

Infrastruktur Jaringan Industrial CpwE dengan Platform GNS3

AHMAD SYAFI NURROYAN

1. LATAR BELAKANG

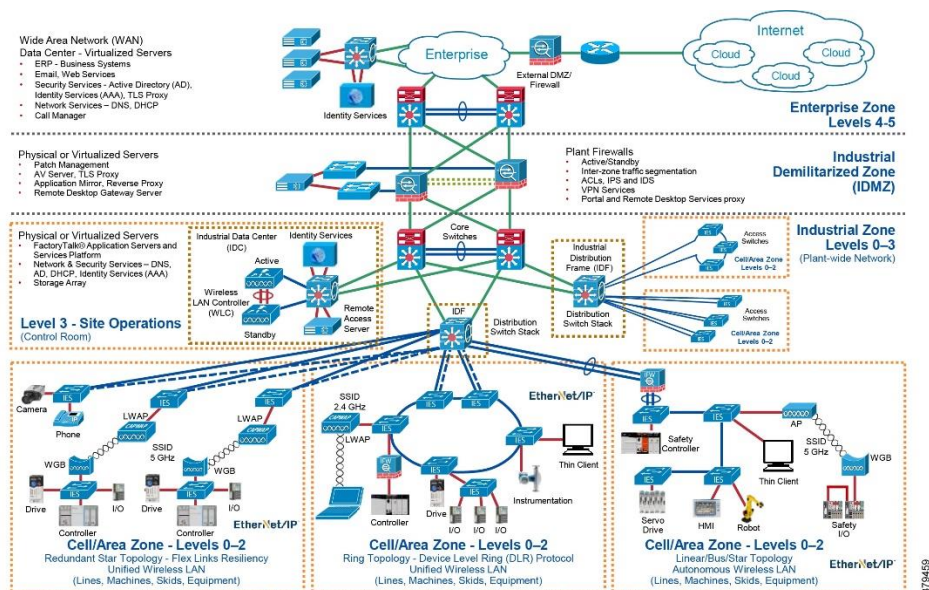
Revolusi Industri 4.0 telah mengubah cara kerja pabrik-pabrik modern. Konsep Smart Factory yang menghubungkan semua sistem produksi secara otomatis kini makin banyak diterapkan. Kunci utamanya ada pada teknologi Industrial Internet of Things (IIoT) yang memungkinkan semua mesin dan peralatan di pabrik saling terhubung dan berbagi data secara langsung. Namun, keberhasilan teknologi ini justru memunculkan masalah baru: bagaimana menggabungkan sistem IT (teknologi informasi) dengan OT (teknologi operasional) di pabrik?

Selama ini, jaringan komputer di kantor (IT) dan jaringan di area produksi (OT) bekerja terpisah. Kantor lebih mementingkan keamanan dan kerahasiaan data, sementara lantai pabrik butuh sistem yang terus berjalan tanpa henti dengan respon yang cepat. Banyak proyek IIoT gagal karena infrastruktur jaringannya tidak bisa menyatukan dua sistem yang berbeda ini. Laporan McKinsey (2023) menyebutkan hanya 26% pabrik yang berhasil menerapkan IIoT dengan baik karena masalah infrastruktur jaringan. IDC (2022) juga mencatat 42% kegagalan transformasi digital di sektor manufaktur disebabkan desain jaringan yang kurang tepat.

Masalahnya makin rumit karena kebanyakan orang IT tidak paham sistem pabrik, begitu juga sebaliknya. Akibatnya, banyak pabrik masih mengandalkan cara manual untuk menghubungkan data dari kantor ke produksi.

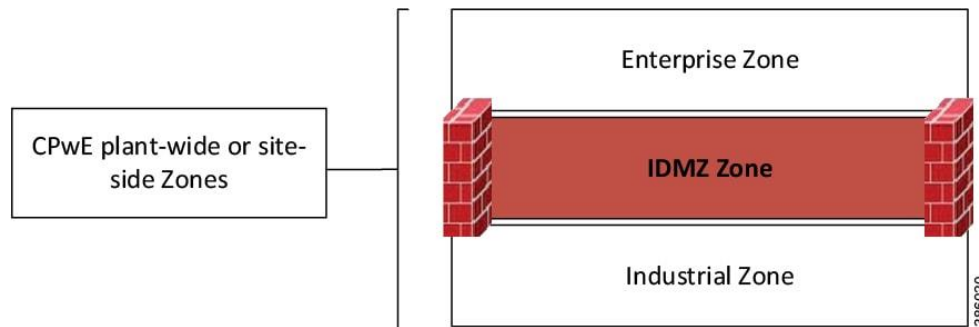
Untuk mengatasi masalah ini, perusahaan besar seperti Cisco dan Rockwell Automation membuat standar bernama Converged Plantwide Ethernet (CPwE). Ini bukan produk jadi, tapi lebih ke panduan desain yang sudah diuji dan terbukti berhasil untuk membangun jaringan pabrik yang handal, aman, dan bisa dikembangkan sesuai kebutuhan.

Arsitektur CPwE yang lengkap punya 5 tingkat (Level 0-4/5), mulai dari sensor di lantai pabrik sampai server di cloud perusahaan.



Meski model 5 tingkat ini sangat detail, inti dari CPwE sebenarnya ada pada pembagian zona (segmentasi). Idennya sederhana: memisahkan jaringan menjadi tiga zona utama yaitu Enterprise Zone

(area kantor), Industrial Zone (area pabrik), dan zona penyangga di tengahnya yang disebut Industrial Demilitarized Zone atau IDMZ.



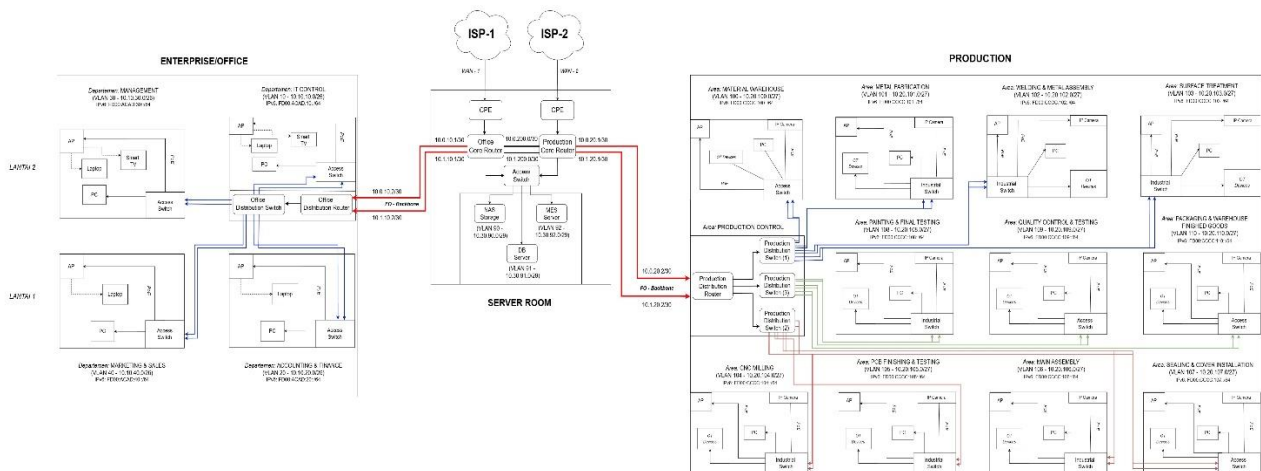
Pembagian zona ini memang terbukti efektif. Studi dari Siemens (2021) menunjukkan pabrik yang menerapkan segmentasi VLAN dan edge computing produktivitasnya naik sampai 28% dan waktu mesin berhenti berkurang 35%.

