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AX Series
Network Partition Solution Guide
[QoS-Based Bandwidth Control]

Edition 1

ALAXALA Networks Corporation

Preface

This manual (*AX Series Network Partition Solution Guide [QoS-Based Bandwidth Control]*) provides specific examples of network systems that utilize network partitions to support bandwidth control for each virtual network taking advantage of QoS control functionality. This manual also provides information on how to build and configure such systems. The guide is designed to help users to propose, construct, and configure systems for customers.

Related documents

- *AX Series Network Partition: Solution Guide [Basic]* and *[Advanced]*
- AX series product manuals (http://www.alaxala.com/en/techinfo/manual/index.html)

Instructions for using this document

The information in this document is based on basic operations verified under the environment specified by ALAXALA and does not guarantee functionality, performance, and reliability under all environmental conditions. Please understand that this document is intended to help with system configuration for our products. Unless otherwise indicated, this document refers to the following OS versions, as of this writing:

AX Series

AX6700S/AX6600S/AX6300S	Ver. 11.5
AX2500S	Ver. 3.2.A
AX1200S	Ver. 2.3.A

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Conventions: The terms "Switch" and "switch"

The term Switch (upper-case "S") is an abbreviation for any or all of the following models:

- AX6700S/AX6600S/AX6300S series switch
- AX3600S, AX2400S series switch
- AX2500S series switch
- AX1200SA series switch

The term switch (lower-case "s") might refer to a Switch, another type of switch from the current vendor, or a switch from another vendor. The context decides the meaning.

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1. Integrating Different Types of Networks

1.1 Advantages and challenges of integrating networks for different uses

The development of digital technology in recent years has accelerated the digitization of various types of information and control functionalities, such as voice and video, the collection of status information using sensors, or the remote and/or automatic control of devices. This trend has intensified to such an extent that a separate network is built for each unit that handles specific information or control functionalities.

Such a trend also applies within organizations such as office buildings, factories, and schools, and it is no longer unusual to build separate networks for different purposes within a single organization. This means, for those who operate and manage the networks, that multiple networks are operated simultaneously. This results in increased cost and labor, for procuring the devices used in the system, for operation management, and for maintenance.

A solution for optimizing labor and cost for devices, operation management, and maintenance would be to integrate the networks of these different systems. However, to attain this goal, certain challenges must be addressed, such as ensuring security between networks and the reliability of the entire system, as well as optimal allocation of resources to each network.

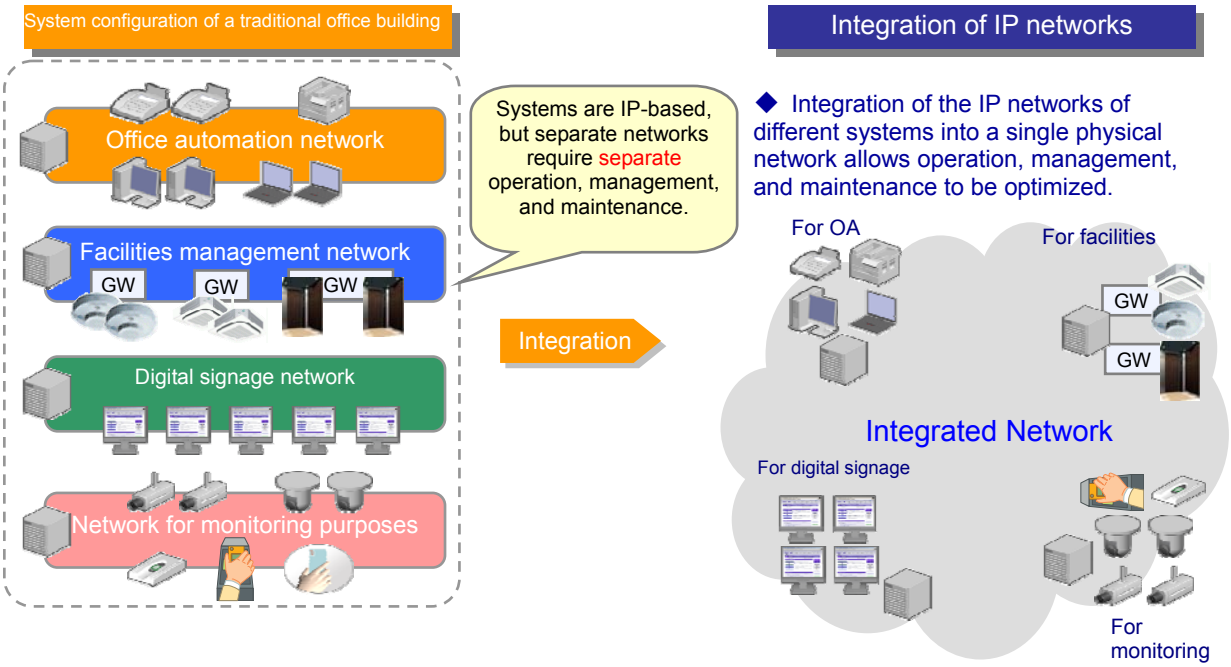

Figure 1.1-1 Network integration in an office building

The ideal solution for such network integration is a network partition—a virtual network technology proposed by ALAXALA. Because a network partition allows multiple independent networks to be merged into a single physical system, it enables network integration while ensuring security between the systems. By using ALAXALA FT switches to configure the physical system as an FT network, the entire system can be also be made highly reliable.

Although multiple virtual networks share the same physical resources in a network partition, specifying for each virtual network upper limits to the number of Layer 3 routes and tables for ARP and MAC addresses, prevents resources from being occupied by particular virtual networks.

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1.2 Virtual networks with bandwidth guarantees

When integrating multiple network systems using virtual networks, you must also consider the bandwidth used by each system as well as the total bandwidth. If the total traffic of the system exceeds the maximum switching capacity of the switch, or if the traffic of a particular network is extremely high, communication in other virtual networks might be affected.

In particular, if different networks handle different types of data, the characteristics of traffic in each network will be completely different. For example, in a network that handles video or audio signals, the available communication bandwidth directly impacts the quality of the video or audio. The higher the quality of the video or audio handled by the network, the higher the bandwidth tends to become than the common data communication carried out using a PC. On the other hand, a network for the remote control of facilities collects data at regular intervals and communicates control commands to the devices. Here, the amount of data is not as great, but it must stay available for communication to keep constant control of the facilities.

Thus, when integrating networks that handle different types of communication data using virtual networks, it is crucial to guarantee the required bandwidth for each network.

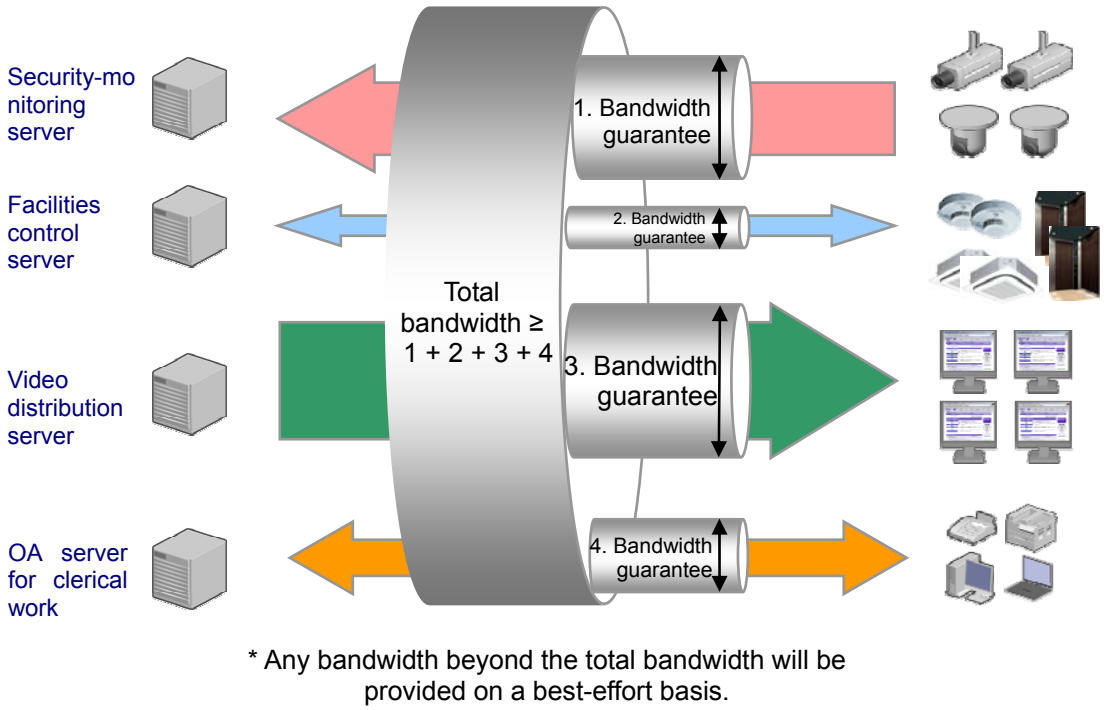

Figure 1.2-1 Bandwidth used by each communication and bandwidth guarantees

The AX series has advanced QoS control functions that provide bandwidth control and priority control for each traffic flow. By combining these functions to guarantee the bandwidth required by each virtual network in the network partition, you can consider the optimal allocation of system resources such as bandwidth to each network. Even if the whole system is congested, each virtual network can maintain minimum communication.

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2. Bandwidth Control for Each Network Based on QoS Control

This chapter provides the framework of the QoS functions of the AX series and explains the principles and configuration of bandwidth guarantees.

2.1 Overview of QoS-based bandwidth control

QoS control combines flow control on the receiving side and send control on the sending side to control the amount of communication (traffic) that goes through the switch, or to prioritize the communication data. The QoS control of the AX series has the following framework for each switch model.

