Final Report (Small Routers, L2 Switches) by Router, etc. Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy

Router, etc. Evaluation Standard Subcommittee had deliberations on the evaluation standards for manufacturers and importers (hereinafter, referred to as "manufacturers") of routers and switches, concerning the energy consumption efficiency of these products. Then, the final report was prepared as follows.

This report covers small routers and L2 switches which had been discussed so far. Deliberation on large routers and L3 switches will be carried on under this subcommittee.

I. Small routers

1. Target Scope (See Attachment 1)

Among routers whose effective transmission rate is 200Mbit/s or lower (100Mbit/s or lower for wireless routers), those having the following characteristics are covered:

- Not having VPN (Virtual Private Network) function; and
- Having 2 or fewer lines in case they have VoIP (Voice over Internet Protocol) function.

2. Details of Evaluation Standards for Manufacturers

(1) Target fiscal year (See Attachment 2)

Fiscal year 2010

(2) Target standard values (See Attachment 3)

Concerning small routers to be shipped by a manufacturer for the domestic market in the target fiscal year, for each category in the table below, the manufacturer has to make sure that the value obtained by weighting and averaging energy consumption efficiency (power consumption) measured according to (3) with the number of shipped units shall not exceed the target standard value.

Category	WAN side interface	LAN side interface	Target standard values (Power consumption: W)
A	Ethernet [*1]	Ethernet [*1]	4.0
B		With VoIP	5.5
C		With wireless	2.4GHz band transmission P = (0.10*X2) + 3.9 5GHz band transmission P = (0.15*X5) + 3.9 2 wave simultaneous transmission P = (0.10*X2) + (0.15*X5) + 5.1 X2: 2.4GHz wireless output (mW/MHz) X5: 5GHz wireless output (mW/MHz)
D	ADSL	Ethernet [*1]	7.4
E		With VoIP	7.4
F		With wireless	8.8

[*1] Ethernet: Registered trade mark by Fuji Xerox Co., Ltd. Standard of LAN.

(3) Energy consumption efficiency measurement method (See Attachment 4)

Energy consumption efficiency shall be the power consumption (W) measured by the following method.

○ Measurement configuration

- It shall be a configuration so that the maximum throughput will be achieved at the measurement packet length of 1500 bytes.
- The measurement shall be made after removing any parts and stopping any functions within the scope of the router's maximum configuration, as long as they are removable or stoppable without interrupting its basic performance/function.
- It is acceptable to conduct the measurement using a cascading connection configuration for ports.
- It shall be a configuration so that the unit under measurement will route received packets.
- Within the scope of the router's maximum configuration, ports not used in the measurement are allowed to be link-down.
- Small routers with wireless LAN interface are measured with the following configuration.

a) It shall be a configuration so that only wireless transmission direction (download side: packets sent from WAN side to wireless LAN side) is measured.
b) If a router is equipped with multiple wireless LAN interfaces which can operate simultaneously, it shall be configured so that all of them will operate simultaneously.
c) It shall be a configuration where data compression function and adjusting function for output power, etc. are stopped.
d) Link rate shall be the maximum link rate of the unit under measurement.

○ Measurement packet

- IP packets for unicast communication shall be used.
- Measurement packet length (PDU (Protocol Data Unit) length of Layer 3) shall be 1500 bytes.
- Header of each layer shall comply with IEEE802.3, IETF or other equivalent standards.
- Data patterns of headers are discretional. Data patterns of measurement packets shall be all 0.
- Bit rate (bit/s) and total number of packets sent to the unit under measurement during the measurement are also allowed to be the required minimum to achieve the maximum performance.

○ Measurement conditions

- Ambient temperature shall be between 16°C and 32°C. However, for small routers with wireless LAN, the temperature range from 0°C to 40°C is also acceptable.
- Supply voltage shall be the rated input voltage (100V or 200V) ±10% in the case of using AC power source. It shall be between DC–57V and DC–40.5V in the case of using DC power source.
- Frequency of AC power source shall be the rated frequency.
- Maximum throughput and power consumption shall be measured while staying in a steady state.
- For products using AC power source, power consumption shall be measured at a plug terminal for outlet.
- In the case of using AC power source, true power shall be referred to as power consumption.
- For small routers having wireless function for LAN side interface, a packet generator shall be used in the measurement.

(4) Display items and others

1) Display items shall be as follows.
- Product name or model name
- Category name
- Frequency band and wireless output of a wireless connection interface (if a router is equipped with a wireless connection interface for LAN side)

- Transmission type of a wireless connection interface (if a router is equipped with a wireless connection interface for LAN side)
- Transmission frequency band which allows for the maximum effective transmission rate (if a router is equipped with a wireless connection interface, whose transmission frequency band is selectable, for LAN side).
- Energy consumption efficiency
- Name of manufacturer

2) Compliance items

- A unit "GHz" shall be used for the frequency band of wireless connection interface, and "mW/MHz" for the wireless output. The values shall be rounded off to one decimal place and indicated as "2.4GHz band: [wireless output], 5GHz band: [wireless output]". The indication shall be omitted for the wireless frequency band which is not supported by the product.
- Transmission type of a wireless connection interface shall be indicated as either 1-wave transmission, 2-wave selective transmission, or 2-wave simultaneous transmission.
- Transmission frequency band which allows for the maximum effective transmission rate shall be indicated as either 2.4GHz band or 5GHz band.
- Energy consumption efficiency shall be expressed in "W" and indicated as a value rounded off to one decimal place.
- Display items shall be indicated in a durable manner at easily observable locations on catalogues describing the product's performance or on materials provided by the manufacturer for product selection.

3. Proposal for energy saving

(1) Actions of users

1) Efforts shall be made to select small routers with excellent energy consumption efficiency and to reduce their energy consumption by appropriate and efficient usage.

(2) Actions of manufacturers

1) Efforts shall be made to promote development of energy-saving technologies for small routers and to develop those with excellent energy consumption efficiency.
2) Aiming at the popularization of small routers with excellent energy consumption efficiency, efforts shall be made to provide appropriate information so that users will be able to select such small routers.

(3) Actions of Government

1) Aiming at the popularization of small routers with excellent energy consumption efficiency, efforts shall be made to take necessary measures, such as activities for promulgation and enlightenment, so as to promote the efforts by users and manufacturers.
2) Implementation of the display items by manufacturers shall be checked periodically and continuously. Also, appropriate law management shall be made so that correct and easy-to-understand information regarding energy consumption efficiency will be provided for users.
3) Energy efficiency standards based on the Top Runner method is a very effective means to reduce energy consumption of products; therefore, efforts shall be made to promote better understanding about and to disseminate the Top Runner method internationally by catching appropriate opportunities.

II. L2 switches

1. Target scope [See Attachment 1]

Box type L2 switches with 3 or more communication ports are covered.

Besides, L2 switches equipped with slots, all of which are supporting detachable optical modules for photoelectric conversion, are regarded as box type.

2. Details of Evaluation Standards for Manufacturers

(1) Target fiscal year [See Attachment 5]

Fiscal year 2011.

(2) Target standard values [See Attachment 6]

Concerning L2 switches to be shipped by a manufacturer to the domestic market in the target fiscal year, for each category in the table below, the manufacturer has to make sure that the value obtained by weighting and averaging energy consumption efficiency measured according to (3) with the number of shipped units shall not exceed the target standard value.

Category	Management function		IP address processing	Standard energy consumption efficiency
A	With management function	With SNMP function	With IP filtering function	$\{(\alpha_A \cdot X + \beta_A) + P_A\}/T$
B			Without IP filtering function	$\{(\alpha_B \cdot X + \beta_B) + P_B\}/T$
C		With Web management and the like		$\{(\alpha_C \cdot X + \beta_C) + P_C\}/T$
D	Without management function			$\{(\alpha_D \cdot X + \beta_D) + P_D\}/T$

Table for αn values

Line speed		100M	1G	10G
Notation (αn)		α_{100M}	α_{1G}	α_{10G}
Power consumption coefficient (W/Port)	Category A	0.578	1.880	15.900
	Category B	0.375	1.880	—
	Category C	0.375	1.133	—
	Category D	0.272	1.133	—

Table for βn values

Line speed		100M	1G	10G	100M+1G		1G+10G
Notation (βn)		β_{100M}	β_{1G}	β_{10G}	$\beta_{100M+1G1}$	$\beta_{100M+1G2}$	β_{1G+10G}
Values (W)	Category A	3.976	9.940	0	2.276	0.576	–10.240
	Category B	3.400	–5.070	—	1.700	0	—
	Category C	3.400	–2.074	—	2.447	1.494	—
	Category D	0.824	–2.074	—	1.494	1.494	—

If the power consumption ($\alpha n \cdot X + \beta n$) meets the following cases, the calculation shall be made using the value specified.

1) If it is less than 3.000 at 100M and 100M+1G, the specified value shall be 3.000.
2) If it is less than 4.500 at 1G, the specified value shall be 4.500.

$\alpha n \cdot X + \beta n$ (W) : Shortened form $\alpha n_{100M} X_{100M} + \alpha n_{1G} X_{1G} + \alpha n_{10G} X_{10G} + \beta n$
Where, n represents category, $\alpha n_{(bps)}$ represents a unit power consumption per port at each category and each line speed, $X_{(bps)}$ represents the number of ports for each line speed, and βn represents a fixed power value for each category.

Example: $\alpha n \cdot X = \alpha n_{100M} X_{100M} + \alpha n_{1G} X_{1G} + \alpha n_{10G} X_{10G}$

T (bit/s) : Throughput measured

Pn (W) : Additional power consumption when taking the effect of PoE power supply into account.

Where, n represents category (n: A, B, C, D).

$$Pn = \frac{0.0347 \cdot Pd / Ps}{1 - 0.0347 \cdot Pd / Ps} \cdot (\alpha n \cdot X + \beta n)$$

$$Ps = (\alpha n \cdot X + \beta n) \cdot 0.850 + 1.000$$

Pd (W) : PoE maximum supply power. For units without PoE, it shall be Pd = 0.

Ps (W) : Secondary power of switch circuits and PoE control circuits.
Secondary power of switch circuits shall be calculated by applying across-the-board 85% power supply efficiency to the basic formula for units without PoE ($\alpha n \cdot X + \beta n$).
Secondary power of PoE control circuits shall be across-the-board 1W.

However, units whose PoE maximum supply power ratio (Pd/Ps) is within 16.000 are only covered.

(3) Energy consumption efficiency measurement method [See Attachment 3]

Energy consumption efficiency shall be the value obtained by dividing power consumption (W) measured according to the following method by the maximum throughput (bit/s). The power consumption shall be the value measured at a point where the frame length (length of data blocks measured (frame)) is 1518 bytes using an actual data communication.

○ Measurement configuration

- It shall be a configuration so that the maximum throughput will be achieved at the measurement packet length of 1518 bytes.
- The measurement shall be made after removing any parts and stopping any functions within the scope of the switch's maximum configuration, as long as they are removable or stoppable without interrupting its basic performance/function.
- It is acceptable to conduct the measurement using a cascading connection configuration for ports. In this case, the maximum throughput shall be calculated taking the number of ports in the cascading connection into consideration.
- It shall be a configuration so that the unit under measurement will switch received frames.
- Within the scope of the switch's maximum configuration, ports not used in the measurement are allowed to be link-down.

○ Measuring frame

- Frames for unicast communication are used.
- Measurement frame length (PDU (Protocol Data Unit) length of Layer 2) shall be 1518 bytes.
- Header of each layer shall comply with IEEE802.3, IETF or other equivalent standards.
- Data patterns of headers are discretional. Data patterns of measurement frames shall be all 0.
- Bit rate (bit/s) and total number of frames sent to the unit under measurement during the measurement are also allowed to be the required minimum to achieve the maximum performance.

○ Measurement conditions

- Ambient temperature shall be between 16°C and 32°C.
- Supply voltage shall be the rated input voltage (100V or 200V) ±10% in the case of

using AC power source. It shall be between DC–57V and DC–40.5V in the case of using DC power source.

- Frequency of AC power source shall be the rated frequency.
- Maximum throughput and power consumption shall be measured in while staying in a steady state.
- For products using AC power source, power consumption shall be measured at a plug terminal for outlet.
- In the case of using AC power source, true power shall be referred to as power consumption.

(4) Display items and others

1) Items to be displayed are as follows.

- Product name or model name
- Category name
- Type and number of line ports
- Maximum effective transmission rate
- Maximum power supplied by use of Power over Ethernet function (if a switch is equipped with it)
- Energy consumption efficiency
- Name of manufacturer

2) Compliance items

- As for the type and number of line ports, the type of either 100Mbit/s, 1Gbit/s or 10Gbit/s as well as corresponding number of ports in a configuration allowing for the maximum throughput (effective transmission rate) shall be indicated respectively as follows: "100Mbit/s × [number of ports], 1Gbit/s × [number of ports], and 10Gbit/s × [number of ports]".
- The maximum effective transmission rate shall be expressed in "Gbit/s" and indicated as a value rounded off to one decimal place.
- The maximum power supplied by use of Power over Ethernet function shall be expressed in "W" and indicated as a value rounded off to one decimal place.
- Energy consumption efficiency shall be expressed in "W/Gbit/s" and indicated as a value rounded off to one decimal place.
- Display items shall be indicated in a durable manner at easily observable locations on catalogues describing the product's performance or on materials provided by the manufacturer for product selection.

3. Proposal for energy saving

(1) Actions of users

1) Efforts shall be made to select L2 switches with excellent energy consumption

efficiency and to reduce their energy consumption by appropriate and efficient usage.

(2) Actions of manufacturers

1) Efforts shall be made to promote development of energy-saving technologies for L2 switches and to develop those with excellent energy consumption efficiency.
2) Aiming at the popularization of L2 switches with excellent energy consumption efficiency, efforts shall be made to provide appropriate information so that users will be able to select such L2 switches.

(3) Actions of Government

1) Aiming at the popularization of L2 switches with excellent energy consumption efficiency, efforts shall be made to take necessary measures, such as activities for promulgation and enlightenment, so as to promote the efforts by users and manufacturers.
2) Implementation of the display items by manufacturers shall be checked periodically and continuously. Also, appropriate law management shall be made so that correct and easy-to-understand information regarding energy consumption efficiency will be provided for users.
3) Energy efficiency standards based on the Top Runner method is a very effective means to reduce energy consumption of products; therefore, efforts shall be made to promote better understanding about and to disseminate the Top Runner method internationally by catching appropriate opportunities.

Attachment 1

Target Scope of Small Routers and L2 Switches

1. Scope of Routers and Switches to be covered

As well as being classified as communication devices according to "Japan standard commodity classification", targeted routers and switches are all of those intended mainly to relay network data using the second layer (data link layer) or the third layer (network layer) among models whose communication function is structured in layers based on OSI (Open System Interconnection) established by ISO (International Organization for Standardization).

However, the following products are excluded from the target scope, because the market size and shipment volume are small and predicted to decrease from now on.

- Routers equipped with satellite interface
  (Shipment volume in FY 2004: approximately 800 units)
- Routers with fixed ATM (asynchronous transfer mode) interface
  (Shipment volume in FY 2004: approximately 9,500 units)
- Dial-up routers
  (Shipment volume in FY 2004: approximately 12,000 units)
- L2 switches equipped with wireless
  (Shipment volume in FY 2006: approximately 28,000 units)

In addition, the following products are also excluded from the target scope, because they fall into a group of models used for special applications, which are characterized by having more than half of ports not complying with IEEE802.3 standard, by depending on power supplied from other products which the routers/switches are incorporated into, etc.

- HomePNA (Home Phoneline Networking Alliance) switches
- DSLAM (Digital Subscriber Line Access Multiplexer) switches
- Access point controlling switches
- Routers/switches to be inserted into extension card slots, etc. of personal computers and the like

Likewise, the following products are excluded from the target scope, because network data relay functions are not considered as their primary functions, because test procedures and evaluation methods for them have not been established, because they fall into the group of early-stage products for which the standards are under development, and so forth. Necessary consideration, however, shall be given, when it is judged that these products should also be included in this target scope based on the changes in shipment volume in future or other information.

- Set-top box (a generic name of products which are equipped with a device to extend capabilities of TV sets, such as image delivery function to TV sets)
- 802.11n products
- PLC products

2. Scope of Small Routers and L2 Switches

Following small routers and L2 switches were reviewed.

(1) Small Routers

Targeted routers are all of those intended mainly to relay network data using the third layer (network layer), among models whose communication function is structured in layers based on OSI (Open System Interconnection) established by ISO (International Organization for Standardization). To be specific, they are products which relay network data referring to IP addresses. Here, this relay operation means that a router counts TTL of IP address header information backward and relays data to other data links.

Among routers defined in the above, small routers are those with effective transmission rate of 200 Mbit/s or below (100 Mbit/s or below for wireless routers).

1) Definition of Target Small Routers

Some small routers are equipped with VPN function[1] which is effective as a security function. As for routers with a VoIP terminal having 3 or ports, although they are multi-function terminals marketed differently from common routers for civil demand as well as devices used as PBX (Private Branch eXchange), some of them also fall in the scope of small routers. If products have one or more of these 2 functions, it is reasonable to review them together with large routers. Thus, they are excluded from the definition of small routers to be covered.

Taking into consideration the above, target small routers is defined as follows.

Among small routers with effective transmission rate of 200 Mbit/s or below (100 Mbit/s or below for wireless routers), models with the following characteristics are defined as small routers to be covered.

- Not equipped with VPN function[1]; and
- Having 2 or fewer lines in the case of being equipped with VoIP function.

[1] VPN stands for Virtual Private Network. VPN function allows users to use public lines as if their own private lines and utilizes tunnel techniques in order to avoid crosstalk. The tunnel techniques include IPSec, PPTP, L2TP and SSL-VPN.

In addition, other small routers (which do not fit the above definition) shall be examined around the same time as large routers which will continue to be deliberated forward.

2) Definition of Effective Transmission Rate (throughput) of Small Routers

As shown in Figure 1-1, effective transmission rate (throughput) of routers is often expressed differently for each product market; thus, there is no uniform way of indication. Here, an expression of effective transmission rate which is used for the calculation of energy efficiency standard is defined as follows.

Effective transmission rate of small routers shall be expressed as follows.

- For those with other than wireless communication: sum of transmission rates of download and upload.
- For those with wireless communication: transmission rate of download.

Category	[1] Small routers (BB routers)	[2] Small routers (Access routers)	[3] Large routers
Expressions	▪ 120 Mbit/s (70 Mbit/s for wireless type) ▪ 70 Mbit/s for download and 50 Mbit/s for upload	▪ 120 Mbit/s (Total sum of maximum output capacity: 70 + 50 Mbit/s)	▪ 240 Mbit/s (Total sum of input and output: 70 + 50 + 70 + 50 Mbit/s)

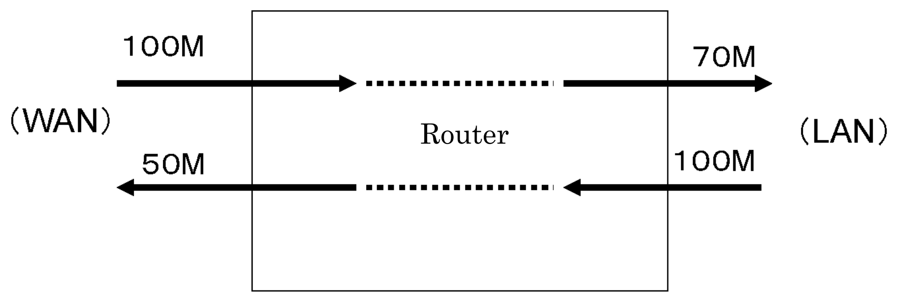


Figure 1-1 Input and Output Rates of Routers

(2) L2 Switches

L2 switches shall be defined as box-type products with 3 or more communication ports and intended mainly to relay network data using the second layer (data link layer), among models whose communication function is structured in layers based on OSI (Open System Interconnection) established by ISO (International Organization for Standardization). To be specific, they are products which relay network data referring to MAC addresses. Meanwhile, box-type L2 switches refer to those enclosed in a chassis which are capable of relaying data on a network through the second layer (data link layer) using a circuit fixedly mounted onto the main body. In addition, L2 switches equipped with slots, all of which are supporting detachable optical modules for optical-electrical conversion, are also considered as box-type.