Proyek ini bertujuan merancang infrastruktur jaringan untuk pabrik skala menengah dengan menggunakan konsep 3 zona dari CPwE. Desainnya memetakan Enterprise Zone untuk bagian IT dan Accounting, IDMZ sebagai ruang server, dan Industrial Zone untuk area kontrol produksi.

Sesuai fokus proyek, perancangan ini hanya berfokus pada infrastruktur network saja tanpa mencakup konfigurasi atau pemrograman dari perangkat *Operation Technology* (OT) spesifik seperti PLC, HMI, atau SCADA. Selain itu, perancangan topologinya juga lebih ke arsitektur jaringan logis, sehingga untuk aspek fisik seperti ketahanan perangkat terhadap lingkungan (M.I.C.E.), grounding, dan UPS memang penting di dunia nyata, namun tidak dibahas dalam lingkup simulasi kali ini.

2. PERANCANGAN TOPOLOGI

2.1 Desain Rancangan Topologi



Dalam topologi yang dirancang, bagian Office terdiri dari 4 departemen dan Production terdiri dari 11 area. Pada setiap departemen Office dan area Production, terdapat satu managed switch atau industrial switch yang berfungsi menyediakan akses VLAN kepada perangkat client seperti PC, Access Point, dan perangkat lainnya. Switch ini juga melakukan trunk ke interface yang terhubung dengan distribution switch. Untuk mencegah masalah *Single Point of Failure (SPOF)*, setiap managed switch dihubungkan ke distribution switch menggunakan 2 link sebagai redundansi.

Distribution switch selanjutnya terhubung ke office router untuk menerima keseluruhan traffic trunk dari router. Masing-masing router pada office dan production dihubungkan ke jalur backbone fiber optik dengan 2 link yang memiliki IP berbeda sebagai redundansi fisik. Penggunaan fiber optik untuk link backbone dipilih karena ketahanannya di lingkungan outdoor dan kemampuannya menjangkau jarak jauh tanpa degradasi sinyal. Selain itu, karena tidak menghantarkan listrik, fiber optik jauh lebih aman dari gangguan yang biasanya muncul di area dengan tegangan tinggi. Misalnya interferensi listrik, ground loop, atau sambaran petir yang bisa merusak perangkat jaringan.

Pada server room terdapat 2 core router yang bertugas menerima dan mendistribusikan traffic ke office maupun production. Kedua core router ini juga saling terhubung menggunakan 2 link fisik sebagai redundansi. Kedua core router tersebut terhubung ke switch yang mengakomodasi server-server internal perusahaan seperti NAS Storage, DB Server, dan MES Server. Koneksi ke kedua core router dilakukan karena server-server tersebut bersifat shared resource yang digunakan oleh office dan production. Untuk koneksi internet, digunakan 2 ISP sebagai mekanisme load balancing sekaligus failover.

2.2 Batasan Sistem (Limitations)

Beberapa batasan lain yang diterapkan pada implementasi simulasi ini dikarenakan keterbatasan fitur perangkat lunak (*software image*) dan sumber daya perangkat keras:

1. **Redundansi Layer 2 via STP (Bukan LACP):** Koneksi redundan antar-switch menggunakan protokol *Spanning Tree* (mode *Active/Standby*). Hal ini dikarenakan keterbatasan *image switch* yang digunakan pada GNS3 tidak mendukung fitur *LACP/EtherChannel* secara penuh.
2. **Limitasi EtherChannel pada Router:** Desain awal merencanakan penerapan LACP pada tautan dari *Office/Production Router* ke *Distributed Switch* untuk redundansi. Namun, hal ini tidak dapat diimplementasikan karena *image* yang digunakan adalah *router murni (pure router)* yang tidak mendukung fitur *Layer 2 EtherChannel* layaknya *Layer 3 Switch*. Oleh karena itu, koneksi tetap menggunakan link ganda namun tanpa agregasi LACP.
3. **Akses Internet pada Zona Produksi:** Mengacu pada standar CPwE, perangkat pada zona produksi (OT) seharusnya terisolasi dan tidak diperbolehkan mengakses internet demi keamanan data. Namun, dalam simulasi ini, akses internet pada zona produksi dibuka secara terbatas untuk keperluan pengujian (*testing*). Hal ini dilakukan karena perangkat *wireless* disimulasikan menggunakan *switch* bawaan GNS3 yang memiliki keterbatasan fitur (tidak dapat melakukan *ping*), sehingga konektivitas perlu uji coba langsung melalui akses internet dari *end-device*.
4. **Absensi Perangkat Firewall Dedikasi:** Desain keamanan ideal menyertakan *Firewall* khusus di antara ISP dan *Core Router*. Namun, komponen ini ditiadakan karena ketiadaan lisensi untuk *image firewall enterprise* dan keterbatasan sumber daya komputasi (RAM/CPU) laptop untuk menjalankan *image open source* (seperti VyOS). Sebagai gantinya, fungsi keamanan dan filter trafik diterapkan menggunakan ACL (*Access Control List*) pada router.
5. **Simulasi Server:** Perangkat server (NAS, DB, MES) diimplementasikan menggunakan *virtual node* ringan (VPCS/Router) yang berfungsi hanya untuk memverifikasi konektivitas IP dan validasi aturan ACL, tanpa menjalankan layanan aplikasi *real* (seperti *service SQL* atau *Web Server*).

2.3 Pembagian IP Address

Lokasi	Nama Jaringan (Departemen/Area)	VLAN ID	IPv4 Subnet	Ipv6 Subnet
Office	IT Control	10	10.10.10.0/26	FD00:ACAD:10::/64
Office	Accounting & Finance	20	10.10.20.0/26	FD00:ACAD:20::/64
Office	Management	30	10.10.30.0/26	FD00:ACAD:30::/64
Office	Marketing & Sales	40	10.10.40.0/26	FD00:ACAD:40::/64
Server	NAS Storage	90	10.30.90.0/29	-
Server	DB Server	91	10.30.91.0/29	-
Server	MES Server	92	10.30.92.0/29	-
Production	Material Warehouse	100	10.20.100.0/27	FD00:CCCC:100::/64
Production	Metal Fabrication	101	10.20.101.0/27	FD00:CCCC:101::/64

Production	Welding & Metal Assembly	102	10.20.102.0/27	FD00:CCCC:102::/64
Production	Surface Treatment	103	10.20.103.0/27	FD00:CCCC:103::/64
Production	CNC Milling	104	10.20.104.0/27	FD00:CCCC:104::/64
Production	PCB Finishing & Testing	105	10.20.105.0/27	FD00:CCCC:105::/64
Production	Main Assembly	106	10.20.106.0/27	FD00:CCCC:106::/64
Production	Sealing & Cover Installation	107	10.20.107.0/27	FD00:CCCC:107::/64
Production	Painting & Final Testing	108	10.20.108.0/27	FD00:CCCC:108::/64
Production	Quality Control & Testing	109	10.20.109.0/27	FD00:CCCC:109::/64
Production	Packaging & Warehouse Finished Goods	110	10.20.110.0/27	FD00:CCCC:110::/64

Koneksi Dari	Koneksi Ke	Link #	IPv4 Subnet	IP Address Sisi 1	IP Address Sisi 2
Office Core Router	Office Router	Link 1	10.0.10.0/30	10.0.10.1	10.0.10.2
Office Core Router	Office Router	Link 2	10.1.10.0/30	10.1.10.1	10.1.10.2
Production Core Router	Production Router	Link 1	10.0.20.0/30	10.0.20.1	10.0.20.2
Production Core Router	Production Router	Link 2	10.1.20.0/30	10.1.20.1	10.1.20.2
Office Core Router	Production Core Router	Link 1	10.0.200.0/30	10.0.200.1	10.0.200.2
Office Core Router	Production Core Router	Link 2	10.1.200.0/30	10.1.200.1	10.1.200.2