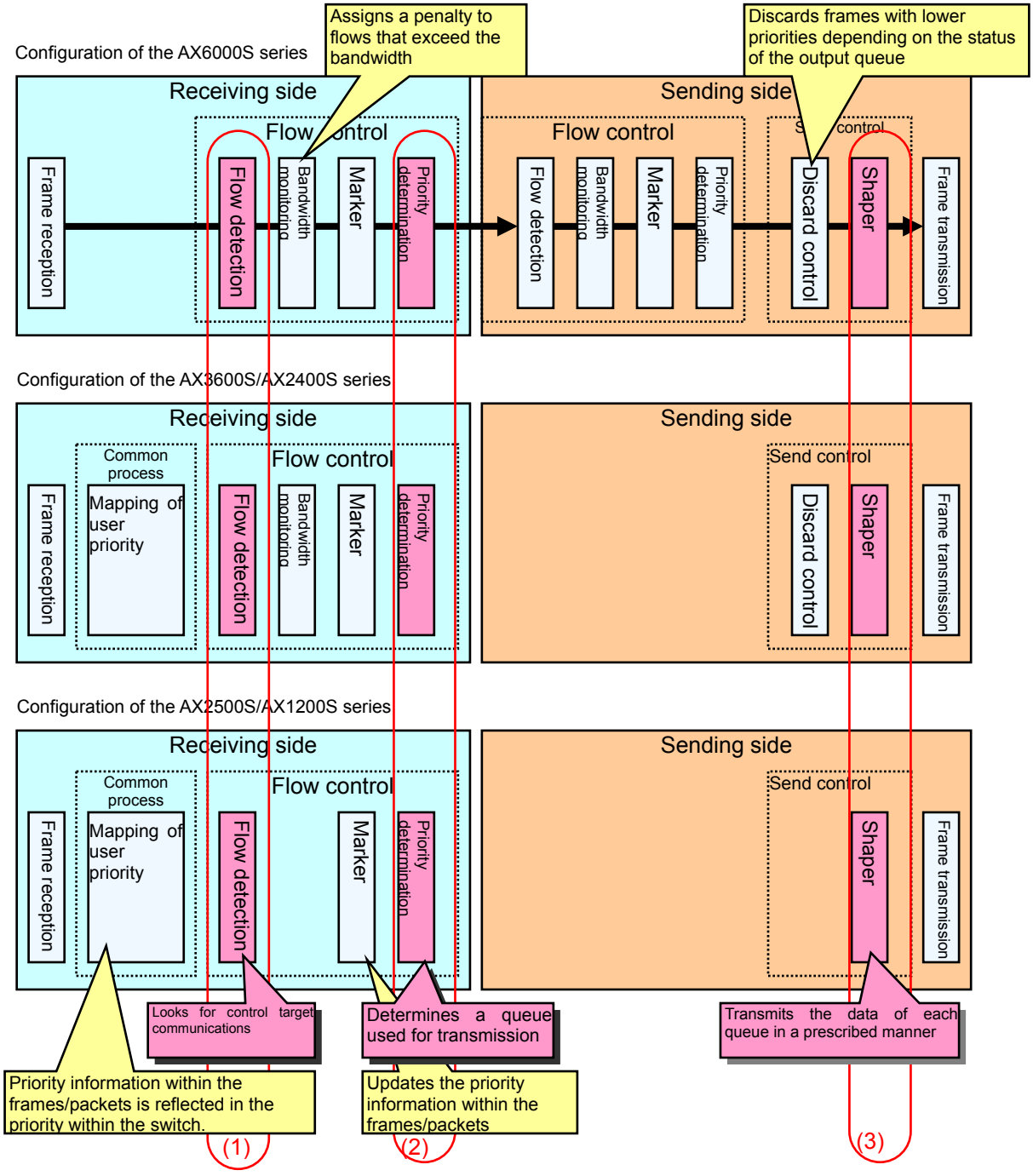

Figure 2.1-1 Diagram of QoS control in the AX series

As shown in Figure 2.1-1 Diagram of QoS control in the AX series, QoS control in the AX series combines

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different blocks within the configuration to perform various types of traffic control, such as priority control and discard control, inside and outside the switch for each traffic flow.

Bandwidth guarantees for virtual networks are provided by configuring each of the following blocks in Figure 2.1-1 Diagram of QoS control in the AX series:

(1) Flow detection on the receiving side
(2) Priority determination on the receiving side
(3) Shaper on the sending side

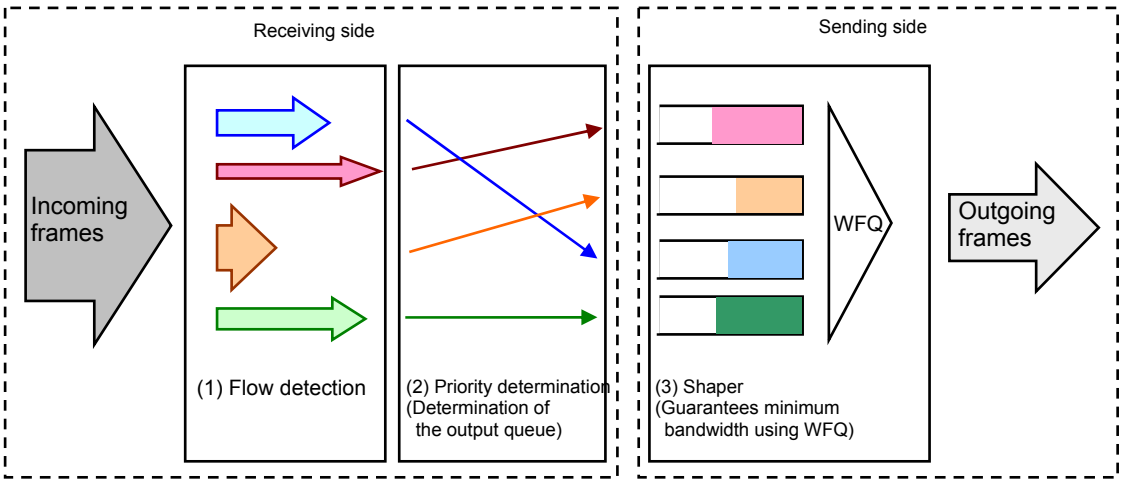

Figure 2.1-2 QoS-based bandwidth guarantee control

(1) Flow detection

This detects target communication flow for QoS control. Just like the flow detection and configuration for an access list, the flow detection for QoS control also identifies communication flow based on the combination of the source IP address and destination IP address, along with the port numbers.
To guarantee bandwidth for each virtual network in a network partition, you must configure flows for each network here.

(2) Priority determination

This determines the priority of the target communication flows detected in (1) flow detection.
The priority in the bandwidth control means the number of the queue to be used for transmission.

(1) and (2) are configured together for each flow using a configuration command (`qos` command).

(3) Setting the shaper

The shaper is the block that controls sequential transmission of data in the output queues based on pre-determined control methods (scheduling). Though the configuration of the shaper differs between switch models, if you want to guarantee minimum bandwidth, you must use a configuration that supports WFQ (Weighted Fair Queue).

For details about the framework of the shaper, see the chapter *Transmission Control* in the *Software Manual Configuration Guide Vol. 2* for the corresponding AX series.

As explained above, the control target communication flows are detected and given priorities in (1) and (2), and are stored in their priorities' respective output queues. They are then transmitted according to their prescribed schedules (in order of priority or evenly, or with minimum bandwidth guaranteed) by the scheduling functionality of the shaper in (3).
Therefore, by configuring the flow detection described in (1) to be performed for each network and by specifying a schedule for the shaper described in (3) that guarantees minimum bandwidth, you can guarantee bandwidth for a specific network.

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2.2 Diagram of network integration using bandwidth-guaranteed virtual networks

As explained thus far, by combining network partition and QoS control functions, you can set up bandwidth-guaranteed virtual networks to integrate networks for different uses. Below we provide some specific examples.

Figure 2.2-1 provides an example of networks for commercial facilities.

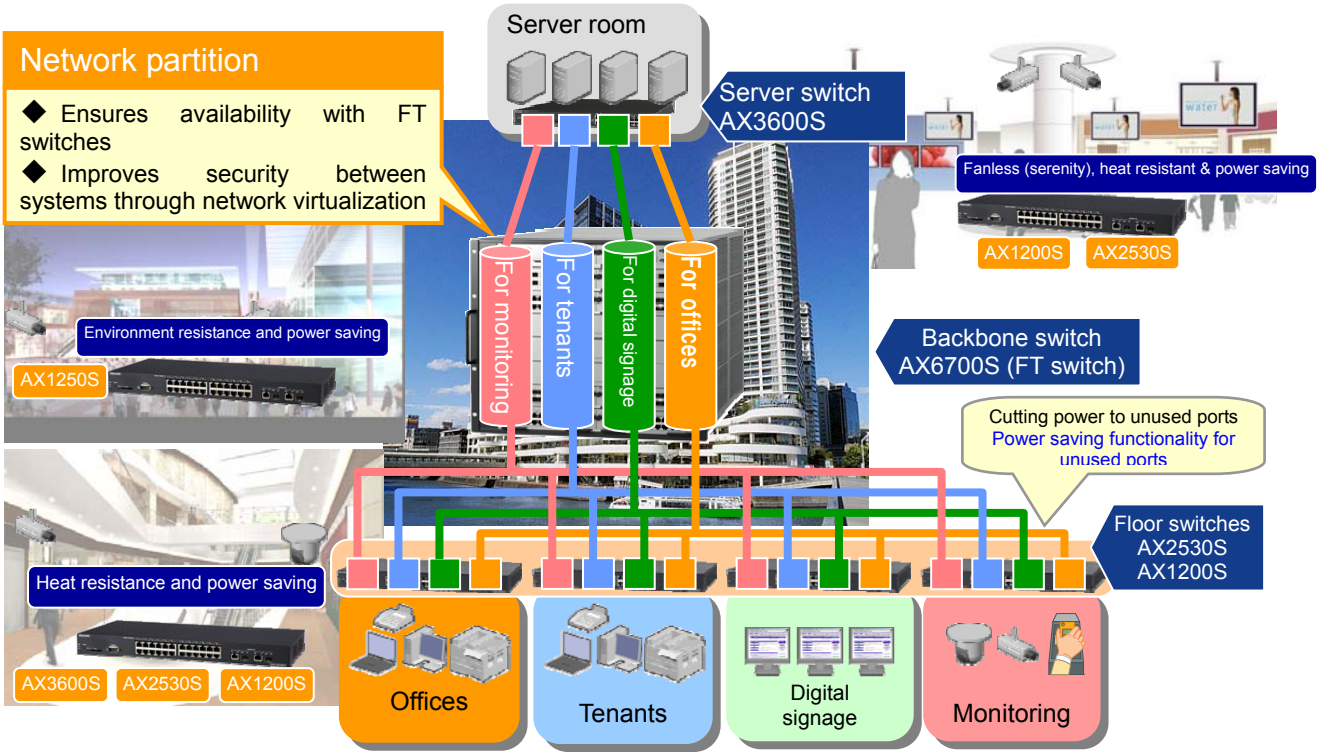

Figure 2.2-1 An example of commercial facilities

The major networks used in this example might include the following types of networks:

- Security monitoring and facilities equipment control within the building
- Digital signage at the store front and in event spaces
- Networks of POS, etc., that are used at the store front or in the tenants
- Networks for clerical work in office spaces

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Another example, as in Figure 2.2-2 An example hospital, showing the major networks in an average general hospital.

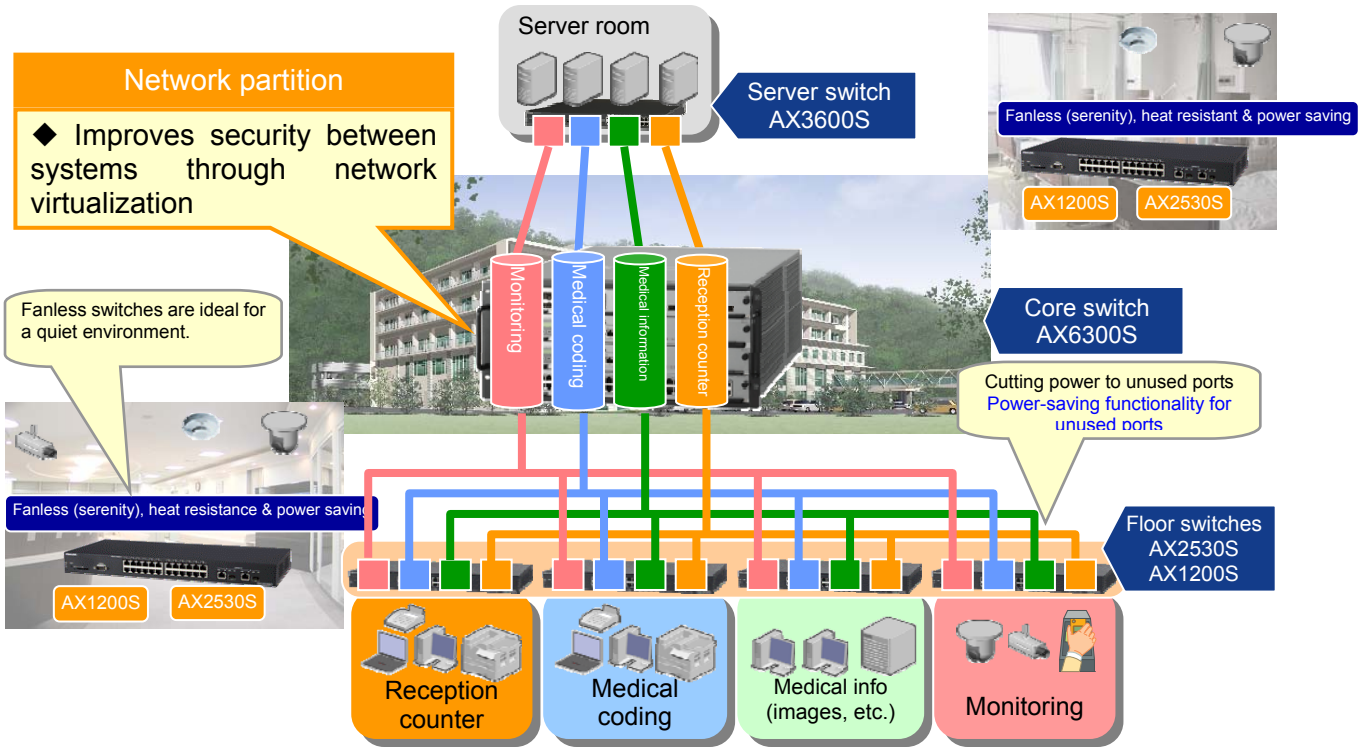

Figure 2.2-2 An example hospital

For a general hospital, the possibilities include networks for the following different uses:

- General monitoring of hospital buildings and patient rooms, along with control of facilities equipment
- Medical information including clinical records and X-ray photograms
- Office work related to medical care, such as the reception of out-patients and the management of in-patients
- Common hospital clerical tasks, such as payment settlements and accounting

Even in such an environment or system that comprises networks for different purposes, network partition combined with QoS control is a powerful solution for integrating systems.

