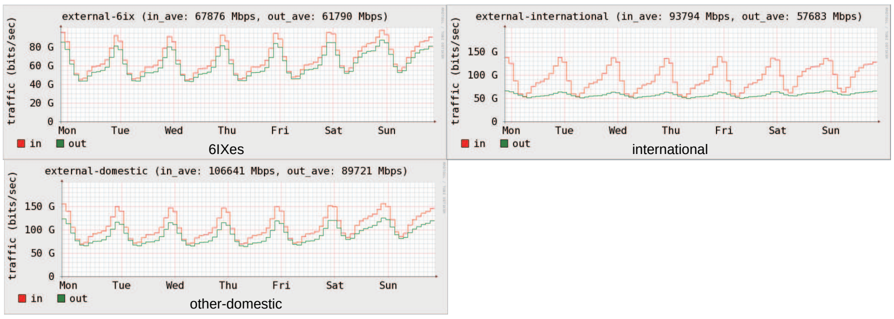
comparing RBB in-volumes among 2004, 2005 and 2006

- the growth came from the constant portion in 2005!
- both constatnt portion and daily fluctuations grew in 2006



weekly external traffic

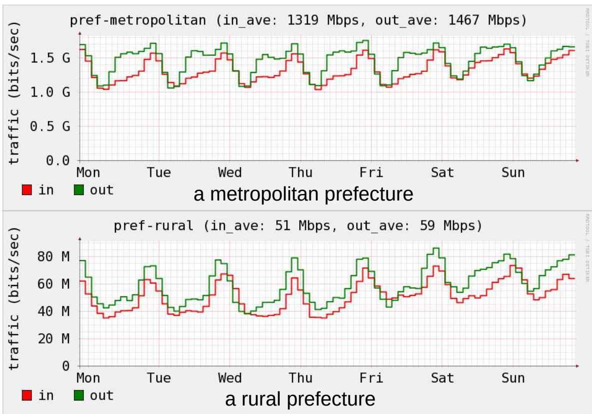
- external traffic is also strongly affected by RBB traffic
  - other-domestic: mainly private peering (also transit, regional IXes)
    - larger than traffic via majior IXes
  - international: inbound much larger than outbound
    - traditional content downloading seems still non-negligible



External weekly traffic in November 2006

prefectural differences in RBB traffic

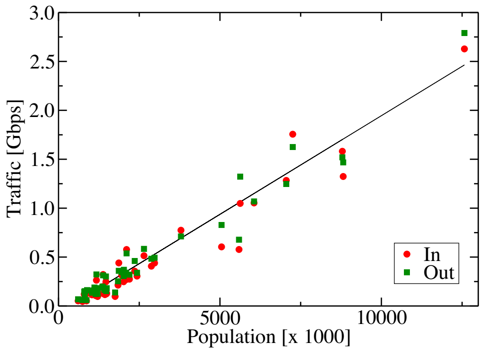
- similar temporal traffic pattern across different prefectures
  - e.g., peak in evening, 70% is constant, regardless the volume
  - metropolitan prefectures with larger office hour traffic



Example prefectural traffic

prefectural population and traffic

- traffic is roughly linear to population!
  - from a scatter plot of population and traffic volume
  - similar result with the number of Internet users
- no clear difference in usage or heavy-hitter ratio



Prefectural traffic volumes are roughly linear to populations

analysis of per-customer traffic in one ISP

- one ISP provided per-customer traffic data for Feb and Jul 2005

- data sets
  - Sampled NetFlow data
    - from edge routers accommodating fiber/DSL RBB customers
  - week-long logs from Feb and Jul 2005

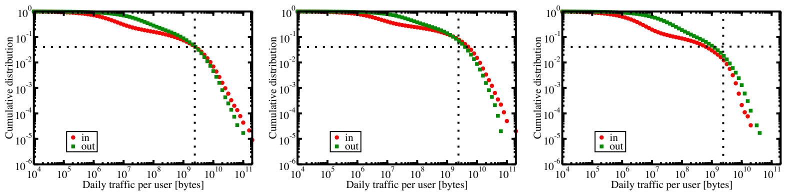
- heavy-hitters: denote users who upload more than 2.5GB/day
  - larger in fiber users

major findings in per-customer traffic data

- 4% of heavy-hitters account for 75% of the total inbound volume
- the fiber users account for 86% of the inbound volume
  - DSL is only 14%
  - even though the number of DSL active users is larger than fiber
- the distribution of heavy-hitters is heavy-tailed
  - no clear boundary between heavy-hitters and normal users
- dominant applications have poor locality and communicate with a wide range and number of peers