3. IMPLEMENTASI DAN KONFIGURASI

1. Konfigurasi Office Core Router

Langkah 1: Menetapkan hostname menjadi OFFICE-CORE-ROUTER serta menonaktifkan fitur IP domain lookup untuk mencegah terjadinya jeda (hang) ketika terjadi kesalahan pengetikan perintah selama proses konfigurasi.

```
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#hostname OFFICE-CORE-ROUTER
% Hostname "OFFICE-CORE-ROUT" is not a legal
OFFICE-CORE-ROUTER(config)#no ip domain-lookup
OFFICE-CORE-ROUTER(config)#
```

Langkah 2: Mengonfigurasi IP address pada interface yang terhubung ke OFFICE-ROUTER.

```
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-CORE-ROUTER(config)#int g0/2
OFFICE-CORE-ROUTER(config-if)#ip add 10.0.10.1 255.255.255.252
OFFICE-CORE-ROUTER(config-if)#no sh
OFFICE-CORE-ROUTER(config-if)#
*Nov 6 15:29:53.761: %LINK-3-UPDOWN: Interface GigabitEthernet0/2,
*Nov 6 15:29:54.763: %LINEPROTO-5-UPDOWN: Line protocol on Interface
ged state to up
OFFICE-CORE-ROUTER(config-if)#exit
OFFICE-CORE-ROUTER(config)#int g0/3
OFFICE-CORE-ROUTER(config-if)#ip add 10.1.10.1 255.255.255.252
OFFICE-CORE-ROUTER(config-if)#no sh
OFFICE-CORE-ROUTER(config-if)#exit
*Nov 6 15:30:28.137: %LINK-3-UPDOWN: Interface GigabitEthernet0/3,
*Nov 6 15:30:29.138: %LINEPROTO-5-UPDOWN: Line protocol on Interface
ged state to up
OFFICE-CORE-ROUTER(config-if)#exit
OFFICE-CORE-ROUTER(config)#
```

Langkah 3: Mengonfigurasi IP Address pada interface yang terhubung ke PRODUCTION-CORE-ROUTER.

```
OFFICE-CORE-ROUTER(config)#
OFFICE-CORE-ROUTER(config)#int g0/5
OFFICE-CORE-ROUTER(config-if)#ip add 10.0.200.1 255.255.255.252
OFFICE-CORE-ROUTER(config-if)#no sh
OFFICE-CORE-ROUTER(config-if)#exit
OFFICE-CORE-ROUTER(config)#int
*Nov 11 16:15:27.282: %IP-4-DUPADDR: Duplicate address 10.0.200.1 on Giga
OFFICE-CORE-ROUTER(config)#int g0/5
OFFICE-CORE-ROUTER(config-if)#exit
OFFICE-CORE-ROUTER(config)#int g0/6
OFFICE-CORE-ROUTER(config-if)#ip add 10.1.200.1 255.255.255.252
OFFICE-CORE-ROUTER(config-if)#no sh
OFFICE-CORE-ROUTER(config-if)#exit
OFFICE-CORE-ROUTER(config)#
```

Langkah 4: Mengonfigurasi IP Address sebagai gateway VLAN pada Servers.

```

OFFICE-CORE-ROUTER#config t
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-CORE-ROUTER(config)#int g0/4.90
OFFICE-CORE-ROUTER(config-subif)#encapsulation dot1q 90
OFFICE-CORE-ROUTER(config-subif)#ip add 10.30.90.1 255.255.255.248
OFFICE-CORE-ROUTER(config-subif)#no sh
OFFICE-CORE-ROUTER(config-subif)#exit
*Nov 11 16:13:09.412: %PLATFORM-5-SIGNATURE_VERIFIED: Image 'flash0:/vios-advent
n
OFFICE-CORE-ROUTER(config-subif)#exit
OFFICE-CORE-ROUTER(config)#int g0/4.91
OFFICE-CORE-ROUTER(config-subif)#encapsulation dot1q 91
OFFICE-CORE-ROUTER(config-subif)#ip add 10.30.91.1 255.255.255.248
*Nov 11 16:13:32.608: %HSRP-5-STATECHANGE: GigabitEthernet0/4.90 Grp 90 state St
OFFICE-CORE-ROUTER(config-subif)#ip add 10.30.91.1 255.255.255.248
OFFICE-CORE-ROUTER(config-subif)#no sh
OFFICE-CORE-ROUTER(config-subif)#exit
OFFICE-CORE-ROUTER(config)#int g0/4.92
OFFICE-CORE-ROUTER(config-subif)#encapsulation dot1q 92
OFFICE-CORE-ROUTER(config-subif)#ip add 10.30.92.1 255.255.255.248
OFFICE-CORE-ROUTER(config-subif)#no sh
OFFICE-CORE-ROUTER(config-subif)#exit
OFFICE-CORE-ROUTER(config)#

```

Langkah 5: Mengonfigurasi OSPF agar dapat terhubung dengan jaringan Office dan Production.

```

Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-CORE-ROUTER(config)#router ospf 1
OFFICE-CORE-ROUTER(config-router)#network 10.0.10.1 0.0.0.3 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.1.10.1 0.0.0.3 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.30.90.2 0.0.0.7 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.30.91.2 0.0.0.7 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.30.92.2 0.0.0.7 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.0.200.2 0.0.0.3 area 0
OFFICE-CORE-ROUTER(config-router)#network 10.1.200.2 0.0.0.3 area 0
OFFICE-CORE-ROUTER(config-router)#

```

Langkah 6: Membuat Access Control List (ACL) untuk mengamankan NAS Storage. Pada tahap ini seluruh trafik OSPF dan tunnel GRE diizinkan melewati perangkat. Selain itu, host pada jaringan IT Control, DB Server, dan MES Server juga diberikan akses penuh. Semua trafik lain di luar ketentuan tersebut diblokir.

Aturan ini diterapkan karena di lingkungan industri, NAS Storage dianggap sangat sensitif. Akses menuju NAS biasanya tidak dilakukan langsung, tetapi melalui DB atau MES sebagai perantara antara server, perangkat produksi, dan departemen akuntansi. Jaringan IT Control tetap diperbolehkan mengakses secara langsung karena mereka yang bertanggung jawab melakukan monitoring dan manajemen seluruh jaringan.

```

ip access-list extended PROTECT_NAS
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.30.91.0 0.0.0.7 any
 permit ip 10.30.92.0 0.0.0.7 any
 deny ip any any log

```

Langkah 7: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Dengan HSRP, Office Core Router bertindak sebagai Active Router, sedangkan Production Core Router berperan sebagai Standby Router. Jika Active Router mengalami gangguan, Standby Router otomatis mengambil alih alamat IP virtual sehingga trafik tetap dapat berjalan tanpa mengganggu layanan. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 90 untuk melindungi NAS Storage.

```
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-CORE-ROUTER(config)#int g0/4.90
OFFICE-CORE-ROUTER(config-subif)#standby 90 ip 10.30.90.6
OFFICE-CORE-ROUTER(config-subif)#standby 90 priority 110
OFFICE-CORE-ROUTER(config-subif)#standby 90 preempt
OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT_NAS out
OFFICE-CORE-ROUTER(config-subif)#
```

Langkah 8: Membuat Access Control List (ACL) untuk melindungi DB Server dengan ketentuan: mengizinkan seluruh trafik OSPF dan tunnel (GRE) untuk dapat melewati perangkat, serta memberikan izin akses penuh kepada seluruh host pada jaringan IT Control, Accounting, seluruh area pada Production, dan MES Server. Seluruh jenis trafik lain di luar ketentuan tersebut diblokir.

```
ip access-list extended PROTECT_DB_SERVER
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.10.20.0 0.0.0.63 any
 permit ip 10.20.0.0 0.0.255.255 any
 permit ip 10.30.92.0 0.0.0.7 any
 deny ip any any log
```