1) Definition of Target L2 Switches

Chassis-type switches shall be discussed along with L3 switches rather than within a scope of L2 switches, since they can also be reviewed within a scope of L3 switches. Thus, L2 switches to be reviewed here are limited to those of box-type.

2) Definition of Effective Transmission Rate (throughput) of Switches

Relaying capacity of switches is generally expressed as [1] switching performance shown in Figure1-2, which is a sum of bits of input and output frames per second. However, in the case of effective transmission rate (throughput), [2] expression using throughput rather prevents measurers from misunderstanding. In addition, a uniformity of expression method with small routers can also be achieved with it. For these reasons, the expression method is defined as follows for the calculation of energy efficiency standards.

Effective transmission rate of L2 switches shall be expressed as follows.

- Number of output frames per second × total number of bits per frame.

Category	[1] Switching capacity	[2] Throughput
Expressions	800 Mbit/s (Number of input frames + number of output frames) × total number of bits per frame, at [1 second]	400 Mbit/s Number of output frames × total number of bits per frame, at [1 second]

In the case of 100 Mbit/s × 4 ports

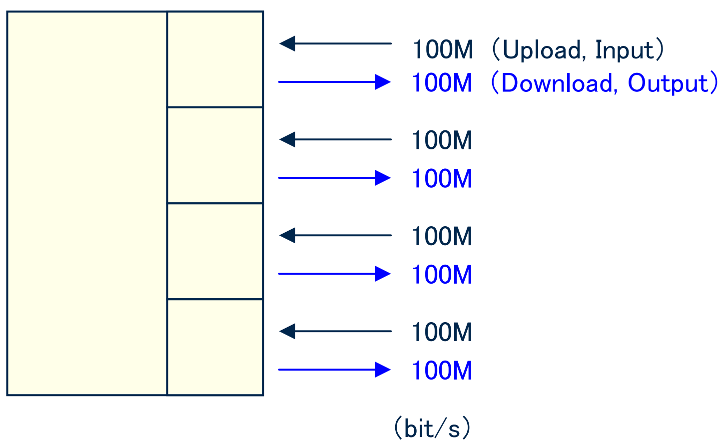


Figure 1-2 Input and Output Rates of Switches

Attachment 2

Target Fiscal Year, etc. for Small Routers

1. Target fiscal year for small routers shall be fiscal year 2010 due to their short product renewal cycle.

2. It is expected that improvement rate of energy consumption efficiency in the target fiscal year will be approximately 16.3% based on assumption that there will be no change in shipment volume and model composition of each category from the current status (actual results of fiscal year 2006).

<Overview of Estimation>

1. Energy consumption efficiency estimated from values of actual achievements for small routers shipped in fiscal year 2006: 6.09W

2. Energy consumption efficiency estimated from the target standard values of small routers to be shipped in the target fiscal year (FY 2010): 5.10W

3. Improvement rate of energy consumption efficiency

$$\frac{(6.09 - 5.10) \times 100}{6.09} = 16.3\%$$

Attachment 3

Categories for Target Setting and Target Standard Values for Small Routers

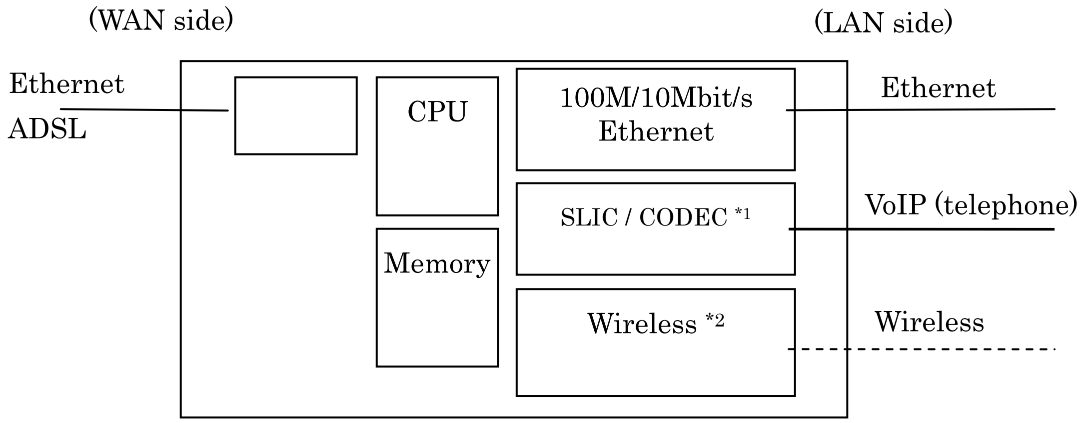
1. Categories for Target Setting

(1) Basic concept

As for small routers covered in this review, following two factors greatly impact on their power consumption. Therefore, category setting shall be made based on these factors (See Figure 3-1).

- WAN side I/F (interface): Type of Ethernet, ADSL
- LAN side I/F (interface): Type of Ethernet, VoIP (telephone), wireless

Ethernet: Registered trade mark of Fuji Xerox Co., Ltd. Standard of LAN.



*1 Routers with VoIP
*2 Routers with wireless

SLIC : Subscriber Loop Interface Circuit
Interface circuit to connect telephones

CODEC: Coder Decoder
Device which digitizes voice signals from telephones and transmits them to WAN side as well as converts digital signals from WAN side to voice signals.

Figure 3-1 Architecture of Small Routers

(2) Specific category setting

1) WAN side I/F

There are two I/F types (Ethernet or ADSL) for small routers.

Transmission distance of Ethernet used for small routers is limited to maximum 100m. Although currently there are 10Mbit/s, 100Mbit/s, 1Gbit/sps, etc. for Ethernet, as far as small routers are concerned, I/F of 10Mbit/s and 100Mbit/s are taken into consideration and collectively called Ethernet in this document.

Meanwhile, ADSL is a communication method connecting buildings of telecommunications carriers with installation locations (such as houses) to transmit data of some dozens of Mbps over long distance (maximum 6 to 7km). To cope with it, the modulation-demodulation processing suitable for the long distance transmission is realized by high-speed DSP (Digital Signal Processor), etc. Compared to Ethernet, ADSL requires more power because of this long distance transmission and the implementation of modulation-demodulation processing.

Thus, from the viewpoint of power consumption, small routers are categorized by the type of I/F for WAN side.

2) LAN side I/F

There are three main systems for LAN side, and they are used in several combinations.

- Ethernet I/F

  Equipped with Ethernet that is the standard interface, the routers can be connected to ADSL, modems, optical network units (ONU), etc. and have high versatility. They can be constructed with fewer circuits than other two systems described below. These routers are hereinafter called wired routers.

  Meanwhile, as in the case of WAN side I/F, I/F of 10Mbits/s and 100Mbits/s are referred to as Ethernet for small routers and collectively called Ethernet in this document.

- VoIP (telephone) I/F

  Equipped with VoIP function, wired routers can transmit voice signals as well as data by means of being connected with telephones. Since SLIC and CODEC functions to transmit voice signals (see Figure 3-1) are added, these wired routers consume more power than ordinary wired routers do. For this reason, they need to be categorized separately from the ordinary ones. Such routers with VoIP functions are hereinafter called VoIP routers. As regards the telephone exchange function, since it is contained in the CPU which executes routing processing that is a basic function of wired routers, it does not likely increase power consumption meaningfully.

- Wireless I/F

  Routers which transmit data via wireless in addition to the wired router function. Because of their easy connectivity and cheaper price, they are spreading widely in recent years. The wireless system is currently standardized as IEEE802.11a, b, g. Since MAC (Media Access Control) and RF (Radio Frequency) circuits are added in order to transmit data by wireless, they consume more power than wired routers. Thus, they need to be categorized separately from wired routers.

Based on the consideration above, the basic categories are set as follows.

Table 3-1. Categories of Small Routers

LAN side I/F / WAN side I/F	Ethernet	With VoIP	With wireless
Ethernet	Wired routers (Category A)	VoIP routers (Category B)	Wireless routers (Category C)
ADSL	ADSL routers (Category D)	ADSL routers with VoIP (Category E)	ADSL routers with wireless (Category F)

2. Target Standard Values

(1) Basic concept

Target standard values are set based on the idea of Top Runner method. The specific policies are as follows.

(a) Target standard values shall be set for every category that has been appropriately defined.

(b) As for the categories where future technological advances are expected to improve efficiency, the target standard values shall allow for the improvement as much as possible.

(c) Target standard values shall not conflict among categories.

(2) Room for improvement of energy consumption efficiency by future technology advances

Because of the following reasons, it seems appropriate not to include the room for energy consumption efficiency improvement of small routers potentially achieved by future technological advancement in the target standard values for now.

(a) In case of wired routers, the transmission rate of the WAN side network is fixed at 100Mbit/s and is not expected to be changed any time soon. Addition of new functions (i.e. addition of new ordinary communication functions except for VoIP or wireless functions) are not anticipated either. Therefore, it is difficult to expect further power saving from new technical innovation.

(b) In case of ADSL routers, the market is shifting to optical access (FTTH) and the net decrease is observed in the number of subscribers (shrinking market) as shown in Figure 3-2. Taking the market shrink as the background factor, it is assumable that new technologies have not been development since 2006. Therefore, it is difficult to anticipate the room for technical improvement.

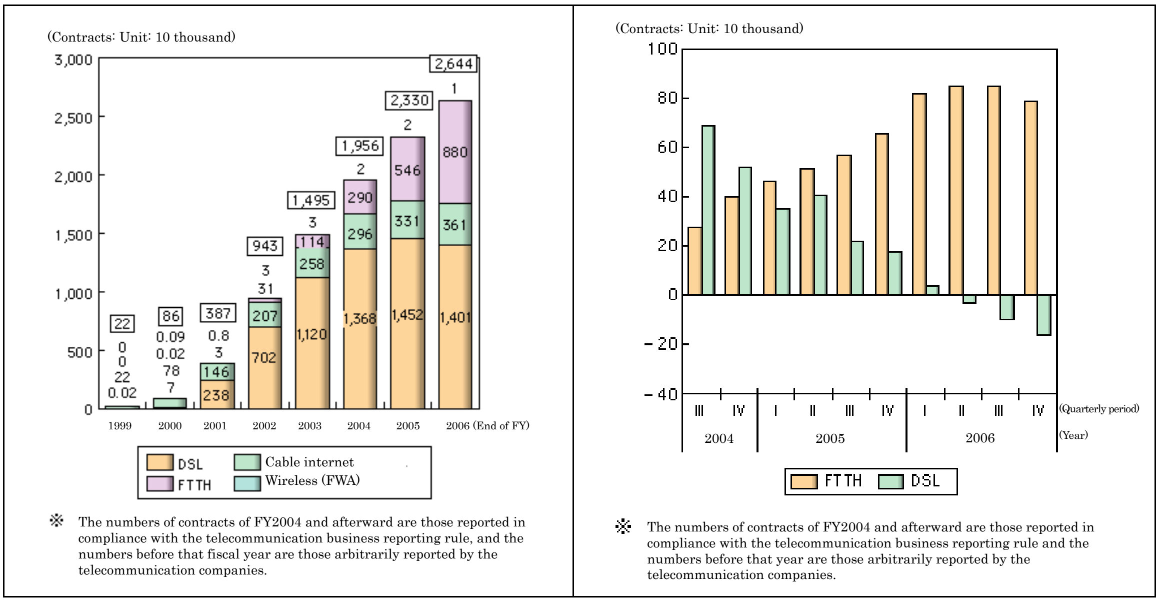


Figure 3-2　Subscribers of ADSL Lines (FY2007 WHITE PAPER Information and Communications in Japan)

(3) Specific Target Standard Values

1) Wired routers: Category A

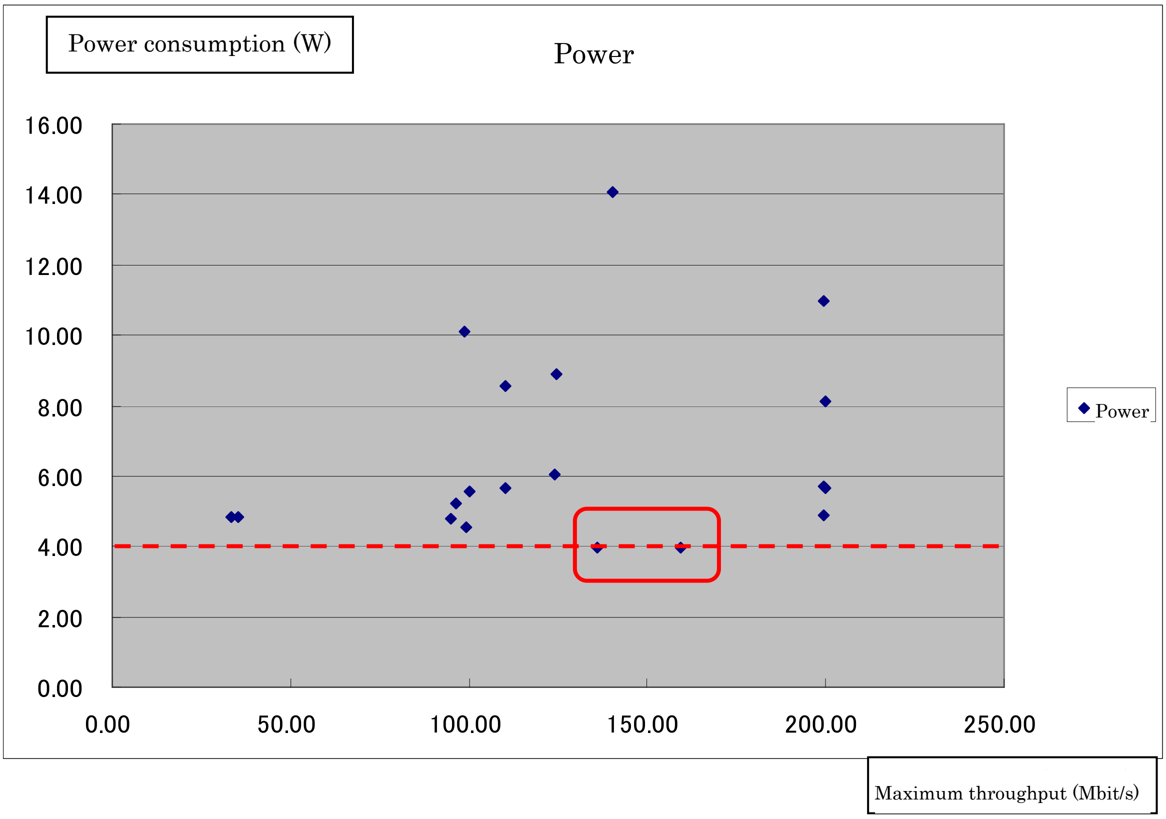


Figure 3-3　Measurement Result of Power Consumption of Wired Routers

Figure 3-3 shows the measurement result of power consumption of wired routers. It turns out to be that the power consumption values are distributed over a wide range from 4W to 14W approximately. It is assumed that some routers consume large amount of energy because they are not strictly designed to save power in part for the lack of energy-saving restriction or because a large variety of functions are mounted on them. Based on the specification analysis, two routers having power consumption of around 4W in the above figure are appeared to be wired routers with basic functions only. For this reason, 4W is taken as the Top Runner (hereinafter, called TR) value.

2) VoIP routers: Category B

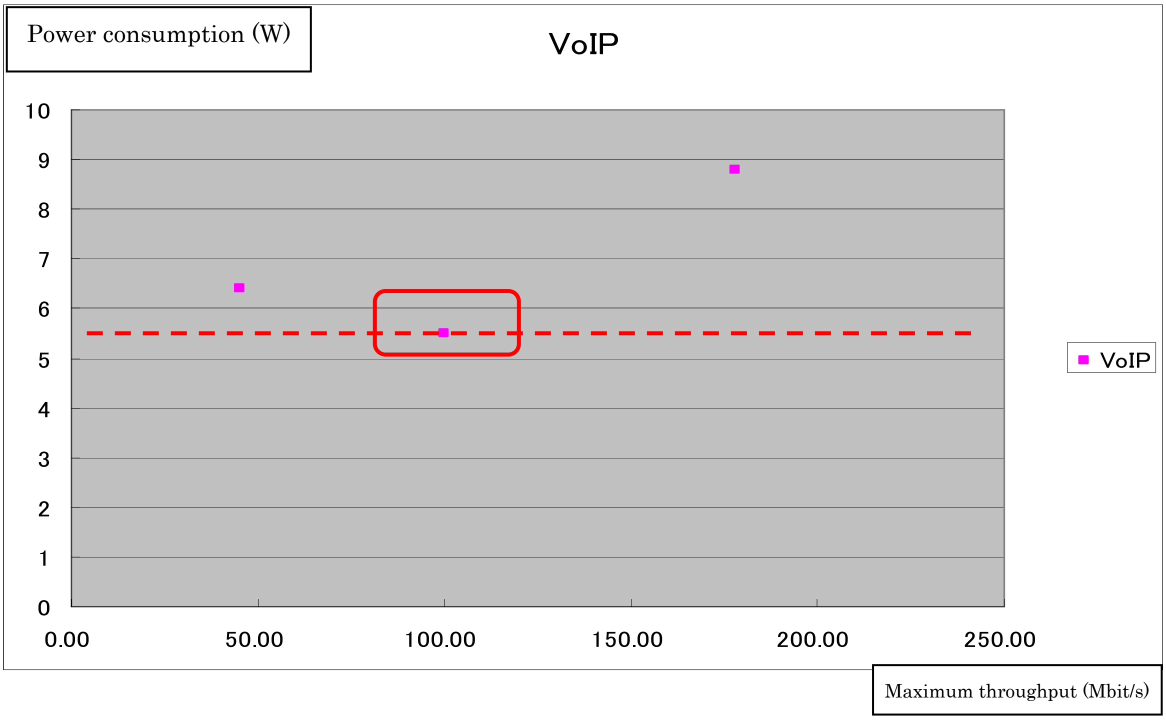


Figure 3-4 Measurement Result of Power Consumption of VoIP Routers

Figure 3-4 shows the measurement result of power consumption of VoIP routers. By collating and analyzing the measurement results and specifications, some values were found to be the noise; thus, they were eliminated. As a result, although the number of samples is limited, 5.5W is decided as the TR value.

3) Wireless routers: Category C

Wireless routers are those using wireless stipulated by the IEEE802.11 working group for data transmission in addition to the wired router function. There are three product groups based on the number of output radio waves.

- 1 wave transmission: Only one type of radio wave is available for transmission. To be more specific, either 802. 11b, g or 802. 11a can be used.
- 2 wave switching transmission: Although 2 types of radio waves are available for transmission, only one type of them can be used at a time.
- 2 wave simultaneous transmission: 2 types of radio waves are available for transmission and can be used simultaneously.

These product groups have different circuit compositions due to the differences in specifications. Typical circuit composition is shown in Figure 3-5.

