Routing Protocol

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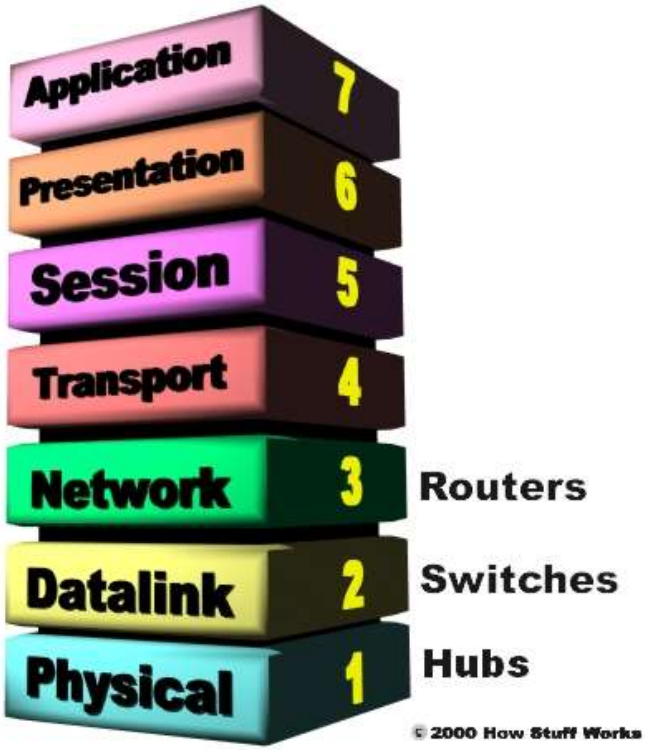
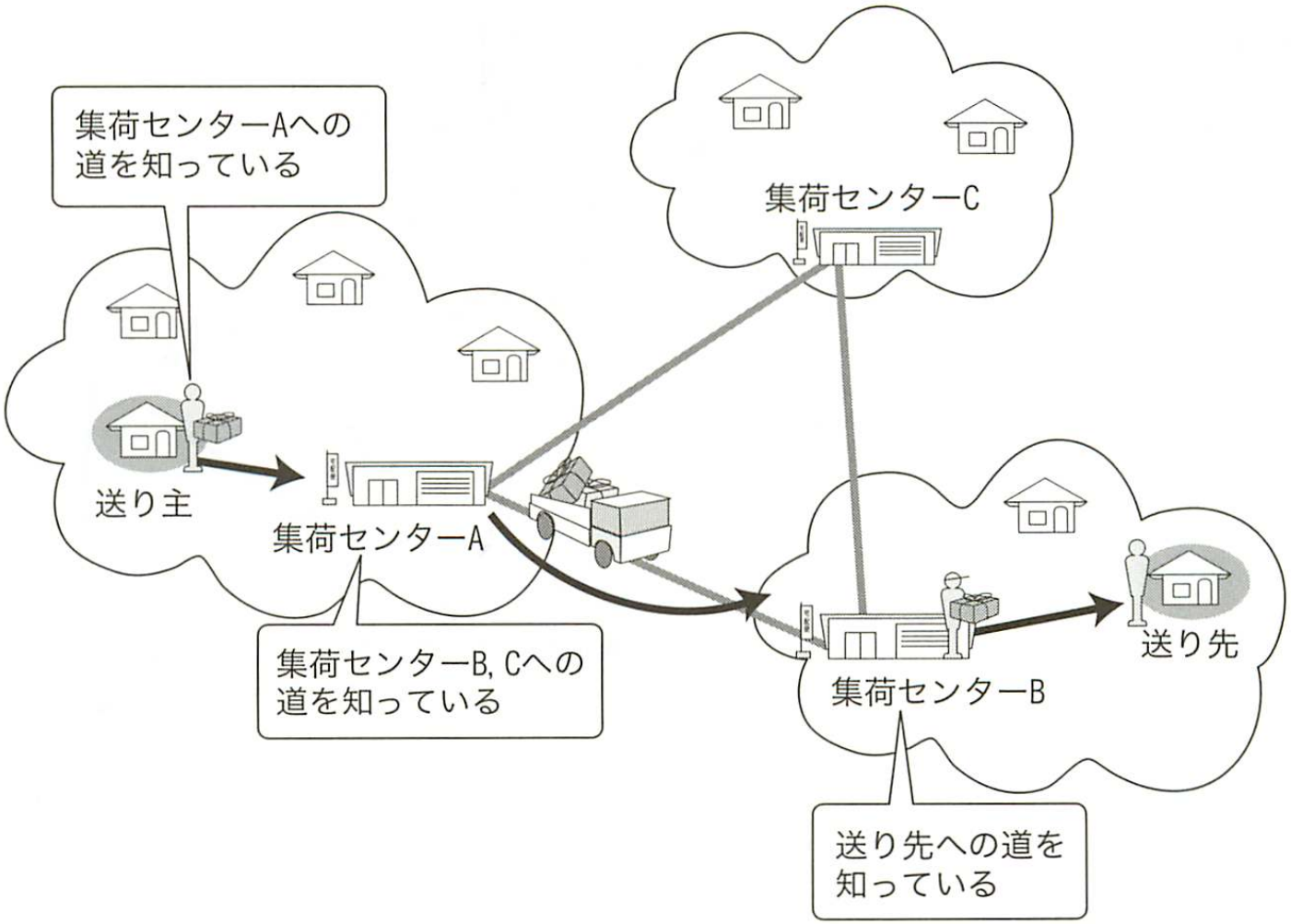
The Concept of Routing

