Deploying and Troubleshooting Web Cache Communication Protocol (WCCP) for WAN Acceleration, Security, and Content Delivery

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Abstract

Deploying application centric services in a highly available and scalable transport network is challenging. Web Cache Communication Protocol (WCCP) was developed by Cisco many years ago for transparently deploying web caching (hence the name). More recently, it’s been used for Cisco and 3rd party security proxies, WAN accelerators, application proxies, Content Delivery Networks (CDN), and more. Many of these devices use and implement WCCP differently when proxied versus transparent. There are many implications to application availability, cluster scaling, router platform hardware specifics, include/exclude traffic strategies, asymmetric routing dependencies, and topology dependencies. In this session, we’ll cover implementing WCCP for scalability, availability, operations, and troubleshooting in light of platform specific capabilities across ISR, 7200, 7600, ASR, Nexus 7000, and Catalyst 3560/3750/4500/6500.
Housekeeping

- We value your feedback—don't forget to complete your online session evaluations after each session & complete the Overall Conference Evaluation which will be available online from Thursday.
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- Please switch off your mobile phones
- Please make use of the recycling bins provided
- Please remember to wear your badge at all times
WCCP Agenda

- Background
- Details
- Planning and Design
- Configuration
- Operations
- Troubleshooting
Background
Background

- WCCP Functions
- Generic Proxy Review
  - Forward
  - Transparent Forward
  - Reverse
  - Transparent Reverse
- WCCP History
Background
Redirect TCP/UDP to Cache

- No change to…
  - Client (i.e., proxy settings)
  - Server (i.e. specially published URLs)
  - Domain Name System (DNS)
  - Route path

- Ability to…
  - Include or exclude traffic with extended Access Lists
  - Balance to scale connections and cache storage
  - Preserve flow symmetry
  - Incur no additional cost
Background
Optional Services

- Routers authenticate caches via WCCP protocol message MD5 authentication based on a shared secret password
- Routers allow caches via group list Access List
- Caches bypass to return traffic to the original path
  - Static by source/destination
  - Dynamic based on authentication failure, overload, etc.
- Graceful Shutdown to preserve connections when taking a cache Out Of Service (OOS)
- Flow Protection to preserve flows through a farm Operational Insertion or Removal (OIR) event
**Background**

**Forward Proxy Cache (FPC)**

- PC browser configured with a company proxy
- PC does not resolve WEB but rather resolves FPC
- FPC resolves WEB on behalf of PC
- Company controls PC and FPC
- Used for corporate Internet policy enforcement
**Background**

**Transparent Forward Proxy Cache (TFPC)**

- PC resolves WEB rather than TFPC
- TFPC does **not** need to resolve WEB on behalf of PC
- Company does not have to own PC and TFPC
- Redirect with Web Cache Control Protocol (WCCP) or load balancer
- Used for corporate Internet security and service provider caching

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**Diagram:**

1. DNS Resolve www.company.com to WEB
2. PC:2000 > WEB:80
   - GET / HTTP/1.1
   - Host: www.company.com
3. TFPC:5000 > WEB:80
   - GET / HTTP/1.1
   - Host: www.company.com
4. WEB:80 > TFPC:5000 200 OK
5. Store Retrieved File with Reply Headers
6. WEB:80 > PC:2000 200 OK
Background
Reverse Proxy Cache (RPC)

- PC browser resolves RPC as if it’s WEB
- RPC is configured with a rule to forward requests destined for host www.company.com to WEB
- Used for Internet content provider Content Delivery Networks
**Background**

**Transparent Reverse Proxy Cache (RPC)**

- PC browser resolves WEB rather than TRPC
- TRPC does not have a rule to forward host www.company.com to WEB
- Redirect with Web Cache Control Protocol (WCCP) or load balancer
- Used for web server offload
Background

History

- WCCPv1 developed in 1997 by Cisco Systems and publicly released in July 2000
  - Provided to appliance vendors under license
  - First implemented in IOS 12.0
  - Web TCP 80 only and no bypass option
- WCCPv2 published as an IETF draft in July 2000 to make the specification open and remove the requirement for licensing
  - Working group was disbanded and draft was allowed to expire
  - First implemented in IOS 12.0(5)T and available on all routers
  - Planned enhancements
    - Configurable WCCP Router ID
    - WCCP Variable Timers – Improved FailOver
    - Improved Interaction between WCCP and NetFlow
- WCCPv3 is an internal specification targeted at IPv6 that was never released
Background
WCCP Client or Cache Support

- Cisco has numerous WCCP Client implementations:
  - Wide Area Application Services (WAAS)
  - IronPort Systems Web Security Appliance (WSA)
  - Application and Content Networking System (ACNS)
  - Enterprise Content Delivery System (eCDS – planned)
  - Virtual Desktop Services (VDS – planned)

- The following non-Cisco products are also known to have WCCP Client implementations:
  - Riverbed, Juniper (Peribit), Bluecoat, Expand Networks, NetApp, Silverpeak, Citrix, Squid
  - There is no WCCP certification. Not all WCCP clients are created equal!
Background
WCCP Server or Router Support

- Cisco is currently the only vendor with a WCCP Server implementation

- The following platforms support WCCP:
  - Internetwork Operating System (IOS) since 12.0
    - In CEF switching path since 12.1T
  - Catalyst 3550 Switches (partial v2 implementation)
  - Catalyst 3560/3750 Switches since 12.2(37)SE
  - Catalyst 4500/4948 Switches since 12.2(31)SG
  - Catalyst 6500/7600 Switches since 12.1E
  - Cisco ASA 5500 / PIX 515, 535 since 7.1.2 (HTTP only)
  - Cisco ASR1K with IOS XE 2.2
  - Nexus 7000 with 4.1(2)
### Details

#### Definitions

- **Devices**
  - WCCP client – cache, web cache, engine, accelerator, appliance, proxy, etc.
  - WCCP server – router or L3 switch

- **Service Group (SG)**
  - Unique and arbitrary number from 0 to 255
  - Web-cache is the only well-known service group represented by SG = 0; All other SGs are considered dynamic SGs
  - Designated cache or lead cache (elected by lowest IP address) instructs router(s) on traffic redirect policy

- **Farm or Cluster**
  - Group of up to 32 caches associated with up to 32 routers using a common SG
  - All WAEs in a cluster must be configured identically

- **Priority**
  - Value of 0 to 255 to control evaluation order on an interface
  - Higher priority SG is evaluated before lower priority SG
  - Only one SG is processed on an interface though many may be evaluated
Details
Registration

- **Cache**
  - Router IP address (not necessarily the Router-Id)
  - Service Group(s)
  - Assignment Method
  - Redirect Method
  - Return Method
  - Egress Method
  - Shared secret password (optional)
  - “Here I Am” sent by cache every 10 seconds (WAAS does 2 seconds)

- **Router**
  - Service Group(s) configured globally
  - Intercept policies configured on interfaces are not required for registration
  - WCCP Router-Id is selected based on the highest IP address on the router or highest loopback (if enabled)
  - “I See You” returned by router with data on all known caches
WCCP Functions

- Intercept – Identify packets for WCCP processing (in or out)
- Assign – Select the cache
- Redirect – Router sends the packet to the cache
- Return – Cache sends the packet back to the router
- Egress – Cache may ignore WCCP negotiated return by using another return method like IP forwarding (routing) or generic GRE
WCCP
Redirect In or Out

WCCP Redirect-in

Ingress Interface  Egress Interface

L2/GRE  L2/GRE

WCCP Enabled Appliance

WCCP Redirect-out

Ingress Interface  Egress Interface

L2/GRE  L2/GRE

WCCP Enabled Appliance

WCCP Exclude-in
Details

Intercept

- Ingress or egress on an interface (ip wccp SG redirect in/out)
- A return packet is not intercepted on an interface if the packet is sourced from the cache IP address or returned in a WCCP GRE tunnel
- Option to deny intercept of all packets entering an interface from intercept policies on all other router interfaces (ip wccp redirect exclude in)
- Only one SG is executed on an interface though multiple can be evaluated
- IOS and NX-OS provide optional support to evaluate all SGs configured on an interface in order of highest WCCP priority (ip wccp check services all)
- Catalyst 6500 evaluates all SGs regardless of WCCP SG priority in order of lower SG value (web-cache SG 0 is always first)
## Details

