Route Optimization (intra-AS)

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Goal of route optimization

- Static routing:
  - More predictable and safer
- Dynamic routing:
  - Automatically reacts on topology changes
  - Lower administration
  - Higher CPU and memory utilization
  - Consumes bandwidth

Using route optimization, we influence the process of best routes selection

- either selection from multiple routes configured statically or routes learned from routing protocol

Route optimization: How to influence routing decision ?

- Selection of proper routing protocol
  - Metric
  - Load balancing support`
- Configuration of routing protocol and link parameters
  - setting of link costs
  - creating router areas, summarization
  - default route propagation, route filtering
  - …
- Local definition of packet forwarding rules for particular router

Metric

- Metric of link/path determines the preference of that link/path
  - Lower metric is preferred
- Various metrics reflect current link properties
  - Scalar metric
  - Composite metric
    - We need to compare metric values
      - Transformed to scalar metric (coefficients)
      - The same transformation method should be used at every router
- Static and dynamic metric
  - Dynamic metric incorporate instant link parameters (may change rapidly)
  - Commonly, only static metric is used
  - Risk of route flapping when dynamic metric of a link changes too often
    - Dynamic measurements of link characteristics (load, error rate) needs to be averaged over time

Load balancing

- How many routes to the same network are maintained in routing table ?
  - Equal-cost load balancing – limited by maximum paths allowed
  - Unequal-cost – limited by variance (and max. paths)
- Load balancing method
  - Per-packet – round-robin, slower implementation (SW)
  - Per-source/Per-destination/Combination of both
    - faster (easier HW implementation when using route cache)
    - load balancing efficiency depends on traffic pattern

Default routes

- Default route limits number of records in routing tables
- Denoted as 0.0.0.0/0
  - Matches every packet
- Static default
  - Possibly more floating static defaults
- Dynamic default (propagated by/learned from IGP protocols)
  - Propagated as 0.0.0.0/0 or as specially-tagged records
  - Receiving router chooses from candidate defaults based on normal metric
  - Origination of default route:
    - Redistribution of static default
    - Router itself is the source of default
      - (router itself doesn't have to have default in it's routing table, but a set of specific routes instead)

Multiprotocol Routing

Multiprotocol Routing - Principle

- Route tables filled-in with routes by more routing processes (protocols)
- Routes learned from multiple routing protocols are uncomparable
  - various routing protocols use noncompatible metrics
- If multiple (potentially different) paths to some network are learned from multiple routing protocols, router must decide which one to place into routing table

Reasons for multiprotocol routing

- History of particular network
- Limited routing protocol support in routers and/or host operating systems
- Different routing protocols feasible in various parts of internetwork
  - fast LANs
  - slow WAN links
  - dial-on demand circuits
  - …

Multiprotocol routing Administrative distance

- Administrative distance (AD) – specifies preference of particular routing protocol
  - AD is Cisco term, but the concept is general
  - Route with lower AD is always better
    - Regardless of metric values
  - Only route metrics with the same ADs can be compared
  - AD has only local scope (not propagated between routers)
- If a path is learned by multiple routing protocols, path from more preferred routing protocol is placed into routing table
  - Only if multiple paths are learned from the same routing protocol, protocol metric is used to choose between them

Administrative Distance settings

- Common AD settings:
  - Connected < Static < OSPF < RIP
    - (lower is more preferred)
- Cisco AD default values:
  - Connected: 0 (cannot be changed)
  - Static 1
  - IGRP (Cisco) 100
  - OSPF 110
  - IS-IS 115
  - RIP 120

Tricks with AD setting

- Set AD for routes to specific networks only
- Set AD for routes received from some neighbor
- Set AD=255: do not use that route
- …

Floating Static Routes

- Floating static route = static route with worse administrative metric than normally used route
- Becomes active ("floats up") when the route normally used is lost
  - routing protocol removes route
  - Next hop specified in primary static route becomes unreachable
- Often used with dial-on-demand links
  - floating static route forwards packet via dial-on-demand circuit

Routing Processes

- Router can run multiple separate routing processes (of various or the same routing protocols)
  - Every process works with subset of router's interfaces
    - multiple routing protocols on the same interface may be useful sometimes also
  - Cisco IOS: can support up to 30 routing processes (instances)
- More instances of the same routing protocol possible
  - Cisco: RIP is an exception, but RIP "contexts" may serve as workaround
- Routing table filled by all routing processes
  - But even DV routing processes have to maintain separate data structures (routing tables of only that protocol)
- Routing processes don't interchange information if not explicitly instructed to do so
- Information interchange can be configured using redistribution