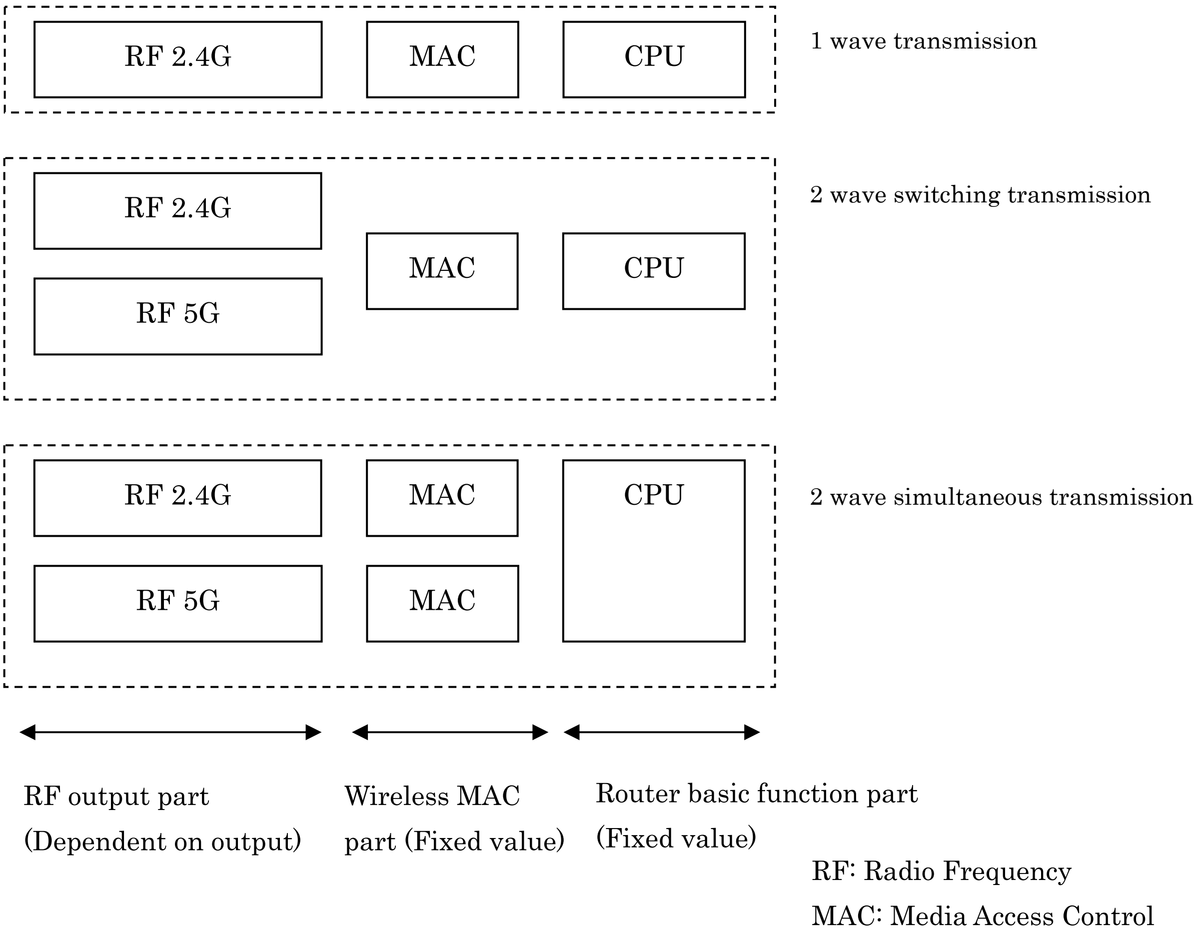


Figure 3-5 Typical Circuit Element Composition of Wireless Routers

As shown in Figure 3-5, power consumption of wireless routers (P) can be expressed as the sum of 3 circuit elements as follows.

P (Power Consumption)
= RF part + Wireless MAC part + Router basic function part

a) RF part

This circuit element sends/receives the wireless and realizes the physical layer of the OSI (Open Systems Interconnection) reference model. Its power consumption depends on the wireless output power density (mW/MHz) and the frequency band used (2.4GHz band or 5GHz band).

b) Wireless MAC part

This circuit element is located between router basic function part and RF part and realizes the function of MAC layer of the OSI reference model. It shall be a fixed value independently of wireless output power density and frequency used.

c) Router basic function part

This circuit element provides the basic function which is common to both wired and wireless routers and realizes the functions of LLC (Logical Link Control) layer or above of the OSI reference model. It is assumed that the 2 wave simultaneous transmission requires more power than the 1 wave transmission does because larger amount of data is processed at the former transmission.

Based on the review above, the logical power of wireless routers can be expressed as follows.

- 1 wave transmission

  2.4GHz band is used.

  $$P = (A2*X2) + B2 + C \quad (a)$$

  5GHz band is used

  $$P = (A5*X5) + B5 + C \quad (b)$$

- 2 wave switching transmission

  Although either 2.4GHz band or 5GHz band can be used, it shall be the frequency band that will provide the maximum throughput.

  2.4GHz band is used.

  $$P = (A2*X2) + B2 + C \quad (a)$$

  5GHz band is used

  $$P = (A5*X5) + B5 + C \quad (b)$$

- 2 wave simultaneous transmission

  $$P = (A2*X2) + B2 + (A5*X5) + B5 + D \quad (c)$$

  Where, the symbols above represent the followings.

  P: Power consumption
  X2: 2.4GHz band wireless output (mW/MHz)
  X5: 5GHz band wireless output (mW/MHz)

A2:	RF output coefficient for 2.4GHz band,	gradient
B2:	Wireless MAC power consumption for 2.4GHz band,	fixed value
A5:	RF output coefficient for 5GHz band,	gradient
B5:	Wireless MAC power consumption for 5GHz band,	fixed value
C:	Power consumption of router basic part,	fixed value
D:	Power consumption of router performance for 2 waves,	fixed value

Following the study focused on the circuit composition, the measurement results of wireless routers are analyzed (Figure 3-6 and Figure 3-7). Although the number of data is not large, following features are found from the analysis.

a) The power consumption is positively related to the wireless output power density.
b) There is fixed power consumption which is not dependent on the wireless output power density.
c) Wireless routers are grouped into 3 types, i.e. 1 wave transmission, 2 wave switching transmission and 2 wave simultaneous transmission (Figure 3-7).

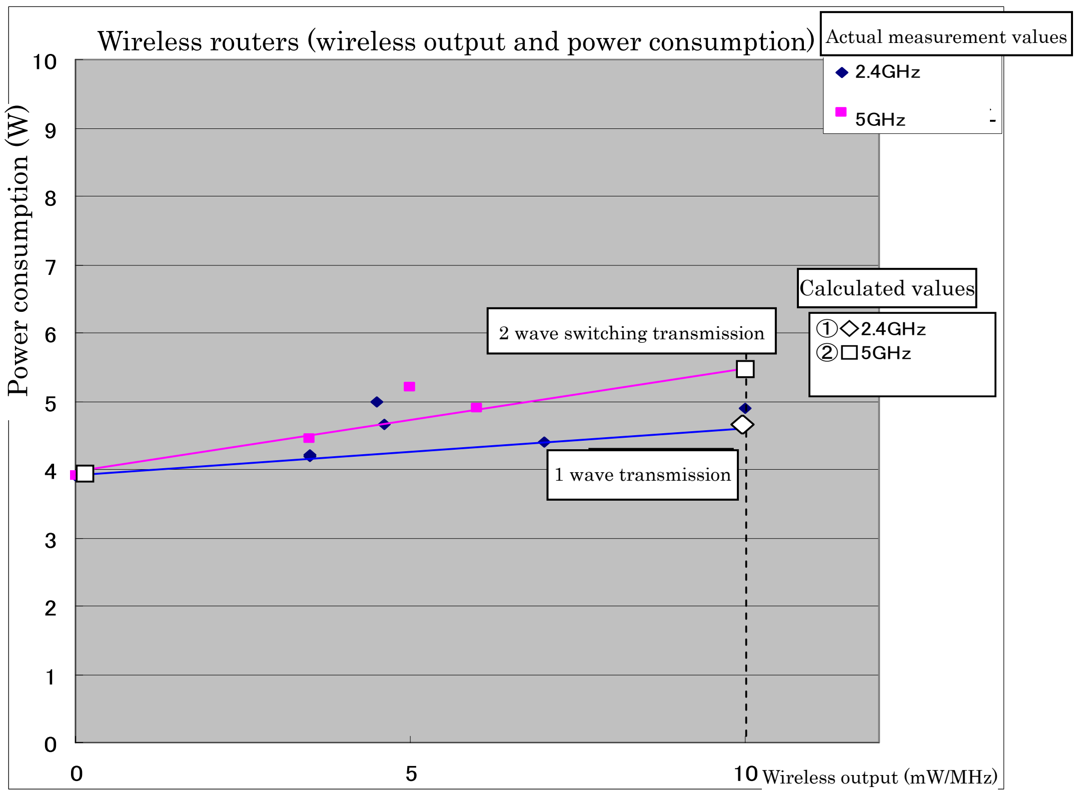


Figure 3-6 Measurement Result of Power Consumption based on Wireless Output Power Density (1 wave transmission, 2 wave switching transmission)

The measurement results of power consumption of both 1 wave transmission and 2 wave switching transmission wireless routers (Figure 3-6) were analyzed based on the concept of logical power mentioned above. As a result, each coefficient and each fixed value in the foregoing expressions (a) and (b) were calculated as follows.

A2 = 0.10, B2 + C = 3.9

A5 = 0.15, B5 + C = 3.9

2.4GHz band is used.

P = (0.10*X2) + 3.9

5GHz band is used.

P = (0.15*X5) + 3.9

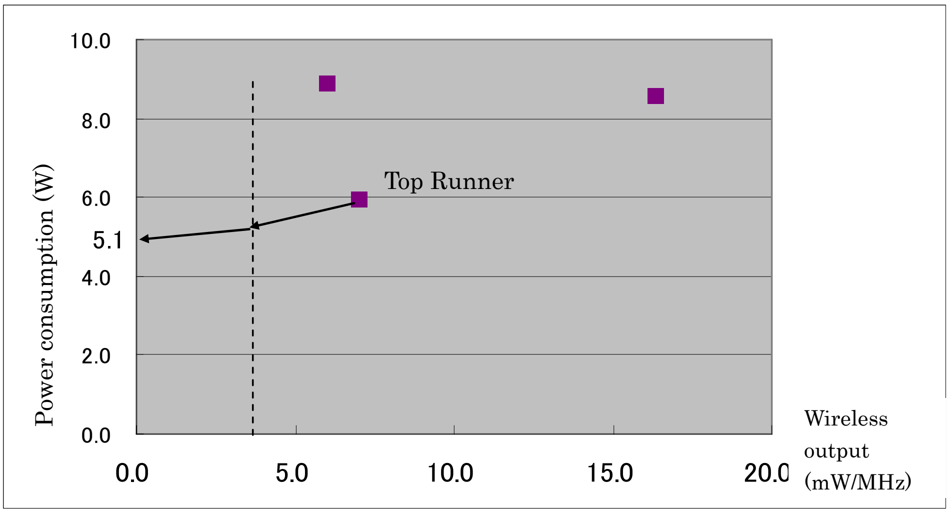


Figure 3-7 Measurement Result of Power Consumption based on Wireless Output Power Density (2 wave simultaneous transmission)

In the measurement result of power consumption of 2 wave simultaneous transmission shown in Figure 3-7, the TR value is 6.0W. According to the specification of the product with this TR value, it is known that the product's transmission power density for 2.4GHz band and 5GHz band is 3.5mW/MHz respectively. With the foregoing expression (c), moving (B2+B5+D) is to the left and P to the right, then A2=0.10, A5=0.15, X2=3.5, X5=3.5 and P(TR)=6.0 are entered. As a result, 5.1W is obtained.

(B2+B5+D) = P – (A2*X2) – (A5*X5)
= 6.0 – (0.10*3.5) – (0.15*3.5)
= 5.1 W

In the case of 2 wave simultaneous transmission

$$P = (0.10*X2) + (0.15*X5) + 5.1$$

4) ADSL routers

The measurement result of power consumption of ADSL routers (Figure 3-8) was analyzed. As a result, 7.4W was taken as the TR value, because there was no meaningful difference between the power consumption values of ADSL routers without VoIP (see ADSL without wireless in Figure 3-8) and ADSL routers with VoIP (see ADSL without wireless & with VoIP in Figure 3-8). The TR value for ADSL routers with wireless was 8.8W. Meanwhile, as a result of the product (specifications) analysis, it was assumed that the product with above TR value was not a special product.

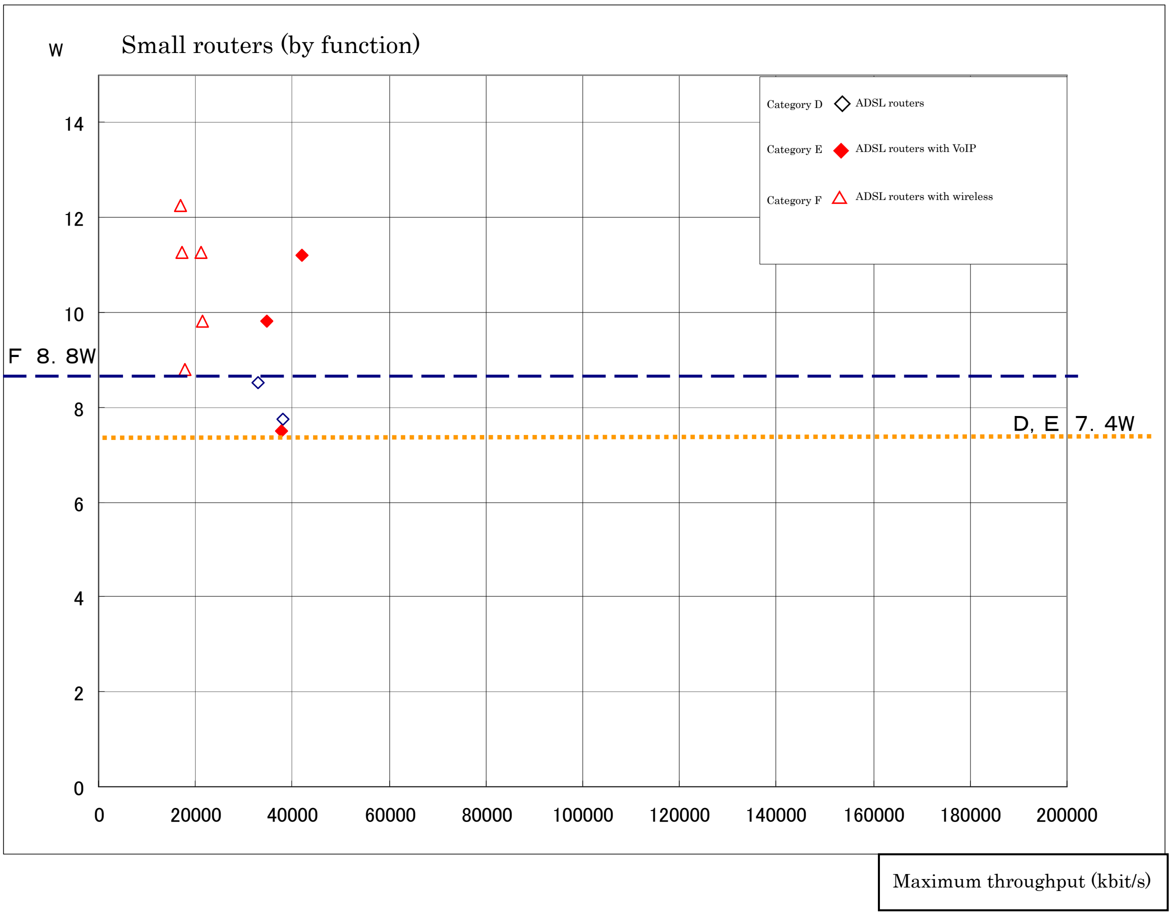


Figure 3-8 Measurement Result of Power Consumption of ADSL Routers

Based on the study above and considering the background stated in 3. (2), the Top Runner values for each category are indicated below as the target standard values.

Table 3-2 Target Standard Value of each Category

LAN side I/F / WAN side I/F	Ethernet	With VoIP	With wireless
Ethernet	4.0W	5.5W	In the case of 1 wave transmission or 2 wave switching transmission: [2.4GHz band is used] $P = (0.10 * X2) + 3.9$ [5GHz band is used] $P = (0.15 * X5) + 3.9$ In the case of 2 wave simultaneous transmission: $P = (0.10 * X2) + (0.15 * X5) + 5.1$ X2: 2.4GHz band wireless output power density (mW/MHz) X5: 5GHz band wireless output power density (mW/MHz)
ADSL	7.4W	7.4W	8.8W

As mentioned above, it became possible to express the target standard values for small routers in fixed values by taking 200Mbit/s as the upper limit of the transmission capacity. As for routers with wireless, it is expressed by a linear expression having wireless output power density as a variable, because there is positive correlation between wireless output power density and power consumption.

Reference 4

Energy Consumption Efficiency of Small Routers and L2 Switches
and the Measurement Method

1. Basic concept

Regarding routers and switches, instead of just trying to reduce absolute amount of energy they consume, the basic concept is an attempt to reduce their energy consumption according to their relaying performance (throughput) which is a basic performance indicator.

Meanwhile, energy consumption efficiency of routers and switches and the measurement method are based on the result of study by "Technical Committee of Routers and Switches" (Chairperson: Itaru Mimura) established under Communications and Information network Association of Japan.

The details are as described below.

2. Specific details about energy consumption efficiency and measurement method

(1) Energy consumption efficiency of small routers and the measurement method

The energy consumption efficiency shall be power consumption (W) measured by the following method.

In general, a positive correlation will be found between power consumption and the maximum throughput (see Figure 4-1), when making a study based on data shown in catalogues, etc. Such correlation seems insignificant in the case of small routers; therefore, power consumption (W) shall be taken as energy consumption efficiency. In addition, since it was predicted that the power consumption would vary depending on a length of measuring packet, measurements were carried out at 5 representative points to see the difference. As shown in Table 4-1, variation in these measured power consumptions was not prominent; therefore, a single measurement point was adopted.

Energy consumption efficiency shall be represented by the following expression.

$$E = P_{1500}$$

E: Energy consumption efficiency (Unit: W)
P_{1500}: Power consumption at measuring packet length of 1500 byte

* For those, such as PPPoE-dedicated models, having a difficulty in being measured at packet length of 1500 byte, the measurement may be conducted using data which will result in the maximum packet length.

A) Measurement configuration

1) It shall be configured so that it can achieve the maximum throughput at measuring packet length of 1500 byte. (Hereinafter, the configuration is referred to as the router maximum configuration.)
   The maximum throughput shall be a value defined by the following expression and measured with the following configurations. The maximum upload output packets and the maximum download output packets shall be counted simultaneously. Power consumption shall be measured at the same time when measuring the maximum throughput[2]. As for broadband routers with wireless LAN interface, the measurement shall be made only for the wireless sending direction (download: packets sending from WAN to wireless LAN), and power consumption shall also be measured at the same time.

$$T_X = (R_{X1} + R_{X2}) \times (X + Y) \times 8$$

   T_X: Maximum throughput (Unit: bit/s)
   R_{X1}: Maximum number of upload output packets transferred per second by a unit-under-measurement
   R_{X2}: Maximum number of download output packets transferred per second by a unit-under-measurement
   X: Packet length (Unit: byte)
   Y: Packet length for overhead[3] (control information) (Unit: byte)

2) Any components which can be detached and any functions which can be turned off without interfering basic performance and capability of routers shall be done so within a scope of the router maximum configuration, when carrying out a measurement.
3) A measurement may be carried out with ports connected according to a cascade topology. When calculating the maximum throughput, the number of ports in the cascading connection shall be taken into consideration.
4) It shall be set so that a unit-under-measurement will perform a routing for received packets. For routers which are incapable of routing between specified

[2] In order to decrease power consumption at the maximum load, it is necessary to make effort to reduce power consumption of a product as a whole. With this effort, it is expected that power consumption will decrease at loads close to those in the actual use.