### Cisco Cache Service Groups

<table>
<thead>
<tr>
<th>ID</th>
<th>Product</th>
<th>Name</th>
<th>Protocol</th>
<th>Port</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>WSA/ACNS</td>
<td>web-cache</td>
<td>6 (TCP)</td>
<td>80</td>
<td>240</td>
</tr>
<tr>
<td>53</td>
<td>ACNS</td>
<td>dns</td>
<td>17 (UDP)</td>
<td>53</td>
<td>202</td>
</tr>
<tr>
<td>60</td>
<td>ACNS</td>
<td>ftp</td>
<td>6 (TCP)</td>
<td>21</td>
<td>200</td>
</tr>
<tr>
<td>61</td>
<td>WAAS</td>
<td>tcp-promiscuous</td>
<td>6 (TCP)</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>62</td>
<td>WAAS</td>
<td>tcp-promiscuous</td>
<td>6 (TCP)</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>70</td>
<td>ACNS</td>
<td>https-cache</td>
<td>6 (TCP)</td>
<td>443</td>
<td>231</td>
</tr>
<tr>
<td>80</td>
<td>ACNS</td>
<td>rtsp</td>
<td>6 (TCP)</td>
<td>554</td>
<td>200</td>
</tr>
<tr>
<td>81/82</td>
<td>ACNS</td>
<td>wmt (MMS)</td>
<td>6 (TCP)/17 (UDP)</td>
<td>1755</td>
<td>201</td>
</tr>
<tr>
<td>83</td>
<td>ACNS</td>
<td>rtspu</td>
<td>6 (TCP)</td>
<td>554</td>
<td>201</td>
</tr>
<tr>
<td>89</td>
<td>WAFS</td>
<td>cifs-cache</td>
<td>6 (TCP)</td>
<td>139, 445</td>
<td>224</td>
</tr>
<tr>
<td>90-97</td>
<td>ACNS</td>
<td>custom</td>
<td>6 (TCP)</td>
<td>User Defined</td>
<td>220-227</td>
</tr>
<tr>
<td>98</td>
<td>ACNS</td>
<td>custom-web-cache</td>
<td>6 (TCP)</td>
<td>User Defined</td>
<td>230</td>
</tr>
<tr>
<td>99</td>
<td>ACNS</td>
<td>reverse-proxy</td>
<td>6 (TCP)</td>
<td>80</td>
<td>235</td>
</tr>
</tbody>
</table>
Details
Assign

- Assignment table is generated on the cache
- Assignment may include source/destination IP and port
- Lead or designated cache (lowest IP address in cluster) provides assignment table to all routers in SG
- Two assignment methods available
  
  **Hash**
  
  Byte level XOR computation divided into 256 buckets (default)
  Available on software IOS routers only

  **Mask**
  
  Bit level AND divided up to 128 buckets (7 bits)
  Available on all ASIC based L3 switches
  Available on software routers as of IOS 12.4(20)T
## Details

**WCCP Traffic Assignment—Mask**

### WCCP Redirect-in

N7K

Ingress Interface

- SIP = xxxxxxx00
- SIP = xxxxxxx11

### Egress Interface

- SIP = xxxxxxx01
- SIP = xxxxxxx10

### Table: WCCP Traffic Assignment

<table>
<thead>
<tr>
<th>SIP</th>
<th>DIP</th>
<th>SP</th>
<th>DP</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>xxxxxxx00</td>
<td>xxxxxxx</td>
<td>xxx</td>
<td>xxx</td>
<td>L2 to WAE-1</td>
</tr>
<tr>
<td>xxxxxxx01</td>
<td>xxxxxxx</td>
<td>xxx</td>
<td>xxx</td>
<td>L2 to WAE-2</td>
</tr>
<tr>
<td>xxxxxxx10</td>
<td>xxxxxxx</td>
<td>xxx</td>
<td>xxx</td>
<td>L2 to WAE-3</td>
</tr>
<tr>
<td>xxxxxxx11</td>
<td>xxxxxxx</td>
<td>xxx</td>
<td>xxx</td>
<td>L2 to WAE-1</td>
</tr>
</tbody>
</table>
Details
Redirect to Cache and Return from Cache

- **Redirect Method**
  
  WCCP GRE - Entire packet WCCP GRE tunneled to the cache (common cache default)
  
  Layer 2 - Frame destination MAC address rewritten to cache MAC

- **Return Method**
  
  WCCP GRE – Packet WCCP GRE returned router (may be returned to same router that performed redirect as in WAAS)
  
  WCCP Layer 2 – Frame returned to router MAC (Not yet supported in WAAS)
Details
Egress from Cache

- IP Forward
  Cache ARPs for default gateway and routes packet (WAAS default)

- WCCP negotiated return
  WCCP GRE
  WCCP L2 return (not yet supported in WAAS)

- Generic GRE
  Return in hardware to Catalyst 6500 Sup720/32 and 7600 (as of WAAS 4.1)
  Implemented since Catalyst 6500 and 7600 (EARL7 based) do not support WCCP GRE return in hardware
Details
WCCP Control Plane Messages

- Control plane messages exchanged over UDP 2048
- Here I Am (HIA)
- I See You (ISU)
- Redirect Assign (RA)
- Removal Query (RQ)
Details
Control Plane Messages

- Messages have different “Components” encoded as TLV

- List of components in WCCP message:
  
  - Security Info Component (SecI)
  - Router Identity Info Component (RII)
  - Web-Cache Identity Info Component (WCII)
  - Assignment Info Component (AI)
  - Alternate Assignment Info Component (AAI)
  - Capability Info Component (CI)
  - Redirect Assign Component (RA)
  - Service Info Component (SI)
  - Router View Information Component (RVI)
  - Web-Cache View Info (WCVI)
  - Assignment Map Component (AM)
  - Router Query Info Component (RQI)
  - Command Extension Component

- Each component serves a particular purpose

- Not all components are present in all messages

- Security Info Component and Service Info Component are present in all four messages
Details

Control Plane Messages (Cont.)

- **Receive ID:**
  - Incremented by Router for each WCCP message it sends
  - WCCP Client to reflect the Receive-ID back to router
  - Maintained separately for each Service Group

- **Membership Change Number (MCN):**
  - Incremented by Router if there was a change in Service Group membership
  - New WCCP Client information sent via RVIC

- **WCCP Clients publish the information about WCCP routers that they are talking to via WCVI**

- **Redirect Assign (RA) message:**
  - Comes from a designated CE
  - Specifies mask assignments for traffic to be redirected by the router
  - Identified by a Assignment Key/Assignment Change Number (ACN)
Details
Initial Handshake

WCCP Router

HIA (SecI, SI, WCII, WCVI)

ISU(SecI, SI, RII, RVI) RecvID:1

HIA (SecI, SI, WCII, WCVI) RecvID:1

ISU(SecI, SI, RII, RVI) RecvID:2 MCN:1

RA (SecI, SI, AI) Recv ID:2 MCN:1 ACN:1

HIA (SecI, SI, WCII, WCVI) RecvID:2

ISU(SecI, SI, RII, RVI) RecvID:3 ACN:1

WCCP Client

First HIA:
Introduce WCCP Client; Define Service Group Properties;

First ISU:
Acknowledge HIA; Accept Service Group Properties;
Initialize RecvID

Second HIA:
Echo RecvID; Set Assignment Weight and status

Second ISU:
Include WCCP Client in Router View; Increment RecvID;
Initialize Member Change Number

First RA:
Echo RecvID and MCN; Set Hash/Mask Tables
Initialize Assignment Change Number

Third HIA:
Echo RecvID & MCN;