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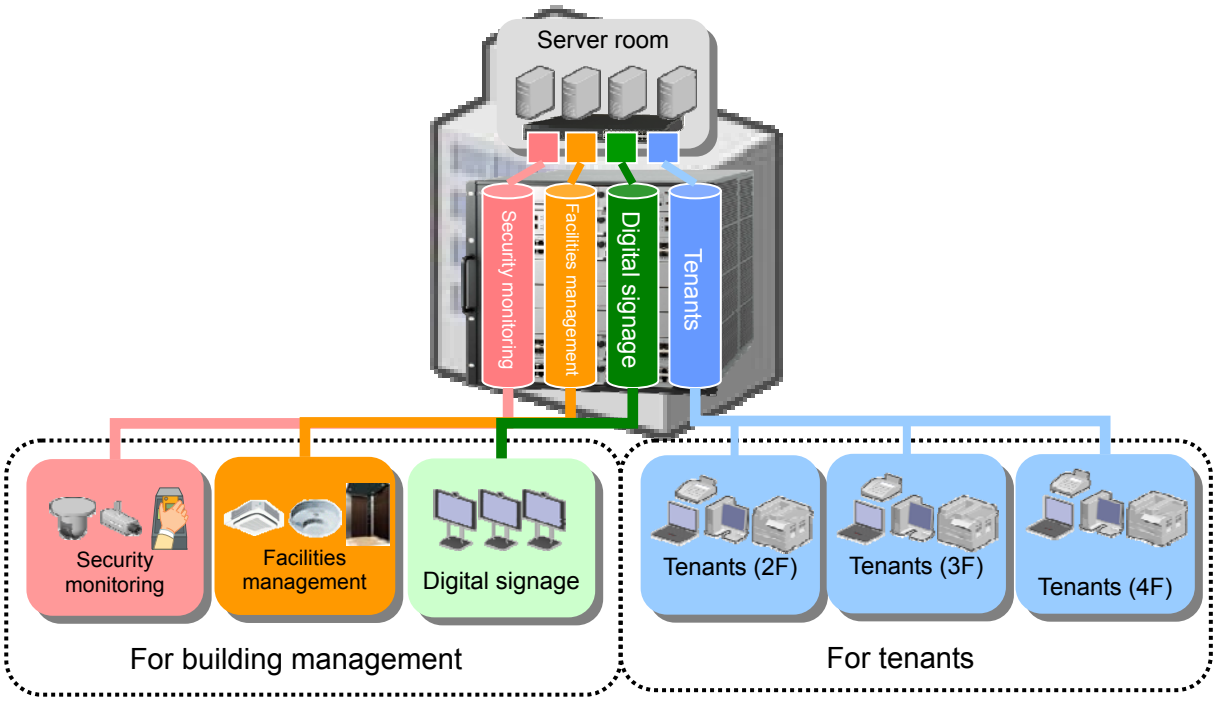
3. Examples of System Integration

As explained thus far, combining ALAXALA's network partition and QoS control functions to configure bandwidth-guaranteed virtual networks will provide a perfect solution for network integration.
To demonstrate this methodology, this chapter provides actual configuration examples of systems that have bandwidth-guaranteed virtual networks.

3.1 An example application on networks within an office building

To showcase the integration of multiple networks for different purposes using a network partition, here is an example of such an application within a common office building.



Usage		Required bandwidth	
For building management	Security monitoring	100 Mbps	
	Facilities management	10 Mbps	
	Digital signage	200 Mbps	
For tenants	For general office automation for the tenants on 2F	50 Mbps	Total 400 Mbps
	For general office automation for the tenants on 3F	50 Mbps	
	For general office automation for the tenants on 4F	50 Mbps	

Figure 3.1-1 Examples of networks in an office building

Figure 3.1-1 *Examples of networks in an office building* shows separate networks for building management and for the tenants of the building.
Various systems operate on the networks for building management, including security systems with surveillance cameras, a control system for the facilities within the building, and digital signage systems that provide notifications, notices of events, and advertisements within the building. The tenant space on each floor of the building houses an independent corporate office where a separate network is operated for office automation and general clerical work for the company.

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Figure 3.1-2 *Physical configurations of the office building networks* shows the actual switch configurations of the networks.

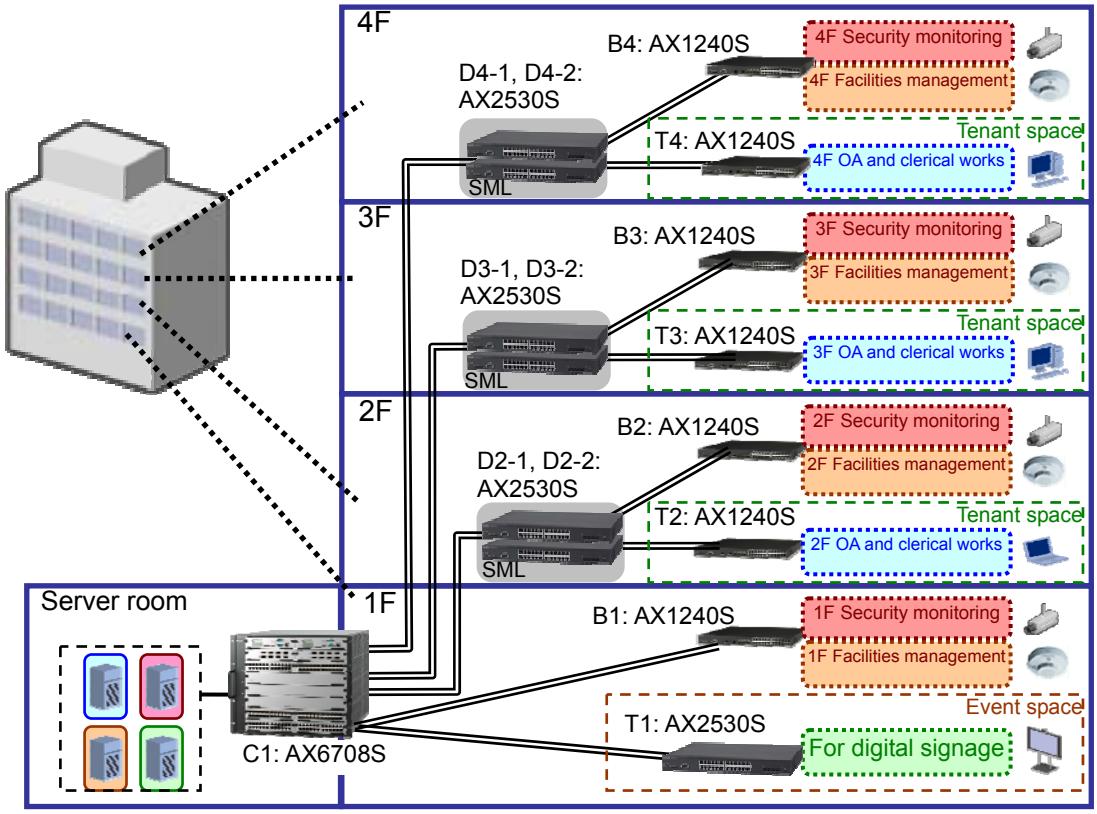

Figure 3.1-2 Physical configurations of the office building networks

This is a four-story building. The first floor is the event space where the digital signage system announces the content and schedule of events and displays advertisements. The second floor and beyond are tenant spaces that house offices of different companies.

The network of this building is built on systems using an AX-series network partition.
Each switch is basically configured as an FT switch. An AX6700S FT switch is placed as the core switch in the server room on the first floor. All the other floors house AX2530S distribution switches with SML configurations that are connected to the core switch and the access switches using link aggregation.
On the first floor, an AX1240S access switch for the building systems and another AX2530S access switch for digital signage are deployed, and they are connected directly to the core switch.
On the second to fourth floors, two AX1240S access switches are placed separately for the building systems (for security monitoring and facilities management) and for the tenants (corporate offices), respectively. These access switches are connected to their respective distribution switches.

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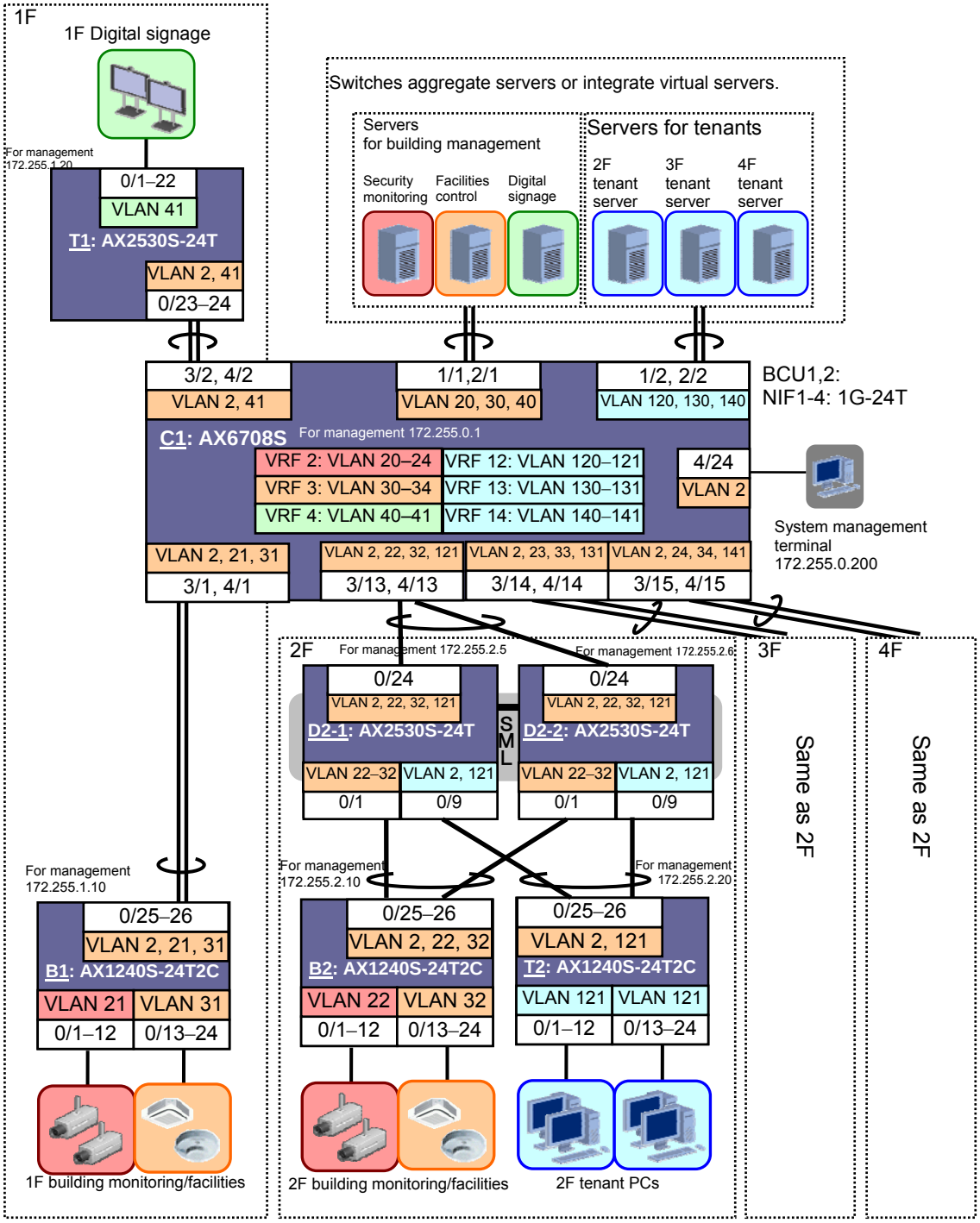
Figure 3.1-3 Detailed logical configuration of the building system shows the logical configuration of the building network.