CCDF of daily traffic per user

- heavy-hitters are statistically distributed
  - over a wide range of traffic volume (heavy-tailed)
    - even up to 200GB/day (19Mbps)!
  - no clear boundary between heavy-hitters and normal users
- lines at 2.5GB/day (230kbps) and the top 4% heavy-hitters
  - knee of the total users's slope
- heavy-hitter population: 4% in total users, 10% in fiber, 2% in DSL

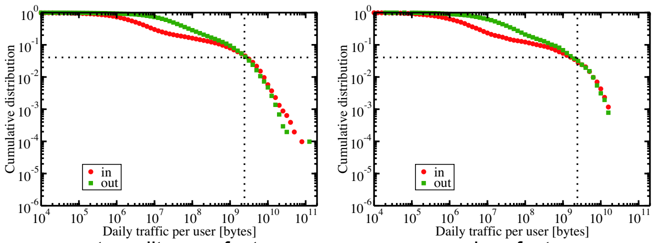


total fiber DSL

CCDF of daily traffic volume per user

prefectural comparison

- distribution similar in all prefectures
  - differences in tail length (population size)
    - probably due to universal broadband access in Japan

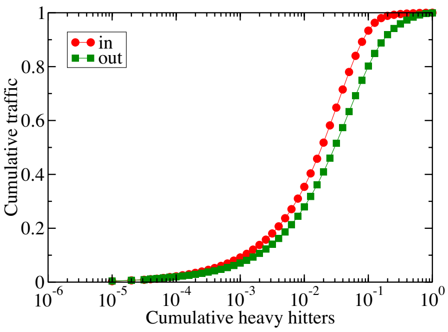


a metropolitan prefecture   a rural prefecture

CCDF of daily traffic volume per user

CDF of traffic volume of heavy-hitters

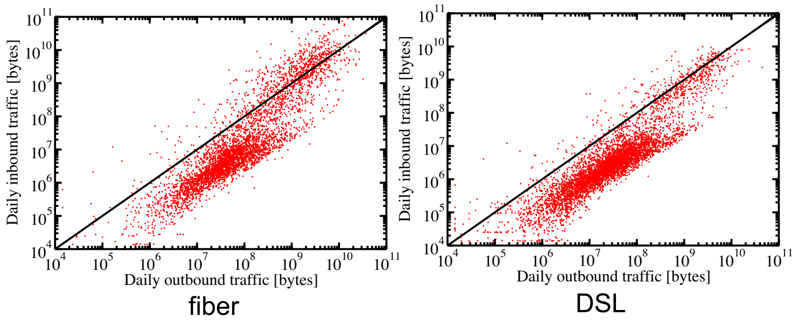
- graph: the top N% of heavy-hitters use X% of the total traffic
- highly skewed distribution in traffic usage
  - the top 4% use 75% of the total inbound traffic
  - the top 4% use 60% of the total outbound traffic



Cumulative Traffic of heavyhitters

correlation of inbound/outbound volumes per user

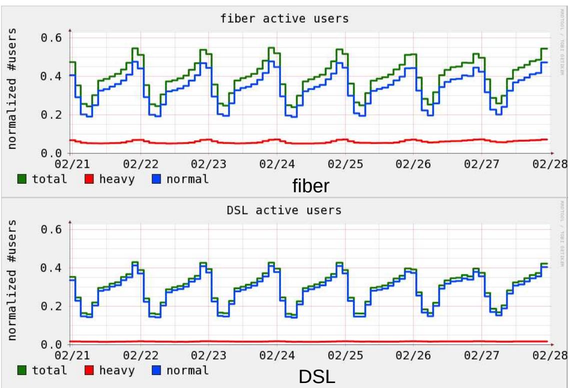
- 2 clusters: one below the unity line, another in high volume region
  - more heavy-hitters in fiber, more lightweight users in DSL
- no qualitative difference between fiber users and DSL users
  - except the percentage of heavy-hitters
- again, no clear boundary between heavy-hitters and normal users