Third ISU:
Increment RecvID; MCN Unchanged; Echo ACN
Details
Steady State

WCCP Router

HIA(Secl,SI,WCII,WCVI)
RecvID:n MCN:m ACN:p

ISU(Secl,SI,RII,RVI)
RecvID:n+1 MCN:m ACN:p

10s

10s

HIA(Secl,SI,WCII,WCVI)
RecvID:n+2 MCN:m ACN:p

ISU(Secl,SI,RII,RVI)
RecvID:n+2 MCN:m ACN:p

WCCP Client

HIA:
Echo RecvID;
Change Number, Assignment Key Unchanged

ISU:
Increment RecvID
Change Number, Assignment Key Unchanged

HIA:
Echo RecvID
Change Number, Assignment Key Unchanged

ISU:
Increment RecvID
Change Number, Assignment Key Unchanged

HIA:
Echo RecvID
Change Number, Assignment Key Unchanged
Details

Client Loss

WCCP Router

ISU(Secl,SI,RII,RVI)
RecvID:n MCN:m ACN:p

WCCP Client

WCCP Client fails to send HIA within 25 seconds

25s

RQ:
Query WCCP Client Directly

WCCP Client fails to respond to RQ within 5 seconds

5s

WCCP Client removed from Hash/Mask tables
Update Router View, Increment MCN
Planning and Design
Planning and Design

Use Cases

- **Security Proxy**
  - Authentication – Balance by client IP to avoid clients being authenticated as many times as there are caches
  - Storage – Balance by server IP to stick specific web sites to a cache and scale storage
  - Connections – Balance by client or server IP unless there is an upstream proxy (then load balance by client IP)
  - Failure – Balance by client IP to minimize affects of a cache failure on clients

- **Content Delivery Network**
  - Live video – Balance by client IP to scale connections
  - On demand video – Balance by server IP to scale storage
  - Portal only – Balance by client IP with redirect ACL match on server IP address

- **WAN acceleration**
  - Flow symmetry – Balance by opposite/mirror in each direction
  - Storage – Balance by client IP to maximize data redundancy
  - Connections – Balance by IP only except when there are one or few hosts with lots of connections then balance by client TCP port
  - Failure – Balance by client IP to minimize affects of a cache failure on clients
Planning and Design Checklist

- **Global placement**
  - Optimize links
  - Optimize applications

- **Local placement**
  - Client or server subnet
  - Dedicated subnet

- **Considerations**
  - Application
    - Include all exclude some
    - Include some exclude remaining
  - Availability (Failure Modes)
  - Balancing connections
  - Scaling storage
  - Multiple WCCP Service Groups
  - Loop avoidance

- **Devices**
  - Router software/hardware
  - Cache software

- **Configuration**
  - Service Group
  - Registration IP address
  - WCCP Router-id
  - Intercept in or out
  - Assign
  - Redirect
  - Return
  - Egress
  - Optional services
Planning and Design
Global Placement

- **Target links**
  - Object caching – Near client at WAN edge
  - Stream splitting - Near client at WAN edge
  - WAN Acceleration – Near client and server at WAN edge

- **Target applications**
  - Object caching – Near server, Internet edge, or branch WAN edge
  - Stream splitting - Near encoder, Internet edge, or branch WAN edge
  - WAN Acceleration – Close to client and server/Internet
Planning and Design

Originate Cache Source IP

- WCCP intercepted in from client OR out toward server
- Cache uses it’s own IP address as the source
- Server S1 replies to E1
- E1 replies to C1 spoofing IP address of S1
**Planning and Design**

Preserve Client IP on Dedicated Network

- WCCP intercepted in from client AND in from server
- Services balance on source from client and destination from server to maintain flow symmetry to same cache
- E1 spoofs C1 to S1
- S1 replies to C1
- E1 spoofs S1 to C1
Planning and Design
Preserve Client IP on Client Network

- WCCP intercepted in from client AND in from server
- Services balance on source from client and destination from server to maintain flow symmetry
- E1 must use WCCP GRE return to avoid loops when placed on client network
- E1 spoofs C1 to S1
- S1 replies to C1
- E1 spoofs S1 to C1
Planning and Design
Transparent Client Transit Network Loop

- R1 is HSRP/VRRP primary for clients and cache
- Routing across client subnet
- R1 upstream WAN failure
- Packets route across client subnet
- R2 intercepts packet a 2nd time and redirects to cache
- E1 receives packet for a 2nd time (WAAS drops packet)

- Device – WCCP GRE or L2 router
- Intercept – In only
- Assign – Mask or Hash
- Redirect – WCCP GRE or L2
- Return – WCCP GRE or L2
- Egress – IP Forward or WCCP negotiated

Network Solution
- Passive interface client subnet
- Route on inter-router subnet
- Use GRE return
- Move SG 61 in on LAN to 62 out on WAN
Planning and Design
Redundant Branch No Inter-Router Link

- R1 is HSRP/VRRP primary for clients and cache
- Routing across client subnet
- R1 upstream WAN failure
- Packets route across client subnet
- No intercept until packet leaves branch
- No loops!

- Device – WCCP GRE router
- Intercept – In/Out on WAN
- Assign – Mask or Hash
- Redirect – WCCP GRE
- Return – WCCP GRE
- Egress – WCCP negotiated
Planning and Design
Redundant L3 Switch

- R1 is HSRP/VRRP primary for clients and cache
- No routing across client subnet
- R1 upstream failure
- Packets route over redundant uplink

- Device – L3 switch
- Registration – sw1/sw2 interface IP
- Assignment – Mask
- Redirect - WCCP L2 redirect
- Return/Egress – IP forwarding
- Network Solution
  - Passive interface routing on all host subnets
  - Route on WAE subnet (no passive interface)
  - Preserves upstream WAN load balancing using CEF equal cost paths
  - Commonly Cisco Catalyst 3560, 3750, 4500, or 6500
Planning and Design
Scaling Transparent Caches

- **Assignment**
  - **Source IP** sticks a client to cache and balances all clients across all caches (use for video streaming, authenticating security proxies, and optimize client cache redundancy)
  - **Source port** balances clients across caches (use for data center replications)
  - **Destination IP** sticks server to cache and balances all servers across all caches (use to linearly scale web cache storage)
  - **Destination port** balances applications across caches (use to optimize server application cache redundancy with increased impact of cache loss on failure)

- **Flow symmetry**
  - Preserved by the cache using it’s source IP address
  - Preserved by applying the opposite/mirror assignment to return traffic
  - For web, web-cache for destination port TCP 80 and SG 95 source port TCP 80
  - For all TCP, SG 61 for source IP and SG 62 for destination IP
Planning and Design
Data Center WAN Distribution/Core

- **WAE with Interface Standby (N+1 Redundancy)**
  - Register – r1/r2 interface IP
  - Assign – Mask
  - Redirect – WCCP GRE or L2
  - Return/Egress - IP Forwarding, generic GRE (6500), or WCCP GRE (ASR)
  - Network
    - Engines on shared subnet between r1 and r2
    - Interface VLAN inter-core link with no WCCP

- **WAE with EtherChannel (N:N Redundancy)**
  - Register – Loopback IP
  - Assign – Mask
  - Redirect – WCCP GRE
  - Return/Egress - IP forward or generic GRE (6500)
  - Network
    - Engines on dedicated subnets (no interface standby)
    - Routed interface link (r1-r2) with no WCCP
Planning and Design
Data Center WAN Edge

- Local WAE Redirect and Return
  Register – r1/r2 interface IP
  Software router (7200/ISR)
    Assignment – Hash
    Redirect - WCCP GRE
    Return/Egress – WCCP GRE or IP forward
  Hardware router (6500/PFC3 or ASR)
    Assign – Mask
    Redirect – WCCP GRE
    Return/Egress – generic GRE (6500), WCCP GRE (ASR), or IP forward return
  Network
    Enable routing on engine subnet (no passive interface)
    MHSRP to alternate WAE default gateway (e1 to r1 and e2 to r2)
    Optional standby interface for router high availability

- Remote WAE GRE Redirect and Return
  Register – Remote r1/r2 loopback IP
  Assign – Hash (7200/ISR) or mask (6500/ASR)
  Redirect - WCCP GRE
  Return/Egress - WCCP GRE (ASR/7200/ISR) or Generic GRE (6500)
  Network
    Consider performance on 7200/ISR
Planning and Design
Data Center Asymmetric Routing Problem

- **Condition**
  - Branch route summarization
  - Connections sent to DC-A when application resides in DC-B
  - SYN and SYN/ACK not seen by same WAE