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Purpose	VRF ID	VLAN ID	IP address	Total used bandwidth
Security monitoring server	2	20	172.20.0.0/16	100 Mbps
1F security monitoring		21	172.21.0.0/16	
2F security monitoring		22	172.22.0.0/16	
3F security monitoring		23	172.23.0.0/16	
4F security monitoring		24	172.24.0.0/16	
The facilities & equipment management server	3	30	172.30.0.0/16	10 Mbps
The 1F facilities & equipment management		31	172.31.0.0/16	
The 2F facilities & equipment management		32	172.32.0.0/16	
The 3F facilities & equipment management		33	172.33.0.0/16	
The 4F facilities & equipment management		34	172.34.0.0/16	
The digital signage & advertising server	4	40	172.40.0.0/16	200 Mbps
The 1F digital signage & advertising		41	172.41.0.0/16	
The 2F tenant's server	12	120	172.120.0.0/16	50 Mbps per tenant Total 400 Mbps for all tenants
The 2F tenant		121	192.168.0.0/24	
The 3F tenant's server	13	130	172.130.0.0/16	
The 3F tenant		131	192.168.0.0/24	
The 4F tenant's server	14	140	172.140.0.0/16	
The 4F tenant		141	192.168.0.0/24	
Network management	global	2	172.255.0.0/16	--

Figure 3.1-3 Detailed logical configuration of the building system

The logical configuration corresponds directly to the configuration in which the networks for security monitoring, facilities management, digital signage, and tenants are integrated into the virtual network of a network partition.

Below, we explain the principle of how to set bandwidth control for each network.
You need to make configurations on the switches, including the core switch and the access switches, in order to guarantee the necessary communication bandwidth that suits the data featuress and the system configuration of each network.

(1) Network for security monitoring

Traffic handled by the security monitoring network is mainly the communication of image data that is sent from surveillance cameras and other devices within the building and stored in the data recording server. As upstream traffic to the server is much heavier than downstream traffic, bandwidth control must be configured to the path leading to the server.

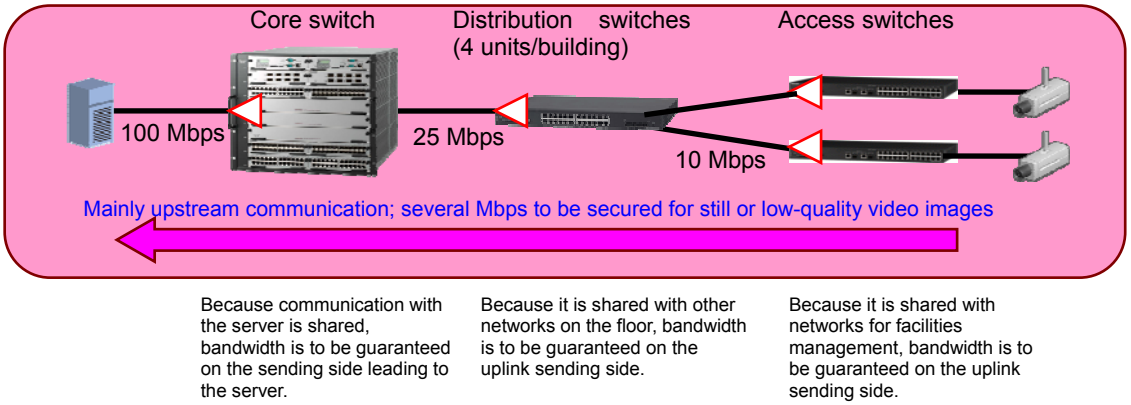

Figure 3.1-4 How to set QoS control on the network for security monitoring

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(2) Network for facilities management

Traffic in a network for facilities management is a bidirectional communication, consisting of data from fire alarms and room temperature sensors, along with remote control information to air conditioning facilities. The total amount of traffic is not particularly high, but communication must never be impaired by increased bandwidth consumption by other networks. Therefore, you must guarantee a minimum bandwidth as shown in the following figure.

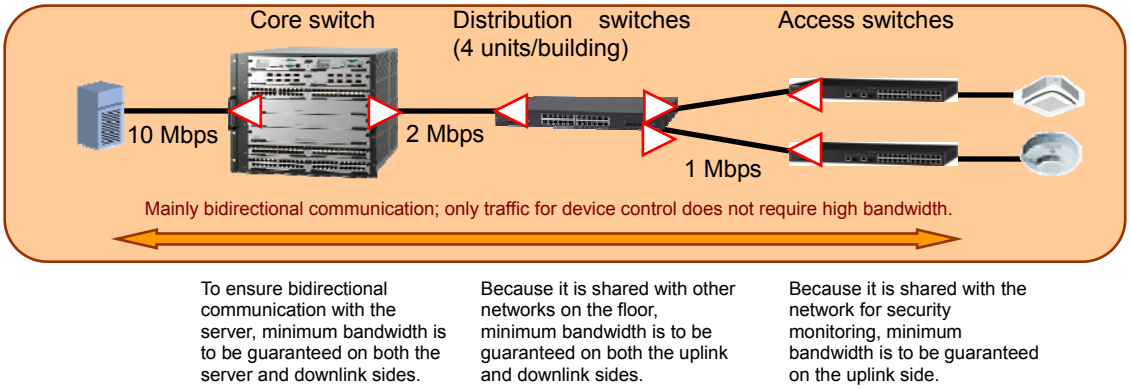

Figure 3.1-5 How to set QoS control on a network for facilities management

(3) Network for digital signage

A network for digital signage mainly handles video data that is sent from a video distribution server to large projectors and advertising displays. Because the traffic is mainly downlink video data, configurations must allow greater bandwidth for the downlink path. Note that because the network is deployed only on the first floor, the access switch is directly connected to the core switch.

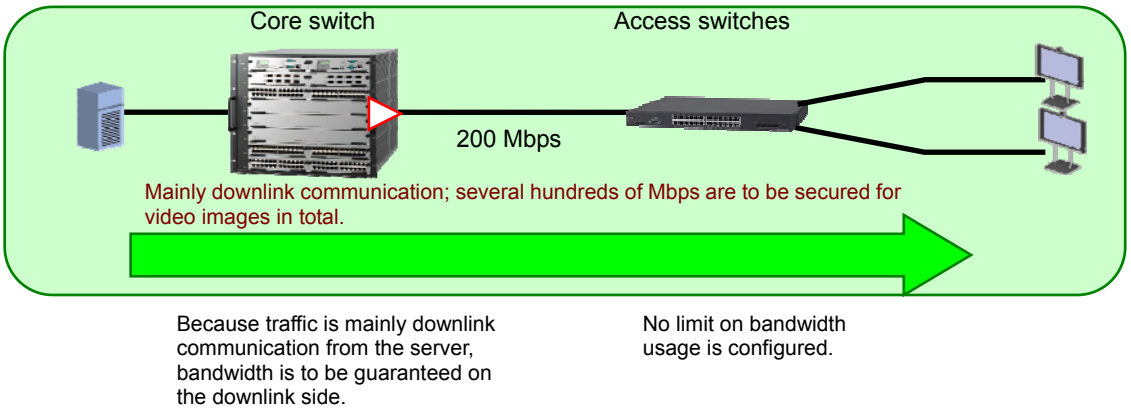

Figure 3.1-6 How to set QoS control on a network for digital signage

(4) Bandwidth control on networks for tenants

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The networks for tenants are none other than corporate office networks where traffic is bidirectional between general business servers and client PCs within the office. The minimum guaranteed bandwidth summed for all tenants is to be configured on the core switch, and the guaranteed bandwidth for each tenant is to be ensured on the distribution switch and access switches on each floor.

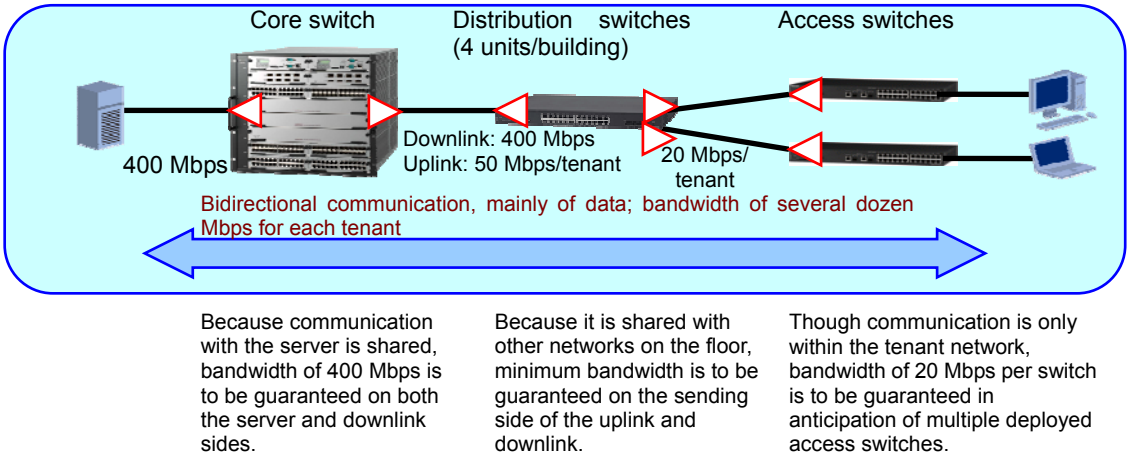

Figure 3.1-7 How to set QoS control on networks for tenants

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3.2 Key points of system integration

Below are some important points for planning the configuration of the application example in this chapter.

(1) Consider the features (bandwidth, responsiveness, and direction) of the communication to be integrated.

To configure bandwidth control efficiently, we recommend that you decide as early as possible at the system planning stage, where bandwidth is to be controlled on the network.
To this end, you need to understand the communication flow on each separate network before configuring the integration process.

(2) A switch configuration that supports a wire rate is recommended.

To guarantee bandwidth is to minimize the chance of communicated frames or packets being discarded.
Possible situations include the following, which take how discards occur in the system into consideration:

(a) If the received communication amount exceeds the bandwidth of the line (the bandwidth of the reception line is already larger than that of the sending line, or the traffic of multiple reception sources is concentrated on a single sending line)
(b) If the received communication amount exceeds the switching capacity of the network switches

Bandwidth control is meant to prioritize data to be sent from the switch or to discard some of the data so that necessary communications will not be discarded whenever possible if a situation such as (a) occurs.
However, in a situation such as (b), the bandwidth on the switch alone cannot guarantee necessary communications.