[3] In case that a line interface of a unit-under-test is Ethernet, the overhead shall be 38 byte (Interframe Gap: 12 byte, Preamble: 8 byte, Ethernet Header: 14 byte, Frame Check Sequence: 4 byte).

ports (routers of asymmetrical configuration[4]), transferring packets via Layer 2 or Layer 1 is not considered as routing; therefore, such packets shall not be included in the calculation of throughput.

5) Ports which are not used in a measurement within a scope of the router maximum configuration are allowed to be link-down.
6) Wired broadband routers with wireless LAN interface shall be measured with the following configuration.
   a) Routers shall be configured so that the wireless sending direction (download side: packets sent from WAN to wireless LAN) are only measured.
   b) If routers are equipped with multiple wireless LAN interfaces which are capable of simultaneous running, they shall be configured so that all the interfaces run at the same time.
   c) Data compression facilities and output power, etc. adjusting functions shall be turned off.
   d) Link rate shall be the maximum link rate of a unit-under-measurement.

B) Measuring packets

1) IP packets for unicast communications shall be used.
2) Length of measuring packet (length of PDU (Protocol Data Unit) of Layer 3) shall be 1500 byte.
3) Header of each layer shall comply with a certain standard, such as IEEE802.3 and IETF.
4) Data pattern of headers shall be discretional. Data pattern of measuring packets shall be all set to 0.
5) Bit rate (bit/s) and total number of packets transferred to a unit-under-measurement in a measurement of power consumption may be the minimum of those needed to achieve the maximum performance.

C) Measurement condition

1) Ambient temperature shall be in a range from 16 °C to 32 °C. As for broadband routers with wireless LAN function, the temperature span may be from 0 °C to 40 °C.
2) Supply voltage shall be in a rage of the rated input voltage (100V or 200V) ± 10% in the case of AC power source. The range shall be DC–57V to DC–40.5V for DC power source.
3) Frequency of AC power source shall be a rated frequency.
4) Maximum throughput and power consumption shall be measured while staying in a steady state.
5) For routers using AC power source, power consumption shall be measured at a

[4] See Figure 4-3

plug terminal for outlet.

6) In the case of using AC power source, true power shall be referred to as power consumption.
7) For small routers having wireless function, a packet generator shall be used in the measurement.

Table 4-1 Measurement Results of Power Consumption of Routers at each Packet Length

Availability of wireless function	Product	Transmission rate	Power consumption at link-up (W)	Power consumption at each packet length					Calculated power consumption (W)
				46 byte	238 byte	494 byte	1006 byte	1500 byte	
Wired	A	35.4 Mbit/s	8.40	8.53	8.51	8.50	8.50	8.53	8.52
	B	38.7 Mbit/s	7.70	7.75	7.75	7.75	7.75	7.75	7.75
	C	108 Mbit/s	5.40	5.32	5.33	5.34	5.37	5.32	5.33
	D	1.75 Gbit/s	58.6	61.7	60.8	60.6	60.4	60.2	60.4
	E	95.6 Gbit/s	370	482	427	409	401	398	403
	F	382 Gbit/s	1328	1757	1539	1476	1445	1436	1456
Wireless	G	17.9 Mbit/s	11.7	12.2	12.1	11.8	12.6	12.2	12.2
	H	20.4 Mbit/s	3.96	3.95	4.09	4.05	4.22	4.21	4.18
	I	21.2 Mbit/s	6.68	7.25	7.34	7.20	7.27	7.39	7.34

(2) Energy consumption efficiency of L2 switches and the measurement method

Energy consumption efficiency shall be a value obtained by dividing power consumption (W) measured according to the following method by the maximum throughput (bit/s). The power consumption and maximum throughput shall be measured using an actual data communication with a frame length (length of a block of data used for the measurement) of 1518 byte.

Reviewing data on catalogues, etc. and actual measurements, it was assumed that the power consumption and the maximum throughput have a positive correlation (see Figure 4-2). Therefore, "W/(bit/s)" was adopted as energy consumption efficiency of L2 switches.

Also, as shown in Table 4-2, it was found that the power consumption hardly depends on the frame length and stays almost constant. For this reason, a single measurement point was adopted.

Energy consumption efficiency shall be a value obtained with the following expression.

$$E = P_{1518} / T_{1518}$$

Where, E, P_{1518}, and T_{1518} represent the following value respectively.

E: Energy consumption efficiency (Unit: W/(bit/s))
P_{1518}: Power consumption at measuring frame length of 1518 byte
T_{1518}: Maximum throughput at measuring frame length of 1518 byte

The maximum throughput shall be a value defined by the following expression and measured with the following configurations. In order to obtain the maximum throughput, the measurement shall be carried out using total number of output frames of all ports, and they are performed simultaneously. In addition, power consumption shall be measured at the same time when measuring the maximum throughput.

$$T_X = R_X \times (X + Y) \times 8$$

T_X: Maximum throughput (Unit: bit/s)
R_X: Summation of numbers of frames output per second by a unit-under-measurement
X: Frame length (Unit: byte)
Y: Frame length for overhead[5] (Unit: byte)

[5] In case that a line interface of a unit-under-measurement is Ethernet, the overhead shall be 20 byte (Interframe Gap: 12 byte, Preamble: 8 byte).

A) Measurement configuration

1) It shall be a configuration so that the maximum throughput will be achieved at the measurement packet length of 1518 bytes. (Hereinafter, the configuration is referred to as the switch maximum configuration.)
2) The measurement shall be made after removing any parts and stopping any functions within the scope of the switch's maximum configuration, as long as they are removable or stoppable without interrupting its basic performance/function.
3) It is acceptable to conduct the measurement using a cascading connection configuration for ports. In this case, the maximum throughput shall be calculated taking the number of ports in the cascading connection into consideration.
4) It shall be a configuration so that the unit under measurement will switch received frames.
5) Within the scope of the switch maximum configuration, ports not used in the measurement are allowed to be link-down.

B) Measuring frames

1) Frames for unicast communication are used.
2) Measurement frame length (PDU (Protocol Data Unit) length of Layer 2) shall be 1518 bytes.
3) Header of each layer shall comply with IEEE802.3, IETF or other equivalent standards.
4) Data patterns of headers are discretional. Data patterns of measurement frames shall be all 0.
5) Bit rate (bit/s) and total number of frames sent to the unit under measurement during the measurement are also allowed to be the required minimum to achieve the maximum performance.

c) Measurement condition

1) Ambient temperature shall be between 16°C and 32°C.
2) Supply voltage shall be the rated input voltage (100V or 200V) ±10% in the case of using AC power source. It shall be between DC–57V and DC–40.5V in the case of using DC power source.
3) Frequency of AC power source shall be the rated frequency.
4) Maximum throughput and power consumption shall be measured in while staying in a steady state.
5) For products using AC power source, power consumption shall be measured at a plug terminal for outlet.
6) In the case of using AC power source, true power shall be referred to as power consumption.

Table 4-2 Measurement Results of Power Consumption of L2 Switches based on Frame Length (Examples)

Product	Switching Capability (Gbit/s)	Power consumption at link-up (W)	Power consumption efficiency based on frame length (W)					Calculated power Consumption (W)
			64 byte	256 byte	512 byte	1024 byte	1518 byte	
A	0.5	3.2	3.2	3.2	3.0	3.2	3.2	3.2
B	1.6	6.0	6.2	6.1	6.1	6.2	6.2	6.2
C	6.4	112.0	114.0	113.0	112.0	113.0	112.0	112.3
D	0.9	16.3	16.4	16.4	16.4	16.4	16.4	16.4
E	0.8	3.9	3.9	3.9	3.9	3.9	3.9	3.9
F	48.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0
G	8.8	33.7	34.7	34.7	34.7	33.7	33.7	33.8
H	1.8	92.0	92.0	92.0	92.0	92.0	92.0	92.0

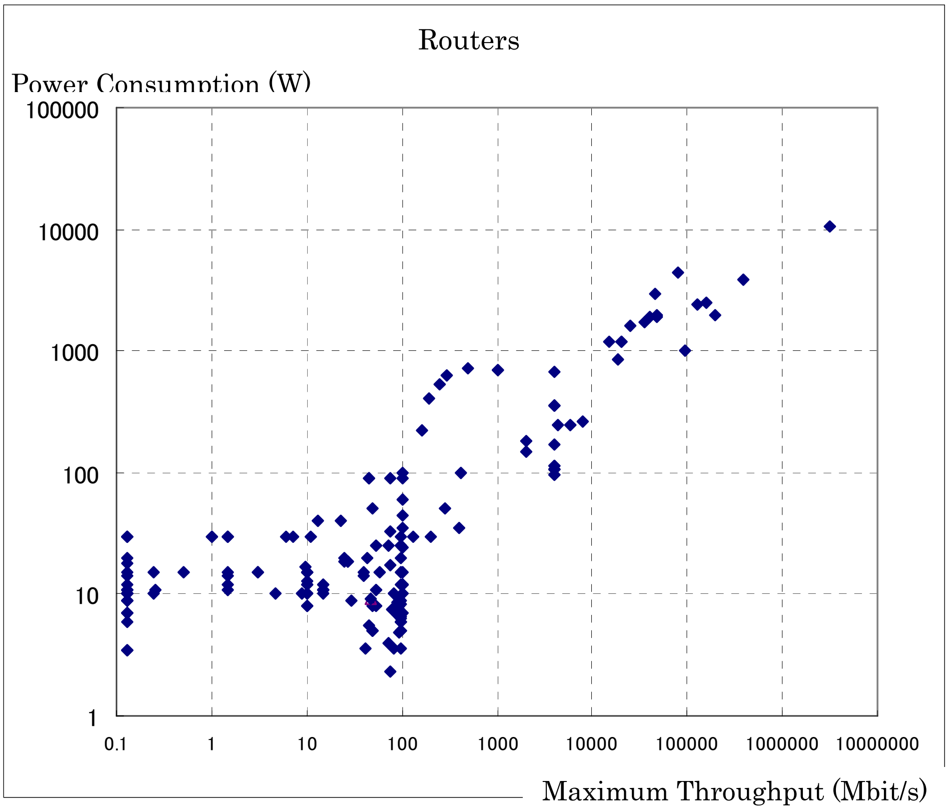


Figure 4-1 Correlation between Power Consumption and Maximum Throughput (Routers)

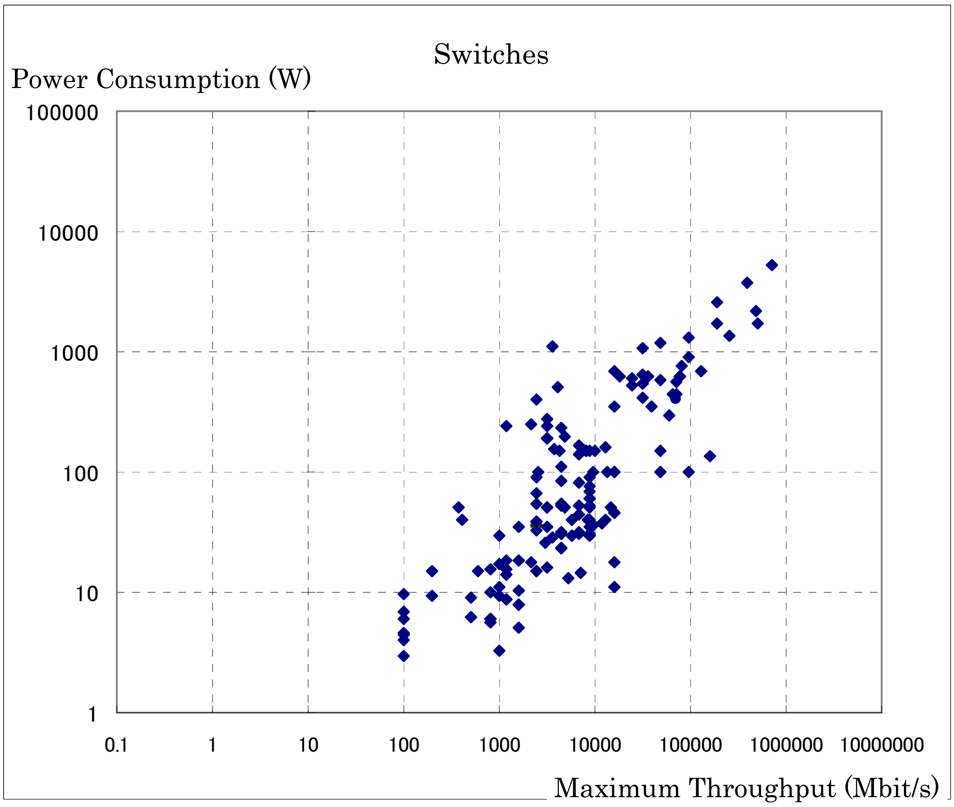


Figure 4-2 Correlation between Power Consumption and Maximum Throughput (Switches)

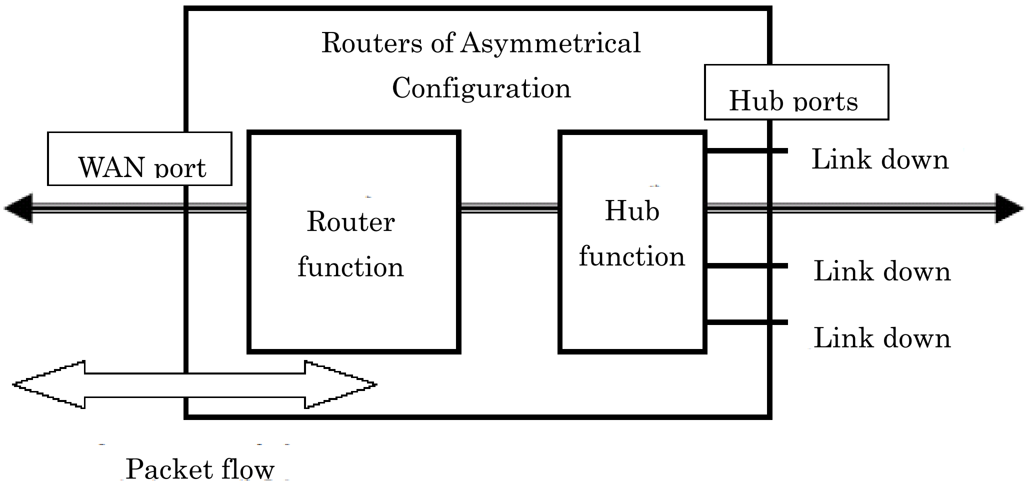


Figure 4-3 Routers of Asymmetrical Configuration

*Routers of asymmetrical configuration:

Routers which are incapable of routing between specified ports.

The maximum performance of them is achieved with WAN port and one of hub ports.

Attachment 5

Target Fiscal Year, etc. of L2 Switches

1. In the power consumption of L2 switches, the power consumed by dedicated LSI (ASIC: Application Specific IC) for L2 switches and memories is dominant. Thus, to achieve the target, new development of components, such as ASIC for L2 switches, is necessary. However, including the development of ASIC, it takes at least 2 to 3 years from the planning phase up to the delivery to develop L2 switches. Also, users need at least 3 years to change/replace old models with new ones. Therefore, the target fiscal year for L2 switches shall be set as fiscal year 2011.

2. In addition, the improvement rate of energy consumption efficiency in the target fiscal year is expected to be approximately 37.7% based on the assumption that there will be no change from the current status (actual result in FY 2006) regarding the shipment volume and the composition of each category.

<Overview of Estimation>

(1) Energy consumption efficiency estimated from values of actual achievements of L2 switches shipped in fiscal year 2006: 6.36 W/Gbit/s

(2) Energy consumption efficiency estimated from the target standard values for L2 switches to be shipped in the target fiscal year (FY2011): 3.96 W/Gbit/s

(3) Improvement rate of energy consumption efficiency

$$\frac{(6.36 - 3.96) \times 100}{6.36} = 37.7\%$$

Attachment 6

Categories for Target Setting and Target Standard Values of L2 Switches

1. Categories for Target Setting

(1) Basic concept

Main factors giving impact to the power consumption of L2 switches are type of communication lines (specifically, line speed of 10Gbit/s, 1Gbit/s, 100Mbit/s) and the number of equipped communication lines (referred to as the number of ports) (see Figure 6-1). The management function realized by using additional electronic circuits (such as CPU), the availability of IP address processing (such as filtering), and the availability of PoE (Power over Ethernet) function which started to spread recently have also significant impact to the power consumption of L2 switches (see Figure 6-2 and Figure 6-5). In the light of the above, categories for L2 switches shall be set based on above described factors.

Ethernet: Registered trade mark of Fuji Xerox Co., Ltd. Standard of LAN.