Routing is the process of selecting paths to transfer IP packets.



Direct Connected Network

- In direct connected network, packets are transfered by using Layer 2 Protocol.
- MAC address, ARP, Ethernet...



IP packets are transfered from router to router hop-by-hop.

Routing Table

宛先	ネットマスク	ネクストホップ	インタフェース
203. 183. 224. 3	255. 255. 255. 255	203. 183. 224. 19	IF-b
203. 183. 224. 4	255. 255. 255. 252	直接	IF-a
203. 183. 224. 16	255. 255. 255. 240	直接	IF-b
203. 183. 224. 128	255. 255. 255. 128	203. 183. 224. 19	IF-b
203. 183. 224. 200	255. 255. 255. 248	203. 183. 224. 18	IF-b
default	0. 0. 0. 0	203. 183. 224. 5	IF-a

Among networks, routers use Routing Table.

Matching with Routing Table

- Perfect Match
- Partial Match (in this case, Longest Match is adopted.)
- Default Gateway

Perfect Match

Entry : 203.183.224.3

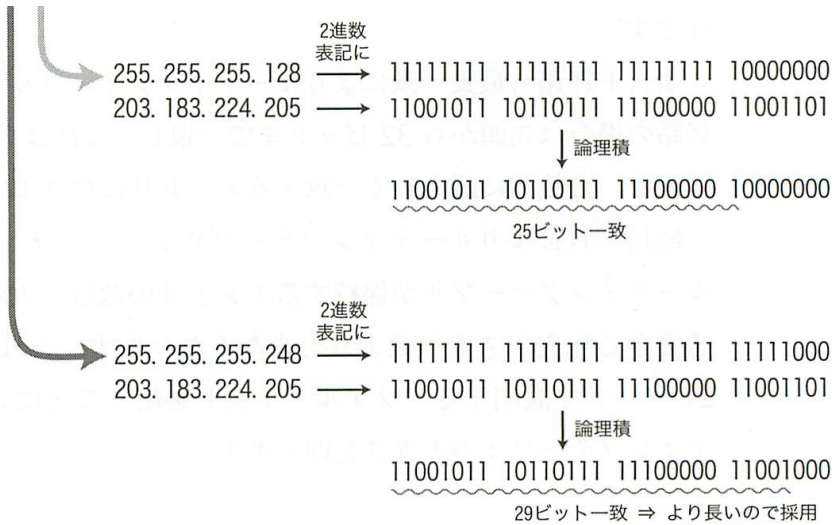
宛先	ネットマスク	ネクストホップ	インタフェース	
203. 183. 224. 3	255. 255. 255. 255	203. 183. 224. 19	IF-b	採用
203. 183. 224. 4	255. 255. 255. 252	直接	IF-a	
203. 183. 224. 16	255. 255. 255. 240	直接	IF-b	
203. 183. 224. 128	255. 255. 255. 128	203. 183. 224. 19	IF-b	
203. 183. 224. 200	255. 255. 255. 248	203. 183. 224. 18	IF-b	
default	0. 0. 0. 0	203. 183. 224. 5	IF-a	

Partial Match

Entry : 203.183.224.205

宛先	ネットマスク	ネクストホップ	インタフェース
203. 183. 224. 3	255. 255. 255. 255	203. 183. 224. 19	IF-b
203. 183. 224. 4	255. 255. 255. 252	直接	IF-a
203. 183. 224. 16	255. 255. 255. 240	直接	IF-b
203. 183. 224. 128	255. 255. 255. 128	203. 183. 224. 19	IF-b
203. 183. 224. 200	255. 255. 255. 248	203. 183. 224. 18	IF-b
default	0. 0. 0. 0	203. 183. 224. 5	IF-a

採用



Default Gateway

Entry : 61.122.116.136

宛先	ネットマスク	ネクストホップ	インタフェース
203. 183. 224. 3	255. 255. 255. 255	203. 183. 224. 19	IF-b
203. 183. 224. 4	255. 255. 255. 252	直接	IF-a
203. 183. 224. 16	255. 255. 255. 240	直接	IF-b
203. 183. 224. 128	255. 255. 255. 128	203. 183. 224. 19	IF-b
203. 183. 224. 200	255. 255. 255. 248	203. 183. 224. 18	IF-b
default	0. 0. 0. 0	203. 183. 224. 5	IF-a

採用

To Make Routing Table

- Static Routing
- Dynamic Routing

Static Routing

Static Routing is achieved by manually adding routes to the routing table. The route is fixed(not changed).