Redistribution

- Redistribution = interchange of information between routing processes (and appropriate protocols)
  - Redistribution of static routes or connected networks into routing protocol is a special case
- Possibility to filter routes during redistribution
- One-way and Two-way redistribution

Problems with Redistribution (1)

- Redistribution from classless to classful protocol
  - Distributing subnets (subnetted major networks) from classless into classful protocol cause problems
    - See http://www.cisco.com/warp/public/105/52.html
    - Cisco: When redistributing from classful routing protocol into OSPF, only classful routes are redistributed by default. Use : „subnets“ keyword in redistribute command to override this behavior.
- Uncompatible metric
  - Route are redistributed with “default” metric
    - (“default” metric value may be specified)

Problems with Redistribution (2)

- Circular redistribution
  - when redistribution takes place on more routers
  - redistributed routes have to be filtered to prevent loops
  - Bad AD setting may cause problems
    - See http://www.cisco.com/warp/public/105/redist.html#ad
- Intra-AS traffic goes through other AS's routers
  - may be resolved by artifical increse of redistributed routes metric

Redistribution – advanced issues

- Possible to specify protocol-dependent parameters
  - metric-type (OSFP: E1,E2)
  - tag
  - …
- If protocol tags external routes, it will not export them again out of AS
- Recommended usege of redistribution if configured on more than one router:
  - oneway redistribution + default route distributed in opposite direction

Redistribution examples

- RIP and IGRP on single router
- RIP and OSPF on single router (external routes)
- Multiple independent routing processes of the same protocol on single router
- Circular redistribution with route filtering
- Typical scenerio:
  - Static routes into stub networks redistributed into backbone routing protocol
  - Dynamic routing protocol in backbone.
  - Stub networks reach other networks using default.

Route tagging

- Some routing protocols allow to append tag to routes they advertise
- Usage:
  - Candidate default route
  - External route
    - Internal routes always preferred over external (internal traffic shouldn't leave AS)
    - External routes should not be advertised back out of AS
  - User-specified route tagging + filtering or redistribution control based on route tags

Route Filtering

- Distance Vector Protocols: filtering of routes in routing updates
  - Rows of advertised/received updates filtered
  - Based on destination network or neighbor (update source)
- Link State Protocols:
  - calculation of SPF always based on entire topology database (no filtering of LSAs!)
  - filtering possible when placing routes into routing table
- Filtering during redistribution
- Cisco: redistribution achieved by Distribute lists (refer to ACL)
  - per routing protocol/per interface

Metric manipulation in DV protocols

- Metric may be manipulated in advertised or received routing updates
- May help to
  - give preference to particular route
  - defend against inter-AS traffic leaking AS
  - defend against circular redistribution

Passive Interface

- Route updates not sent out of passive interface
  - Received updates accepted
- Hellos not sent – adjacencies not established
- Applied on Ethernet stub network, dial-up lines, routing domain (AS) boundaries
- Network connected to passive interface normally advertised into routing protocol

Route Summarization

- Advantages
  - Fewer records in routing tables
  - Less bandwidth taken by routing updates
- Rules
  - Summarization on major network boundary or router choosen by administrator
    - Some routing protocols allows for summarization only at specific routers (OSPF: ABR, ASBR)
  - Summarization into classful network or general supernet
    - Only router which „owns“ the whole address range may summarize that range
  - Need for hierarchical IP addressing plan
- Behavior of routing protocols:
  - Some routing protocols summarize by default
    - In some of them, it is possible to turn it off (RIPv2, BGP), in others not (RIP)

Policy routing

- Extended form of static routing
- Route decision based on SOURCE (instead of destination) address or incoming interface of routed packet
  - may also depend on destination address
- Defined statically by "route maps" on particular router(s)
  - Entry format:
    packet matching criteria => outgoing interface | next hop
  - General format of route map entry: "match X set Y"
- Route maps have higher priority than routing tables
  - But apply only when outgoing interface is up
- Examples:
  - Two parallel links, traffic sourced from one subnet not allowed to pass the faster link (because of political reasons)
  - Two links to different ISPs; some internal subnets communicate with Internet via ISP1, others via ISP2

Labs

Load balancing: RIP, IGRP, OSPF (few notes about ISIS)
Floating static routes

RIP-OSPF redistribution (two-way at single router)
AD of routing protocols
RIP-RIP circular redistribution, RIP-OSPF circular redistribution (harmless)

OSPF-OSPF redistribution
Policy routing: debug ip policy, sh route map