- **Solutions**
  - Advertise summary route for each data center to eliminate asymmetric routing
  - WAE in server farm distribution with WCCP or ACE
  - WAE cross registers with WAN edge or distribution routers in both data centers
Planning and Design
Data Center Asymmetric Routing Solutions

- WAE cross registers with WAN edge or distribution routers in both data centers
- WAE in server farm distribution with WCCP or ACE
Planning and Design
Two Data Center WAN Distribution

- Device – Catalyst 6500
- Register – r3/r4/r5/r6 loopback IP
- Assign - Mask
- Redirect - WCCP GRE
- Return/Egress - IP forwarding or generic GRE

Network

Engines (e1, e2, e3, e4,...) attached to WAN distribution

Interfaces from WAN (r1 and r2) have WCCP 61 in

Interfaces from Server Farms (r7,r8,r9,r10) have WCCP 62 in

No WCCP on inter-switch links between r3, r4, r5, and r6
Planning and Design
Two Data Center WAN Edge

- **Software router (7200/ISR)**
  - Register – r1/r2 loopback IP
  - Assign – Hash
  - Redirect - WCCP GRE
  - Return/Egress – WCCP GRE

- **Hardware router (6500/ASR)**
  - Register – r1/r2 loopback IP
  - Assign – Mask
  - Redirect - WCCP GRE
  - Redirect
  - Return/Egress - generic GRE (6500) or WCCP GRE (ASR)
Planning and Design
Two Data Center Server Farm

- Device – Catalyst 6500
- Inter-switch routed (N:N HA)
  - Register – r7/r8/r9/r10 Loopback IP
  - Assign – Mask
  - Redirect - WCCP GRE Redirect
  - Return/Egress - generic GRE (6500) or IP forward
  - Network – WAE EtherChannel
- Inter-switch VLAN (N+1 HA)
  - Register – r7/r8/r9/r10 interface IP
  - Assign – Mask
  - Redirect - WCCP L2 Redirect
  - Return/Egress – IP forward
  - Network – WAE Standby Interface
Planning and Design
Choosing the Right Mask for Many Branches

- **Branch**
  - DHCP allocated addressing
  - Balance hosts to multiple engines 0x1 to 0x7F (or similar)
  - Balancing to a single engine (mask selection is irrelevant)

- **Retail Data Center**
  - Site /24 allocation per site
  - Balance sites or engines with 0x100 to 0x7F00 (or similar)

- **Enterprise Data Center**
  - Regional/16 allocation
  - Balance regions with 0x10000 to 0x7F0000 (or similar)

\[
\begin{align*}
0xF &= 0000:0000.0000:0000.0000:0000.0000:1111 \\
0xF00 &= 0000:0000.0000:0000:1111.0000:0000 \\
0xF0000 &= 0000:0000.0000:1111.0000:0000.0000:0000
\end{align*}
\]
Planning and Design
Catalyst 6500 WCCP Planning

- Mask
  1 to 7 bits representing 2 (2^1) to 128 (2^7) buckets
  Mask TCAM is 4096 entries
  WCCP redirect ACL deny statements don’t use mask TCAM
  WCCP redirect ACL permit statements use up to the Number of ACL Entries * Number of Buckets
  For 7 bit mask, TCAM could be exhausted in 32 permit ACL entries
    (4096/27)
  For 1 bit mask, TCAM could be exhausted in 2048 permit ACL entries
    (4096/21)

- Optional global accelerated keyword
  Restricts registration to mask assignment and L2 redirect only
  Implemented to ensure hardware processing on Sup2

- Multiple SGs are processed in lowest SG numeric order
Planning and Design
Cache Physically out of Path Considerations

- Path MTU Discovery – Caches will not be in the path
- TCP MSS – Used to manage MTU but must be implemented bidirectionally (WAAS uses 1432 by default)
- Capturing Fragments – Port information is missing from non-initial fragments when using port based permit ACL
- Creating Fragments – WCCP GRE adds headers
- Router fragmentation will drive up the CPU
# Planning and Design
## Core Platform Recommendations

<table>
<thead>
<tr>
<th>Function</th>
<th>Nexus 7000</th>
<th>Cat 6500 Sup 2T</th>
<th>Cat 6500 Sup720/32 7600</th>
<th>Cat 6500 Sup2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registration Timers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial</td>
<td>???</td>
<td>Not supported</td>
<td>Not supported</td>
<td></td>
</tr>
<tr>
<td>Assign</td>
<td>Mask Only</td>
<td>Mask</td>
<td>Mask</td>
<td></td>
</tr>
<tr>
<td>Redirect</td>
<td>L2</td>
<td>GRE or L2</td>
<td>GRE or L2</td>
<td>GRE or L2</td>
</tr>
<tr>
<td>Redirect List</td>
<td>L3/L4 ACL</td>
<td>Extended ACL</td>
<td>Extended ACL</td>
<td>Extended ACL</td>
</tr>
<tr>
<td>Direction</td>
<td>In or Out</td>
<td>In</td>
<td>In</td>
<td>In</td>
</tr>
<tr>
<td>Return</td>
<td>L2 only</td>
<td>GRE or L2</td>
<td>L2</td>
<td>L2 or generic GRE</td>
</tr>
<tr>
<td><strong>VRFs</strong></td>
<td>Supported</td>
<td>Supported</td>
<td>Not supported</td>
<td>Not supported</td>
</tr>
<tr>
<td><strong>IOS</strong></td>
<td>4.2(6); 5.0(3)</td>
<td>TBD</td>
<td>6500</td>
<td>12.1(27)E; 12.2(18)SXF14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.2(18)SXF14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.2(33)SXH4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.2(33)SXI/2/2a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7600</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.2(18)SXD1</td>
<td></td>
</tr>
</tbody>
</table>
## Planning and Design
### Edge Platform Recommendations

<table>
<thead>
<tr>
<th>Function</th>
<th>Software</th>
<th>ASR 1000</th>
<th>Cat 4500</th>
<th>Cat 3750</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registration Timers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supported</td>
<td>Supported</td>
<td>Not supported</td>
<td>Not supported</td>
<td></td>
</tr>
<tr>
<td>Hash or Mask</td>
<td>Mask Only</td>
<td>Mask only</td>
<td>Mask only</td>
<td></td>
</tr>
<tr>
<td>Redirect</td>
<td>GRE or L2</td>
<td>L2 only</td>
<td>L2 only</td>
<td></td>
</tr>
<tr>
<td>Redirect List</td>
<td>Extended ACL</td>
<td>No Redirect List Support</td>
<td>Extended ACL (no deny)</td>
<td></td>
</tr>
<tr>
<td>Direction</td>
<td>In or Out</td>
<td>In only</td>
<td>In only</td>
<td>In only</td>
</tr>
<tr>
<td>Return</td>
<td>GRE or L2</td>
<td>L2 only</td>
<td>L2 only</td>
<td></td>
</tr>
<tr>
<td>VRFs</td>
<td>Supported</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>IOS</td>
<td>12.1(14); 12.2(26); 12.3(13); 12.4(10); 12.1(3)T; 12.2(14)T; 12.3(14)T5; 12.4(15)T8;15.0(1)M</td>
<td>2.4(2)</td>
<td>12.2(50)SG1</td>
<td>12.2(46)SE</td>
</tr>
</tbody>
</table>
Configuration
# Configuration Control

<table>
<thead>
<tr>
<th>Function</th>
<th>Cache</th>
<th>Router</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interception Direction</td>
<td>Unaware</td>
<td>Configured and Applied</td>
</tr>
<tr>
<td>Registration/Timers</td>
<td>Request</td>
<td>Response</td>
</tr>
<tr>
<td>Assignment (Hash/Mask)</td>
<td>Configured/Created</td>
<td>Applied</td>
</tr>
<tr>
<td>Redirect</td>
<td>Request/Negotiated</td>
<td>Response/Negotiated</td>
</tr>
<tr>
<td>Return</td>
<td>Request/Negotiated</td>
<td>Response/Negotiated</td>
</tr>
<tr>
<td>Egress</td>
<td>Configured and Applied</td>
<td>Unaware</td>
</tr>
</tbody>
</table>
Configuration Parameters

- Router
  - Global
    - Service Group
    - Redirect List
    - Password
    - Group List
  - Interface
    - In
    - Out
    - Exclude In
  - Access-List