Langkah 9: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 91 untuk melindungi DB Server.

```
OFFICE-CORE-ROUTER(config)#int g0/4.91
OFFICE-CORE-ROUTER(config-subif)#standby 91 ip 10.30.91.6
OFFICE-CORE-ROUTER(config-subif)#standby 91 priority 110
OFFICE-CORE-ROUTER(config-subif)#standby 91 preempt
OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT
*Nov 7 09:08:28.094: %HSRP-5-STATECHANGE: GigabitEthernet0/4.91 Grp 91 sta
OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT_DB_SERVER out
OFFICE-CORE-ROUTER(config-subif)#exit
```

Langkah 10: Membuat Access Control List (ACL) untuk melindungi MES Server dengan ketentuan: mengizinkan seluruh trafik OSPF dan tunnel (GRE) untuk dapat melewati perangkat, serta memberikan izin akses penuh kepada seluruh host pada jaringan IT Control, dan seluruh area pada Production. Seluruh jenis trafik lain di luar ketentuan tersebut diblokir.

```
ip access-list extended PROTECT_MES_SERVER
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.20.0.0 0.0.255.255 any
 deny ip any any log
```

Langkah 11: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 92 untuk melindungi MES Server.

```
OFFICE-CORE-ROUTER(config)#int g0/4.92
OFFICE-CORE-ROUTER(config-subif)#standby 92 ip 10.30.92.6
OFFICE-CORE-ROUTER(config-subif)#standby 92 priority 110
OFFICE-CORE-ROUTER(config-subif)#standby 92 preempt
OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT_MES_SER
*Nov 7 09:09:33.240: %HSRP-5-STATECHANGE: GigabitEthernet0/4.92 Grp 92 state St
OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT_MES_SERVER
% Incomplete command.

OFFICE-CORE-ROUTER(config-subif)#ip access-group PROTECT_MES_SERVER out
OFFICE-CORE-ROUTER(config-subif)#
```

Langkah 12: Menerapkan DHCP client pada interface g0/0 untuk mendapatkan alamat IP secara otomatis dari ISP, kemudian mengonfigurasi interface tersebut sebagai NAT outside karena berfungsi sebagai sumber koneksi internet.

```
OFFICE-CORE-ROUTER(config)#int g0/0
OFFICE-CORE-ROUTER(config-if)#ip address dhcp
OFFICE-CORE-ROUTER(config-if)#ip dhcp client default-router distance 10
OFFICE-CORE-ROUTER(config-if)#ip nat outside
-Traceback= 13148Bz 16079Ez 1604DBz 1602B8z 15A275z 15AE3Fz 3EAA141z 3EA9575z
E8297Cz 1E16248z 1175473z - Process "Exec", CPU hog, PC 0x00155F4C

OFFICE-CORE-ROUTER(config-if)#
OFFICE-CORE-ROUTER(config-if)#
*Nov 7 10:07:02.463: %SYS-3-CPUHOG: Task is running for (1999)msecs, more th
*Nov 7 10:07:02.856: %LINEPROTO-5-UPDOWN: Line protocol on Interface NVI0, c
OFFICE-CORE-ROUTER(config-if)#no sh
OFFICE-CORE-ROUTER(config-if)#
*Nov 7 10:07:14.653: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed s
*Nov 7 10:07:15.659: %LINEPROTO-5-UPDOWN: Line protocol on Interface Gigabit
OFFICE-CORE-ROUTER(config-if)#
```

Langkah 13: Menerapkan NAT inside pada interface yang terhubung ke Office Router dan Production Core Router, sedangkan interface yang menuju VLAN Servers tidak dikonfigurasi NAT karena server internal perusahaan tidak diperbolehkan mengakses internet. Hal ini dilakukan untuk menjaga keamanan dan integritas data sensitif di lingkungan internal, mencegah kebocoran informasi atau serangan dari luar, serta memastikan server hanya dapat diakses melalui jalur yang sah, misalnya melalui firewall, DB Server, atau MES Server.

```
OFFICE-CORE-ROUTER(config)#int range g0/2 - 3
OFFICE-CORE-ROUTER(config-if-range)#ip nat inside
OFFICE-CORE-ROUTER(config-if-range)#exit
OFFICE-CORE-ROUTER(config)#int range g0/5 - 6
OFFICE-CORE-ROUTER(config-if-range)#ip nat inside
OFFICE-CORE-ROUTER(config-if-range)#exit
OFFICE-CORE-ROUTER(config)#
```

Langkah 14: Menerapkan access-list untuk mengizinkan semua alamat IP pada topologi yang diperbolehkan mengakses internet agar dapat terhubung ke jaringan publik.

```
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-CORE-ROUTER(config)#access-list 10 permit 10.0.0.0 0.255.255.255
OFFICE-CORE-ROUTER(config)#ip nat inside source list 10 int g0/0 overload
OFFICE-CORE-ROUTER(config)#
```

Langkah 15: Mengumumkan default route ke seluruh router OSPF lainnya, sehingga jika sumber internet dari ISP 2 pada Production Core mengalami gangguan, router ini dapat berfungsi sebagai failover.

```
OFFICE-CORE-ROUTER(config)#router ospf 1
OFFICE-CORE-ROUTER(config-router)#default-information originate metric 10 metr$
OFFICE-CORE-ROUTER(config-router)#
```

2. Konfigurasi Production Core Router

Langkah 1: Menetapkan hostname menjadi PRODUCTION-CORE-ROUTER serta menonaktifkan fitur IP domain lookup untuk mencegah terjadinya jeda (hang) ketika terjadi kesalahan pengetikan perintah selama proses konfigurasi.

```
Enter configuration commands, one per line. End with
Router(config)#hostname PRODUCTION-CORE-ROUTER
% Hostname "PRODUCTION-CORE-ROUTER" is not a legal LAT
PRODUCTION-CORE-ROUTER(config)#no ip domain-lookup
PRODUCTION-CORE-ROUTER(config)#
```

Langkah 2: Mengonfigurasi IP address pada interface yang terhubung ke PRODUCTION-ROUTER.

```

PRODUCTION-CORE-ROUT(config)#int g0/2
PRODUCTION-CORE-ROUT(config-if)#ip add 10.0.20.1 255.255.255.252
PRODUCTION-CORE-ROUT(config-if)#no sh
PRODUCTION-CORE-ROUT(config-if)#exit
PRODUCTION-CORE-ROUT(config)#int g0/4
*Nov 6 16:07:58.120: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, ch
PRODUCTION-CORE-ROUT(config)#int g0/3
PRODUCTION-CORE-ROUT(config-if)#
*Nov 6 16:07:59.120: %LINEPROTO-5-UPDOWN: Line protocol on Interface
PRODUCTION-CORE-ROUT(config-if)#ip add 10.1.20.1 255.255.255.252
PRODUCTION-CORE-ROUT(config-if)#no sh
PRODUCTION-CORE-ROUT(config-if)#exi
PRODUCTION-CORE-ROUT(config)#
*Nov 6 16:08:14.758: %LINK-3-UPDOWN: Interface GigabitEthernet0/3, ch
PRODUCTION-CORE-ROUT(config)#

```

Langkah 3: Mengonfigurasi IP Address pada interface yang terhubung ke OFFICE-CORE-ROUTER.

```

NOV 11 16:22:10.854: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.1 on GigabitEthernet0/5
PRODUCTION-CORE-ROUT(config)#
PRODUCTION-CORE-ROUT(config)#int g0/5
PRODUCTION-CORE-ROUT(config-if)#ip add 10.0.200.2 255.255.255.252
PRODUCTION-CORE-ROUT(config-if)#no sh
PRODUCTION-CORE-ROUT(config-if)#exit
PRODUCTION-CORE-ROUT(config)#int g
*Nov 11 16:22:10.854: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.1 on GigabitEthernet0/5
PRODUCTION-CORE-ROUT(config)#int g0/6
PRODUCTION-CORE-ROUT(config-if)#ip add 10.1.200.2 255.255.255.252
PRODUCTION-CORE-ROUT(config-if)#no sh
PRODUCTION-CORE-ROUT(config-if)#exit
PRODUCTION-CORE-ROUT(config)#
*Nov 11 16:22:28.784: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.1 on GigabitEthernet0/6
PRODUCTION-CORE-ROUT(config)#