Therefore, in order to prevent situations like (b) from occurring, we recommend that the configuration of the switch itself support the wire rate. If a situation like (b) never occurs, that is, no data is discarded within the network switches, the locations where discards occur are confined to the lines. Thus, if the bandwidth of the lines can be guaranteed, that translates into the bandwidth being guaranteed for the entire system, and, as a result, system design can be substantially simplified.

(3) In principle, bandwidth control must be configured on the sending side of the switch.

Bandwidth control such as the minimum bandwidth guarantee is to be configured on the sending ports of each switch.
When integrating a system, configure bandwidth control on the sending-side ports of the switches to suit the features of the communication handled by each network.
For example, the design must be made to control the bandwidth on the downlink ports for a network that mainly handles communication from the server to terminals, and on the uplink ports for a network where the traffic from terminals to the server is higher.

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3.3 Key points of configuration

Below we explain some key points for configuring switches, including the specification of settings.

(1) Establish a different flow detection condition for each partition.

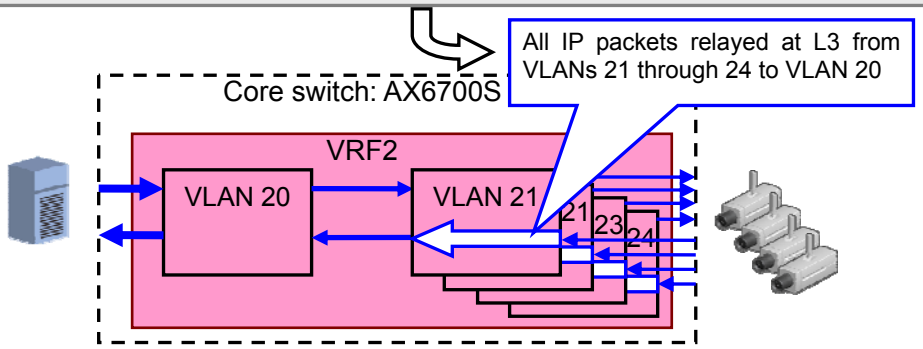
QoS control is to be performed on each flow. To perform bandwidth control for each network, configure the conditions of flow detection for each virtual network as a communication unit.

An actual example below shows how to configure flow detection settings on the core switch of the configuration example explained in previous sections.

For example, we provide the flow detection conditions for a security monitoring network.
The core switch performs bandwidth control on upstream communication to the server for the security monitoring network. Specifically, the communication that flows from VLANs 21 through 24 to VLAN 20 within the core switch is the traffic leading to the server.
Because flow detection is to be performed on the receiving side, configure flow detection for L3 relay on VLANs 21 through 24. The flow detection conditions are compiled into `QOS-KANSHI-UP`, which targets all IP packets that pass through VLANs 21 through 24.

```
(config)# ip qos-flow-list QOS-KANSHI-UP
(config-ip-qos)# qos ip any any action priority-class 3

(config)# interface range vlan 21-24
(config-range-if)# ip qos-flow-group QOS-KANSHI-UP in layer3-forwarding
```



(2) Note that CoS values in the AX3600S, AX2400S, AX2500S, and AX1200S series do not match the output queue numbers.

In determining priority for the AX3600S, AX2500S, AX2400S, and AX1200S series, a parameter CoS that ranges from `0` to `7` is used as the index designating the frame's priority within the switch. However, the queue number on the sending side ranges from `1` to `8`. When mapping CoS values to the output queues, be careful of the discrepancies between the values.
(See *(1) in Chapter 4 Considerations*.)

Setting the output queue length also alters the mapping relationship between the CoS values and the output queue numbers. (The length of the output queue is set to the shortest by default on all the switches: 64B on AX3600S & AX2500S and 32B on AX2400S & AX1200S.)

(3) Also set a lower priority on flows that are not subject to bandwidth control in the AX6700S/AX6600S/AX6300 series.

By default, AX6700S/AX6600S/AX6300S series assign an output priority of `4` on relay flows that are not subject to flow detection or not given an explicit priority. (See *(2) in Chapter 4 Considerations*.)

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When using WFQ on the shaper on the sending side, if the output priority of communication that is not subject to bandwidth control remains a value of 4, you might experience difficulties in planning the entire system. This is because the default setting can make it difficult to assign necessary bandwidth to communications that originally required bandwidth control. Therefore, we recommend that you define a lower priority for the communication (flow) on which no bandwidth control is to be applied.

(4) For guaranteeing bandwidth, we recommend using WFQ on the transmission shaper.

Bandwidth control is performed on the shaper on the sending side. If you want to configure bandwidth guarantees of different required bandwidths for different flows (networks), use WFQ (Weighted Fair Queue).

Though WRR (Weighted Round Robin) and RR (Round Robin) do allow a certain level of bandwidth control, they do not support different bandwidth guarantee settings for different flows (networks) (RR evenly divides the bandwidth to be used), or they might complicate the planning process (WRR performs RR scheduling based on the weighted ratio).

(5) Define send control on each physical interface if the interfaces are subject to link aggregation.

Send control (shaper) must be configured on the physical interfaces. If interfaces are subject to link aggregation, configure each physical interface.

To guarantee minimum bandwidth for send control, we recommend that you configure send control on each port included in the link aggregation. This can maintain minimum bandwidth if link aggregation begins degraded operation due to a problem such as line failure.

(6) The method to set WFQ differs between AX6700S/AX6600S/AX6300 series and other AX series.

The procedure of setting bandwidth for using WFQ on the shaper differs between AX6700S/AX6600S/AX6300S series and other AX series (AX3600S, AX2500S, AX2400S, and AX1200S). (See *(4)* in *Chapter 4 Considerations*.)

The configuration of WFQ on the AX6700S/AX6600S/AX6300S series is especially complex, and must meet the following three conditions:

Condition (1): All four queues that can be used for WFQ must be configured.
Condition (2): Bandwidth must be set based on the weighted ratio, and the total value must be exactly 100.
Condition (3): First, set the largest weight value for the largest queue number, and then set the next largest weight value to the next largest queue number, and so on.

In an actual example, we show how to configure the server (uplink) side from the configuration example explained in previous sections.

The respective bandwidth values are to be guaranteed for the following three types of traffic that flow from the core switch to the server:

- 400 Mbps for the tenants in total
- 200 Mbps for the security monitoring network
- 10 Mbps for the facilities management network

Because send control is to be performed on the three types of traffic, three output queues is sufficient, but condition (1) above dictates that all four queues must be configured. Therefore, a provisional configuration of 10 Mbps is to be set for the dummy queue.
Condition (2) requires that weight values be set so that the total becomes 100. Therefore, make the following calculation:

10 : 10 : 200 : 400 = 10 / (10 + 10 + 200 + 400) : 10 / (10 + 10 + 200 + 400) : 200 / (10 + 10 + 200 + 400) : 400 / (10 + 10 + 200 + 400) = 1 : 2 : 32 : 65 (The value 1 is given to the last expletive 10 Mbps to make the total value 100.)

Based on condition (3), the values obtained as above are to be defined as an output queue list (QLIST-WFQ-UP) as follows:

```
(config)# qos-queue-list QLIST-WFQ-UP 4pq+4wfq 1% 2% 32% 65%
```

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3.4 Configuration examples

Below we provide configuration setting examples for the configuration explained in the previous sections.

(1) Configuration of the core switch (AX6708S series)

Configuration of C1 (AX6708S series)

Suppression of spanning trees

```
(config)# spanning-tree disable
```

In the AX series, PVST+ is enabled by default, but to configure it as an FT switch, suppress PVST+.

Configuration of the VRF

```
(config)# vrf mode l2protocol-disable
All BSUs will be restarted automatically when the
selected mode differs from current mode.
Do you wish to change mode (y/n): y

(config)# vrf definition 2
(config)# vrf definition 3
(config)# vrf definition 4
(config)# vrf definition 12
(config)# vrf definition 13
(config)# vrf definition 14
```

Configure the VRF not to use L2 protocol concurrently.
(The system prompts you to confirm the restart of BSUs. If you agree, enter y.)

Configure to use VRF 2.
Configure to use VRF 3.
Configure to use VRF 4.
Configure to use VRF 12.
Configure to use VRF 13.
Configure to use VRF 14.

Configuration of the QoS flow list

```
(config)# ip qos-flow-list QOS-KANSHI-UP
(config-ip-qos)# qos ip any any action
priority-class 3

(config)# ip qos-flow-list QOS-KANSHI-DW
(config-ip-qos)# qos ip any any action
priority-class 1

(config)# ip qos-flow-list QOS-SETSUBI-UP
(config-ip-qos)# qos ip any any action
priority-class 2

(config)# ip qos-flow-list QOS-SETSUBI-DW
(config-ip-qos)# qos ip any any action
priority-class 2

(config)# ip qos-flow-list QOS-DSIGN-UP
(config-ip-qos)# qos ip any any action
priority-class 1

(config)# ip qos-flow-list QOS-DSIGN-DW
(config-ip-qos)# qos ip any any action
priority-class 3

(config)# ip qos-flow-list QOS-TENNANT-UP
(config-ip-qos)# qos ip any any action
priority-class 4

(config)# ip qos-flow-list QOS-TENNANT-DW
(config-ip-qos)# qos ip any any action
priority-class 4
```

Create a QoS flow list for the security monitoring network.
Assign class 3 priority to all the flows leading to the server (uplink) (configuration key point (1)), and priority class 1 to all the flows leading to the clients (downlink). (Configuration key point (3))

Create QoS flow lists for the facilities management network.
Because the segment (VLAN) to which the servers are connected and the segment (VLAN) to which client devices are connected are separated, create two flow lists each, one for the flow leading to the server (uplink) and the other for the flow leading to the client devices (downlink). Assign priority class 2 to all the flows. (Configuration key point (1))

Create a QoS flow list for the digital signage network.
Assign priority class 1 to all the flows leading to the server (uplink) (configuration key point (3)), and priority class 3 to all the flows leading to the client devices (downlink). (Configuration key point (1))

Create QoS flow lists for the tenant network.
Because the segment (VLAN) to which the servers are connected and the segment (VLAN) to which client devices are connected are separated, create two flow lists each, one for the flow leading to the server (uplink) and the other for the flow leading to the client devices (downlink). Assign priority class 4 to all the flows. (Configuration key point (1))

Configuration of the QoS queue list (shaper control)

```
(config)# qos-queue-list QLIST-WFQ-UP 4pq+4wfq 1%
2% 32% 65%


(config)# qos-queue-list QLIST-WFQ-DW 4pq+4wfq 2%
2% 19% 77%
```

Set send control 4PQ+4WFQ for the flow leading to the server (uplink) and assign a WFQ bandwidth ratio of (10) : 10 : 200 : 400 = 1 : 2 : 32 : 65.
(The setting for queue 1 ((10) = 1) is a dummy.) (Configuration key points 3.3(4) and (6))
Set send control 4PQ+4WFQ for the flow leading to the clients (downlink) and assign a WFQ bandwidth ratio of (10) : 10 : 100 : 400 = 2 : 2 : 19 : 77. (The setting for queue 1 ((10) = 2) is a dummy.) (Configuration key points 3.3(4) and (6))

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Configuration of C1 (AX6708S series)

Configuration of VLANs

(config)# vlan 2,20-24,30-34,40-41,120-121,130-131,140-141	Configure the VLANs that are to be used.