- Cache
  - Service Group
  - Router IP Address
  - Assignment
    - Hash
    - Mask
  - Redirect/Return
    - WCCP GRE
    - L2
  - Egress method
    - IP forwarding (routing)
    - WCCP negotiated
    - Generic GRE
  - Enable
WCCP
Common and Specific Configuration

- **WAE common configuration**
  
  ```
  wae(config) # wccp router-list N <ip-address-list>
  wae(config) # wccp version 2
  ```

- **Router common configuration**
  
  ```
  rtr(config) # ip wccp 61 <redirect-list acl-name>
  rtr(config) # ip wccp 62 <redirect-list acl-name>
  ```

- **Interface configuration**
  
  ```
  rtr(config-if) # ip wccp <61|62> redirect in
  rtr(config-if) # ip wccp <61|62> redirect out
  rtr(config-if) # ip wccp redirect exclude in
  ```

- **WCCP cache configurations vary for**
  
  Assignment (WAAS default is hash)
  Redirect (WAAS default is WCCP GRE)
  Return (WAAS default is WCCP GRE)
  Egress (WAAS default is IP forward)
# Configuration
WAAS Redirect, Return, and Egress Configuration

<table>
<thead>
<tr>
<th>IP Forward Return / Egress</th>
<th>WCCP GRE Redirect</th>
<th>WCCP L2 Redirect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7200,ISR,ASR,6500</strong></td>
<td>wccp tcp-promiscuous router-list 1</td>
<td>7200,ISR,ASR,6500,3750/3560,4500,7K wccp tcp-promiscuous router-list 1 12-redirect mask-assign wccp tcp-promiscuous mask src-ip-mask &lt; 0xF</td>
</tr>
<tr>
<td><strong>7200,ISR,ASR</strong></td>
<td><strong>egress-method negotiated-return</strong> <strong>intercept-method wccp</strong></td>
<td><strong>Not supported</strong></td>
</tr>
<tr>
<td><strong>wccp tcp-promiscuous router-list 1</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WCCP GRE Return / Egress</th>
<th><strong>7200,ISR,ASR</strong></th>
<th><strong>egress-method generic-gre</strong> <strong>intercept-method wccp</strong></th>
<th><strong>7200,ISR</strong></th>
<th><strong>Not supported</strong></th>
<th><strong>Not supported (minor alarm)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>wccp tcp-promiscuous router-list 1</strong></td>
<td></td>
<td></td>
<td><strong>wccp tcp-promiscuous router-list 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6500,ASR</strong></td>
<td>**wccp tcp-promiscuous mask src-ip-mask &lt; 0xF</td>
<td>0xF00</td>
<td>0xF0000 &gt;</td>
<td>**wccp tcp-promiscuous mask src-ip-mask &lt; 0xF</td>
<td>0xF00</td>
</tr>
<tr>
<td><strong>mask-assign</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Configuration

Best Practices

- **Registration**
  - Do NOT use a virtual gateway address (HSRP, VRRP, GLBP)
  - Use interface IP address if L2 adjacent to WCCP router
  - Use highest loopback address if not L2 adjacent to WCCP router
  - Do not configure large MTU (>1500 bytes) on cache gateway router interfaces
  - Consider Control Plane Policing of large assignment tables with large WCCP farms

- **Assignment**
  - Use mask assignment for all hardware routers (6500, 7600, ASR)
  - Use the appropriate mask based on balancing requirements and router capabilities
  - Use hash assignment on software routers (7200, ISR)

- **Redirect**
  - WCCP GRE redirect for 6500/PFC3, 7600, ASR, ISR, 7200
  - L2 redirect for Catalyst 6500, 4500, 3750, 3560
  - Catalyst 6500 redirect list should be basic extended ACL with no permit port ranges, DSCP matches, etc.

- **Return/Egress**
  - IP forwarding when you can
  - WCCP GRE return on ISR/7200 (consider performance) and ASR
  - Generic GRE return on Catalyst 6500 and 7600 if asymmetric routed data center or on host subnet
  - For GRE return, implement static /32 route to WCCP router id or GRE loopback for optimal return
Operations
Operations
WCCP Cluster Changes

- Planned Actions
  
  Cache In Service – Cisco flow protection
  Cache Out of Service – Cisco graceful shutdown and flow protection

  Application In or Out of Service
    
    Routers WCCP redirect ACL changes on the fly
    Cache bypass or Pass Through (PT) policy

- Unplanned Events
  
  Probability of failure – WCCP adds no additional device to the infrastructure thereby maximizing the network MTBF

  Cache hard failure – WCCP relies on hello timers of 3 X 10 seconds (plans to offer tunable timers)

  Cache soft failure – Caches should unregister WCCP upon detecting a process failure

  Failure domain – WCCP supports router redirect deny ACL or cache bypass thereby limiting the application failure domain (i.e. call control and management traffic)
**WCCP**

**Typical Redirect List**

- **Permit all applications but deny specific**
  
  Avoid redirection of management traffic with a universal ACL

  Apply bidirectional ACL to service groups 61 and 62

  Create the redirect ACL before enabling WCCP service groups 61 and 62

  Do not enable logging on WCCP redirect ACL

- **Permit specific applications only**

```plaintext
ip access-list extended wccp-waas
remark WAAS WCCP Redirect List
deny tcp any any eq telnet
deny tcp any any eq 22
deny tcp any any eq 161
deny tcp any any eq 162
deny tcp any any eq 123
deny tcp any any eq bgp
deny tcp any any eq tacacs
deny tcp any any eq 2000
deny tcp any any eq 2443
deny tcp any any eq 5060
deny tcp any any eq 1718
deny tcp any any eq 1719
deny tcp any any eq 1720
deny tcp any any eq 8443
deny tcp any any eq 689
deny tcp any eq telnet any
deny tcp any eq 22 any
deny tcp any eq 161 any
deny tcp any eq 162 any
deny tcp any eq 123 any
deny tcp any eq bgp any
deny tcp any eq tacacs any
deny tcp any eq 2000 any
deny tcp any eq 2443 any
deny tcp any eq 5060 any
deny tcp any eq 1718 any
deny tcp any eq 1719 any
deny tcp any eq 1720 any
deny tcp any eq 8443 any
deny tcp any eq 689 any
! Below optional per branch in pilot
permit tcp any <<branch subnet>>
permit tcp <<branch subnet>> any
deny tcp any any
```
WCCP
Operational Best Practices

- Router initial configuration (router first then WAE add below)
  - Create WCCP redirect ACL
  - Configure global IP WCCP # redirect-list...
  - Configure interfaces

- Router configuration changes
  - Global service group configuration changes – Unregister all affected WCCP clients with no WCCP version 2, remove interface config, remove/change global config, apply new global config, apply new interface config, re-register WCCP clients
  - Interface configuration changes – Leave WAE WCCP clients registered
  - Redirect-list changes – Leave WAE WCCP clients registered

- WAE Moves, Adds and Changes
  - Add – Configure egress-method, WCCP router-list, WCCP tcp-promiscuous, WCCP version 2
  - Moves/Changes – No WCCP version 2, follow add procedure
Troubleshooting
Troubleshooting
WCCP Router and Cache Show Commands

- **Router/Switch**
  - Registration
  - Assignment
  - Redirect
  - Return
  - Authentication
  - Free TCAM

- **Cache**
  - Registration
  - Assignment
  - Redirect
  - Return
  - Egress Method
  - Bypass
  - Pass Through
Troubleshooting
Router Registration

Router# show ip wccp
Global WCCP information:
   Router information:
      Router Identifier:                   10.88.81.242
      Protocol Version:                    2.0

   Service Identifier: 61

   Number of Service Group Clients:     1
      Number of Service Group Routers:    1
      Total Packets s/w Redirected:       68755
      Process:                            2
      CEF:                                68753
   Service mode:                        Open
   Service access-list:                 -none-
   Total Packets Dropped Closed:        0
   Redirect access-list:                -none-
   Total Packets Denied Redirect:       0
   Total Packets Unassigned:            0
   Group access-list:                   -none-
   Total Messages Denied to Group:      0
   Total Authentication failures:        0
   Total Bypassed Packets Received:     0