Static Routing Problems

- Traffic can not be arrived if network structure changed or an incident occured on the route.
- When the network is large, it takes a lot of costs to manage the routing tables.

Dynamic Routing

The router updates the routing table by exchaning routing information among routers in response to conditions.

Dynamic Routing Algorithms

- Distance Vector Method
- Link State Method

Distance Vector Method

- Adjacent routers exchange routing information.
- Based on that infromation, routers make the table, then calculate the shortest path by using Bellman-Ford algorithm.

Features of Distance Vector Method

- Simple and easily implemented.
- It takes long time to prevail the routing information among all routes in the network.
- Infinity counting problem.
- Can not judge quolity of path (Bandwidth etc. . .).

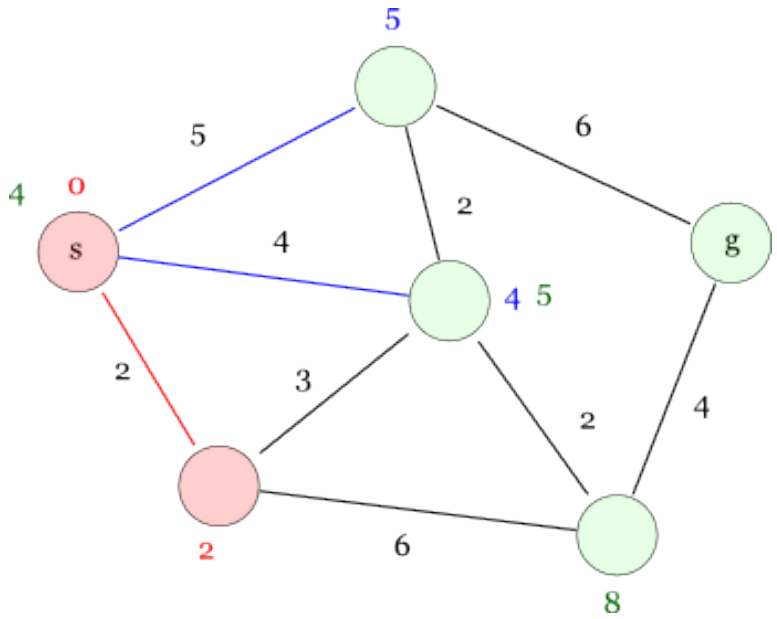
Link State Method

- Routers have LSDB(Link State Data Base) and know network topology.
- Routers exchange LSA(Link State Advertisement).
- Based on topology, each router calculate the shortest path by Dijkstra's algorithm.

Features of Link State Method

- Faster caluculation compared to Distance Vector Method.
- If the network becomes large, efficiency is down.

Dijkstra's algorithm



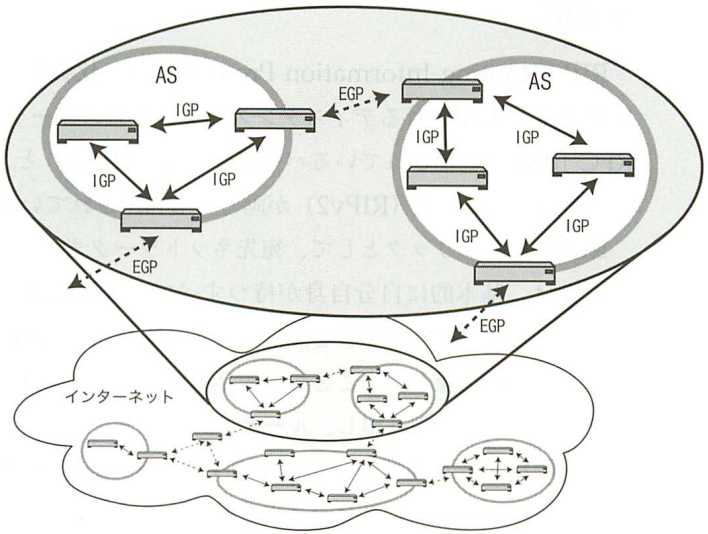
Dynamic Routing Protocol

Divide broadly into two categories.