```

Langkah 4: Mengonfigurasi IP Address sebagai gateway VLAN pada Servers.

```

PRODUCTION-CORE-ROUTER#config t
Enter configuration commands, one per line. End with CNTL/Z.
PRODUCTION-CORE-ROUT(config)#int g0/4.90
PRODUCTION-CORE-ROUT(config-subif)#encapsulation dot1q 90
PRODUCTION-CORE-ROUT(config-subif)#ip add 10.30.90.2 255.255.255.248
PRODUCTION-CORE-ROUT(config-subif)#no sh
PRODUCTION-CORE-ROUT(config-subif)#exit
PRODUCTION-CORE-ROUT(config)#int g0/4.91
PRODUCTION-CORE-ROUT(config-subif)#encapsulation dot1q 91
PRODUCTION-CORE-ROUT(config-subif)#ip add 10.30.9
*Nov 11 16:19:59.465: %HSRP-5-STATECHANGE: GigabitEthernet0/4.90 Grp 90 stat
PRODUCTION-CORE-ROUT(config-subif)#ip add 10.30.91.2 255.255.255.248
PRODUCTION-CORE-ROUT(config-subif)#no sh
PRODUCTION-CORE-ROUT(config-subif)#exit
PRODUCTION-CORE-ROUT(config)#int g0/4.92
PRODUCTION-CORE-ROUT(config-subif)#encapsulation dot1q 92
PRODUCTION-CORE-ROUT(config-subif)#ip add 10.30.92.2 255.255.255.248
PRODUCTION-CORE-ROUT(config-subif)#no
*Nov 11 16:20:40.289: %HSRP-5-STATECHANGE: GigabitEthernet0/4.91 Grp 91 stat
PRODUCTION-CORE-ROUT(config-subif)#no sh
PRODUCTION-CORE-ROUT(config-subif)#exit
PRODUCTION-CORE-ROUT(config)#

```

Langkah 5: Mengonfigurasi OSPF agar dapat terhubung dengan jaringan Office dan Production.

```

Enter configuration commands, one per line. End with CNTL/Z.
PRODUCTION-CORE-ROUT(config)#router ospf 1
PRODUCTION-CORE-ROUT(config-router)#network 10.0.20.1 0.0.0.3 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.1.20.1 0.0.0.3 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.30.90.1 0.0.0.7 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.30.91.1 0.0.0.7 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.30.92.1 0.0.0.7 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.0.200.1 0.0.0.3 area 0
PRODUCTION-CORE-ROUT(config-router)#network 10.0.200.1 0.0.0.3 area 0
*Nov 6 16:18:59.727: %OSPF-5-ADJCHG: Process 1, Nbr 10.30.92.2 on GigabitEthernet0/4.90
PRODUCTION-CORE-ROUT(config-router)#network 10.1.200.1 0.0.0.3 area 0
PRODUCTION-CORE-ROUT(config-router)#e
*Nov 6 16:19:09.794: %OSPF-5-ADJCHG: Process 1, Nbr 10.30.92.2 on GigabitEthernet0/4.90
PRODUCTION-CORE-ROUT(config-router)#

```

Langkah 6: Membuat Access Control List (ACL) untuk mengamankan NAS Storage. Pada tahap ini seluruh trafik OSPF dan tunnel GRE diizinkan melewati perangkat. Selain itu, host pada jaringan IT Control, DB Server, dan MES Server juga diberikan akses penuh. Semua trafik lain di luar ketentuan tersebut diblokir.

Aturan ini diterapkan karena di lingkungan industri, NAS Storage dianggap sangat sensitif. Akses menuju NAS biasanya tidak dilakukan langsung, tetapi melalui DB atau MES sebagai perantara antara server, perangkat produksi, dan departemen akuntansi. Jaringan IT Control tetap diperbolehkan mengakses secara langsung karena mereka yang bertanggung jawab melakukan monitoring dan manajemen seluruh jaringan.

```

ip access-list extended PROTECT_NAS
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.30.91.0 0.0.0.7 any
 permit ip 10.30.92.0 0.0.0.7 any
 deny ip any any log

```

Langkah 7: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Dengan HSRP, Production Core Router bertindak sebagai Standby Router, sehingga jika salah satu router mengalami gangguan, trafik tetap dapat berjalan melalui Production Core Router tanpa mengganggu layanan. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 90 untuk melindungi NAS Storage.

```

PRODUCTION-CORE-ROUT(config)#int g0/4.90
PRODUCTION-CORE-ROUT(config-subif)#standby 90 ip 10.30.90.6
PRODUCTION-CORE-ROUT(config-subif)#standby 90 priority 100
PRODUCTION-CORE-ROUT(config-subif)#ip access-group PROTECT_NAS
*Nov 7 09:25:19.610: %HSRP-5-STATECHANGE: GigabitEthernet0/4.90 Grp 90
PRODUCTION-CORE-ROUT(config-subif)#ip access-group PROTECT_NAS out
PRODUCTION-CORE-ROUT(config-subif)#

```

Langkah 8: Membuat Access Control List (ACL) untuk melindungi DB Server dengan ketentuan: mengizinkan seluruh trafik OSPF dan tunnel (GRE) untuk dapat melewati perangkat, serta memberikan izin akses penuh kepada seluruh host pada jaringan IT Control,

Accounting, seluruh area pada Production, dan MES Server. Seluruh jenis trafik lain di luar ketentuan tersebut diblokir.

```
ip access-list extended PROTECT_DB_SERVER
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.10.20.0 0.0.0.63 any
 permit ip 10.20.0.0 0.0.255.255 any
 permit ip 10.30.92.0 0.0.0.7 any
 deny ip any any log
```

Langkah 9: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 91 untuk melindungi DB Server.

```
PRODUCTION-CORE-ROUT(config-subif)#exit
PRODUCTION-CORE-ROUT(config)#int g0/4.91
PRODUCTION-CORE-ROUT(config-subif)#standby 91 ip 10.30.91.6
PRODUCTION-CORE-ROUT(config-subif)#standby 91 priority 100
PRODUCTION-CORE-ROUT(config-subif)#ip access-group PROTECT_DB_SERVER
% Incomplete command.

PRODUCTION-CORE-ROUT(config-subif)#ip access-group PROTECT_DB_SERVER out
PRODUCTION-CORE-ROUT(config-subif)#
```

Langkah 10: Membuat Access Control List (ACL) untuk melindungi MES Server dengan ketentuan: mengizinkan seluruh trafik OSPF dan tunnel (GRE) untuk dapat melewati perangkat, serta memberikan izin akses penuh kepada seluruh host pada jaringan IT Control, dan seluruh area pada Production. Seluruh jenis trafik lain di luar ketentuan tersebut diblokir.

```
ip access-list extended PROTECT_MES_SERVER
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 any
 permit ip 10.20.0.0 0.0.255.255 any
 deny ip any any log
```

Langkah 11: Mengonfigurasi HSRP sebagai mekanisme redundansi gateway karena terdapat dua link sebagai gateway VLAN Servers, masing-masing berasal dari Office Core Router dan Production Core Router. Selanjutnya, Access Control List (ACL) diterapkan pada interface VLAN 92 untuk melindungi MES Server.

```
PRODUCTION-CORE-ROUT(config-subif)#exit
PRODUCTION-CORE-ROUT(config)#int g0/4.92
PRODUCTION-CORE-ROUT(config-subif)#standby 92 ip 10.30.92.6
PRODUCTION-CORE-ROUT(config-subif)#standby 92 priority 100
PRODUCTION-CORE-ROUT(config-subif)#ip access-group PROTECT_MES_SERVER out
PRODUCTION-CORE-ROUT(config-subif)#
```