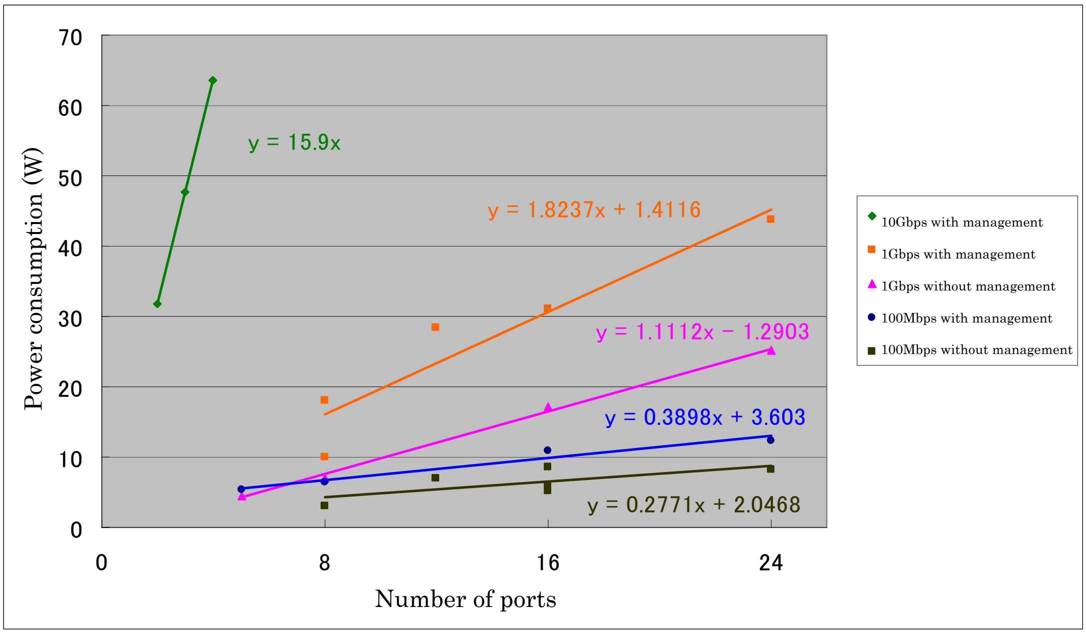


Figure 6-1 Comparison by Communication Line Speed and Presence of Management Function

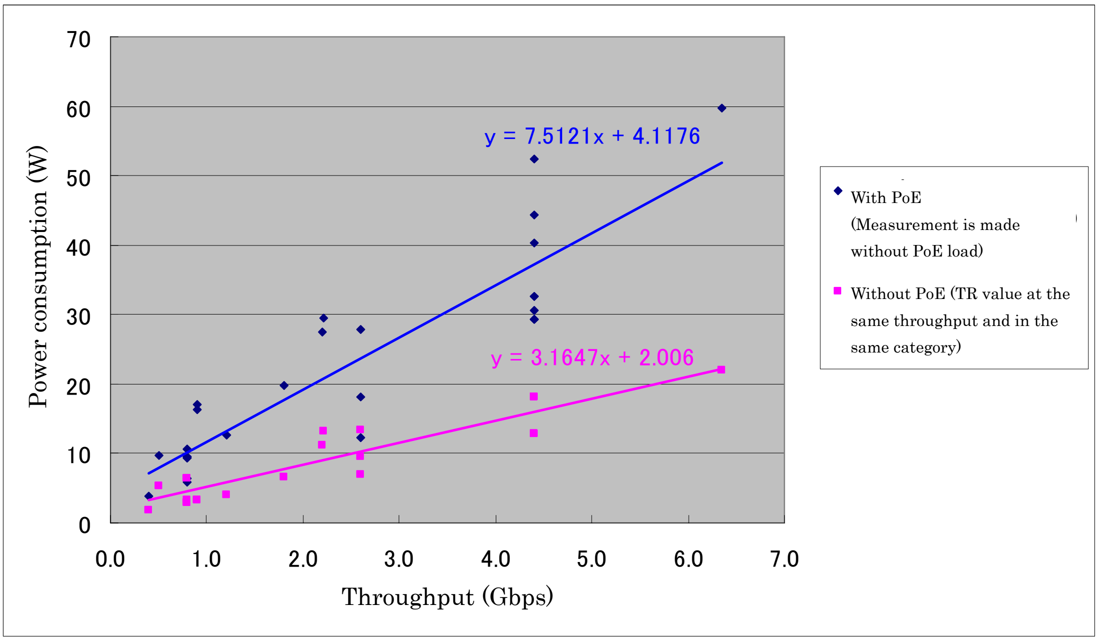


Figure 6-2　Comparison of switches with and without PoE function

(2) Specific category setting

1) Line speed and the number of ports

As for L2 switches, variety of combinations of line speed and the number of ports are available depending on the usage within networks, the number of connected terminals and the communication band (see Figures 6-3 & 6-4). There are products the line speed and the number of ports of which are different even if their throughput is the same. For example, with respect to the products with 44 Gbit/s, some may have 2 ports of 10Gbit/s line and 24 ports of 1Gbit/s line, and others may only have 44 ports of 1Gbit/s line. Besides, the range of throughput is wide (tens Mbit/s to tens Gbit/s), and the number of ports ranges from 3 ports to 48 ports or more. It is not practical to handle all the combinations as different categories, because it makes the categories complicated and the number of products to be covered in each category becomes fewer. Therefore, for such products having various combinations of line speed and ports, power consumption standard values shall be determined by use of relational expressions with the communication line speed and the number of ports as variables, instead of categorical approach.

Figure 6-3　Example of L2 switch (1G × 48 ports + 10G × 2)

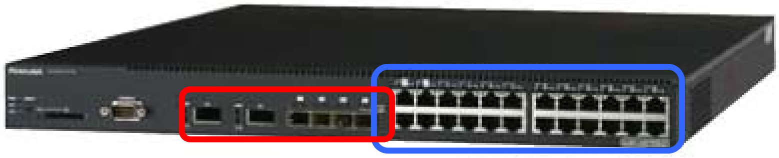


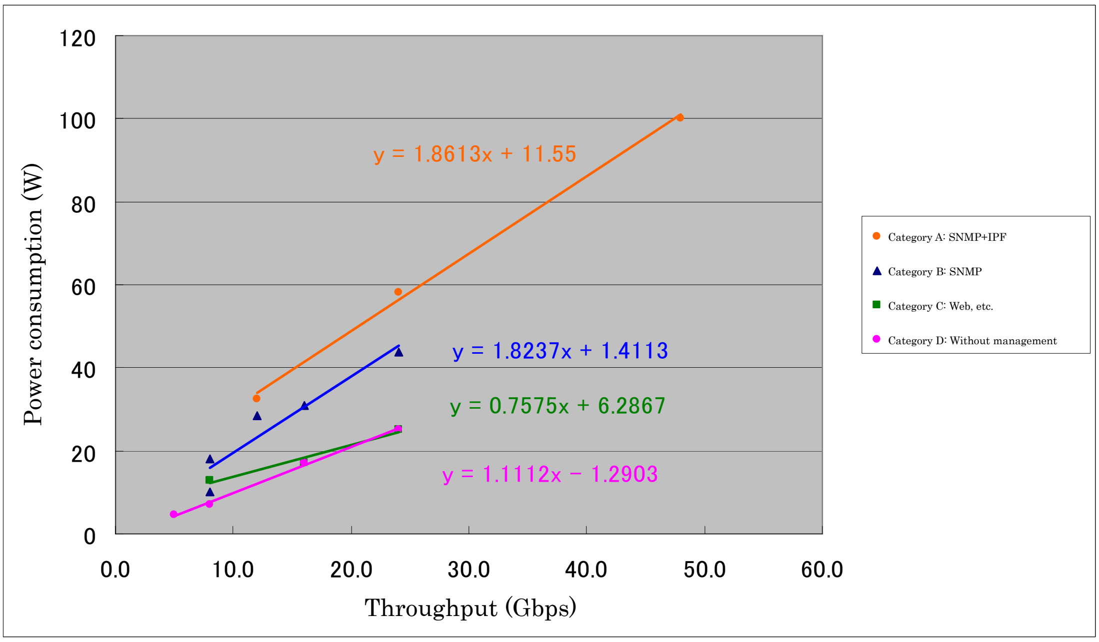
Figure 6-4 Example of L2 switch (1G × 24 ports)

2) Management function

With respect to L2 switches, the availability of management function (SNMP (Simple Network Management Protocol) function, Web management function, etc.) is difficult to be expressed in a relational expression using physical amount; therefore, it is appropriate to handle it by separating categories. As shown in Figure 6-5, actual measurement reveals that the power consumption characteristics will vary depending on the availability and the type of management function. In this Figure, the comparison is made with a single line speed of 1Gbit/s to illustrate the power characteristics based on the difference in management function. From the figure, it is observed that L2 switches supporting SNMP which is an enhanced management function consume large amount of power, that those supporting Web which is a relatively simplified function consume less power, and that those without any management function consume much less power.

3) IP filtering function

Likewise, with respect to L2 switches, the IP address processing function is difficult to be expressed in a relational expression using physical amount; therefore, it is appropriate to handle it by separating categories. The IP filtering function is included in the IP address processing function. It is the function to filter communication packets at IP level referring to IP address of sender/receiver, protocol, ports, etc. in order to enhance security and to allow flexible network design. It is equipped to recent high-function L2 switches. As shown in Figure 6-5, the power consumption clearly differs according to the availability of IP filter function (see Category A and Category B).



IPF: IP filtering

Figure 6-5 Categorical Comparison in the case of with 1Gbit/s and without PoE (Management Function)

4) PoE

The power consumption of L2 switches differs depending on the availability of PoE function even though they have the same number of ports. In other words, the products supporting PoE is consequently equipped with large capacity of power supply to supply power through ports; therefore, power supplied through ports and power steadily consumed by the power supply exist within them. As a result of the study, it is found that a relational expression using the maximum supply power (rated) of PoE as a variable is possible (as for details, see the appendix). Thus, the target standard value for L2 switches supporting PoE shall be determined by use of the relational expression, instead of categorical approach.

From the above, L2 switches are first classified by the availability of management function. Then, those equipped with management function are further divided into a group of those having SNMP function and a group of those having Web management function and the like. For those with SNMP function, the availability of IP filtering function is taken into consideration for the further grouping. Consequently, the basic categories of L2 switches shall be set as 4 categories as shown in Table 6-1.

Table 6-1 Categories of L2 switches

<table>
<tr><th colspan="2">Management function</th><th>IP address processing</th><th>Category</th></tr>
<tr><td rowspan="3">With management function</td><td rowspan="2">With SNMP function</td><td>With IP filtering function</td><td>A</td></tr>
<tr><td>Without IP filtering function</td><td>B</td></tr>
<tr><td>With Web management and the like</td><td></td><td>C</td></tr>
<tr><td>Without management function</td><td colspan="2"></td><td>D</td></tr>
</table>

* IP filtering function is a function that blocks the transmission of frames of specific IP addresses referring to the IP addresses.

2. Target Standard Values

(1) Basic concept

Target standard values are set based on the idea of Top Runner method. The specific policies are as follows.

(a) Target standard values shall be set for every category that has been appropriately defined.

(b) As for the categories where future technological advances are expected to improve efficiency, the target standard values shall allow for the improvement as much as possible.

(c) Target standard values shall not conflict among categories.

(2) Room for improvement of energy consumption efficiency by future technology advances

Because of the following reasons, it seems appropriate not to include the room for energy consumption efficiency improvement of L2 switches potentially achieved by future technological advancement in the target standard values for now.

1) Target standard values are determined by using the relational expression described in paragraph (3) below. When deriving the relational expression, since it is a linear approximation, the coefficient is obtained by using the values of two products having the number of ports associated with excellent energy efficiency (Top Runner values) as representing values. Consequently, for L2 switches having different number of ports except for those with the representing values, energy consumption efficiency target standard values are higher than the current Top Runner values (of the product group).

2) Especially in case of switches supporting 100Mbit/s to 1Gbit/s, it is difficult to expect further energy saving by new technological innovation, because new

functions are not anticipated to be added, because the chips used in the products have sufficiently achieved the performance target with current semi-conductor technologies, and etc.

(3) Specific target standard values

As mentioned in 1-(2) above, basic categories are those 4 categories. To deal with the variability of line speeds, the target standard values shall be determined by relational expressions. The concept is described below.

1) Standard power consumption based on line speed and number of ports

According to the conventional studies, it was known that power consumption of a L2 switch having ports of single line speed only is the sum of power constantly required by products (power consumed by power supply and basic circuits) and increasing power as the number of ports increases. In other words, the power consumption approximately proportionate to the number of ports equipped. Being supported by the graph (power consumption vs. number of ports/throughput) plotting Top Runner values of products with different number of ports, this interpretation is assumed to be correct. The power consumption is fundamentally expressed by the expression (1) below.

Power consumption $P = \alpha_{\text{line speed}} \cdot X_{\text{line speed}} + \beta_{\text{line speed}}$ … Expression (1)

Where,

$\alpha_{\text{line speed}}$ is unit power consumption per port at ports of that line speed (coefficient).

$\beta_{\text{line speed}}$ is power constantly consumed by product of that line speed (fixed value).

$X_{\text{line speed}}$ is the number of ports of that line speed.

As a result of analyzing the measurement data, it was found that α varies depending on the line speed. To be more specific, the relationship is $\alpha_{100M} < \alpha_{1G} < \alpha_{10G}$, showing that the power consumption per port (coefficient) increases as the line speed becomes faster.

2) Extension in case of products supporting multiple lines speeds

As mentioned above, some L2 switches are equipped with various ports of multiple line speeds (hereinafter, called port-mix). Products which are equipped with a few high-speed lines for the network core (center side) and many lines of relatively low speed at the terminal side are currently available in the market. In this paragraph, extension of the relational expression is operated so as to represent such port-mix products. Basic idea of this extension is to total the relational expressions for every port.

$$P_{MIX} = (\alpha_{100M} \cdot X_{100M} + \beta_{100M}) + (\alpha_{1G} \cdot X_{1G} + \beta_{1G}) + (\alpha_{10G} \cdot X_{10G} + \beta_{10G})$$

$= (\alpha_{100M} \cdot X_{100M} + \alpha_{1G} \cdot X_{1G} + \alpha_{10G} \cdot X_{10G}) + (\beta_{100M} + \beta_{1G} + \beta_{10G})$ …Expression (2)

As for the term $(\beta_{100M} + \beta_{1G} + \beta_{10G})$ expressing the power constantly consumed, it will not be the simple sum in the case of port-mix products, because the circuits can be partially shared. In light of the above, βn is obtained from the values measured for each category. Based on this idea, the relational expression becomes the expression (3) as below.

$= (\alpha_{100M} \cdot X_{100M} + \alpha_{1G} \cdot X_{1G} + \alpha_{10G} \cdot X_{10G}) + \beta$… Expression (3)

In this connection, αn is known to be different in each category based on the analysis. In other words, for those which perform highly-functional processing such as IP filtering, they consume power differently at each type of port. This is reasonable because the capacities of circuits, memories and etc. increases to realize the required function.

Based on these ideas, the coefficient α is set for each category. The coefficients of power consumption per port obtained from measured Top Runner values are as per Table 6-2, and they are adopted as the coefficients of the expression (2).

Table 6-2 List of coefficient α

Line speed		100M	1G	10G
Notation (αn)		α_{100M}	α_{1G}	α_{10G}
Power consumption coefficient (W/Port)	Category A	0.578	1.880	15.900
	Category B	0.375	1.880	—
	Category C	0.375	1.133	—
	Category D	0.272	1.133	—

*) Currently Category B, C, and D for 10G are not available; therefore, their coefficients are not set this time.

As mentioned above, coefficient βn is not the simple sum of the fixed value βn of every line speed and varies depending on the combination of line speed (port). Thus, the coefficient βn is determined for each combination of line speed based on the measurement data.

In the measurements of products having both 100Mbit/s and 1Gbit/s ports, reverse are cases in which 1) energy consumption of products with 100Mbit/s port only and 2) energy consumption of products with 100Mbits/s + 1Gbits/s × 2 ports are reversed [1)> 2)]. Meanwhile, when comparing with 3) products having 100Mbit/s + 1Gbit/s × 1 port, there are some cases in which no difference in the unit power corresponding to 1Gbit/s port [2)≈3)]. Therefore, a combination of 100Mbit/s + 1Gbit/s × 1 port is established for β to make 100Mbit/s < 100Mbit/s + 1Gbit/s × 1 < 100Mbit/s + 1Gbit/s × 2. In this connection, 1Gbit/s × 1 port is expressed as $\beta_{100M + 1G1}$ and 1Gbit/s × 2 ports or more is expressed as $\beta_{100M + 1G2}$.

Each coefficient (βn) obtained from Top Runner values in the measurements is as per Table 6-3 below.[6]

Table 6-3 List of Coefficients β

Line speed		100M	1G	10G	100M+1G		1G+10G
Notation (βn)		β_{100M}	β_{1G}	β_{10G}	$\beta_{100M+1G1}$	$\beta_{100M+1G2}$	β_{1G+10G}
Values (W)	Category A	3.976	9.940	0	2.276	0.576	–10.240
	Category B	3.400	–5.070	—	1.700	0	—
	Category C	3.400	–2.074	—	2.447	1.494	—
	Category D	0.824	–2.074	—	1.494	1.494	—

*) Although a combination of 100Mbit/s line + 100Gbit/s line is possible, it is not included here because there is no such product with the combination. In addition, coefficients for Category B, C and D of 10Gbit/s are not provided here due to the lack of existing products falling into these categories.

3) Target standard values for products with fewer ports

As for small L2 switches, the same as in the case of small routers, there is an area in which the correlation between the performance (throughput/number of ports) and the power consumption deviates from the foregoing relational expression (linear approximation). This is probably the case where the constant power consumption is greater than the power consumed by communication lines and also where the power proportionate to the number of ports is extremely lower than the constant power consumption. Specifically, in the case of L2 switches with less than 8 ports, the standard value obtained by the expression (3) and the current Top Runner value are different. For these products with less than 8 ports, the current Top Runner value shall be set as the target standard.

To be more specific, the standard values are set as follows for products of 1Gbit/s × 5 ports or less in Category D and products of 100Mbit/s × 8 ports or less in Category D.[7]

a) For products of 100Mbit/s × 8 ports or fewer in Category D, target standard value shall be 3.0W.
b) For products of 1Gbit/s × 5 ports or fewer in Category D, target standard value shall be 4.5W.

As for the products currently not existing, if, as a result of calculation using the

6 In Table 6-3, there is a field in which βn(y intercept) becomes a minus value. βn is the constant power consumption when the number of ports is 0; therefore, it shall be reasonably a plus value. In fact, when the number of ports is 3 or more (box switch of this time), it is always a plus value. This reverse phenomenon is probably due to the rationalization effect made to the circuits by port-mix.

7 In theory, products of 100Mbit/s × 5 ports should be the ones with minimum value. However, because Top Runner value of 8 port products is slightly smaller, the target standard value for them is set as the standard value (fixed).

relational expression, the value becomes smaller than above 2 values, these 2 values are applied. For port mix products, the value of those the line speed of which is slower is applied. The relevant products are specifically described below.

c) For products with 1G × 5 ports or fewer in Category B and Category C, the target standard value shall be 4.5W.