- IGP - Interior Gateway Protocol
- EGP - Exterior Gateway Protocol

AS - Autonomous System

a collection of connected Internet Protocol (IP) routing prefixes under the control of one or more network operators that presents a common, clearly defined routing policy to the Internet(e.g. ISP,WIDE)



AS number

- AS has a unique number
- assigned by NIC(Network Information Center)
- NIC includes JPNIC.

IGP

- within an AS (autonomous system).
- RIP, IGRP, EIGRP, OSPF

EGP

- among AS (autonomous system).
- EGP, BGP

RIP

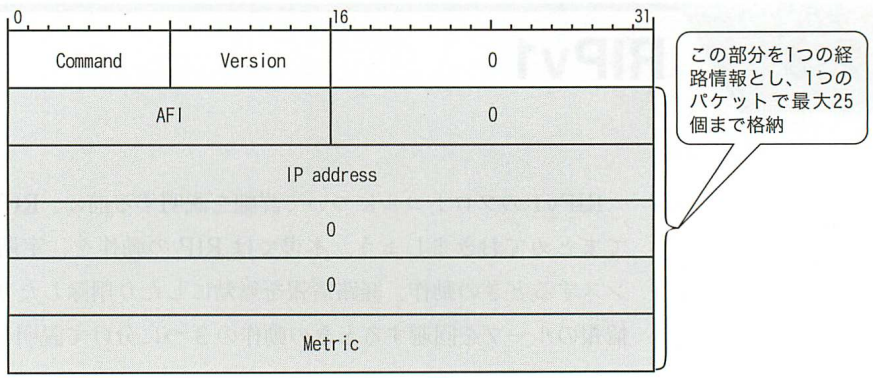
Routing Information Protocol

- using Distance Vector Method.
- version 1 and 2

RIP v1 Features

- Regular Update
- Delete path information
- Avoid Routing Loop

RIP Packet



using UDP port 520.

Metric

- the number of router hops
- metric is between 0 to 16
- Each time passing a router, metric is counted up.
- The number 16 represents that the network is unreachable.

Regular Update

When Regular Update received, routers update the table based on

- Destination IP Address
- Next Hop Address
- Metric
- Elapsed time since last update

Elapsed Time

To broadcast regular update(update message) every 30 seconds to the next hops. If elapsed time exceeds 180 seconds, routers recognize the routing path is dead.

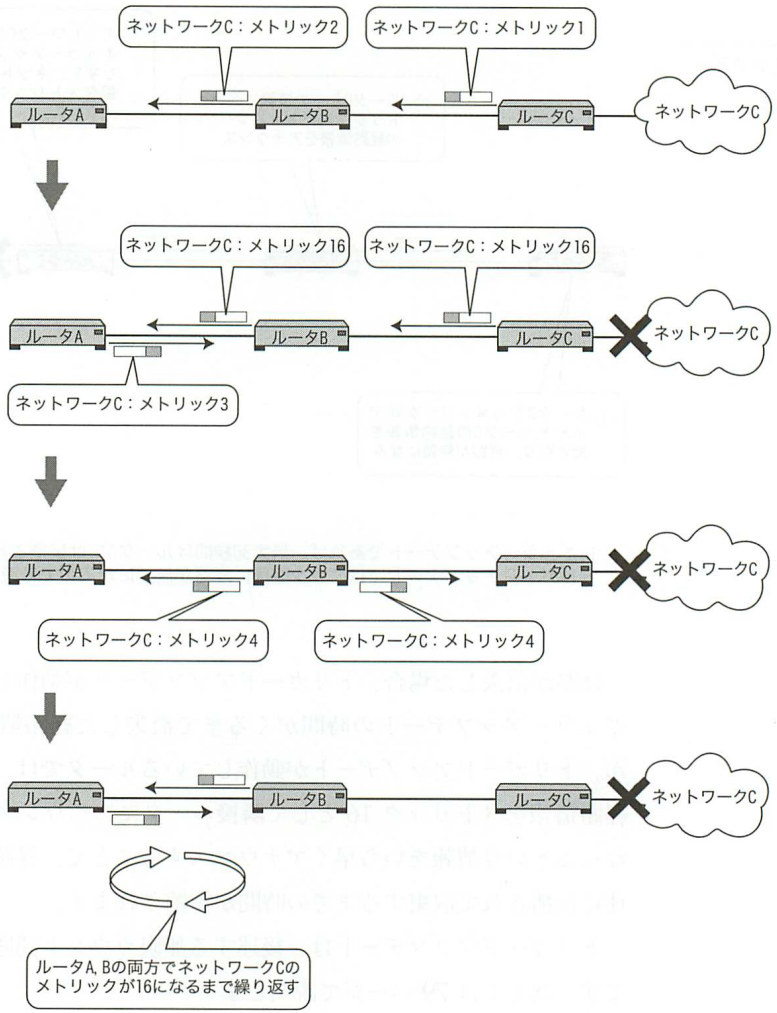
Removing Path

If elapsed time exceeds 180 seconds, routers recognize the routing path is dead(not removed). If elapsed time exceeds 120 seconds, routers remove the routing path.