Langkah 12: Menerapkan DHCP client pada interface g0/0 untuk mendapatkan alamat IP secara otomatis dari ISP, kemudian mengonfigurasi interface tersebut sebagai NAT outside karena berfungsi sebagai sumber koneksi internet.

```

Enter configuration commands, one per line. End with CNTL-Z.
PRODUCTION-CORE-ROUT(config)#int g0/0
PRODUCTION-CORE-ROUT(config-if)#ip address dhcp
PRODUCTION-CORE-ROUT(config-if)#ip dhcp client default-router distance 10
PRODUCTION-CORE-ROUT(config-if)#ip nat outside
-Traceback= 13148Bz 16079Ez 1604DBz 1602B8z 15A275z 15AE3Fz 41AB2F8z 4192F2Ez 41
50680Cz 25FAE71z 1E8297Cz - Process "Exec", CPU hog, PC 0x00155F4C

PRODUCTION-CORE-ROUT(config-if)#
PRODUCTION-CORE-ROUT(config-if)#
*Nov  7 10:11:03.659: %SYS-3-CPUHOG: Task is running for (2000)msecs, more than
*Nov  7 10:11:04.005: %LINEPROTO-5-UPDOWN: Line protocol on Interface NVI0, chan
PRODUCTION-CORE-ROUT(config-if)#no sh
PRODUCTION-CORE-ROUT(config-if)#

```

Langkah 13: Menerapkan NAT inside pada interface yang terhubung ke Office Router dan Production Core Router, sedangkan interface yang menuju VLAN Servers tidak dikonfigurasi NAT karena server internal perusahaan tidak diperbolehkan mengakses internet. Hal ini dilakukan untuk menjaga keamanan dan integritas data sensitif di lingkungan internal, mencegah kebocoran informasi atau serangan dari luar.

```

PRODUCTION-CORE-ROUT(config)#
PRODUCTION-CORE-ROUT(config)#int range g0/2 - 3
PRODUCTION-CORE-ROUT(config-if-range)#ip nat inside
PRODUCTION-CORE-ROUT(config-if-range)#exit
PRODUCTION-CORE-ROUT(config)#int range g0/5 - 6
PRODUCTION-CORE-ROUT(config-if-range)#ip nat inside
PRODUCTION-CORE-ROUT(config-if-range)#end
PRODUCTION-CORE-ROUTER#

```

Langkah 14: Menerapkan access-list untuk mengizinkan semua alamat IP pada topologi yang diperbolehkan mengakses internet agar dapat terhubung ke jaringan publik.

```

Enter configuration commands, one per line. End with CNTL-Z.
PRODUCTION-CORE-ROUT(config)#access-list 10 permit 10.0.0.0 0.255.255.255
PRODUCTION-CORE-ROUT(config)#ip nat inside source list 10 int g0/0 overload
PRODUCTION-CORE-ROUT(config)#

```

Langkah 15: Mengumumkan default route ke seluruh router OSPF lainnya, sehingga jika sumber internet dari ISP 1 pada Office Core mengalami gangguan, router ini dapat berfungsi sebagai failover.

```

PRODUCTION-CORE-ROUT(config)#router ospf 1
PRODUCTION-CORE-ROUT(config-router)#default-information originate metric 10 me$
PRODUCTION-CORE-ROUT(config-router)#

```

3. Konfigurasi Office Router

Langkah 1: Menetapkan hostname menjadi OFFICE-ROUTER serta menonaktifkan fitur IP domain lookup untuk mencegah terjadinya jeda (hang) ketika terjadi kesalahan pengetikan perintah selama proses konfigurasi.

```
Router(config)#hostname OFFICE-ROUTER
OFFICE-ROUTER(config)#no ip domain-lookup
OFFICE-ROUTER(config)#
```

Langkah 2: Mengonfigurasi IP Address pada interface yang terhubung dengan OFFICE-CORE-ROUTER.

```
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-ROUTER(config)#int g0/0
OFFICE-ROUTER(config-if)#ip add 10.0.10.2 255.255.255.252
OFFICE-ROUTER(config-if)#no sh
OFFICE-ROUTER(config-if)#exit
OFFICE-ROUTER(config)#
*Nov  6 16:28:01.606: %LINK-3-UPDOWN: Interface GigabitEthernet0/0:
*Nov  6 16:28:02.607: %LINEPROTO-5-UPDOWN: Line protocol on Interface
OFFICE-ROUTER(config)#int g0/3
OFFICE-ROUTER(config-if)#ip add 10.1.10.2 255.255.255.252
OFFICE-ROUTER(config-if)#no sh
OFFICE-ROUTER(config-if)#exit
OFFICE-ROUTER(config)#
```

Langkah 3: Mengonfigurasi IP Address sebagai gateway VLAN 10 (IT Control) dan VLAN 20 (Departemen Accounting).

```
OFFICE-ROUTER(config)#int g0/2.10
OFFICE-ROUTER(config-subif)#encapsulation dot1q 10
OFFICE-ROUTER(config-subif)#ip add 10.10.10.1 255.255.255.192
OFFICE-ROUTER(config-subif)#no sh
OFFICE-ROUTER(config-subif)#exit
OFFICE-ROUTER(config)#int g0/2.20
OFFICE-ROUTER(config-subif)#encapsulation dot1q 20
OFFICE-ROUTER(config-subif)#ip add 10.10.20.1 255.255.255.192
OFFICE-ROUTER(config-subif)#no sh
OFFICE-ROUTER(config-subif)#exit
OFFICE-ROUTER(config)#
```

Langkah 4: Mengonfigurasi IPv6 sebagai gateway VLAN 10 dan VLAN 20.

```

OFFICE-ROUTER(config)#int g0/2.10
OFFICE-ROUTER(config-subif)#ipv6 address FD00:ACAD:10::1/64
OFFICE-ROUTER(config-subif)#no ipv6 nd suppress-ra
OFFICE-ROUTER(config-subif)#exit
OFFICE-ROUTER(config)#int g0
*Nov 7 12:05:54.857: %PLATFORM-5-SIGNATURE_VERIFIED: Image 'flash0:
n
OFFICE-ROUTER(config)#int g0/2.20
OFFICE-ROUTER(config-subif)#ipv6 address FD00:ACAD:20::1/64
OFFICE-ROUTER(config-subif)#no ipv6 nd suppress-ra
OFFICE-ROUTER(config-subif)#

```

Langkah 5: Mengonfigurasi DHCP Server untuk masing-masing VLAN

```

Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-ROUTER(config)#
OFFICE-ROUTER(config)#ip dhcp pool vlan10
OFFICE-ROUTER(dhcp-config)#network 10.10.10.0 255.255.255.192
OFFICE-ROUTER(dhcp-config)#default-router 10.10.10.1
OFFICE-ROUTER(dhcp-config)#dns-server 8.8.8.8
OFFICE-ROUTER(dhcp-config)#exit
OFFICE-ROUTER(config)#ip dhcp pool vlan20
OFFICE-ROUTER(dhcp-config)#network 10.10.20.0 255.255.255.192
OFFICE-ROUTER(dhcp-config)#default-router 10.10.20.1
OFFICE-ROUTER(dhcp-config)#dns-server 8.8.8.8
OFFICE-ROUTER(dhcp-config)#exit
OFFICE-ROUTER(config)#ip dhcp excluded-address 10.10.10.1
^
% Invalid input detected at '^' marker.

OFFICE-ROUTER(config)#ip dhcp excluded-address 10.10.10.1
OFFICE-ROUTER(config)#ip dhcp excluded-address 10.10.20.1
OFFICE-ROUTER(config)#