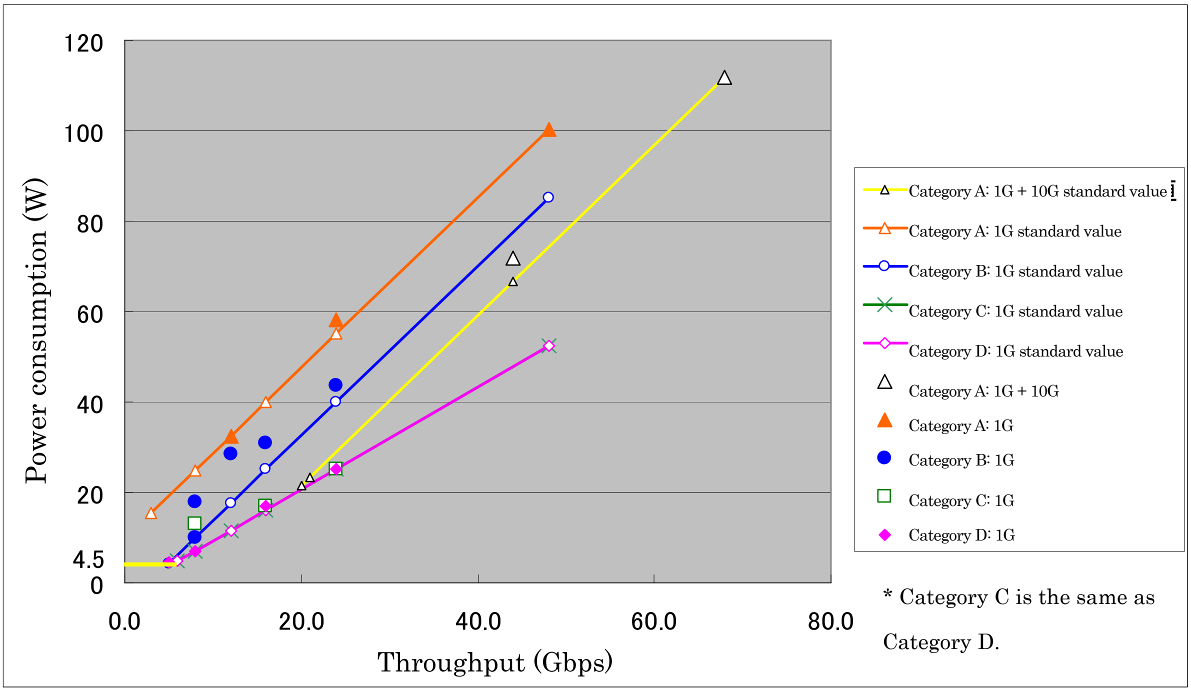


Figure 6-6 Power Consumption Target Standard Value, 1G and 1G + 10G, without PoE

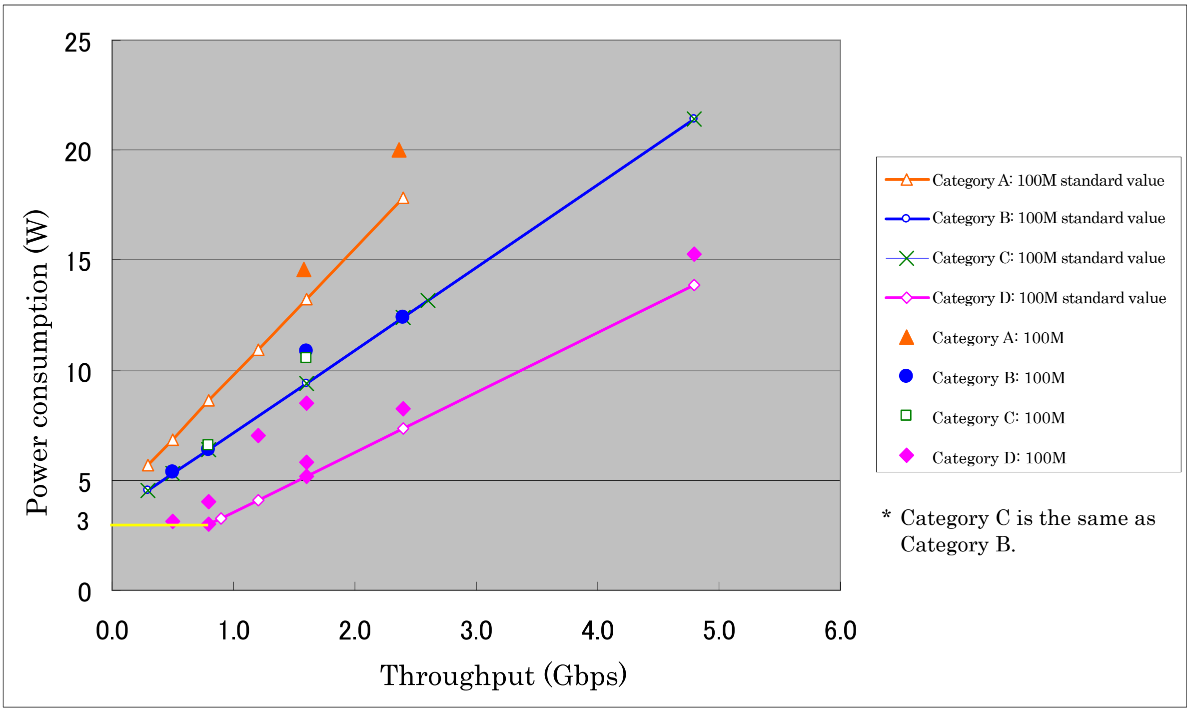


Figure 6-7 Power Consumption Standard Value, 100M without PoE

4) Concept of PoE standard value (See the attachment for details)

PoE supporting products combine switching function and power supply function. It can be paraphrased that "a product with PoE is one without PoE plus PoE function" or "a product without PoE is one with PoE the power supply capacity of which is zero". The standard value shall be determined using a relational expression in a way that satisfies this correlation. To do this, a correction term (corresponding to the power increased by PoE) is added to the relational expression (3). Concept of the correction terms are described in the attachment in detail, and it is briefly described here. As a result of reviewing, it was found that these correction terms could turn the maximum supply power of PoE (Pd) and the power consumption of L2 switch circuit (Ps) into parameters. Thus, they are determined by using Top Runner values of current PoE products so that the method resulting in the best power consumption efficiency would be selected when installing the PoE function.

Meanwhile, as regards mainstream models, the ratio of maximum supply power capacity to power consumption of L2 switch circuit (the maximum supply power ratio) is within 16 times. In addition, models with the ratio exceeding 16 times are rare, and the shipment volume is small. Therefore, the products with the ratio of up to 16 times shall be targeted here.

Based on the study results above, the Top Runner values for each category are summarized as follows.

Table 6-4 Categories and standard values for L2 switches

Management function		IP address processing	Category	Standard energy consumption efficiency
With management function	With SNMP function	With IP filtering function	A	$\{(\alpha_A \cdot X + \beta_A) + P_A\}/T$
		Without IP filtering function	B	$\{(\alpha_B \cdot X + \beta_B) + P_B\}/T$
	With Web management and the like		C	$\{(\alpha_C \cdot X + \beta_C) + P_C\}/T$
Without management function			D	$\{(\alpha_D \cdot X + \beta_D) + P_D\}/T$

Table for αn values

Line speed		100M	1G	10G
Notation (αn)		α_{100M}	α_{1G}	α_{10G}
Power consumption coefficient (W/Port)	Category A	0.578	1.880	15.900
	Category B	0.375	1.880	—
	Category C	0.375	1.133	—
	Category D	0.272	1.133	—

Table for βn values

Line speed		100M	1G	10G	100M+1G		1G+10G
Notation (βn)		β_{100M}	β_{1G}	β_{10G}	$\beta_{100M+1G1}$	$\beta_{100M+1G2}$	β_{1G+10G}
Value (W)	Category A	3.976	9.940	0	2.276	0.576	−10.240
	Category B	3.400	−5.070	—	1.700	0	—
	Category C	3.400	−2.074	—	2.447	1.494	—
	Category D	0.824	−2.074	—	1.494	1.494	—

If the power consumption ($\alpha n \cdot X + \beta n$) meets the following cases, the calculation shall be made using the value specified.

1) If it is less than 3.000 at 100Mbit/s and at 100Mbit/s + 1Gbit/s, the specified value shall be 3.000.
2) If it is less than 4.500 at 1Gbit/s, the specified value shall be 4.500.

$\alpha n \cdot X + \beta n$ (Watt) : Shortened form of $\alpha n_{100M} X_{100M} + \alpha n_{1G} X_{1G} + \alpha n_{10G} X_{10G} + \beta n$

Where, n represents category, $\alpha n_{(bps)}$ represents a unit power consumption per port at each category and each line speed, $X_{(bps)}$ represents the number of ports for each line speed, and βn represents a fixed power value for each category.

Example: $\alpha n \cdot X = \alpha n_{100M} X_{100M} + \alpha n_{1G} X_{1G} + \alpha n_{10G} X_{10G}$

T (bps) : Throughput measured.

Pn (Watt) : Additional power consumption when taking the effect of PoE power supply into account.

Where, n expresses the category (n: A, B, C, D)

$$Pn = \frac{0.0347 \cdot Pd/Ps}{1 - 0.0347 \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n)$$

$$Ps = (\alpha n \cdot X + \beta n) \cdot 0.850 + 1.000$$

Pd (Watt) : PoE maximum supply power. In the case of units without PoE, it shall be Pd = 0

Ps (Watt) : Secondary power of switch circuits and PoE control circuits.
Secondary power of switch circuits shall be calculated by applying across-the-board 85% power supply efficiency to the basic formula for units without PoE ($\alpha n \cdot X + \beta n$).
Secondary power of PoE control circuits shall be across-the-board 1W.

However, units whose PoE maximum supply power ratio (Pd/Ps) is within 16.000 are only covered.

Appendix: Concept of Standard Value for Products with PoE Power Supply Function (Detail)

1. Basic concept

PoE (Power over Ethernet) function is a function which supplies power to opposing products through communication cables made of metal. As VoIP terminals, wireless access points, etc. becoming popular in recent years, PoE also started to spread as a function to supply power to such devices.

PoE is a complex product of power supply function and L2 switch function, and the majority of current products are in a form where PoE function is added to L2 switch that is a base of the product. Therefore, it is desirable to determine the standard value using the same relational expression which can comprehensively cover products with and without PoE.

Thus, as a basic concept, a relational expression correcting power according to the power supply capacity of PoE is developed for the products without PoE function based on the relational expression for products with PoE function. The standard values shall be calculated using the obtained expression.

Based on the concept above, the expression f is introduced which relates the power consumption standard value for products with PoE function to the standard value of products without PoE function. It can be developed using the maximum supply power of PoE (Pd) and expressed as follows.

Standard value P for products without PoE
= f (Pd) · Standard value P_{PoE} for products with PoE ……A1

It is more understandable to see that the standard value for products with PoE function is made of the standard value of products without PoE function with incremental power according to the additional function. Therefore, the expression A1 is transformed to the expression A2 below. The concept is that a correction for increment by PoE is made to the standard value for products without PoE. (See Additional Explanation: Concept of the Relational Expression.)

Standard value P_{PoE} for products with PoE
= Standard value P for products without PoE /f (Pd)
= $(\alpha n \cdot X + \beta n) / f(Pd)$ ……A2

The relational expression f(Pd) is determined from the plot diagram of measurement results of products with PoE (Figure 6-8) and defined as follows.

$$f(Pd) = 1 - \gamma n \cdot Pd/Ps$$

Pd : PoE maximum supply power

Ps : Secondary power of switching circuit and PoE control circuit

γn : Correction coefficient for PoE maximum supply power ratio (Pd/Ps)

Pd/Ps is the maximum supply power ratio showing the multiplying factor of PoE's maximum supply power to the secondary power of switch circuit (including PoE control circuit). The current measurement of PoE is conducted according to the method without setting load (terminals, etc.) for PoE. With this method, as the PoE's maximum supply power ratio increases, the load factor of power supply decreases, resulting the measurement to be made at the point where the conversion efficiency of power supply is low. This is corrected by the relational expression f(Pd).

Based on the above, the standard power of PoE is expressed as follows.

$$P_{PoE} = (\alpha n \cdot X + \beta n) / (1 - \gamma n \cdot Pd/Ps) \qquad \text{.........A3}$$

The expression A3 can be transformed as follows.

$$P_{PoE} = (\alpha n \cdot X + \beta n) + \frac{\gamma n \cdot Pd/Ps}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n) \qquad \text{........ A4}$$

Pn can be expressed as follows. (See Additional Explanation for the detail of this transformation)

$$Pn = \frac{\gamma n \cdot Pd/Ps}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n) \qquad \text{.........A5}$$

Since Pd (maximum supply power) = 0 in the expression A5 for products without PoE function, additional portion Pn = 0. Thus, both products with PoE and without PoE can be expressed by one relational expression.

As power for each category is included in the secondary power Ps of switch circuit, γn is commonly defined for all categories and fixed as follows based on actual measurement.

$$\gamma n = 0.0347$$

Secondary power Ps of switch circuit (including PoE control circuit) is expressed as follows.

Ps = Switch circuit's secondary power + PoE control circuit's secondary power

Secondary power of switch circuit is determined by introducing 85% power supply efficiency (Figure 6-9) in the standard expression for products without PoE and can be expressed as follows.

Switch circuit secondary power = $(\alpha n \cdot X + \beta n) \cdot 0.85$

Meanwhile, secondary power of PoE control circuit is defined as 1.00W based on actual measurement.

(1) Concept of addressing products with PoE supply power

As for PoE extra incrementation, it is necessary to increase the extra correction rate (inverse number of f(Pd)). It is because the larger the capacity of maximum supply power, which is calculated with Pd/Ps (maximum supply power ratio) expressing how many times it is larger than the power consumed by switch circuit, etc., the more the power supply load; moreover, the low power supply efficiency is used in the current measurement method where PoE load is not applied.

In Figure 6-8, it is judged for f(Pd) that a primary approximation is possible from the typical examples of the power supply efficiency curve against the power supply's load rate shown in Figure 6-9. The inclination of the straight line is obtained from the Top Runner values in the measurement result of products with PoE.

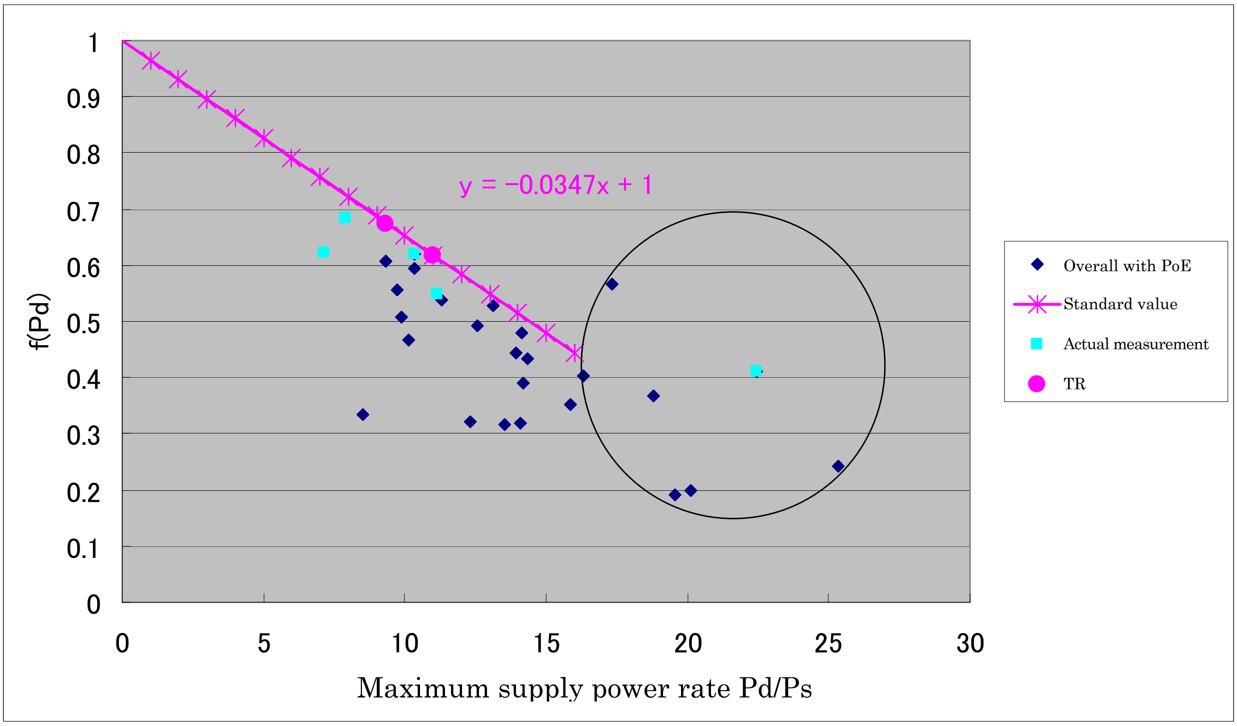


Figure 6-8 Measurement Result for Correction Coefficient γn (inclination) obtained from the Maximum Supply Power Rate using Primary Approximation

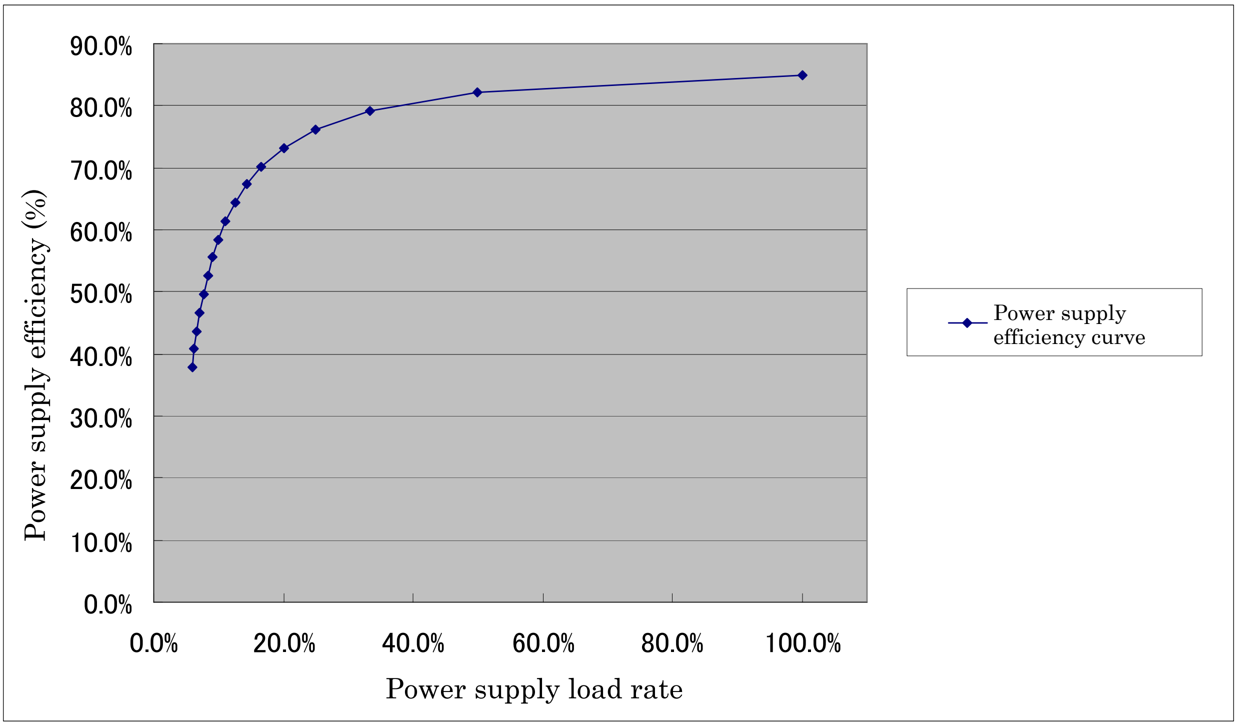


Figure 6-9 Typical Examples of Power Supply Efficiency Curve

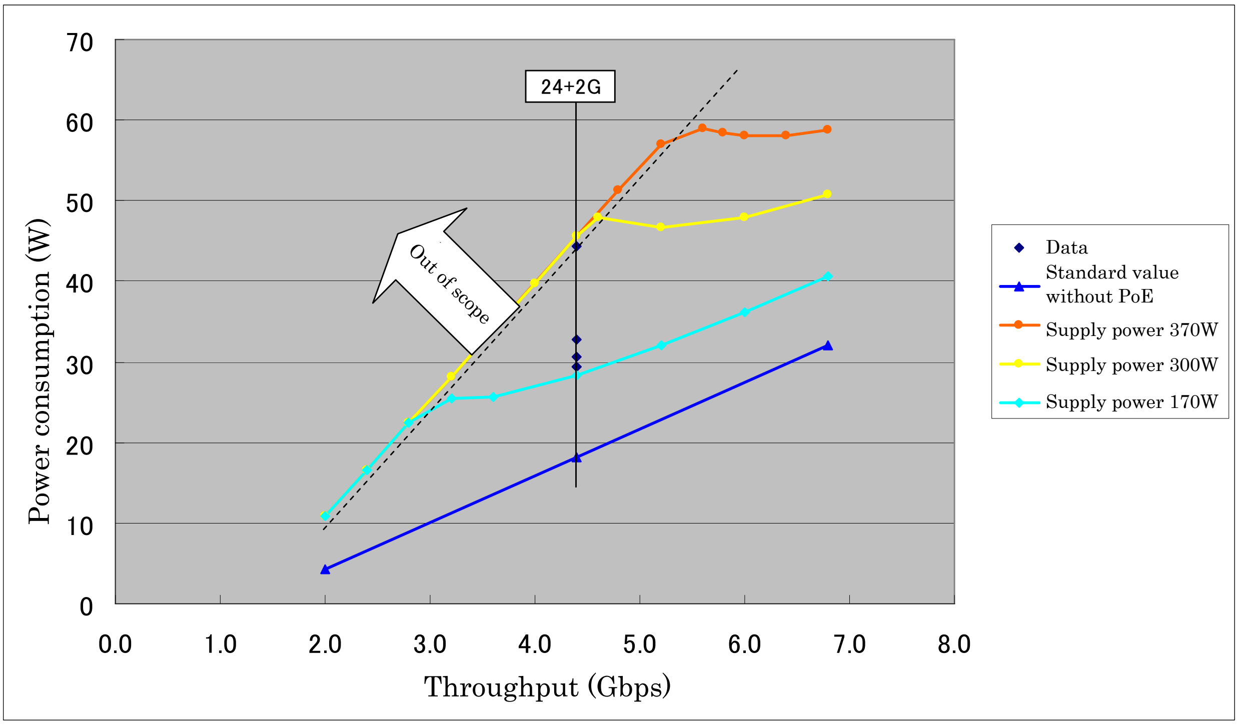


Figure 6-10 Standard Values for Products with PoE and Area of Outside the Scope

2. Supplementary explanation on target scope of PoE products

Reviewing the actual measurement of L2 switches, it is found that currently the majorities of products are those whose ratio of the maximum supply power capacity against the power consumption of L2 switch circuit is 16 or lower as shown in Figure 6-8. There are some PoE products plotted in the area where the maximum supply power rate exceeds 16 as encircled by ○ in Figure 6-8, and their deviation from the standard expression is large. In the case of the maximum supply power rate exceeding 16, the measurement is made under low load condition in which the load of switch circuit's secondary power is around 6% or less of the maximum supply power including PoE, making the fixed power consumption of power supply dominant. It also results in lowering the conversion efficiency as shown in Figure 4-9. Therefore, it becomes difficult to perform calculation by the relational expression using the maximum supply power rate (Pd/Ps).