daily per-user inbound/outbound volumes

number of active users

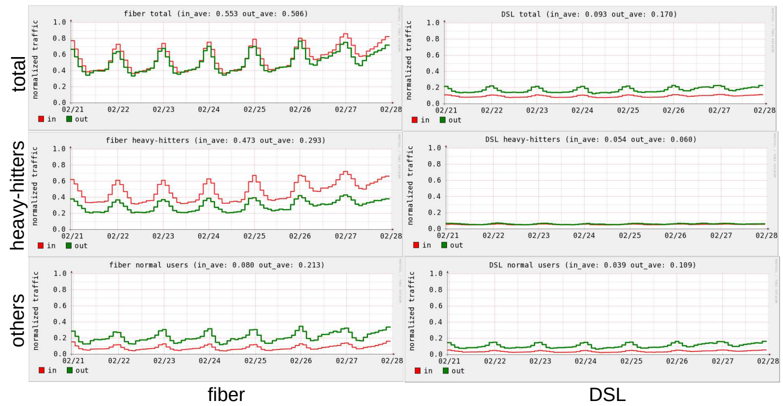
- numbers are normalized to the fiber/DSL combined peak
- total numbers are similar between fiber and DSL
- heavy-hitters are fairly constant, especially in DSL



Normalized number of active users

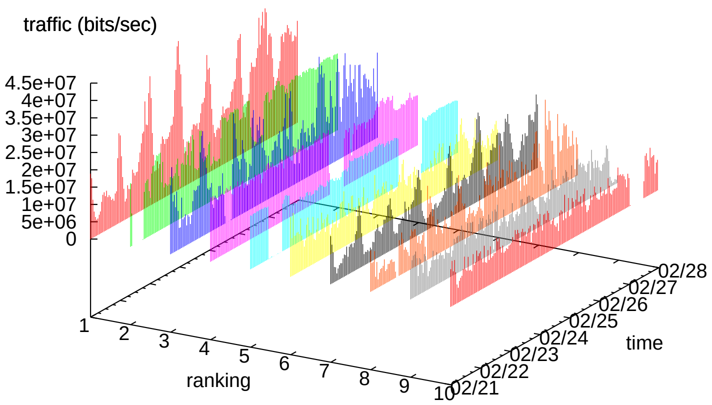
comparison of fiber/DSL traffic

- again, normalized to the combined peak
- inbound: 86% is from fiber users, DSL is only 14%
- total traffic is heavily influenced by fiber heavy-hitters



uploading behavior of top 10 heavy-hitters

- one hour average traffic over a week
  - considerable variations, suggesting differences in usage



protocols/ports ranking

- port 80 (http) is only 9%
- 83% is TCP dynamic ports!
  - each port usage is small except port 80

protocol	port	name	(%)	port	name	(%)
TCP	*		**97.43**			
	(< 1024		13.99)	81	-	0.15
	80	http	9.32	25	smtp	0.14
	20	ftp-data	0.93	119	nntp	0.13
	554	rtsp	0.38	21	ftp	0.11
	443	https	0.30	22	ssh	0.09
	110	pop3	0.17		others	2.27
	(>= 1024		83.44)	1935	macromedia-fsc	0.20
	6699	winmx	1.40	1755	ms-streaming	0.20
	6346	gnutella	0.92	2265	-	0.13
	7743	winny	0.48	1234	-	0.12
	6881	bittorrent	0.25	4662	edonkey	0.12
	6348	gnutella	0.21		others	79.41
UDP	*		**1.38**	6257	winmx-	0.06
	6346	gnutella	0.39		others	0.93
ESP			**1.09**			
GRE			**0.07**			
ICMP			**0.01**			
others			**0.02**			