--More--
Troubleshooting
Router Registration

Router# \texttt{show ip wccp}

Global WCCP information:

Router information:
  
  \begin{itemize}
  \item \textbf{Router Identifier:} 10.88.81.242
  \item \textbf{Protocol Version:} 2.0
  \end{itemize}

Service Identifier: 61

\begin{itemize}
  \item \textbf{Number of Service Group Clients:} 1
  \item \textbf{Number of Service Group Routers:} 1
  \item \textbf{Total Packets s/w Redirected:} 68755
  \item \textbf{Process:} 2
  \item \textbf{CEF:} 68753
  \item \textbf{Service mode:} Open
  \item \textbf{Service access-list:} none
  \item \textbf{Total Packets Dropped Closed:} 0
  \item \textbf{Redirect access-list:} none
  \item \textbf{Total Packets Denied Redirect:} 0
  \item \textbf{Total Packets Unassigned:} 0
  \item \textbf{Group access-list:} none
  \item \textbf{Total Messages Denied to Group:} 0
  \item \textbf{Total Authentication failures:} 0
  \item \textbf{Total Bypassed Packets Received:} 0
  \end{itemize}

\textit{More}
Troubleshooting
Router Redirect

Router# show ip wccp
Global WCCP information:
  Router information:
    Router Identifier: 10.88.81.242
    Protocol Version: 2.0

  Service Identifier: 61
    Number of Service Group Clients: 1
    Number of Service Group Routers: 1

  Total Packets s/w Redirected: 68755
    Process: 2
    CEF: 68753

  Service mode: Open
  Service access-list: -none-
  Total Packets Dropped Closed: 0
  Redirect access-list: 
  Total Packets Denied Redirect: 0
  Total Packets Unassigned: 
  Group access-list: 
  Total Messages Denied to Group: 0
  Total Authentication failures: 0
  Total Bypassed Packets Received: 0

--More--

Verify That Counters Are Incrementing on Software-Based Platforms
Troubleshooting Router Redirect

Router# show ip wccp
Global WCCP information:
   Router information:
      Router Identifier:                   10.88.81.242
      Protocol Version:                    2.0

   Service Identifier: 61
   Number of Service Group Clients:
   Number of Service Group Routers:
   Total Packets s/w Redirected:
      Process:
      CEF:                               68753
   Service mode:                        Open
   Service access-list:                -none-
   Total Packets Dropped Closed:       0
   Redirect access-list:               -none-
   Total Packets Denied Redirect:      0
   Total Packets Unassigned:           0
   Group access-list:                  -none-
   Total Messages Denied to Group:     0
   Total Authentication failures:      0
   Total Bypassed Packets Received:    0

Counter Will Increment for Packets That Match Service Group but Do Not Match Redirect-List
### Troubleshooting Router Assignment

**Verify WAE State in Service Group**

```
Router# show ip wccp 61 detail
WCCP Client information:
    WCCP Client ID:          10.88.81.242
    Protocol Version:        2.0
    State:                   Usable
    Redirection:             GRE
    Packet Return:           GRE
    Assignment:              HASH
    Initial Hash Info:       FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
                            FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
    Assigned Hash Info:      FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
                            FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
    Hash Allotment:          256 (100.00%)
    Packets s/w Redirected:  68755
    Connect Time:            3w6d
    Bypassed Packets
        Process:             2
        CEF:                 68753
    Errors:                 0
```

**Current Time in the Service Group**
Troubleshooting
Router Assignment

- Hidden IOS command shows target WAE for src/dst IP address and port combination (hash only)

```
show ip wccp <service> hash <dst-ip><src-ip><dst-port><src-port>
```

Router# show ip wccp 61 hash 0.0.0.0 10.88.81.10 0 0
WCCP hash information for:
   Primary Hash:  Src IP: 10.88.81.10
   Bucket:         9
   WCCP Client: 10.88.81.12

Target WAE
### Troubleshooting L3 Switch Assignment

Cat6k# `sh ip wccp 61 det`

**WCCP Client information:**
- **WCCP Client ID:** 10.88.80.135
- **Protocol Version:** 2.0
- **State:** Usable
- **Redirection:** L2
- **Packet Return:** GRE
- **Packets Redirected:** 0
- **Connect Time:** 1d18h

**Assignment:** MASK

<table>
<thead>
<tr>
<th>Mask</th>
<th>SrcAddr</th>
<th>DstAddr</th>
<th>SrcPort</th>
<th>DstPort</th>
<th>CE-IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>0x000001741</td>
<td>0x000000000</td>
<td>0x0000</td>
<td>0x0000</td>
<td>0xA585087 (10.88.80.135)</td>
</tr>
<tr>
<td>0001</td>
<td>0x000000000</td>
<td>0x000000000</td>
<td>0x0000</td>
<td>0x0000</td>
<td>0xA585087 (10.88.80.135)</td>
</tr>
<tr>
<td>0002</td>
<td>0x000000000</td>
<td>0x000000000</td>
<td>0x0000</td>
<td>0x0000</td>
<td>0xA585087 (10.88.80.135)</td>
</tr>
<tr>
<td>0003</td>
<td>0x000000000</td>
<td>0x000000000</td>
<td>0x0000</td>
<td>0x0000</td>
<td>0xA585087 (10.88.80.135)</td>
</tr>
</tbody>
</table>

*Service group mask*
Troubleshooting
L3 Switch Redirect

- Catalyst 6500 / 7600 platforms are capable of WCCP in both software and hardware forwarding paths
- Inspecting TCAM programming shows whether WCCP is handled in software or hardware

```
Cat6k# show tcam interface Vlan900 acl in ip

* Global Defaults not shared

Entries from Bank 0

Entries from Bank 1

permit tcp host 10.88.80.135 any
punt ip any any (8 matches)
```

‘Punt’ entries caused by:
Hash Assignment
Outbound Redirection
Redirect Exclude In
Unknown WAE MAC
Troubleshooting
L3 Switch Redirect

Cat6k# configure terminal
Enter configuration commands, one per line. End with CTRL/Z.
Cat6k(config)# service internal
Cat6k(config)# end
Cat6k#

Cat6k# show ip wccp 61 internal
Internal WCCP client information (1):
    Index:                   0
    WCCP Client ID:          10.88.80.135
    Protocol Version:        2.0
    State:                   0007 (AUV )
    Connect Time:            00:00:05
    Redirection:             L2
                              MAC:       0000.0000.0000
    Packet Return:           GRE
    L2 Address Changes:      0
    Assignment:              MASK
    Redirect Assignments:
                              Received:   0
                              Invalid:    0
                              Duplicate:  0
< snip >
Cat6k#

HIA from WAE must enter same interface that WAE MAC is known through
Troubleshooting
Catalyst 6500 Switch Redirect

Cat6k# sh tcam int vlan 900 acl in ip

* Global Defaults not shared

Entries from Bank 0

Entries from Bank 1

<table>
<thead>
<tr>
<th>permit</th>
<th>tcp</th>
<th>host</th>
<th>10.88.80.135</th>
<th>any</th>
</tr>
</thead>
<tbody>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.0.0</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.0.1</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.0.64</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.0.65</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.1.0</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.1.1</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.1.64</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.1.65</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.2.0</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.2.1</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.2.64</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.2.65</td>
<td>255.255.232.190</td>
</tr>
<tr>
<td>policy-route</td>
<td>tcp</td>
<td>any</td>
<td>0.0.3.0</td>
<td>255.255.232.190</td>
</tr>
</tbody>
</table>

‘policy-route’ entries = full hardware redirection
Troubleshooting
Nexus 7000 TCAM Entries

switch(config-if)# show sys internal access-list interface eth1/1 input entries detail module 1

Flags: F - Fragment entry  E - Port Expansion
       D - DSCP Expansion  M - ACL Expansion

Tcam 0 resource usage:
----------------------
Label_a = 0x800
Bank 0
------
    IPv4 Class
    Policies: SPM WCCP()
    Entries:
        [Index] Entry [Stats]
        ---------------------
[0000] redirect(0x43005) tcp 11.11.11.0/255.255.255.1 eq 1000 22.22.22.0/24 eq 2000 [0]
[0001] redirect(0x43005) tcp 11.11.11.1/255.255.255.1 eq 1000 22.22.22.0/24 eq 2000 [0]