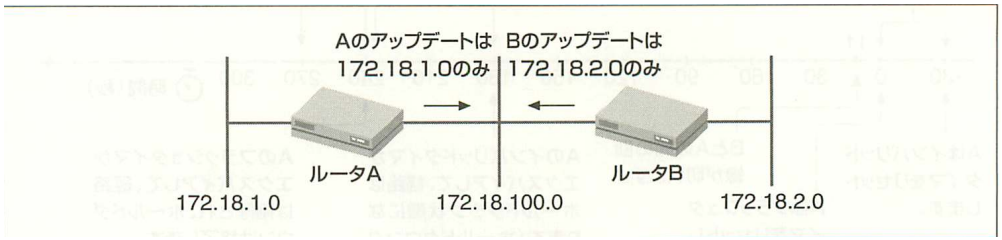
Triggered Update

To reduce the time of removing dead path, If the network structure changed, routers quickly send path information to next routers.

Avoid Loop


ネットワークC：メトリック2
ネットワークC：メトリック1
ルータA
ルータB
ルータC
ネットワークC
ネットワークC：メトリック16
ネットワークC：メトリック16
ルータA
ルータB
ルータC
ネットワークC
ネットワークC：メトリック3
ルータA
ルータB
ルータC
ネットワークC
ネットワークC：メトリック4
ネットワークC：メトリック4
ルータA
ルータB
ルータC
ネットワークC
ルータA, Bの両方でネットワークCの
メトリックが16になるまで繰り返す

Split Horizon

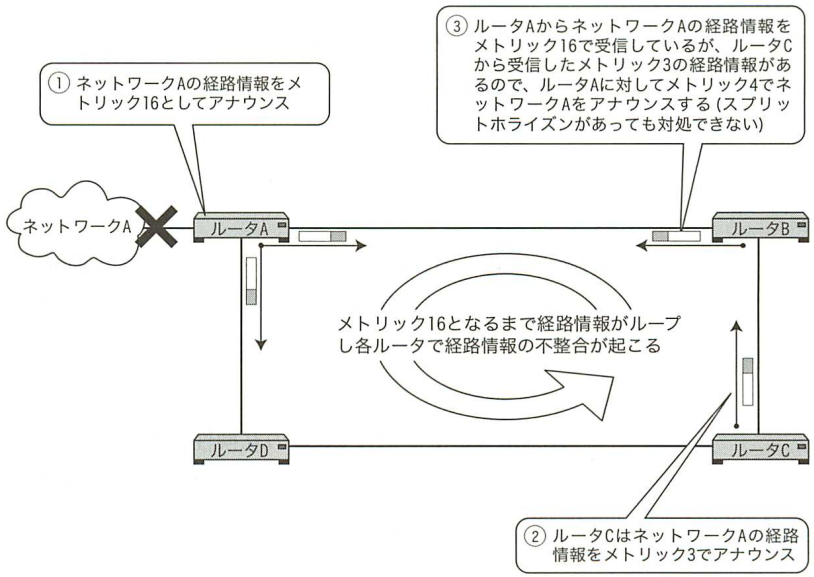


Not send the routing update to sender back

Poizoned Riverse

If a path is down, send information whose metric is 16.

Unavoidable Infinity Counting



However using Split Horizon and Poizoned Riverse, unavoidable infinity counting occured. Countermeasure is only reducing time to convergence by Triggerd Update.

RIP v2

RIP v1 is classful routing protocol, but RIP v2 is classless.

Class

クラス	プリフィックス	IP アドレス範囲	1 つのネットワークあたりのホスト数	プライベートアドレス
A	0	0.0.0.0〜 127.255.255.255	16,777,214 個	10.0.0.0〜 10.255.255.255
B	10	128.0.0.0〜 191.255.255.255	65,534 個	172.16.0.0〜 172.31.255.255
C	110	192.0.0.0〜 223.255.255.255	254 個	192.168.0.0〜 192.168.255.255
D	1110	224.0.0.0〜 239.255.255.255	（マルチキャスト用）	-
E	1111	240.0.0.0〜 255.255.255.255	（実験用）	-

Problems on RIP

- Take a long time to convergence.
- The maximum of the metric is 15.
- Can not detect the true shortest path (e.g. considering bandwidth).

IGRP and EIGRP

Interior Gateway Routing Protocol Enhanced Interior Gateway Routing Protocol

- Cisco Inc. developed this protocol.
- Only use with Products of Cisco Inc.