geographic traffic matrix of RBB traffic

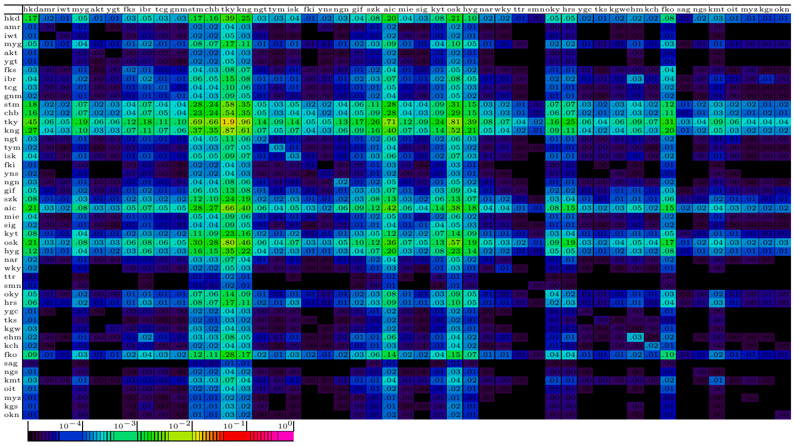
- RBB (home users), DOM (other domestic), INTL (international)
  - both ends are classified by commercial geo-IP databases
- 62% of residential traffic is user-to-user
- 90% is inside Japan (among RBB and DOM)
  - possible reasons are:
    - language and cultural barriers
    - p2p super-nodes among bandwidth-rich domestic fiber users

$src \backslash dst$	ALL	RBB	DOM	INTL
ALL	100.0	84.8	11.1	4.1
RBB	77.0	62.2	9.8	3.9
DOM	18.0	16.7	1.1	0.2
INTL	5.0	4.8	0.2	0.0

prefectural traffic matrix

(src on Y-axis, dst on X-axis)

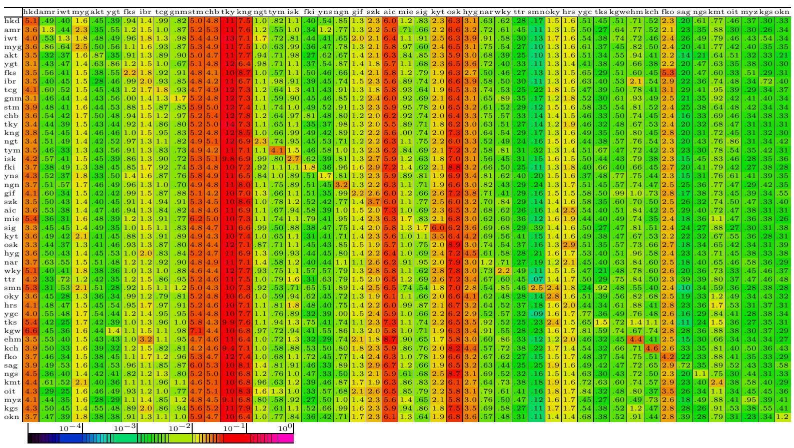
- looking into 47 prefectures
  - traffic volumes are roughly linear to prefectural populations



27

prefectural traffic matrix normalized to src

- the sum of columns is 100% for each row
- no clear difference among prefectures
  - similar distribution, only small locality (1-3%) is found
  - similar result when normalized to dst



28

implications

- we tend to attribute the skews in usage to the divide between a handful of heavy-hitters and the rest of the users
  - but there are diverse and widespread heavy-hitters
- heavy-hitters are no longer exceptional extremes
  - too many of them, statistically distributed over a wide range
    - casual users start playing with p2p applications, become heavy-hitters, and eventually shift from DSL to fiber
    - or, sometimes users subscribe to fiber first, and then, look for applications to use the abundant bandwidth
  - these users' behavior would be easily affected by social, economic or political factors (they don't care about underlying technologies)
    - in fact, a shift from p2p file-sharing to video downloading has been observed
  - but surely users as a whole are shifting towards high-volume usage
- is this specific to Japan?
  - a model of widespread symmetric residential broadband access
    - with language/cultural barriers, geographic concentration

conclusion

- we need to prepare for the future to accommodate innovations brought by empowered end-users
- our study to understand residential broadband traffic
  - cooperation with major ISPs and government
  - detailed analysis of traffic data from one ISP
- RBB traffic accounts for 2/3 of ISP backbone traffic
  - a significant impact on pricing and cost structures of ISP business
- future work
  - we will continue collecting aggregated traffic logs from ISPs
  - plans to compare results with other Japanese ISPs, other countries

- acknowledgments
  - IIJ, Japan Telecom, K-Opticom, KDDI, NTT Communications, POWEREDCOM, SOFTBANK BB for data collection support
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