L4 protocol cam entries usage: none

No mac protocol cam entries are in use

NOTE: For egress direction, use “output entries detail” in the command above
Troubleshooting
Checking TCAM Statistics for WCCP

switch(config-if)# show sys internal access-list interface eth1/1 input statistics module 1
tcam 0 resource usage:
------------------------
Label_a = 0x800
Bank 0
------
IPv4 Class
Policies: SPM WCCP()
Entries:
[Index] En0x43005try [Stats]
---------------------
[0000] redirect(0x43005) tcp 11.11.11.0/255.255.255.1 eq 1000 22.22.22.0/24 eq 2000 [100]
[0001] redirect(0x43005) tcp 11.11.11.1/255.255.255.1 eq 1000 22.22.22.0/24 eq 2000 [20]

L4 protocol cam entries usage: none

No mac protocol cam entries are in use

switch(config-if)# show system internal forwarding adjacency module 1
Device: 1   Index: 0x43005   dmac: 0002.0002.0002   smac: 0018.bad8.0ec9   e-vpn: 1
e-lif: 0x4011   packets: 0   bytes: 0

switch(config-if)# show sys internal forwarding adjacency entry 0x43005 detail module 1
Device: 1   Index: 0x43005   DMAC: 0002.0002.0002   SMAC: 0018.bad8.0ec9
LIF: 0x4011 (Ethernet9/17)   DI: 0x432   ccc: 4   L2_FWD: NO   RDT: YES
packets: 0   bytes: 0   zone enforce: 0

DI should be valid (i.e. non zero)

Statistics
Troubleshooting
Router Debug Commands

- **WCCP Control Packet Debugging (debug ip wccp packets)**
  The text of each packet debug message and a description of its meaning can be found in WCCP v2 packet debug messages.
  A message is generated for every valid HIA and RA message received from all WCCP Clients for all service groups.
  A message is generated for every ISU and RQ sent to all WCCP Clients for all service groups.
  Packet debugging will therefore confirm the basic operation of a service group from startup to steady state.
  Use packet debugging to confirm communication with a particular WCCP Client.
  Use packet debugging to confirm that a particular service group is active.

- **WCCP Event Debugging (debug ip wccp events)**
  The text of each message and a description of its meaning can be found in WCCP v2 event debug messages.
  Event debugging shows the operation of the WCCP control plane in detail.
  Use event debugging when a service fails to start up or does not appear to redirect traffic.
  Use event debugging to track changes in the router view of a service group including membership and assignment changes.
Troubleshooting Router Packet Debug Messages

- "WCCP-PKT:<service id>: Sending Removal_Query packet to <IP address> w/ rcv_id <Receive ID>"
  
  An RQ message has been sent to the WCCP Client in the service group <service id> identified by <IP address> because the 25 second cache query timer for that client has expired i.e. no HIA message has been received in that time. A valid response will be expected to echo the value of <Receive ID> contained in this message.

- "WCCP-PKT:<service id>: Sending I_See_You packet to <IP address> w/ rcv_id <Receive ID>"
  
  An ISU message has been sent to the WCCP Client in the service group <service id> identified by the address <IP address> in response to the receipt of a valid HIA message from that client. A new value of <Receive ID> is included in the ISU message which will be expected in the next HIA message from that client confirming that this message was received correctly.

- "WCCP-PKT:<service id>: Received valid Redirect_Assignment packet from <IP address> w/rcv_id <Receive ID>"
  
  An RA message has been received from the WCCP Client in the service group <service id> identified by <IP address>. The value of <Receive ID> is as expected and the message contents will be processed and assignments for the service group made accordingly.

- "WCCP-PKT:<service id>: Ignored duplicate Here_I_Am packet received from <IP address>"
  
  An HIA message from the WCCP Client in the service group <service id> identified by the address <IP address> has been ignored because the ID field in the IP protocol header is the same as the last value received from this client. This mechanism is used to suppress duplicate packets which arise when using a group address to reach the clients in a service group.

- "WCCP-PKT:<service id>: Received valid Here_I_Am packet from <IP address> w/rcv_id <Receive ID>"
  
  An HIA message has been received from the WCCP Client in the service group <service id> identified by <IP address>. The message contains the correct value for <Receive ID>. It will be processed as a valid message and will cause the cache query timer to be reset for the client to be reset.

- "WCCP-PKT:???: I_See_You packet from <IP address> ignored"
  
  An ISU message from the WCCP Client identified by <IP address> has been received and ignored. This mechanism is used to filter packets sent using a multicast address when a service group has such an address configured. The ?? means there is no identifiable service group associated with the message.
Troubleshooting

Router Event Debug Messages

"WCCP-EVNT:<service id>: Built new router view: <number> routers, <number> usable WCCP clients, change #<change number>"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> fails source check"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> missing assignment"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> w/bad num rtrs %d"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> w/bad wc count %d"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> w/bad assignment"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> w/o our rtr_id"

"WCCP-EVNT:<service id>: Redirect_Assignment packet from <source IP address> w/bad rcv_id <receive ID>"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> w/bad num rtrs <number>"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> w/bad wc count <number>"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; bad source IP address"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; malformed"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; bad web_cache id"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; WC limit exceeded"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; missing service info"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> view; <interface name> ignored"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> view; Rtr <source IP address> ignored"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; bad source IP address"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> view; w/bad num rtrs <number>"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address> ignored; bad web_cache id"

"WCCP-EVNT:<service id>: Here_I_Am packet from <source IP address>: <reason>"

"WCCP-EVNT:???: Packet from <source IP address> too short"

"WCCP-EVNT:???: Unknown msg_type <message type value> on <interface name> from <source IP address>"

"WCCP-EVNT:Router Id changed from <old IP address> to <new IP address>"
Troubleshooting
Cache Registration

WAE-612# `show wccp services`
Services configured on this File Engine
  TCP Promiscuous 61
  TCP Promiscuous 62

WAE-612# `show wccp status`
WCCP version 2 is enabled and currently active

WAE-612# `show wccp routers`

Router Information for Service: TCP Promiscuous 61

<table>
<thead>
<tr>
<th>Router Id</th>
<th>Sent To</th>
<th>Recv ID</th>
<th>AssKeyIP</th>
<th>AssKeyCN</th>
<th>MemberCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.77.22.3</td>
<td>10.88.80.129</td>
<td>00090C46</td>
<td>10.88.80.133</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Routers not Seeing this Wide Area Engine
  -NONE-

Routers Notified of from other WAE's
  -NONE-

Multicast Addresses Configured
  -NONE-

Verify WCCP Is Configured and Enabled

Verify Bi-Directional Communication with WCCP-Enabled Routers
Troubleshooting
Cache Redirect

WAE-612# show wccp gre

<table>
<thead>
<tr>
<th>Counter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent GRE packets received:</td>
<td>5531561</td>
</tr>
<tr>
<td>Transparent non-GRE packets received:</td>
<td>0</td>
</tr>
<tr>
<td>Transparent non-GRE non-WCCP packets received:</td>
<td>0</td>
</tr>
<tr>
<td>Total packets accepted:</td>
<td>5051</td>
</tr>
<tr>
<td>Invalid packets received:</td>
<td>0</td>
</tr>
<tr>
<td>Packets received with invalid service:</td>
<td>0</td>
</tr>
<tr>
<td>Packets received on a disabled service:</td>
<td>0</td>
</tr>
<tr>
<td>Packets received too small:</td>
<td></td>
</tr>
<tr>
<td>Packets dropped due to zero TTL:</td>
<td></td>
</tr>
<tr>
<td>Packets dropped due to bad buckets:</td>
<td></td>
</tr>
<tr>
<td>Packets dropped due to no redirect address:</td>
<td></td>
</tr>
<tr>
<td>Packets dropped due to loopback redirect:</td>
<td></td>
</tr>
<tr>
<td>Pass-through pkts dropped on assignment update:</td>
<td></td>
</tr>
<tr>
<td>Connections bypassed due to load:</td>
<td>0</td>
</tr>
<tr>
<td>Packets sent back to router:</td>
<td>0</td>
</tr>
<tr>
<td>GRE packets sent to router (not bypass):</td>
<td>0</td>
</tr>
<tr>
<td>Packets sent to another WAE:</td>
<td>0</td>
</tr>
<tr>
<td>GRE fragments redirected:</td>
<td>0</td>
</tr>
<tr>
<td>GRE encapsulated fragments received:</td>
<td>0</td>
</tr>
<tr>
<td>Packets failed encapsulated reassembly:</td>
<td>0</td>
</tr>
<tr>
<td>Packets failed GRE encapsulation:</td>
<td>0</td>
</tr>
</tbody>
</table>