Based on the study, since models with the above mentioned ratio of which exceeds 16 are not many and the shipment volume is low, it was decided that those with the above mentioned ratio of which is within 16 are to be target products.

Figure 6-10 shows the standard value (baseline) of incrementation for products with PoE defined by the relational expression (example of 100Mbit/s + 1Gbit/s). The baseline is not straight because the inverse number of the correction coefficient f(Pd) is taken. Area above the dotted line is excluded from the target scope because the maximum supply power ratio of 100Mbit/s × 24 + 1Gbit/s × 2 (expressed as 24 + 2G) exceeds 16 there.

Among existing products, only those with the maximum supply power rate up to 25 are available; however, it potentially becomes 40 or more depending on the specifications. (For example, 100M × 8 ports of category D can have the maximum supply power up to 123.2W (=15.4W × 8), which results in the value to be 40 times compared with 3W of the power consumption standard for power supply of the switch.) In this area, power consumption of PoE is extremely large compared with that of the switch. Therefore, it is appropriate to review this area again when relevant products are introduced in the market, while taking the efficiency improvement of power supply into consideration.

3. Supplementary explanation (details about expansion of expressions)

(1) Parameters:

Pn: Additional power of PoE control circuit for each category

$$Pn = \frac{\gamma n \cdot Pd/Ps}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n)$$

Pd: PoE maximum supply power (based on the rated power)

Ps: Secondary power of switch circuit and PoE control circuit

However, the lower limit of $1 - \gamma n \cdot Pd/Ps$ shall be 0.4.

Ps: Secondary power of switch circuit and PoE control circuit (the power of circuit side is called secondary power)

$Ps = A+B$

A: Secondary switch circuit power

A = Target standard value for products having port structure without PoE $(\alpha n \cdot X + \beta n) \times$ power supply efficiency 85%

B: Secondary PoE control circuit power (fixed value: 1.00 watt)

$\alpha n \cdot X + \beta n$: Standard power based on line speeds and their combinations (Shortened form of $\alpha n_{100M} x_{100M} + \alpha n_{1G} x_{1G} + \alpha n_{10G} x_{10G} + \beta n$)

γn: Correction coefficient (the lower limit of $1 - \gamma n \cdot Pd/Ps$ is 0.4, i.e. the upper limit of the incrementation rate is 2.5)

(2) Concept of the relational expression

Based on the concept that the power for controlling PoE shall be added, the relational expression is formulated as follows.

$$(\alpha n \cdot X + \beta n) / T + Pn / T \qquad \text{.............} (1)$$

Since $nA = A + (n-1)A$, the conversion of this relational expression becomes as follows.

$$\frac{(\alpha n \cdot X + \beta n) / T}{1 - \gamma n \cdot Pd/Ps}$$

$$= \frac{1}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n) / T$$

$$= (\alpha n \cdot X + \beta n) / T + \frac{1 - (1 - \gamma n * Pd/Ps)}{1 - \gamma n * Pd/Ps} \cdot (\alpha n \cdot X + \beta n) / T$$

$$= (\alpha n \cdot X + \beta n) / T + \frac{\gamma n \cdot Pd/Ps}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n) / T$$

Then,

$$Pn = \frac{\gamma n \cdot Pd/Ps}{1 - \gamma n \cdot Pd/Ps} \cdot (\alpha n \cdot X + \beta n)$$

Thus, the expression (1) is expressed this way.

Through this conversion, PoE control load power is now expressed as an incrementation, becoming easier to understand.

Attachment 7

Routers, etc. Evaluation Standard Subcommittee
Energy Efficiency Standard Subcommittee of the Advisory Committee for Natural Resources and Energy
Background of Holding

First Subcommittee Meeting (July 19, 2005)

- Disclosure of the Routers, etc. Evaluation Standard Subcommittee
- Current status of routers and switches
- Scope of targeted routers and switches

Second Subcommittee Meeting (September 13, 2005)

- Scope of targeted routers and switches
- Energy consumption efficiency and the measurement method for routers, etc.

Third Subcommittee Meeting (June 11, 2007)

- Activities of the Routers, etc. Evaluation Standard Subcommittee so far
- Review of measurement method for routers, etc.
- Scope of targeted small routers, etc.

Fourth Subcommittee Meeting (August 2, 2007)

- Scope of targeted small routers, etc.
- Energy consumption efficiency and the measurement method for small routers, etc.

Fifth Subcommittee Meeting (January 11, 2008)

- Categories for target setting and target standard values for small routers
- Categories for target setting and target standard values for L2 switches

Sixth Subcommittee Meeting (February 21, 2008)

- Interim summary report

Interim report was open for public comments during the period from March 1, 2008 through March 30, 2008; and 1 comment was received. Since it was not directly related to the content of the interim report, no changes in the language was required. As a result, the interim report was adopted as the final report.

Attachment 8

Routers, etc. Evaluation Standard Subcommittee,
Energy Efficiency Standards Subcommittee of the Advisory Committee
on Natural Resources and Energy
List of Members

Chairman:	YUTAKA MATSUSHITA	Chairman, Forum for Agreeable Living with Intelligence, Communication & Electronics
Members:	TADAHITO AOKI	Chief Researcher, Energy and Environment System Laboratories, NTT (Attended from 3rd subcommittee meeting)
	AKIRA ISHIHARA	Standing Director, the Energy Conservation Center, Japan (Attended from 3rd subcommittee meeting)
	KAZUHITO OMAKI	Research Coordinator, National Institute of Advanced Industrial Science and Technology
	TSUYOSHI KINOSHITA	110Senior Director, Cisco Systems, Inc. (Attended from 5th subcommittee meeting)
	YOICHI SHINODA	Professor, Japan Advanced Institute of Science and Technology, Information Science Center
	SEIICHI SHIN	Professor, Electro-Communications Faculty, the University of Electro-Communications
	YUKIO NAKANO	Senior Researcher, Central Research Institute of Electric Power Industry
	TOSHIHISA MASUDA	General Manager, Technology Department, The Energy Conservation Center, Japan (Attended 1st and 2nd subcommittee meetings)
	ITARU MIMURA	Chairman, Communications and Information Network Association of Japan, Router & Switch Technical Committee
	MIKIO YAMASAKI	Chief Researcher, Energy System Project, Energy and Environment System Laboratories, NTT (Attended 1st and 2nd subcommittee meetings)
	TOSHIHIKO YAMATO	Operating Officer on Alliance & Technology, Cisco Systems, Inc. (Attended 1st through 4th subcommittee meetings)
	TAEKO YUINE	Executive Director and Consumer Consulting Office Head, Nippon Association of Consumer Specialists

Reference data 1

Current Status of Routers and Switches

1. Market trend

1.1 History of routers and switches

- The first router in the world (1976)

Router is a device for transmitting packets defined by IP (Internet Protocol) to destination computers according to their addresses. It was produced by BBN Corp., U.S.A. for the first time in 1976 to be used on the "ARPANET" which was the first computer network in the world. Processing of routers was realized by software on general purpose computers, and its performance was approximately 100 packet/s.

- Routers sold for commercial purpose for the first time in the world (1986)

"ProNET p4200", the first commercial router in the world, was launched by Proteon Corp., U.S.A. in January, 1986 as a multi protocol router which was capable of working with protocols other than IP. 2 month later, Cisco Systems, Inc. U.S.A., which is a maker specialized in routers, launched a multi protocol router "AGS", and then routers rapidly spread in the market. It was a dedicated device put in a box type enclosure, but the performance was around 10k packet/s because, likewise in previous routers, it was using a bus neck architecture where a line card for sending and receiving packets and a processor were connected with one bus.

- IP processing by hardware (first half of 1990s)

In 1990s, the internet started to be used actively for commercial purposes. Cisco Systems, Inc. launched "Cisco 7000" in 1993 which achieved 270k packet/s by having the IP processing then dominant done in hardware.

- Rapid spread of internet and advancement of speed of routers (latter half of 1990s up to now)

As the internet spread rapidly, the traffic increased exponentially, and improvement of router speed was always requested. In 1997, Cisco launched "Cisco 12000" using a distributed architecture where a distributed processing of IP was carried out at hardware of each line card. In Cisco 12000, multiple line cards were connected with a cross bar switch to solve the bus neck, and the performance finally achieved 10M packet/s.

Furthermore, Hitachi, Ltd. introduced GR2000 in 1998 which adopted a distributed architecture and CRS-1 in 2004 which combined multiple enclosures and achieved the performance of 100G packet/s.

Currently, new products are being developed to build the NGN (New Generation Network) as well as in response to the advancement of speed and enlargement of capacity of the internet.

1.2 Forms of products

1) Router

Router is a communication device designed to relay data flowing on a network, which is formatted according to an internet communication protocol, to other networks. It has a route selecting function that judges which route should be used to send the data based on the addresses in the network layer (IP layer).

2) Switch

Switch is a network relay device, and it is classified into Layer 2 switch, Layer 3 switch, and so forth according to the layer used to judge the destination of packet form data. The switch which judges the destination of packets using the data (such as MAC address of Ethernet) on the data link layer (second layer) of the OSI reference model is called Layer 2 switch. Meanwhile, Layer 3 switch uses the data on the network layer (third layer) to judge the destination of packets. It utilizes IP and others which exist in the network layer.

(Note) OSI reference model

Figure -1 OSI reference model

Layer	Layer name
7th layer (Layer 7)	Application layer
6th layer (Layer 6)	Presentation layer
5th layer (Layer 5)	Session layer
4th layer (Layer 4)	Transport layer
3rd layer (Layer 3)	Network layer
2nd layer (Layer 2)	Data link layer
1st layer (Layer 1)	Physical layer

1.3 Types of routers and switches

1) Routers

Cluster type	High-end devices which communication carriers use for backbone networks.
High reliability type	Devices where power supply, common control part and fan can be configured redundantly. Based on the redundant parts, there are category I (all common parts are redundant) and category II (only power supply is redundant).
Popular type	Devices which do not belong to any of the cluster type, high reliability type or broadband (mainly for enterprise use) as well as which do not have redundant configuration.
Broadband	Devices with WAN side (less than 1 Gbps) × 1 port and LAN side × 2 ports or more. However, configuration and management function by Telnet is not available. Based on the availability of wireless LAN function, there are category I (with wireless LAN) and category II (without wireless LAN).
With external power supply function	Among the above types of routers, devices with power supply function for equipment connected.

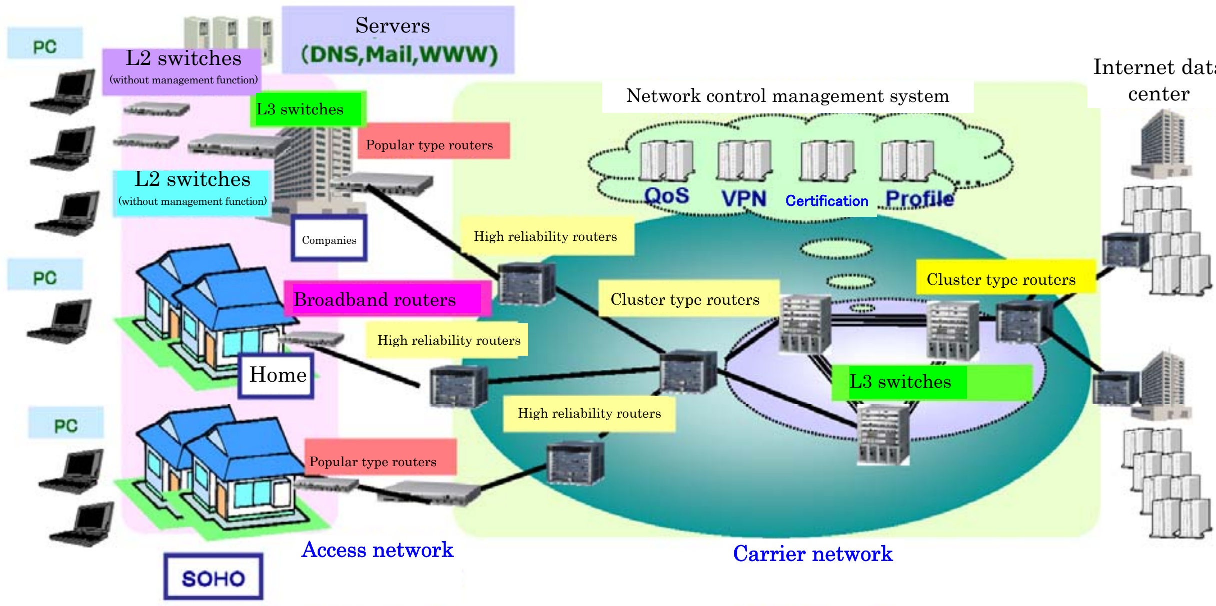


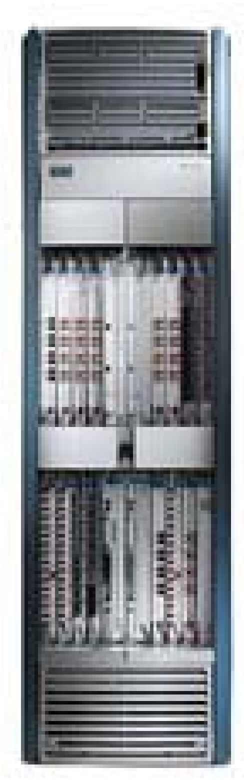
Figure-2 IP network architecture

Figure-2 shows an IP network architecture composed of routers and switches. Current IP network includes carrier IP networks composed of carrier ISPs (Internet Service Providers) and access networks connecting homes or companies with the IP network. The carrier IP network is a network provided by communication carriers. The access network is a network connecting homes or companies with the carrier ISP. Cluster type routers and high reliability type routers are mainly used in the carrier IP networks and the internet data centers. Broadband routers are mainly used at homes, and popular type routers are used in SOHOs and enterprise networks.

2) Switches

- Layer 2 switches: Switches which judge the destination of packets from the data (such as MAC address of Ethernet) on the data link layer (note) (second layer) of the OSI reference model.
- Layer 3 switches: Switches which send packets judging the destination from the data on the network layer (third layer), such as IP etc. present on the network layer.

Figure-3　Typical routers and switches

Routers	Product image (Outer dimensions are those of typical model expressed in W × D × H, mm)
Cluster type router	 (Outer dimensions: 599 × 914 × 2134) (Cisco Systems)
High reliability type router	 (Outer dimensions: 440 × 490 × 441) (ALAXALA Networks)

<table>
<tr><td>High reliability type router</td><td>
(Outer dimensions: 440 × 678 × 101) (ALAXALA Networks)</td></tr>
<tr><td>Popular type router</td><td>

(Outer dimensions: 220 × 141.5 × 42.6) (YAMAHA)</td></tr>
<tr><td>Broadband router (wired)</td><td>
(Outer dimensions: 88 × 26 × 138) (corega)</td></tr>
<tr><td>Broadband router (wireless)</td><td>
(Outer dimensions: 153 × 111 × 28) (I-O Data Device)

(Outer dimensions: 28 × 144 × 130) (BUFFALO)</td></tr>
</table>

Switches	Product image
Layer 2 switch	 (Outer dimensions: 446 × 380 × 43) (ALAXALA Networks)  (Outer dimensions: 436 × 450 × 44) (Hitachi Cable)
Layer 3 switch	 (Outer dimensions: 443 × 544 × 395) (ALAXALA Networks)  (Outer dimensions: 440 × 352 × 44) (Allied Telesis)

1.4 Status of domestic shipment

As the internet rapidly spreads, the domestic market size for routers and switches is drastically growing. This is likely to continue hereafter.

1) Market trend as a whole

Overall shipment size of routers and switches in the domestic market are indicated by the number of units and by the number of ports below. It is estimated that the number of routers shipped in FY2012 will be 1.5 times more than in FY2006; and similarly it is expected to be 1.3 times more for switches.

Figure-4 Changes of domestic shipments of routers and switches

(Unit: 1,000 units for routers, 1,000 ports for switches)

Fiscal year	2004 Actual	2005 Actual	2006 Actual	2007 Estimation	2008 Estimation	2009 Estimation	2010 Estimation	2011 Estimation	2012 Estimation
Routers	3,360	3,980	4,268	4,789	5,123	5,364	5,661	5,992	6,517
Switches	30,690	31,970	31,840	33,510	35,510	37,390	38,990	40,730	42,350

Source: "Mid-term demand estimation of communication equipment, FY2007" CIAJ
The numbers are the total of voluntary statistics by CIAJ based on voluntary responses from the member companies and demand estimations for products not covered in the CIAJ statistics.

2) Trend of routers by product category

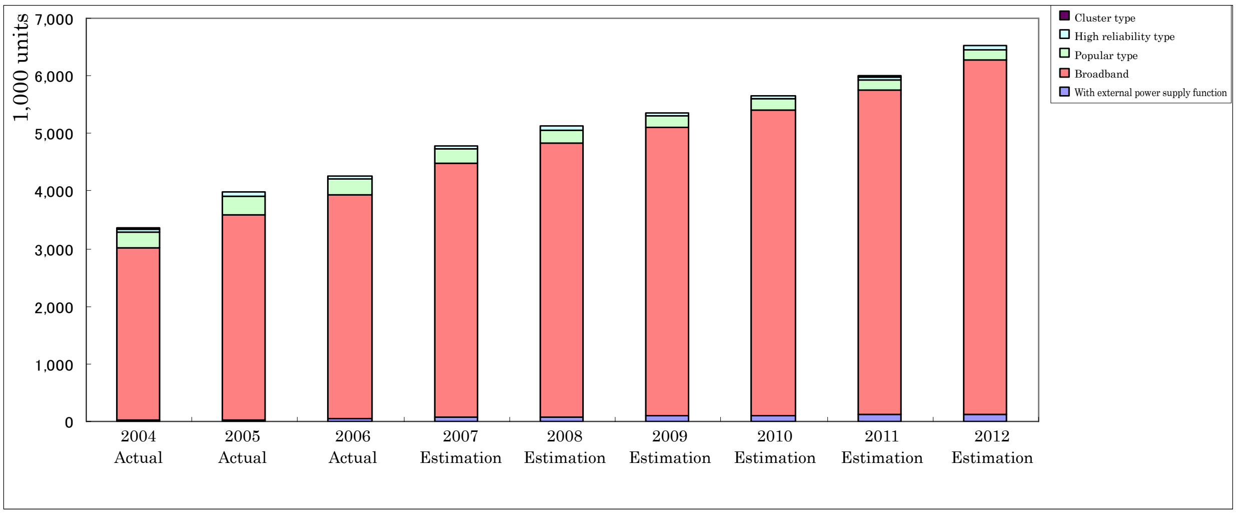
Changes of domestic shipments of routers by product category are shown below. With respect to the actual shipment numbers in FY2006 by product category, broadband routers account for 91% of the total.