Configuration of VLAN interfaces

(config)# interface vlan 2 (config-if)# ip address 172.255.0.1 255.255.0.0	VLAN 2 is to be used globally for system management. Assign an IP address to VLAN 2.
(config)# interface vlan 20 (config-if)# vrf forwarding 2 (config-if)# ip address 172.20.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-KANSHI-DW in layer3-forwarding	Configure VLAN 20 to use VRF 2. Assign an IP address to VLAN 20. Apply the QoS flow list for security monitoring to VLAN 20. This dictates that queue 1 is to be used for sending downlink traffic, such as from VLAN 20 and VLAN 21. (Configuration key point (3))
(config)# interface vlan 21 (config-if)# vrf forwarding 2 (config-if)# ip address 172.21.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-KANSHI-UP in layer3-forwarding	Configure VLAN 21 to use VRF 2. Assign an IP address to VLAN 21. Apply the QoS flow list for security monitoring to VLAN 21. This dictates that queue 3 is to be used for sending traffic that goes through VLAN 21. (Configuration point (1))
(config)# interface vlan 22 (config-if)# vrf forwarding 2 (config-if)# ip address 172.22.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-KANSHI-UP in layer3-forwarding (config)# interface vlan 23 (config-if)# vrf forwarding 2 (config-if)# ip address 172.23.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-KANSHI-UP in layer3-forwarding (config)# interface vlan 24 (config-if)# vrf forwarding 2 (config-if)# ip address 172.24.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-KANSHI-UP in layer3-forwarding	Make configurations for VLANs 22 to 24 similar to those of VLAN 21. (Configuration key point (1))
(config)# interface vlan 30 (config-if)# vrf forwarding 3 (config-if)# ip address 172.30.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-SETSUBI-DW in layer3-forwarding	Configure VLAN 30 to use VRF 3. Assign an IP address to VLAN 30. Apply the QoS flow list for facilities management downlink to VLAN 30. This dictates that queue 2 is to be used for sending traffic that goes through VLAN 30. (Configuration point (1))
(config)# interface vlan 31 (config-if)# vrf forwarding 3 (config-if)# ip address 172.31.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-SETSUBI-UP in layer3-forwarding	Configure VLAN 31 to use VRF 3. Assign an IP address to VLAN 31. Apply the QoS flow list for facilities management uplink to VLAN 31. This dictates that queue 2 is to be used for sending traffic that goes through VLAN 31. (Configuration point (1))
(config)# interface vlan 32 (config-if)# vrf forwarding 3 (config-if)# ip address 172.32.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-SETSUBI-UP in layer3-forwarding (config)# interface vlan 33 (config-if)# vrf forwarding 3 (config-if)# ip address 172.33.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-SETSUBI-UP in layer3-forwarding (config)# interface vlan 34 (config-if)# vrf forwarding 3 (config-if)# ip address 172.34.0.1 255.255.0.0 (config-if)# ip qos-flow-group QOS-SETSUBI-UP in layer3-forwarding	Make similar configurations for VLANs 32 to 34 as for VLAN 31. (Configuration key point (1))

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Configuration of C1 (AX6708S series)

```
(config)# interface vlan 40
(config-if)# vrf forwarding 4
(config-if)# ip address 172.40.0.1 255.255.0.0
(config-if)# ip qos-flow-group QOS-DSIGN-DW in
layer3-forwarding

(config)# interface vlan 41
(config-if)# vrf forwarding 4
(config-if)# ip address 172.41.0.1 255.255.0.0
(config-if)# ip qos-flow-group QOS-DSIGN-UP in
layer3-forwarding

(config)# interface vlan 120
(config-if)# vrf forwarding 12
(config-if)# ip address 172.120.0.1 255.255.0.0
(config-if)# ip qos-flow-group QOS-TENNANT-DW in
layer3-forwarding

(config)# interface vlan 121
(config-if)# vrf forwarding 12
(config-if)# ip address 192.168.0.1 255.255.255.0
(config-if)# ip qos-flow-group QOS-TENNANT-UP in
layer3-forwarding

(config)# interface vlan 130
(config-if)# vrf forwarding 13
(config-if)# ip address 172.130.0.1 255.255.0.0
(config-if)# ip qos-flow-group QOS-TENNANT-DW in
layer3-forwarding

(config)# interface vlan 131
(config-if)# vrf forwarding 13
(config-if)# ip address 192.168.0.1 255.255.255.0
(config-if)# ip qos-flow-group QOS-TENNANT-UP in
layer3-forwarding

(config)# interface vlan 140
(config-if)# vrf forwarding 14
(config-if)# ip address 172.140.0.1 255.255.0.0
(config-if)# ip qos-flow-group QOS-TENNANT-DW in
layer3-forwarding

(config)# interface vlan 141
(config-if)# vrf forwarding 14
(config-if)# ip address 192.168.0.1 255.255.255.0
(config-if)# ip qos-flow-group QOS-TENNANT-UP in
layer3-forwarding
```

Configure VLAN `40 to` use VRF `4`.
Assign an IP address to VLAN `40`.
Apply the QoS flow list for digital signage downlink to VLAN `40`. This dictates that queue `3` is to be used for sending traffic that goes through VLAN `40`. (Configuration key point (1))

Configure VLAN `41` to use VRF `3`.
Assign an IP address to VLAN `41`.
Apply the QoS flow list for digital signage to VLAN `41`.
This dictates that queue `1` is to be used for sending uplink traffic, such as from VLAN `41` and VLAN `40`. (Configuration key point (3))

Configure VLAN `120` to use VRF `12`.
Assign an IP address to VLAN `120`.
Apply the QoS flow list for the downlink for 2F tenants to VLAN `120`. This dictates that queue `4` is to be used for sending uplink traffic, such as from VLAN `120` and VLAN `40`. (Configuration key point (1))

Configure VLAN `121` to use VRF `12`.
Assign an IP address to VLAN `121`.
Apply the QoS flow list for the uplink for 2F tenants to VLAN `121`. This dictates that queue `4` is to be used for sending traffic that goes through VLAN `121`. (Configuration key point (1))

Make similar configurations for VLAN `130` & VLAN `131` and for VLAN `140` & VLAN `141` as for VLAN `120` & VLAN `121`. (Configuration key point (1))

Configuration of the physical port interfaces

Configuration of the ports

```
(config)# interface gigabitethernet 4/24
(config-if)# switchport access vlan 2

(config)# interface range gigabitethernet 1/1,
gigabitethernet 2/1
(config-if-range)# channel-group 1 mode on
(config-if-range)# qos-queue-group QLIST-WFQ-UP

(config)# interface range gigabitethernet 1/2,
gigabitethernet 2/2
(config-if-range)# channel-group 2 mode on
(config-if-range)# qos-queue-group QLIST-WFQ-UP
```

Set port `4/24` as an access port of VLAN `2` for system management.

Configure ports `1/1` and `2/1` as channel group `1` for connecting servers for building management. Also, apply the QoS queue list for the uplink to the shaper. (Configuration key points 3.3(4) and (5))

Configure ports `1/2` and `2/2` as channel group `2` for connecting tenant servers. Also, apply the QoS queue list for the uplink to the shaper. (Configuration key points 3.3(4) and (5))

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Configuration of C1 (AX6708S series)	
(config)# interface range gigabitethernet 3/1, gigabitethernet 4/1 (config-if-range)# channel-group 10 mode on (config-if-range)# qos-queue-group QLIST-WFQ-DW (config)# interface range gigabitethernet 3/2, gigabitethernet 4/2 (config-if-range)# channel-group 11 mode on (config-if-range)# qos-queue-group QLIST-WFQ-DW (config)# interface range gigabitethernet 3/13, gigabitethernet 4/13 (config-if-range)# channel-group 12 mode on (config-if-range)# qos-queue-group QLIST-WFQ-DW (config)# interface range gigabitethernet 3/14, gigabitethernet 4/14 (config-if-range)# channel-group 13 mode on (config-if-range)# qos-queue-group QLIST-WFQ-DW (config)# interface range gigabitethernet 3/15, gigabitethernet 4/15 (config-if-range)# channel-group 14 mode on (config-if-range)# qos-queue-group QLIST-WFQ-DW	Configure ports 3/1 and 4/1 as channel group 10 for connecting the access switches for building equipment on 1F. Also, apply the QoS queue list for downlink to the shaper. (Configuration key points 3.3(4) and (5)) Configure ports 3/2 and 4/2 as channel group 11 for connecting the access switches for digital signage on 1F. Also, apply the QoS queue list for downlink to the shaper. (Configuration key points 3.3(4) and (5)) Configure ports 3/13 and 4/13 as channel group 12 for connecting the distribution switch on 2F. Also, apply the QoS queue list for downlink to the shaper. (Configuration key points 3.3(4) and (5)) Configure ports 3/14 and 4/14 as channel group 13 for connecting the distribution switch on 3F. Also, apply the QoS queue list for downlink to the shaper. (Configuration key points 3.3(4) and (5)) Configure ports 3/15 and 4/15 as channel group 14 for connecting the distribution switch on 4F. Also, apply the QoS queue list for downlink to the shaper. (Configuration key points 3.3(4) and (5))
Configuration of the port channel	
(config)# interface port-channel 1 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 20,30,40 (config)# interface port-channel 2 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 120,130,140 (config)# interface port-channel 10 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 2,21,31 (config)# interface port-channel 11 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 2,41 (config)# interface port-channel 12 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 2,22,32,121 (config)# interface port-channel 13 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 2,23,33,131 (config)# interface port-channel 14 (config-if)# switchport mode trunk (config-if)# switchport trunk allowed vlan 2,24,34,141	Set port channel 1 as a trunk port and allow it to transfer VLANs 20, 30, and 40. Set port channel 2 as a trunk port and allow it to transfer VLANs 120, 130, and 140. Set port channel 10 as a trunk port and allow it to transfer VLANs 2, 21, and 31. Set port channel 11 as a trunk port and allow it to transfer VLANs 2 and 41. Set port channel 12 as a trunk port and allow it to transfer VLANs 2, 22, 32, and 121. Set port channel 13 as a trunk port and allow it to transfer VLANs 2, 23, 33, and 131. Set port channel 14 as a trunk port and allow it to transfer VLANs 2, 24, 34, and 141.

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(2) Configuration of the switch (AX2530S series) for digital signage on 1F

Configuration of T1 (AX2530S-24T6X)	
Suppression of spanning trees	
`(config)# spanning-tree disable`	On the AX series, PVST+ is enabled by default, but to configure it as an FT switch, suppress PVST+.
Configuration of VLANs	
`(config)# vlan 2,41`	Configure the VLANs that are to be used.
Configuration of VLAN interfaces	
`(config)# interface vlan 2` `(config-if)# ip address 172.255.1.20 255.255.0.0`	Use VLAN 2 for system management. Assign an IP address to VLAN 2.
Configuration of the physical port interfaces	
Configuration of the ports	

`(config)# interface range gigabitethernet 0/23-24`
`(config-if-range)# channel-group 1 mode on`
 	
`(config)# interface range gigabitethernet 0/1-22`
`(config-if-range)# switchport access vlan 41`
	Configure ports 0/23 to 24 as channel group 1 for connecting the uplink.
	
	Configure ports 0/1 to 22 as access ports of VLAN 41 for connecting the devices used for the digital signage system.

Configuration of the port channel	

`(config)# interface port-channel 1`
`(config-if)# switchport mode trunk`
`(config-if)# switchport trunk allowed vlan 2,41`
	Set port channel 1 as a trunk port and allow it to transfer VLANs 2 and 41.