Either of These Counters Should Be Incrementing If WCCP Redirection Is Working
# Troubleshooting Cache Redirect

```
WAE-612# show wccp gre
Transparent GRE packets received:              0
Transparent non-GRE packets received:          234624
Transparent non-GRE non-WCCP packets received: 0
Total packets accepted:                        72511
Invalid packets received:                      0
Packets received with invalid service:         0
Packets received on a disabled service:        0
Packets received too small:                    0
Packets dropped due to zero TTL:               0
Packets dropped due to bad buckets:            0
Packets dropped due to no redirect address:    0
Packets dropped due to loopback redirect:      0
Pass-through pkts dropped on assignment update:0
Connections bypassed due to load:              0
Packets sent back to router:                   0
GRE packets sent to router (not bypass)        0
Packets sent to another WAE:                   0
GRE fragments redirected:                      0
GRE encapsulated fragments received:           0
Packets failed encapsulated reassembly:        0
Packets failed GRE encapsulation:              0
--More--
```

For Packets Redirected Using WCCP L2-Redirect Forwarding Method
Troubleshooting
Cache Redirect

WAE-612# show wccp gre
Transparent GRE packets received: 0
Transparent non-GRE packets received: 0
Transparent non-GRE non-WCCP packets received: 102764
Total packets accepted: 98723
Invalid packets received: 0
Packets received with invalid service: 0
Packets received on a disabled service: 0
Packets received too small: 0
Packets dropped due to zero TTL: 0
Packets dropped due to bad buckets: 0
Packets dropped due to no redirect address: 0
Packets dropped due to loopback redirect: 0
Pass-through pkts dropped on assignment update: 0
Connections bypassed due to load: 0
Packets sent back to router: 0
GRE packets sent to router (not bypass): 0
Packets sent to another WAE: 0
GRE fragments redirected: 0
GRE encapsulated fragments received: 0
Packets failed encapsulated reassembly: 0
Packets failed GRE encapsulation: 0
--More--

For Packets L2 Redirected Using Non-WCCP (L4, PBR, Etc.) Interception Method
Troubleshooting
Cache Redirect

WAE-612# show wccp gre
Transparent GRE packets received: 753110
Transparent non-GRE packets received: 0
Transparent non-GRE non-WCCP packets received: 0
Total packets accepted: 505123
Invalid packets received: 0
Packets received with invalid service: 0
Packets received on a disabled service: 0
Packets received too small: 0
Packets dropped due to zero TTL: 0
Packets dropped due to bad buckets: 0
Packets dropped due to no redirect address: 0
Packets dropped due to loopback redirect: 0
Pass-through pkts dropped on assignment update: 0
Connections bypassed due to load: 0
Packets sent back to router: 0
GRE packets sent to router (not bypass): 0
Packets sent to another WAE: 0
GRE fragments redirected: 0
GRE encapsulated fragments received: 0
Packets failed encapsulated reassembly: 0
Packets failed GRE encapsulation: 0

--More--

Packets Accepted for Optimization (I.E. Auto-Discovery Found Peer WAE)
Troubleshooting
Cache Redirect

WAE-612# show wccp gre
Transparent GRE packets received: 345678
Transparent non-GRE packets received: 0
Transparent non-GRE non-WCCP packets received: 0
Total packets accepted:
Invalid packets received:
Packets received with invalid service:
Packets received on a disabled service:
Packets received too small: 0
Packets dropped due to zero TTL: 0
Packets dropped due to bad buckets: 0
Packets dropped due to no redirect address: 0
Packets dropped due to loopback redirect: 0
Pass-through pkts dropped on assignment update: 0
Connections bypassed due to load: 0
Packets sent back to router: 0
GRE packets sent to router (not bypass) 234514
Packets sent to another WAE: 0
GRE fragments redirected: 0
GRE encapsulated fragments received: 0
Packets failed encapsulated reassembly: 0
Packets failed GRE encapsulation: 0
--More--

Only Includes Packets Handled Using WCCP
Return Egress Method
WAE-612# show wccp gre

Transparent GRE packets received: 23534
Transparent non-GRE packets received: 0
Transparent non-GRE non-WCCP packets received: 0
Total packets accepted:
Invalid packets received:
Packets received with invalid service:
Packets received on a disabled service:
Packets received too small:
Packets dropped due to zero TTL:
Packets dropped due to bad buckets: 0
Packets dropped due to no redirect address: 0
Packets dropped due to loopback redirect: 0
Pass-through pkts dropped on assignment update: 0
Connections bypassed due to load: 0
Packets sent back to router:
GRE packets sent to router (not bypass): 0
Packets sent to another WAE: 1444
GRE fragments redirected: 0
GRE encapsulated fragments received: 0
Packets failed encapsulated reassembly: 0
Packets failed GRE encapsulation: 0

--More--
### Troubleshooting

**Cache Egress**

```plaintext
WAE674# show egress-methods

Intercept method : WCCP

<table>
<thead>
<tr>
<th>Destination</th>
<th>Egress Method Configured</th>
<th>Egress Method Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>any</td>
<td>WCCP Negotiated Return</td>
<td>WCCP GRE</td>
</tr>
</tbody>
</table>

TCP Promiscuous 61 :
- WCCP negotiated return method : WCCP GRE

TCP Promiscuous 62 :
- WCCP negotiated return method : WCCP GRE

< snip >
```

**IP Forwarding**

WCCP GRE

**Generic GRE**

Cisco Public
Troubleshooting
WAAS Cache Egress Mismatch

- Only WCCP GRE Return is supported as a ‘negotiated-return’ egress method
  
  WAE raises minor alarm if negotiated return method is L2

- Generic GRE egress method only supported with WCCP GRE as the intercept-method
  
  WAE raises minor alarm if negotiated intercept method is L2

- Alarm cleared when mismatch is resolved by altering the egress method and/or WCCP configuration

- Verify configured and used egress method with `sh egress-method` CLI command
Troubleshooting
Cache Egress Mismatch

WAE612# sh egress-methods
Intercept method : WCCP
   TCP Promiscuous 61 :
      WCCP negotiated return method : WCCP GRE

<table>
<thead>
<tr>
<th>Destination</th>
<th>Configured</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>any</td>
<td>Generic GRE</td>
<td>IP Forwarding</td>
</tr>
</tbody>
</table>

WARNING: WCCP has negotiated WCCP L2 as the intercept method for which generic GRE is not supported as an egress method in this release. This device uses IP forwarding as the egress method instead of the configured generic GRE egress method.

TCP Promiscuous 62 :
   WCCP negotiated return method : WCCP GRE

<table>
<thead>
<tr>
<th>Destination</th>
<th>Configured</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>any</td>
<td>Generic GRE</td>
<td>IP Forwarding</td>
</tr>
</tbody>
</table>

WARNING: WCCP has negotiated WCCP L2 as the intercept method for which generic GRE is not supported as an egress method in this release. This device uses IP forwarding as the egress method instead of the configured generic GRE egress method.
WCCP Session Summary

- Global placement
- Local placement
- Device planning
- Deployment Considerations
- Configuration
- Operations
- Troubleshooting
Recommended Reading

- **Application Acceleration and WAN Optimization Fundamentals** (Cisco Press)
  Ted Grevers, Joel Christner
  Overview of technologies employed in today’s acceleration systems

- **Deploying Cisco Wide Area Application Services** (Cisco Press), 1st and 2nd edition
  Joel Christner, Zach Seils, Nancy Jin
  Extensible guide for deploying and managing Cisco WAAS
  1st edition: *Cisco WAAS v4.0*
  2nd edition: *Cisco WAAS v4.1*
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