Figure-5 Changes of domestic shipments of routers by product category (Unit: 1,000 units)

Fiscal year	2004 Actual	2005 Actual	2006 Actual	2007 Estimation	2008 Estimation	2009 Estimation	20107 Estimation	2011 Estimation	2012 Estimation
Cluster type	10	1	1	1	1	1	1	1	1
High reliability type	60	60	62	62	62	63	65	66	66
Popular type	270	329	259	230	215	200	190	175	160
Broadband	2,990	3,559	3,885	4,419	4,760	5,005	5,295	5,635	6,170
With external power supply function	30	31	61	77	85	95	110	115	120
Total	3,360	3,980	4,268	4,789	5,123	5,364	5,661	5,992	6,517

Source: "Mid-term demand estimation of communication equipment, FY2007" CIAJ
The numbers are the total of voluntary statistics by CIAJ based on voluntary responses from the member companies and demand estimations for products not covered in the CIAJ statistics.

Figure-6 Graph of changes of domestic shipments of routers by product category



3) Trend of switches by product category

Changes of domestic shipments of switches by product category are shown below. In terms of the ratio of actual numbers of ports in FY2006, L2 switches accounts for 86% of the total.

Figure-7 Changes of domestic shipments of switches by product category

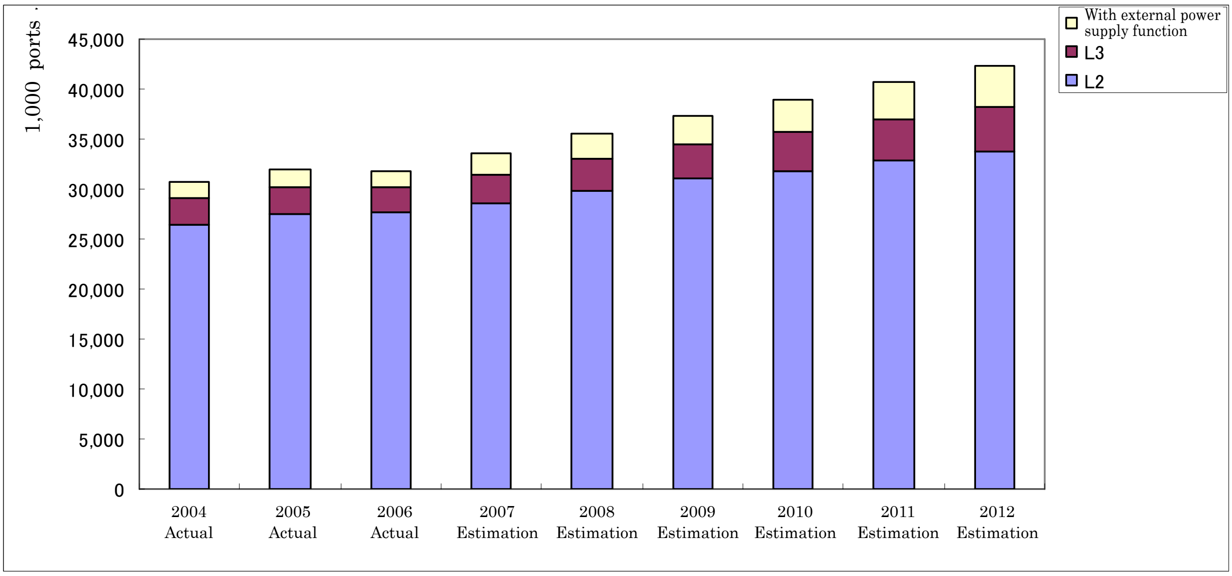
(Unit: 1,000 ports)

Fiscal year	2004 Actual	2005 Actual	2006 Actual	2007 Estimation	2008 Estimation	2009 Estimation	2010 Estimation	2011 Estimation	2012 Estimation
L2	26,470	27,560	27,660	28,630	29,880	31,010	31,730	32,780	33,700
L3	2,550	2,650	2,430	2,760	3,130	3,520	3,910	4,150	4,450
With external power supply function	1,670	1,760	1,750	2,120	2,500	2,860	3,350	3,800	4,200
Total	30,690	31,970	31,840	33,510	35,510	37,390	38,990	40,730	42,350

Source: "Mid-term demand estimation of communication equipment, FY2007" CIAJ

The numbers are the total of voluntary statistics by CIAJ based on voluntary responses from the member companies and demand estimations for products not covered in the CIAJ statistics.

Figure-8 Graph of changes of domestic shipments of switches by product category



1.5 Major domestic and overseas manufacturers shipping products to the domestic market

Table-9 shows major manufacturers of routers and switches.

Figure-9 Major manufacturers shipping products to the domestic market (in the order of the Japanese syllabary)

Routers	I-O Data Device, Allied Telesis, ALAXALA Networks, Corega, Cisco Systems (overseas), Juniper Networks (overseas), NEC, Buffalo, Hitachi, FURUKAWA ELECTRIC, Fujitsu, YAMAHA
Switches	Allied Telesis, ALAXALA Networks, Extreme Networks (overseas), SII Network Systems, Corega, Cisco Systems (overseas), Hewlett-Packard Japan (overseas), NEC, Buffalo, Hitachi Cable, Foundry Networks (overseas), Fujitsu, Matsushita Network Operations

Reference data 2

Glossary

NO	Term	Meaning
1	ACL (Access Control List)	List that describes packet processing methods, resources for the processing, etc. for network equipment such as routers and switches.
2	ADSL (Asymmetric Digital Subscriber Line)	Communication method that enables high-speed data communication of some to some tems of Mbit/s using copper subscriber lines which are laid from telephone stations to each household or company office. It was developed around 1990. While the high-speed data communication is realized using already laid 2-core copper lines, in most cases it can be used only within the area of some km away from the telephone station because, as the distance becomes longer, the maximum transmission rate goes down affected by attenuation or noise. As its name “asymmetric” indicates, it uses asymmetric communication method, with which the data transmission speed is different between the downward direction, i.e. from the telephone station to users, and the upward direction.
3	ASIC (Application Specific Integrated Circuit)	Collective name for ICs designed and manufactured for specific applications. It includes full custom LSI, gate array, standard cells, etc.
4	ATM (Asynchronous Transfer Mode)	Transmission method where different types of information such as data and sound are divided into cells of 53 byte fixed length and sent. The cells are sent only when there are data to be send; therefore, it is called “asynchronous”. The destinations are sorted by an exchanger called ATM switch. This is used to effectively utilize high-speed transmission such as optical fiber.
5	CODEC (Coder Decoder)	Devices and softwares which can code and decode data in a bi-directional way using an encoding method.
6	CPU (Central Processing Unit)	CPU is a key circuit for computers which executes various computing, information processing, product control, etc. according to programs.
7	DC-DC conversion efficiency	Efficiency of voltage conversion from DC to DC.
8	DSLAM (Digital Subscriber Line Access Multiplexer)	Device that aggregate DSL lines and relays to high-speed back-bone lines.
9	DSP (Digital Signal Processor)	Microprocessor dedicated to processing of digital signals and capable of high-speed data processing.

NO	Term	Meaning
10	FTTH (Fiber To The Home)	A plan to build a high-speed communication environment using optical fibers for the access network connecting the subscriber lines from telephone stations to each home. It started when Southern Bell, a local telephone company, tested it in Florida in 1986. In 1994, NTT started to promote the FTTH aiming to change all lines to optical fiber by 2010 in Japan. (It was requested to be completed by 2005 at the government's economic policy ministers' meeting in 1997.)
11	HomePNA (Home Phone Network Alliance)	HomePNA is the standard for connecting to the internet using telephone lines in homes.
12	IEEE802 committee	IEEE is the Institute of Electrical and Electronics Engineers in U.S. 802 committee is its sub-group responsible for the standardization of LAN etc.
13	IEEE802.11n	One of the wireless LAN standards expected to be finalized by IEEE in the latter half of 2008. The effective rate is expected to be 100Mbps or above. It enables high-speed wireless communication based on MIMO (Multiple Input Multiple Output) which executes sending and receiving of data using multiple antennas.
14	IETF (Internet Engineering Task Force)	An international organization developing technical standards (mainly architectures and protocols) to be used on Internet.
15	Interframe GAP Gap between frames (GAP)	Gaps between frames containing information. It is required to be at least 12 bytes for Ethernet. Frame length does not include gaps.
16	IP (Internet Protocol)	Protocol of the network layer (third layer) of the OSI reference model. It executes the best effort type datagram-oriented communication between two nodes based on IP addresses assigned to each node on the network. Since IP is the best effort type datagram-oriented communication, it may happen that packets do not reach the intended destination or multiple packets are delivered there. Resending of undelivered packets, etc. in such cases are all controlled by the higher protocols (TCP: Transmission Control Protocol, etc).

NO	Term	Meaning
17	IP-VPN (Internet Protocol-Virtual Private Network)	VPN (Virtual Private Network) using the private IP network of communication carriers as the communication route. Since the internet which needs to go through multiple providers' networks is not used here, the end-to-end IP connection with high confidentiality and good communication quality can be realized.
18	IP telephone service	Utilizing the VoIP technology, voice communication system is built on IP network. Each service provider provides a telephony service to users, and normal telephones are utilized as terminals.
19	IPSec	Encryption protocol to provide falsificationproof and confidentiality for data in IP packet unit using encrypt technology.
20	L2/L3	L2 is the abbreviation of Layer 2 expressing the data link layer (Layer 2/second layer) of the OSI reference model. L3 is the abbreviation of Layer 3 expressing the network layer (Layer 3/third layer) of the OSI reference model.
21	L2TP (Layer 2 Tunneling Protocol)	One of the tunneling protocols standardized by the IETF (Internet Engineering Task Force). It is mainly used for the VPN (Virtual Private Network).
22	LAN (Local Area Network)	The network which connects computers on the same floor, in the same building or in the neighboring buildings with a relatively high-speed data transfer means such as Ethernet.
23	LLC (Logical Link Control)	Among two sub-layers of the second layer (data link) of the OSI reference model, LLC layer is the higher one with functions such as error control and frame control.
24	MAC (Media Access Control) MAC address	Address for controlling access to media and unique to every NIC (Network Interface Card). It is the sub layer of the second layer (data link layer) in the OSI reference model in terms of computer network technology. In the case of Ethernet, MAC address is 48bits, where the first 24bits is the address unique to each vendor managed by IEEE (Institute of Electrical and Electronics Engineers, U.S.A.) and the last 24bits is the number unique to each NIC. There are no NICs in the world which have the same MAC address. Ethernet sends and receives data based on these MAC addresses. A switch with management function has at least one MAC address. A router has the number of MAC addresses which combines the number of WAN and one of the LAN sides.

NO	Term	Meaning
25	ONU (Optical Network Unit)	Terminator installed at the terminal side (home side) in the optical fiber communication (FTTH). It converts the optical fiber communication to Ethernet, etc.
26	OSI (Open System Interconnection)	A protocol system where computer communication methods are provided for each layer by ISO (International Organization for Standardization) so that communication among computers can be realized between different vendors. There are seven layers, and the TCP/IP (Transmission Control Protocol/Internet Protocol) has become the de facto standard of communication protocol as Internet spreads and expands.
27	PBX (Private Branch eXchange)	Telephone exchange in premises, i.e. relay device connecting multiple telephones in premises (internal phones) to public telephone networks.
28	PLC (Power Line Communication)	Technology using power (electric light) lines in homes as communication lines.
29	PoE (Power over Ethernet)	Technology providing power to terminals, etc. through stranded cables (UTP) which are used for cabling of Ethernet. It has been standardized as IEEE 802.3af. Examples of the powered terminals are IP telephones, network cameras, switching hubs, wireless LAN access points, etc.
30	PPPoE (Point to Point Protocol over Ethernet)	Technology by which frames based on PPP (protocol for realizing TCP/IP connection with telephone lines and modems) which is normally used for dial-up connections are capsulized with Ethernet frames and sent through Ethernet.
31	PPTP (Point to Point Tunneling Protocol)	PPTP is mainly used for remote access. It is a tunneling protocol which Point to Point Protocol (PPP) is extended to become.
32	preamble	Preambles (8 bytes) are attached to the heads of frames flowing on Ethernet but are not included in the frame length. Preambles are used to find a lead of signals at a receiving part and also used as a trigger to regenerate clock.
33	RF (Radio Frequency)	High frequency signals for wireless communications, etc.

NO	Term	Meaning
34	SLIC (Subscriber-Loop-Interface-Circuit)	Interface for telephone line.
35	SNMP (Simple Network Management Protocol)	Protocol providing the communication method for controlling and monitoring communication devices on IP network.
36	SOHO (Small Office / Home Office)	SOHO refers to offices with small number of workers or self-employed individuals working at home. This term is often used in contrast with large companies. Thanks to the improved cost performance of personal computers, increasing numbers of small offices belonging to small-to-medium-sized businesses and personal users can now afford to introduce computers or even utilize LAN. Although the size of a computer system introduced into a SOHO is not large compared with that of a large company, the share by SOHO in the personal computer market is anything but small because the number of small-to-medium-sized businesses and self-employed individuals are quite large.
37	SSL (Secure Sockets Layer): SSL-VPN	Protocol providing safe communications by means of encrypting information on the internet. VPN using SSL is called SSL-VPN.
38	TTL (Time to Live)	TTL is the value described in IP header. Every time a packet passes through a router, 1 is subtracted. Endless looping of packets is avoided by disposing packets when their TTL becomes 0.
39	VoIP (Voice over IP)	Technology realizing voice communication on IP network. It is intended to reduce the communication cost as a result of raising line operation rate by means of integrating the intrastructures of telephone network and data network. It frequently refers to the system for companies designed to enable telephone-to-telephone calls by connecting LAN-to-LAN with data communication networks.
40	VPN (Virtual Private Network)	Technology enabling many subscribers to use a public communication network as if it is for their own use, instead of using dedicated communication lines. Typical usage is for LAN-to-LAN connections.

NO	Term	Meaning
41	WAN (Wide Area Network)	Term normally used in contrast with LAN, meaning networks covering wide areas by connecting computers (LANs) located in remote areas from each other.
42	Web (World Wide Web)	A document system developed by CERN (European Center for Nuclear Research). It allows jump commands to other documents to be embedded in a document. Using URL (Uniform Resource Locator) as this jump command, users can jump to any document in WWW servers in the world which are participating in the internet.
43	xDSL (x Digital Subscriber Line)	Collective name of the technologies that realize high-speed communication using twist pair cables. If only devices supporting these technologies are installed at the telephone station side and the subscriber side, communication lines as high-speed as digital lines can be realized through the existing telephone lines. Typical technology is ADSL that realizes faster downward transmission rate. Other technologies such as RADSL, HDSL, VDSL, etc. are also included under this collective term.
44	Ethernet	A standard of communication method invented by Palo Alto Research Center, U.S. Xerox and stadardized by the IEEE (Institute of Electrical and Electronics Engineers). It stipulates communication speed, cables used for the communication, methods for sending and receiving data. Many of the communication systems currently being used in and out of Japan comply with this standard. 10BASE-T and 100 BASE-T used for company's internal LAN are also complying with this standard. The IEEE is an academic organization working on the development of industrial standards. The 802.3 committee under IEEE continues to study Ethernet.
45	Internet VPN (Internet Virtual Private Network)	Among VPNs (Virtual Private Network), this term refers to the one executed through Internet. IP packets for LAN are capsuled with IP headers for Internet in order to be sent/received, because the IP address information used for LAN are usually different from the one used for Internet.
46	Throughput	Data transmission rate among network systems. Specifically, it refers to the system's effective transmission rate such as file transmission rate between terminals. Mainly bit/s is used as the unit. Throughput varies according to various factors such as CPU capacity, memory capacity, speed of relays, traffic; therefore, caution should be exercised when measuring the throughput.

NO	Term	Meaning
47	Dial up	The method with which users log in remote computers or utilize resources of those computers through public lines, modems and the like. This is also called remote access.
48	Dial up Router	Routers equipped with dial up connection function. The communication cost due to connecting to public lines can be saved by connecting to external networks only when necessary. The operation is easy for users, because the connection and disconnection are done automatically. Since dial up routers are usually equipped with receiving function also, they can be used as connection servers for dial up connection requests from outside.
49	Traffic	It originally means “transit, going and coming back”, but, in the field of telecommunication, it means going and coming of packets flowing on networks. The condition where a great deal of data is flowing on networks and congested is described “the traffic is big”. To the contrary, the condition where there is few data flowing on networks is described as “the traffic is small”.
50	Network Processor	Dedicated processors designed to execute high-speed processing for highend communication service such as security, encrypting, traffic control and to be appropriate for network equipment such as broadband routers and wireless LAN access points.
51	Hub	Also called the concentrator. In the case of cabling based on 10BASE-T, the network is constructed by connecting nodes around a hub in the shape of star. The parts to which modular jacks of 10BASE-T cables are connected are called ports, and there are variations, such as 4, 8, 12, 16, 24 ports, based on the size of the hub. The advanced hub which has overcome weakness of conventional hubs and is equipped with a function to learn MAC addresses and a transfer function is called switching hub. They have developed into current L2/L3 switches as the speed becomes faster.
52	Fast Ethernet	Collective name of standards of Ethernet, such as 100BASE-T and 100VG-AnyLAN, with the transmission rate (100Mbit/s) which is 10 times faster than that of ordinary Ethernet.

NO	Term	Meaning
53	Frame	The unit of signals sent through the data link layer (second layer) of the OSI reference model. Although this term is used synonymously with packets, in fact IP packets are capsulized with Ethernet frames.
54	Protocol	Rules or agreements for data communication among computers. Internet is based on the protocol called TCP/IP (Transmission Control Protocol/Internet Protocol).
55	Header	Character string placed at the head of packets, managing various information such as sender's address and receiver's address. Routers and switches send packets to proper receivers based on this header information.
56	Modem	Device enabling computers to communicate with each other through telephone lines by means of converting digital signals to analog signals (vice versa).
57	Routing	Route control, by which, looking into the destination information of the packets sent out on the network, routes are controlled so that the packets will arrive at destination devices properly.
58	Redundancy	To construct a system with equipment of slightly more than necessary so that the system can continue to provide service even if a part of the equipment goes down. For example, a network redundancy is realized by prepareing multiple access lines to Internet so that troubles can be avoided even if one of the lines is disconnected; and another type of redundancy is similarly realized by preparing multiple devices in a system to avoid any troubles.
59	Wireless LAN	LAN in which communications are performed using wireless meas such as radio waves or light instead of wired cables. When supporting products were launched by each company in 2000, it started to spread rapidly. Since wired cable laying is not required, it can save the effort to lay the cables anew when desks are moved in an office for repositioning for example. There is also a growing need for wireless LAN in homes where it is difficult to lay cables.