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(3) Configuration of access switches (AX1240S series) for building management on 1F

Configuration of B1 (AX1240S-24T2C)	
Suppression of spanning trees	
`(config)# spanning-tree disable`	On the AX series, PVST+ is enabled by default, but to configure it as an FT switch, suppress PVST+.
Configuration of the QoS flow list	

`(config)# ip qos-flow-list QOS-KANSHI-UP`
`(config-ip-qos)# qos ip any any action cos 2`
 	
`(config)# ip qos-flow-list QOS-SETSUBI-UP`
`(config-ip-qos)# qos ip any any action cos 1`
	Create a QoS flow list for the security monitoring network. Set CoS value 2 to all the flows.
	(Configuration key points (1) and (2))
	Create a QoS flow list for the facilities management network. Set CoS value 1 to all the flows.
	(Configuration key points (1) and (2))

Configuration of the QoS queue list (shaper control)	
`(config)# qos-queue-list QLIST-WFQ-UP wfq min-rate2 1M min-rate3 10M`	Set WFQ to the uplink send control and set the minimum bandwidths of queues 2 and 3 to 1 Mbps and 10 Mbps, respectively. (Configuration key point 3.3(4))
Configuration of VLANs	
`(config)# vlan 2,21,31`	Configure the VLANs that are to be used.
Configuration of VLAN interfaces	

`(config)# interface vlan 2`
`(config-if)# ip address 172.255.1.10 255.255.0.0`
 	
`(config)# interface vlan 21`
`(config-if)# ip qos-flow-group QOS-KANSHI-UP in`
 	
`(config)# interface vlan 31`
`(config-if)# ip qos-flow-group QOS-SETSUBI-UP in`
	Use VLAN 2 for system management.
	Assign an IP address to VLAN 2.
	
	Apply the QoS flow list for security monitoring to VLAN 21.
	This dictates that the communication that goes through VLAN 21 is sent using queue 3.
	
	Apply the QoS flow list for facilities management to VLAN 31.
	This dictates that the communication that goes through VLAN 31 is sent using queue 2.

Configuration of the physical port interfaces	
Configuration of the ports	

`(config)# interface range gigabitethernet 0/25-26`
`(config-if-range)# channel-group 1 mode on`
`(config-if-range)# qos-queue-group QLIST-WFQ-UP`
 	
`(config)# interface range fastethernet 0/1-12`
`(config-if-range)# switchport access vlan 21`
 	
`(config)# interface fastethernet 0/13-24`
`(config-if-range)# switchport access vlan 31`
	Configure ports 0/25 to 26 as channel group 1 for connecting the uplink.
	Apply the queue list for the uplink to the shaper.
	(Configuration key points (1), (2), and (5))
	Configure ports 0/1 to 12 as access ports of VLAN 21 for connecting security monitoring devices.
	Configure ports 0/13 to 24 as access ports of VLAN 31 for connecting facilities equipment for management.

Configuration of the port channel	

`(config)# interface port-channel 1`
`(config-if)# switchport mode trunk`
`(config-if)# switchport trunk allowed vlan 2,21,31`
	Set port channel 1 as a trunk port and allow it to transfer VLANs 2, 21, and 31.

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(4) Configuration of the distribution switch (AX2530S series) on 2F

Configuration of D2-1 (AX2530S-24T6X)

Enabling SML

(config)# system sml domain 20 Please execute the reload after saving all the following commands, as these commands become effective after reboot. - system sml id - system sml peer-link - system sml domain	Set 20 to SML domain ID. (* On switches D3-1 and D3-2, set 30 to SML domain ID, while on switches D4-1 and D4-2, set 40 to SML domain ID.) A message appears to prompt you to save the configuration and restart the switch.
(config)# system sml id 1 Please execute the reload after saving all the following commands, as these command become effective after reboot. - system sml id - system sml peer-link - system sml domain	Set 1 to SML ID of the switch D2-1. (* On the switch D2-2, set 2 to SML ID.) A message appears to prompt you to save the configuration and restart the switch.
(config)# system sml peer-link interface gigagitethernet 0/25-26 Please execute the reload after saving all the following commands, as these command become effective after reboot. - system sml id - system sml peer-link - system sml domain	Set the two ports of 0/25 and 0/26 as peer links. A message appears to prompt you to save the configuration and restart the switch.
(config)# save @(config)# exit @# reload Restart OK? (y / n): y Please wait a few minutes. The reload command is executing.	Save the configuration. After saving the configuration, @ appears at the command prompt. Restart the switch as is.

Configuration of the QoS flow list

(config)# ip qos-flow-list QOS-KANSHI (config-ip-qos)# qos ip any 172.20.0.0 0.0.255.255 action cos 2 (config)# ip qos-flow-list QOS-SETSUBI (config-ip-qos)# 10 qos ip any 172.30.0.0 0.0.255.255 action cos 1 (config-ip-qos)# 20 qos ip 172.30.0.0 0.0.255.255 any action cos 1 (config)# ip qos-flow-list QOS-TENNANT (config-ip-qos)# 10 qos ip any 172.120.0.0 0.0.255.255 action cos 3 (config-ip-qos)# 20 qos ip 172.120.0.0 0.0.255.255 any action cos 3 This is used for the tenants on 2F. For the tenants on 3F, 172.130.0.0, for the tenants on 4F, 172.140.0.0.	Create a QoS flow list for the security monitoring network. Set CoS value 2 to each of the uplink and downlink flows. (Configuration key points (1) and (2)) Create a QoS flow list for the facilities management network. Set CoS value 1 to each of the uplink and downlink flows. (Configuration key points (1) and (2)) Create a QoS flow list for the network for the tenants on 2F. Set CoS value 3 to each of the uplink and downlink flows. (Configuration key points (1) and (2))

Configuration of the QoS queue list (shaper control)

(config)# qos-queue-list QLIST-WFQ-UP wfq min-rate2 2M min-rate3 25M min-rate4 50M (config)# qos-queue-list QLIST-WFQ-DW wfq min-rate2 2M min-rate4 50M	Set WFQ to the uplink send control and set the minimum bandwidths of queues 2, 3, and 4 to 2 Mbps, 25 Mbps, and 50 Mbps, respectively. (Configuration key point 3.3(4)) Set WFQ for the downlink send control and set the minimum bandwidths of queues 2 and 4 to 2 Mbps and 50 Mbps, respectively. (Configuration key point 3.3(4))

Configuration of VLANs

(config)# vlan 2,22,32,121	Configure the VLANs that are to be used for the tenants on 2F.

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Configuration of D2-1 (AX2530S-24T6X)

Configuration of VLAN interfaces

```
(config)# interface vlan 2
(config-if)# ip address 172.255.2.5 255.255.0.0

(config)# interface vlan 22
(config-if)# ip qos-flow-group QOS-KANSHI in

(config)# interface vlan 32
(config-if)# ip qos-flow-group QOS-SETSUBI in

(config)# interface vlan 121
(config-if)# ip qos-flow-group QOS-TENNANT in
```

Use VLAN 2 for system management.
Assign an IP address to VLAN 2.

Apply the QoS flow list for security monitoring to VLAN 22.
(Configuration key points (1) and (2))
Apply the QoS flow list for facilities management to VLAN 32.
(Configuration key points (1) and (2))
Apply the QoS flow list for the tenants on 2F to VLAN 121.
(Configuration key points (1) and (2))

Configuration of the physical port interfaces

Configuration of the ports

```
(config)# interface gigabitethernet 0/24
(config-if)# channel-group 1 mode on
(config-if)# qos-queue-group QLIST-WFQ-UP

(config)# interface gigabitethernet 0/1
(config-if)# channel-group 11 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW

(config)# interface gigabitethernet 0/2
(config-if)# channel-group 12 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW

(config)# interface gigabitethernet 0/9
(config-if)# channel-group 21 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW

(config)# interface gigabitethernet 0/10
(config-if)# channel-group 22 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW

(config)# interface gigabitethernet 0/11
(config-if)# channel-group 23 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW

(config)# interface gigabitethernet 0/12
(config-if)# channel-group 24 mode on
(config-if)# qos-queue-group QLIST-WFQ-DW
```

Configure port 0/24 as channel group 1 for uplink connection.
Apply the QoS queue list for the uplink to the shaper.
(Configuration key points 3.3(4) and (5))

Configure ports 0/1 and 0/2 as channel groups 11 and 12, used for the downlinks to connect the access switches for building security monitoring and facilities management, respectively.
Apply the QoS queue list for the downlink to the shaper.
(Configuration key points 3.3(4) and (5))

Configure ports 0/9, 0/10, 0/11, and 0/12 as channel groups 11, 12, 13, and 14, used for the downlinks to connect the access switches for the tenants, respectively.
Apply the QoS queue list for the downlink to the shaper.
(Configuration key points 3.3(4) and (5))

Configuration of the port channel

```
(config)# interface port-channel 1
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,22,32,121

(config)# interface port-channel 11
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,22,32

(config)# interface port-channel 12
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,22,32

(config)# interface port-channel 21
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,121

(config)# interface port-channel 22
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,121

(config)# interface port-channel 23
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,121

(config)# interface port-channel 24
(config-if)# switchport mode trunk
(config-if)# switchport trunk allowed vlan 2,121
```

Set port channel 1 as a trunk port and allow it to transfer VLANs 2, 22, 32, and 121.

Set port channels 11 and 12 as trunk ports and allow them to transfer VLANs 2, 22, and 32.

Set port channels 21, 22, 23, and 24 as trunk ports and allow them to transfer VLANs 2 and 121.

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* The same configurations are to be made on the distribution switches on 3F and 4F (D3-1, D3-2, D4-1, and D4-2), except for the part for flow settings (which are written in red above) and except when the SML domain IDs and the VLAN numbers to be used do not match (VLAN 22 to 23 and 24, VLAN 32 to 33 and 34, VLAN 121 to 131 and 141).

(5) Configuration of access switches (AX1240S series) for building management on 2F

Configuration of B2 (AX1240S-24T2C)	
Suppression of spanning trees	
`(config)# spanning-tree disable`	On the AX series, PVST+ is enabled by default, but to configure it as an FT switch, suppress PVST+.
Configuration of the QoS flow list	

`(config)# ip qos-flow-list QOS-KANSHI-UP`
`(config-ip-qos)# qos ip any any action cos 2`
 	
`(config)# ip qos-flow-list QOS-SETSUBI-UP`
`(config-ip-qos)# qos ip any any action cos 1`
	Create a flow list for the security monitoring network. Set CoS value 2 to the uplink flow.
	(Configuration key points (1) and (2))
	Create a flow list for the facilities management network. Set CoS value 1 to the uplink flow.
	(Configuration key points (1) and (2))

Configuration of the QoS queue list (shaper control)	
`(config)# qos-queue-list QLIST-WFQ-UP wfq min-rate2 1M min-rate3 10M`	Set WFQ to uplink send control and set the minimum bandwidth of queues 2 and 3 to 1 Mbps and 10 Mbps, respectively. (Configuration key point 3.3(4))
Configuration of VLANs	
`(config)# vlan 2,22,32`	Configure the VLANs that are to be used.
Configuration of VLAN interfaces	

`(config)# interface vlan 2`
`(config-if)# ip address 172.255.2.10 255.255.0.0`
 	
`(config)# interface vlan 22`
`(config-if)# ip qos-flow-group QOS-KANSHI-UP in`
 	
`(config)# interface vlan 32`
`(config-if)# ip qos-flow-group QOS-SETSUBI-UP in`
	Set the IP address of the switch to VLAN 2 to use the VLAN for system management.
	
	Apply the flow list for security monitoring to VLAN 22.
	(Configuration key points (1) and (2))
	Apply the flow list for facilities management to VLAN 32.
	(Configuration key points (1) and (2))

Configuration of the physical port interfaces	
Configuration of the ports	

`(config)# interface range gigabitethernet 0/25-26`
`(config-if-range)# channel-group 1 mode on`
`(config-if-range)# qos-queue-group QLIST-WFQ-UP`
 	
`(config)# interface range fastethernet 0/1-12`
`(config-if-range)# switchport access vlan 22`
 	
`(config)# interface fastethernet 0/13-24`
`(config-if-range)# switchport access vlan 32`
	Configure ports 0/25 to 26 as channel group 1 for uplink connection. Apply the queue list for the uplink to the shaper.
	(Configuration key points 3.3(4) and (5))
	
	Configure ports 0/1 to 12 as access ports of VLAN 22 for connecting security monitoring devices.
	