OSPF

Open Shortest Path First

- using Link State Method.

Features of OSPF

- not use Transport Protocol.
- use Unicast and Multicast.
- Metric is cost considering bandwidth or delay
- Routing Loop does not happen.
- Saving bandwidth and convergence is fast.
- Hierarchial routing for large-scale network

OSPF Packets

- Hello
- Database Description
- Link State Request
- Link State Update
- Link State Acknowledgement

LSA and LSDB

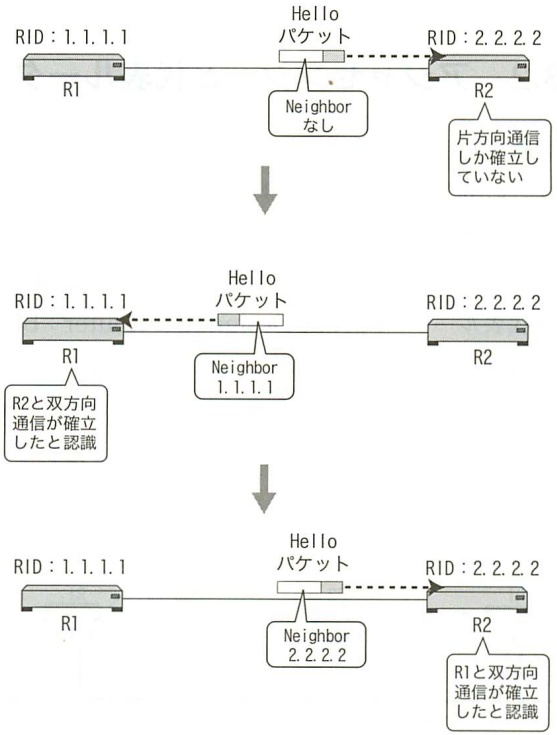
In OSPF network, each router has information of network topology as LSDB(Link State Data Base). LSA(Link State Advertisement) is an entry of LSDB. LSA types.

- Router-LSA
- Network-LSA
- Network-Summary-LSA
- ASBR-Summary-LSA
- AS-External-LSA

Behaviour of OSPF

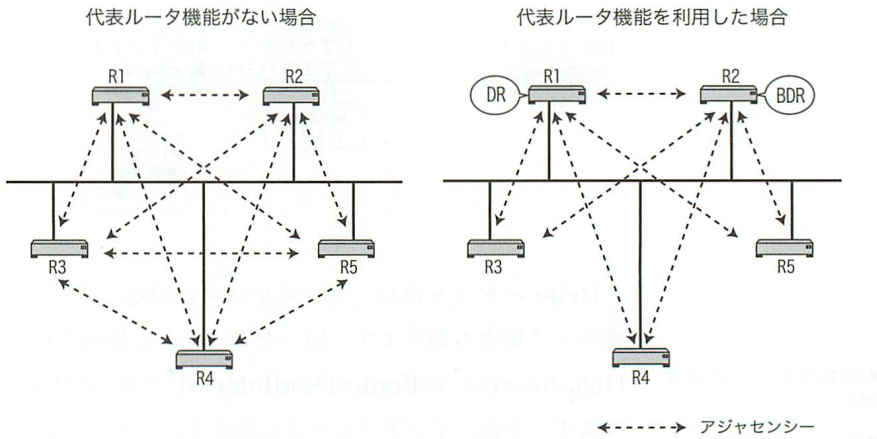
- Detect Neighbors.
- Elect Designated Routers.
- Synchronize LSDB.
- Each router calculate the shortest path based on LSDB.

Detect Neighbors



One router send hello packet with multicast, another one which received the packet responses, then connection established. This process is like TCP.

Elect Designated Routers

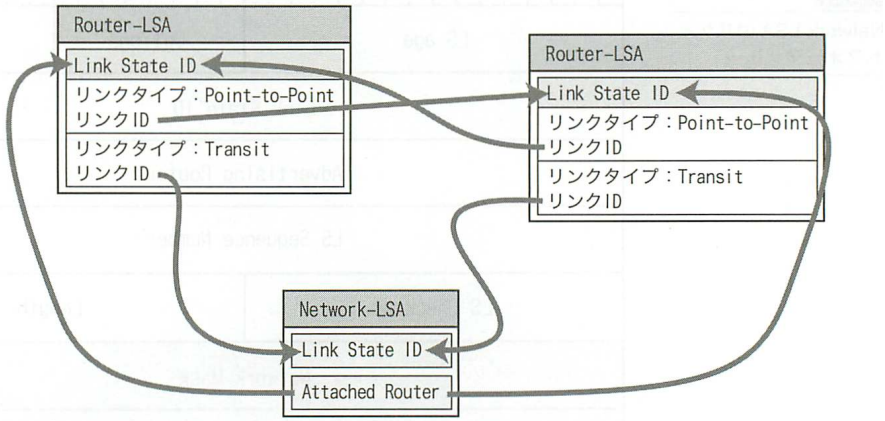


Instead of establishing adjacency with all neighbors, each router establishes one with DR and BDR router.
Electing process is too complex. . .