```

Langkah 6: Mengonfigurasi OSPF agar dapat terhubung dengan jaringan Servers dan Production.

```

Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-ROUTER(config)#router ospf 1
OFFICE-ROUTER(config-router)#network 10.0.10.2 0.0.0.3 area 0
OFFICE-ROUTER(config-router)#network 10.0.10.2 0.0.0.3 area 0
*Nov 6 17:08:17.812: %OSPF-5-ADJCHG: Process 1, Nbr 10.30.92.2 on C
OFFICE-ROUTER(config-router)#network 10.10.10.1 0.0.0.63 area 0
OFFICE-ROUTER(config-router)#network 10.10.20.1 0.0.0.63 area 0
OFFICE-ROUTER(config-router)#network 10.1.10.2 0.0.0.3 area 0
OFFICE-ROUTER(config-router)#
*Nov 6 17:09:38.123: %OSPF-5-ADJCHG: Process 1, Nbr 10.30.92.2 on C

```

Langkah 7: Membuat Access Control List (ACL) untuk VLAN 10 (IT Control). Pada tahap ini seluruh trafik OSPF, tunnel GRE, protokol udp untuk dhcp server, dan icmp diizinkan melewati perangkat. Selain itu, semua host VLAN 10 dapat mengakses jaringan manapun.

```

ip access-list extended ACL_FROM_IT
 permit ospf any any
 permit gre any any
 permit ip 10.10.10.0 0.0.0.63 10.0.0.0 0.255.255.255
 permit ip 10.10.10.0 0.0.0.63 any
 permit udp any eq bootpc any eq bootps
 permit icmp any any
OFFICE-ROUTER#

```

Langkah 8: Membuat Access Control List (ACL) untuk VLAN 20. Pada tahap ini, seluruh trafik OSPF, tunnel GRE, serta protokol UDP untuk DHCP Server diizinkan melewati perangkat. Selanjutnya dilakukan pemfilteran: VLAN 20 (Accounting) tidak diperbolehkan mengakses NAS maupun MES Server, dan juga tidak boleh terhubung dengan area Production. Sementara itu, akses ICMP, DB Server, dan internet tetap diizinkan. Semua trafik lain di luar ketentuan tersebut diblokir.

```
ip access-list extended ACL_FROM_FINANCE
 permit ospf any any
 permit gre any any
 permit udp any eq bootpc any eq bootps
 deny ip 10.10.20.0 0.0.0.63 10.30.90.0 0.0.0.7
 deny ip 10.10.20.0 0.0.0.63 10.30.92.0 0.0.0.7
 deny ip 10.10.20.0 0.0.0.63 10.20.0.0 0.0.255.255
 permit icmp any any
 permit ip 10.10.20.0 0.0.0.63 10.30.91.0 0.0.0.7
 permit ip 10.10.20.0 0.0.0.63 any
 deny ip any any log
```

Langkah 9: Menerapkan ACL pada interface VLAN 10 dan VLAN 20.

```
OFFICE-ROUTER(config)#int g0/2.10
OFFICE-ROUTER(config-subif)#ip access-group ACL_FROM_IT in
OFFICE-ROUTER(config-subif)#exit
OFFICE-ROUTER(config)#int g0/2.20
OFFICE-ROUTER(config-subif)#ip access-group ACL_FROM_FINANCE in
OFFICE-ROUTER(config-subif)#exit
OFFICE-ROUTER(config)#
```

Langkah 10: Mengaktifkan unicast routing pada router agar host di jaringan dapat melakukan SLAAC (Stateless Address Autoconfiguration) untuk mendapatkan alamat IPv6 secara otomatis.

```
OFFICE-ROUTER(config)#ipv6 unicast-routing
OFFICE-ROUTER(config)#
```

Langkah 11: Mengonfigurasi tunnel GRE untuk melewatkan trafik IPv6 pada jaringan.

```
Enter configuration commands, one per line. End with CNTL/Z.
OFFICE-ROUTER(config)#int tu0
OFFICE-ROUTER(config-if)#
*Nov 14 12:56:46.740: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to down
OFFICE-ROUTER(config-if)#tunnel source Loopback0
OFFICE-ROUTER(config-if)#tunnel destination 1.1.1.2
OFFICE-ROUTER(config-if)#
*Nov 14 12:57:20.229: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up
OFFICE-ROUTER(config-if)#tunnel mode gre ip
OFFICE-ROUTER(config-if)#ipv6 enable
OFFICE-ROUTER(config-if)#ipv6 address FD00:1111:1::1/64
OFFICE-ROUTER(config-if)#
```

Langkah 12: Membuat static route untuk menghubungkan jaringan IPv6 dari Office ke Production.

```
!
ipv6 route FD00:CCCC:100::/64 Tunnel0
ipv6 route FD00:CCCC:101::/64 Tunnel0
ipv6 route FD00:CCCC:102::/64 Tunnel0
ipv6 route ::/0 FD00:1111:1::2
ipv6 ioam timestamp
!
```

4. Konfigurasi Production Router

Langkah 1: Menetapkan hostname menjadi PRODUCTION-ROUTER serta menonaktifkan fitur IP domain lookup untuk mencegah terjadinya jeda (hang) ketika terjadi kesalahan pengetikan perintah selama proses konfigurasi.

```
Router(config)#hostname PRODUCTION-ROUTER
% Hostname "PRODUCTION-ROUTE " is not a legal LAT r
PRODUCTION-ROUTER(config)#no ip domain-lookup
PRODUCTION-ROUTER(config)#
```

Langkah 2: Mengonfigurasi IP Address pada interface yang terhubung dengan PRODUCTION-CORE-ROUTER.

```
PRODUCTION-ROUTER(config)#int g0/0
PRODUCTION-ROUTER(config-if)#ip add 10.0.20.2 255.255.255.252
PRODUCTION-ROUTER(config-if)#no sh
PRODUCTION-ROUTER(config-if)#exi
PRODUCTION-ROUTER(config)#int g
*Nov 6 17:19:16.650: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
PRODUCTION-ROUTER(config)#int g0/5
*Nov 6 17:19:17.649: %LINEPROTO-5-UPDOWN: Line protocol on Interfac
PRODUCTION-ROUTER(config)#int g0/7
PRODUCTION-ROUTER(config-if)#ip add 10.1.20.2 255.255.255.252
PRODUCTION-ROUTER(config-if)#no sh
PRODUCTION-ROUTER(config-if)#exit
PRODUCTION-ROUTER(config-if)#
```

Langkah 3: Mengonfigurasi IP Address sebagai gateway area Production.

```

PRODUCTION-ROUTER(config)#
PRODUCTION-ROUTER(config)#int g0/1.100
PRODUCTION-ROUTER(config-subif)#encapsulation dot1q 100
PRODUCTION-ROUTER(config-subif)#ip add 10.20.100.1 255.255.255.224
PRODUCTION-ROUTER(config-subif)#no sh
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/4.101
PRODUCTION-ROUTER(config-subif)#encapsulation dot1q 101
PRODUCTION-ROUTER(config-subif)#ip add 10.20.101.1 255.255.255.224
PRODUCTION-ROUTER(config-subif)#no sh
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/6.102
PRODUCTION-ROUTER(config-subif)#encapsulation dot1 102
PRODUCTION-ROUTER(config-subif)#ip add 10.20.102.1 255.255.255.224
PRODUCTION-ROUTER(config-subif)#no sj
PRODUCTION-ROUTER(config-subif)#no sh
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#

```

Langkah 4: Mengonfigurasi IPv6 sebagai gateway area Production.

```

PRODUCTION-ROUTER(config)#int g0/1.100
PRODUCTION-ROUTER(config-subif)#ipv6 address FD00:CCCC:100::1/64
PRODUCTION-ROUTER(config-subif)#no ipv6 nd suppress-ra
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/4.101
PRODUCTION-ROUTER(config-subif)#ipv6 address FD00:CCCC:101::1/64
PRODUCTION-ROUTER(config-subif)#no ipv6 nd suppress-ra
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/6.102
PRODUCTION-ROUTER(config-subif)#ipv6 address FD00:CCCC:102::1/64
PRODUCTION-ROUTER(config-subif)#no ipv6 nd suppress-ra
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#