	Configure ports 0/13 to 24 as access ports of VLAN 32 for connecting facilities equipment for management.

Configuration of the port channel	

`(config)# interface port-channel 1`
`(config-if)# switchport mode trunk`
`(config-if)# switchport trunk allowed vlan 2,22,32`
	Set port channel 1 as a trunk port and allow it to transfer VLANs 2, 22, and 32.

* The same configurations are to be made on the access switches for building management on 3F and 4F (B3 and B4), except when the VLAN numbers to be used do not match (VLAN 22 to 23 and 24, VLAN 32 to 33 and 34).

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(6) Configuration of access switches (AX1240S series) for the tenants on 2F

Configuration of T2 (AX1240S-24T2C)	
Suppression of the spanning tree	
`(config)# spanning-tree disable`	On the AX series, PVST+ is enabled by default, but to configure it as an FT switch, suppress PVST+.
Configuration of the QoS flow list	
`(config)# ip qos-flow-list QOS-TENNANT-UP` `(config-ip-qos)# qos ip any any action cos 3`	Create a flow list for the network for the tenants. Set CoS value `3` to the uplink flow. (Configuration key points (1) and (2))
Configuration of the QoS queue list (shaper control)	
`(config)# qos-queue-list QLIST-WFQ-UP wfq min-rate4 20M`	Set WFQ to the uplink send control and set the minimum bandwidth of queue `4` to 20 Mbps. (Configuration key point 3.3(4))
Configuration of VLANs	
`(config)# vlan 2,121`	Configure the VLANs that are to be used.
Configuration of VLAN interfaces	

`(config)# interface vlan 2`
`(config-if)# ip address 172.255.2.20 255.255.0.0`
 	
`(config)# interface vlan 121`
`(config-if)# ip qos-flow-group QOS-TENNANT-UP in`
	Use VLAN `2` globally for system management.
	Assign an IP address to VLAN `2`.
	
	Apply the flow list for the tenants to VLAN `121`.
	(Configuration key points (1) and (2))

Configuration of the physical port interfaces	
Configuration of the ports	

`(config)# interface range gigabitethernet 0/25-26`
`(config-if-range)# channel-group 1 mode on`
`(config-if-range)# qos-queue-group QLIST-WFQ-UP`
 	
`(config)# interface range fastethernet 0/1-24`
`(config-if-range)# switchport access vlan 121`
	Configure ports `0/25` to `26` as channel group `1` for uplink connection. Apply the queue list for the uplink to the shaper. (Configuration key points 3.3(4) and (5))
	
	Configure ports `0/1` to `24` as access ports of VLAN `121` for connecting terminal PCs of the tenants on 2F.

Configuration of the port channel	

`(config)# interface port-channel 1`
`(config-if)# switchport mode trunk`
`(config-if)# switchport trunk allowed vlan 2,121`
	Set port channel `1` as a trunk port and allow it to transfer VLANs `2` and `121`.

* The same configurations are to be made on the access switches for the tenants on 3F and 4F (T3 and T4), except when the VLAN numbers to be used do not match (VLAN `121` to `131` and `141`).

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4. Considerations

(1) Mapping of priority values to the output queue numbers on the AX series

Priority determination in the AX6700S/AX6600S/AX6300S series uses a parameter called output priority that indicates to which queue the frame is queued.
Priority determination in the AX3600S, AX2500S, AX2400S, and AX1200S series uses a parameter CoS ranging from 0 to 7 that indicates the priority of the frame within the switch.

On the other hand, the output queue numbers used for send control range from 1 to 8, which are common to all AX series. Therefore, when mapping CoS values to the output queues, be careful of the mismatch between values.

Table 4-1 Mapping of output priorities/CoS values to the output queues

AX6700S/AX6600S/AX6300S Output priority	AX3600S, AX2500S, AX2400S, AX1200S CoS value	All AX series Queue number when sending (when 8 queues are used).
1	0	1
2	1	2
3	2	3
4	3	4
5	4	5
6	5	6
7	6	7
8	7	8

(2) Default priority value

The following values are applied to the relay flows to which no priority determination is set, including those that do not match the flow detection conditions or those to which no explicit priority is specified.

Table 4-2 Mapping of output priorities/Cos values to the output queues

AX series and their priority parameter	Type of relay frame	Priority set to the frame
Output priority#1 of AX6700S/AX6600S/AX6300S	All frames	4
CoS value of AX3600S, AX2500S, AX2400S, and AX1200S	Frames without a VLAN Tag	3
	Frames with a VLAN Tag	User priority within the VLAN Tag#2

#1: When a NIF that supports the legacy shaper is used or when VLAN mapping is not used for a NIF that supports a hierarchical shaper

Different priority values other than above are applied to frames issued by the AX series themselves, such as control frames and communication sent to the AX series. For details, see the explanation on the flow control and priority determination in the *Software Manual Configuration Guide Vol. 2* for the AX series.

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(3) Supported send control functionality differs depending on the NIF of the AX6700S/AX6600S/AX6300S series.

In the AX6700S/AX6600S/AX6300S series, the supported send control functionality is different for each type of NIF to be used. To use WFQ for guaranteeing bandwidth, use NIFs with legacy shaper support.
(In addition to these, there are NIFs with hierarchical shaper support that provide more advanced send control functionality.)

Table 4-3 List of NIF types that support shaper functionality

Supported send control function	Type of NIF for AX6000S series	
	AX6700S/AX6600S	AX6300S
Legacy shaper	NK1G-24T, NK1G-24S, NK10G-4RX, NK10G-8RX, NK10G-1RX#1	NH1G-24T, NH1G-24S, NH10G-4RX, NH10G-8RX, NH10G-1RX#1
Hierarchical shaper	NK1GS-8M	NK1GS-6M
No shaper functionality	--	NH1G-16S, NH1G-48T

#1: NK10G-1RX and NH10G-1RX only support PQ in the port output queues.

For details about the supported functionality for each NIF, see *6.10 Correspondence between NIF models and send control functionality* in the *AX6700S/AX6600S/AX6300S Software Manual Configuration Guide Vol. 2*.

(4) How to configure bandwidth if WFQ is selected for the shaper

If WFQ is selected for the shaper, the method for setting sending bandwidth differs between the models.

(a) AX6700S/AX6600S/AX6300S series

There are three types of settings where WFQ can be used (`4pq+4wfq`, `2pq+4wfq+2beq`, and `4wfq+4beq`), all of which are configurations with four WFQ queues.
A ratio called a *weighted ratio*, ranging from `1` to `100` (%) and which determines the sending bandwidth, is set to each WFQ queue. You cannot skip setting a weighted ratio for any of the queues and must allocate the values so that the total becomes `100`. In addition, make sure that the greater the weighted ratio, the larger the queue number.

Example: How to set `4pq+4wfq`
`qos-queue-list` *qos-queue-list-name* `4pq+4wfq` *rate1*`%` *rate2*`%` *rate3*`%` *rate4*`%`

Set *rate1* through *rate4* to satisfy all the following conditions:
Condition 1: Set the values to all of *rate1* through *rate4*. (You cannot omit any of the values.)
Condition 2: *rate1* + *rate2* + *rate3* + *rate4* = 100
Condition 3: *rate1* ≤ *rate2* ≤ *rate3* ≤ *rate4*

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(b) AX3600S, AX2400S, AX2500S, and AX1200S series

WFQ can be set only for configurations with eight WFQ queues. For each queue you can directly specify the minimum bandwidth by kbit/s (or Mbit/s, Gbit/s), or you can omit a value. If you choose not to set a value to a queue, the bandwidth for the queue is not guaranteed. In addition, set the values so that the total bandwidth does not exceed the bandwidth of the line.

Table 4-4 Setting range of the minimum guaranteed bandwidth

Setting unit#1	Setting range#2	Incremental step size
Gbit/s	1 G–10 G	1 Gbit/s
Mbit/s	1 M–10,000 M	1 Mbit/s
kbit/s	1,000–10,000,000	100 kbit/s#3
	64–960	64 kbit/s#4

#1: 1G, 1M, and 1k correspond to 1,000,000,000, 1,000,000, and 1,000, respectively.

#2: The default unit for bandwidth setting is kbit/s. Therefore, if you enter the value in kbit/s, you can omit "k" after the figure.

#3: If the set value is 1,000 k or greater, specify the value with a 100 k step (1,000, 1,100, 1,200 ... 10,000,000).

#4: If the set value is less than 1,000 k, specify the value with a 64k step (64, 128, 192 ... 960).

Note that in the AX2500S and AX1200S series, when entering the configuration, if you set the bandwidth in units of Mbit/s or Gbit/s, the value appears as kbit/s in the display of the configuration (even if you specify 1 M or 1 G, if you show the configuration using a operation command such as `show running-config`, the values are shown as 1,000 or 1,000,000.)

Example: When using `wfq`
`qos-queue-list` *qos-queue-list-name* `wfq [min-rate1` *rate1*`] [min-rate2` *rate2*`] ... [min-rate7` *rate7*`] [min-rate8` *rate8*`]`

Set *rate1* through *rate8* to satisfy the following condition:
Condition: *rate1* + *rate2* + *rate3* + *rate4* + *rate5* + *rate6* + *rate7* + *rate8* ≤ Line bandwidth

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Appendix

This section lists the configuration examples that we explained in this guide.
The text files of all the configurations for the switches in the respective network configurations in Chapter 3 are attached to this file. (Adobe Acrobat 5.0 or later, or Adobe Reader 6.0 or later, is required to extract the attached files.)
For each configuration, see the attached file that corresponds to the same name listed below.

3.1 Examples of applications to networks within an office building

	Name of the switch and the target switch	Target file
L3 core switch	C1 (AX6708S)	3-1_NPAR-QoS_C1.txt
Distribution switch (2F-1)	D2-1 (AX2530S-24T)	3-1_NPAR-QoS_D2-1.txt
Distribution switch (2F-2)	D2-2 (AX2530S-24T)	3-1_NPAR-QoS_D2-2.txt
Distribution switch (3F-1)	D3-1 (AX2530S-24T)	3-1_NPAR-QoS_D3-1.txt
Distribution switch (3F-2)	D3-2 (AX2530S-24T)	3-1_NPAR-QoS_D3-2.txt
Distribution switch (4F-1)	D4-1 (AX2530S-24T)	3-1_NPAR-QoS_D4-1.txt
Distribution switch (4F-2)	D4-2 (AX2530S-24T)	3-1_NPAR-QoS_D4-2.txt
Access switch for building management (1F)	B1 (AX1240S-24T2C)	3-1_NPAR-QoS_B1.txt
Access switch for building management (2F)	B2 (AX1240S-24T2C)	3-1_NPAR-QoS_B2.txt
Access switch for building management (3F)	B3 (AX1240S-24T2C)	3-1_NPAR-QoS_B3.txt
Access switch for building management (4F)	B4 (AX1240S-24T2C)	3-1_NPAR-QoS_B4.txt
Access switch for digital signage (1F)	T1 (AX2530S-24T)	3-1_NPAR-QoS_T1.txt
Access switch for digital signage (2F)	T2 (AX1240S-24T2C)	3-1_NPAR-QoS_T2.txt
Access switch for digital signage (3F)	T3 (AX1240S-24T2C)	3-1_NPAR-QoS_T3.txt
Access switch for digital signage (4F)	T4 (AX1240S-24T2C)	3-1_NPAR-QoS_T4.txt

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