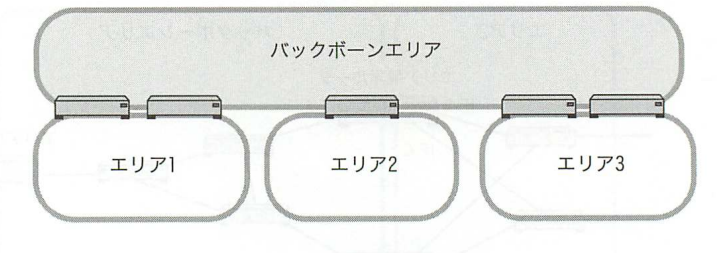
Synchronize LSDB

- Routers can detect diffrence among their LSDB by exchanging Database Description Packets.
- If there is diffrence, router send Link State Request Packet to make up a lack.
- The router which received that packet returns Link State Update Packet.
- Finally, Link State Acknowledgment Packet is sent.

Router-LSA and Network-LSA



Routing among Areas



OSPF supports Routing among Areas for large-scale network.

Features of Routing among Areas

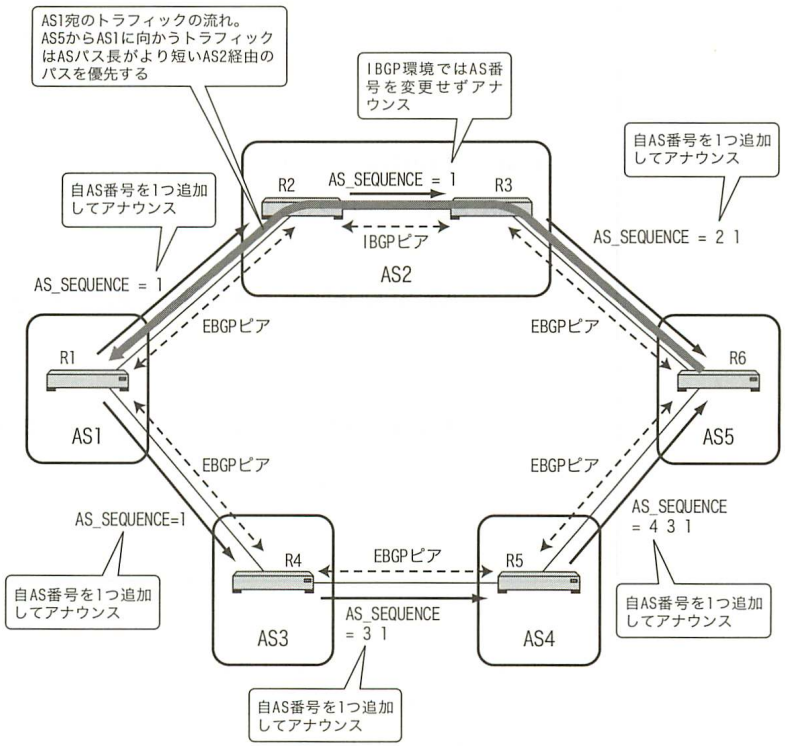
- Router-LSA and Network-LSA are flooding within an area.
- LSDB are managed by each area.
- Routers within an area know only LSDB of their own area.
- The shortest path are structured by each area.
- Routing of other area is caluculated by Distance Vector Method.
- Thanks to Backbone Area, Loop Routing can be avoided.

BGP

Border Gateway Protocol

- Path Vector Method
- TCP(port 179)

Path Vector Method



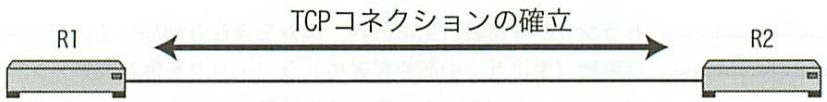
• AS番号の情報は、一番右側が起点のAS番号となり、他のASを経由するたびに左端に1つずつASの番号が追加される。

Routing Loop can be avoided by memoring path(AS number).

Behaviour of BGP

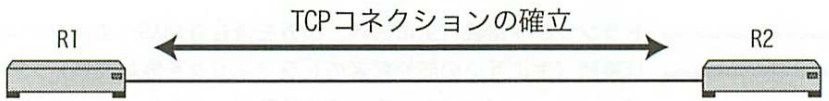
- Establish TCP Connection
- Exchange Basic Information
- Exchange Routing Information
- Confirm Keep Alive
- Update Diffrence

Establish TCP Connection



- R1/R2のどちらから確立してもかまわないが、採用されるのは先に確立されたもののみ。同じタイミングによる衝突が発生した場合、より大きな値のルータIDを持つルータのコネクションを採用。

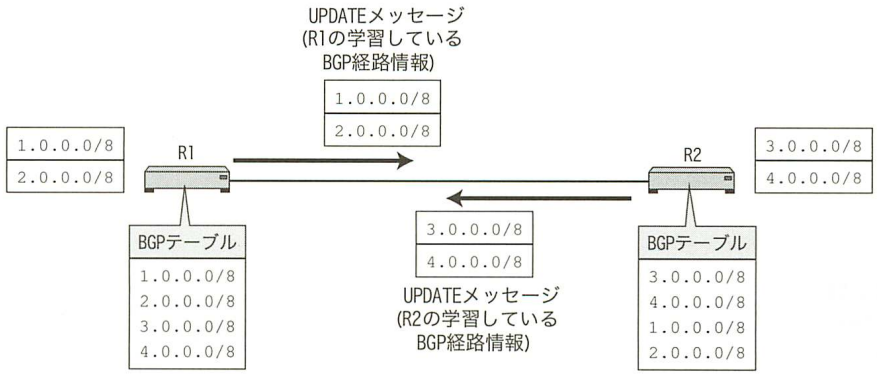
Exchange Basic Information



- R1/R2のどちらから確立してもかまわないが、採用されるのは先に確立されたもののみ。同じタイミングによる衝突が発生した場合、より大きな値のルータIDを持つルータのコネクションを採用。

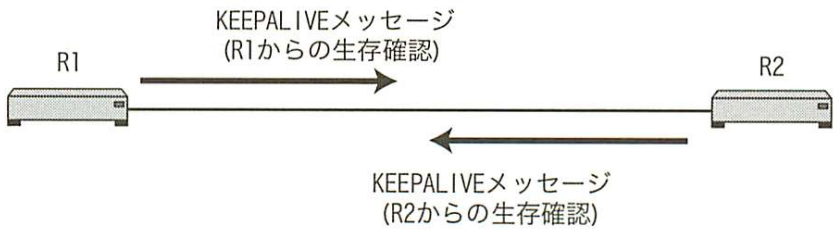
Using OPEN Message.

Exchange Routing Information



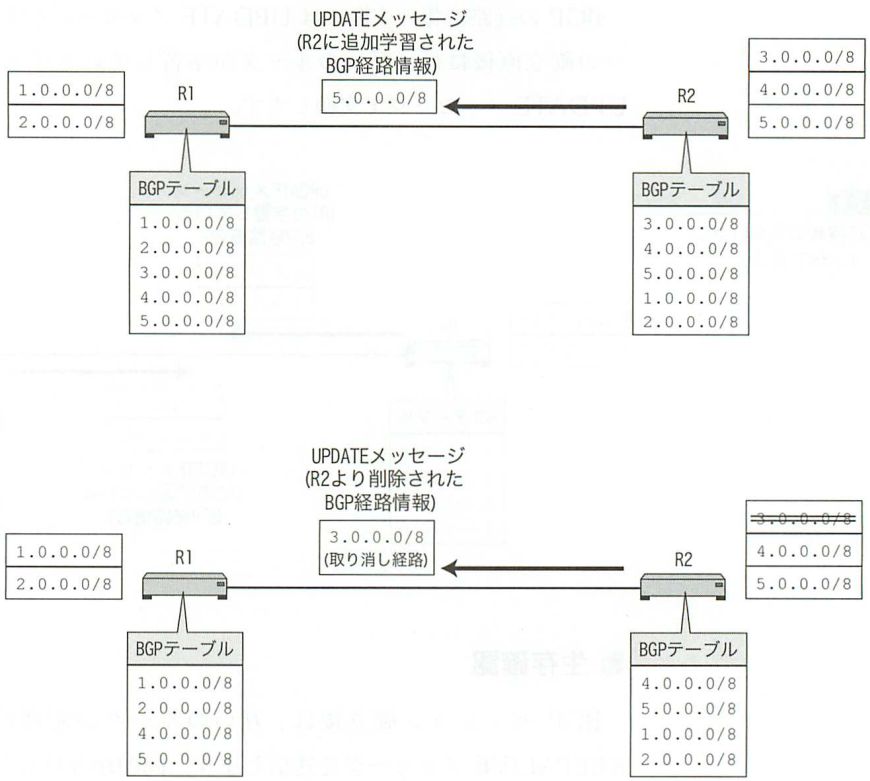
Using UPDATE Message.

Confirm Keep Alive



Using KEEPALIVE Message.

Update Diffrence



Using UPDATE Message.