```

Langkah 5: Mengonfigurasi DHCP Server untuk masing-masing VLAN.

```

PRODUCTION-ROUTER(config)#ip dhcp pool vlan100
PRODUCTION-ROUTER(dhcp-config)#network 10.20.100.0 255.255.255.224
PRODUCTION-ROUTER(dhcp-config)#default-router 10.20.100.1
PRODUCTION-ROUTER(dhcp-config)#dns-server 8.8.8.8
PRODUCTION-ROUTER(dhcp-config)#exit
PRODUCTION-ROUTER(config)#ip dhcp pool vlan101
PRODUCTION-ROUTER(dhcp-config)#network 10.20.101.0 255.255.255.224
PRODUCTION-ROUTER(dhcp-config)#default-router 10.20.101.1
PRODUCTION-ROUTER(dhcp-config)#dns-server 8.8.8.8
PRODUCTION-ROUTER(dhcp-config)#exit
PRODUCTION-ROUTER(config)#ip dhcp pool vlan102
PRODUCTION-ROUTER(dhcp-config)#network 10.20.102.0 255.255.255.224
PRODUCTION-ROUTER(dhcp-config)#default-router 10.20.102.1
PRODUCTION-ROUTER(dhcp-config)#dns-server 8.8.8.8
PRODUCTION-ROUTER(dhcp-config)#exit
PRODUCTION-ROUTER(config)#$luded-address 10.20.100.1 10.20.101.1 10.20.102.1
ip dhcp excluded-address 10.20.100.1 10.20.101.1 10.20.102.1
PRODUCTION-ROUTER(config)#$luded-address 10.20.100.1
PRODUCTION-ROUTER(config)#ip dhcp excluded-address 10.20.101.1
PRODUCTION-ROUTER(config)#ip dhcp excluded-address 10.20.102.1
PRODUCTION-ROUTER(config)#

```

Langkah 6: Mengonfigurasi OSPF agar dapat terhubung dengan jaringan Servers dan Office.

```

PRODUCTION-ROUTER(config)#
PRODUCTION-ROUTER(config)#router ospf 1
PRODUCTION-ROUTER(config-router)#network 10.0.20.0 0.0.0.3 area 0
PRODUCTION-ROUTER(config-router)#network 10.20.100.0 0.0.0.31 area 0
PRODUCTION-ROUTER(config-router)#network 10.20.101.0 0.0.0.31 area 0
PRODUCTION-ROUTER(config-router)#network 10.20.102.0 0.0.0.31 area 0
PRODUCTION-ROUTER(config-router)#network 10.1.20.0 0.0.0.3 area 0
PRODUCTION-ROUTER(config-router)#

```

Langkah 7: Membuat Access Control List (ACL) untuk seluruh area Production. Pada tahap ini, seluruh trafik OSPF, tunnel GRE, serta protokol UDP untuk DHCP Server diizinkan melewati perangkat. Selanjutnya dilakukan pemfilteran: tidak diperbolehkan mengakses NAS server, dan juga tidak boleh terhubung dengan area Office. Sementara itu, akses ICMP, DB Server, MES Server dan internet tetap diizinkan. Semua trafik lain di luar ketentuan tersebut diblokir.

```

ip access-list extended ACL_FROM_AREA_1
 permit ospf any any
 permit gre any any
 permit udp any eq bootpc any eq bootps
 deny ip 10.20.100.0 0.0.0.31 10.30.90.0 0.0.0.7
 deny ip 10.20.100.0 0.0.0.31 10.10.0.0 0.0.255.255
 permit icmp any any
 permit ip 10.20.100.0 0.0.0.31 10.30.91.0 0.0.0.7
 permit ip 10.20.100.0 0.0.0.31 10.30.92.0 0.0.0.7
 permit ip 10.20.100.0 0.0.0.31 any
 deny ip any any log

```

```

ip access-list extended ACL_FROM_AREA_2
 permit ospf any any
 permit gre any any
 permit udp any eq bootpc any eq bootps
 deny ip 10.20.101.0 0.0.0.31 10.30.90.0 0.0.0.7
 deny ip 10.20.101.0 0.0.0.31 10.10.0.0 0.0.255.255
 permit icmp any any
 permit ip 10.20.101.0 0.0.0.31 10.30.91.0 0.0.0.7
 permit ip 10.20.101.0 0.0.0.31 10.30.92.0 0.0.0.7
 permit ip 10.20.101.0 0.0.0.31 any
 deny ip any any log

```

```

ip access-list extended ACL_FROM_AREA_3
 permit ospf any any
 permit gre any any
 permit udp any eq bootpc any eq bootps
 deny ip 10.20.102.0 0.0.0.31 10.30.90.0 0.0.0.7
 deny ip 10.20.102.0 0.0.0.31 10.10.0.0 0.0.255.255
 permit icmp any any
 permit ip 10.20.102.0 0.0.0.31 10.30.91.0 0.0.0.7
 permit ip 10.20.102.0 0.0.0.31 10.30.92.0 0.0.0.7
 permit ip 10.20.102.0 0.0.0.31 any
 deny ip any any log
PRODUCTION-ROUTER#

```

Langkah 8: Menerapkan ACL pada seluruh area Production.

```

Enter configuration commands, one per line. End with CNTL/Z.
PRODUCTION-ROUTER(config)#int g0/1.100
PRODUCTION-ROUTER(config-subif)#ip access-group ACL_FROM_AREA_1 in
% Incomplete command.

PRODUCTION-ROUTER(config-subif)#ip access-group ACL_FROM_AREA_1 in
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/4.101
PRODUCTION-ROUTER(config-subif)#ip access-group ACL_FROM_AREA_2 in
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#int g0/6.102
PRODUCTION-ROUTER(config-subif)#ip access-group ACL_FROM_AREA_3 in
PRODUCTION-ROUTER(config-subif)#exit
PRODUCTION-ROUTER(config)#

```

Langkah 9: Mengaktifkan unicast routing pada router agar host di jaringan dapat melakukan SLAAC (Stateless Address Autoconfiguration) untuk mendapatkan alamat IPv6 secara otomatis.

```

Enter configuration commands, one per line. End with C
PRODUCTION-ROUTER(config)#ipv6 unicast-routing
PRODUCTION-ROUTER(config)#

```

Langkah 10: Mengonfigurasi tunnel GRE untuk melewati trafik IPv6 pada jaringan.

```

PRODUCTION-ROUTER(config)#int tu0
PRODUCTION-ROUTER(config-if)#
Nov 14 12:58:13.782: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to down
PRODUCTION-ROUTER(config-if)#tunnel source Loopback0
PRODUCTION-ROUTER(config-if)#tunnel destination 2.2.2.2
PRODUCTION-ROUTER(config-if)#
Nov 14 12:58:47.324: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up
PRODUCTION-ROUTER(config-if)#tunnel mode gre ip
PRODUCTION-ROUTER(config-if)#ipv6 enable
PRODUCTION-ROUTER(config-if)#ipv6 address FD00:1111:1::2/64
PRODUCTION-ROUTER(config-if)#

```

Langkah 11: Membuat static route untuk menghubungkan jaringan IPv6 dari Production ke Office.

```

!
ipv6 route FD00:ACAD:10::/64 Tunnel0
ipv6 route FD00:ACAD:20::/64 Tunnel0
ipv6 route ::/0 FD00:1111:1::1
ipv6 ioam timestamp
!

```

5. Konfigurasi Distribusi Switch (Office)

Langkah 1: Membuat Vlan database (vlan 10 dan vlan 20)

```

DISTRIBUTED-SWITCH#vlan database
DISTRIBUTED-SWITCH(vlan)#vlan 10
VLAN 10 added:
  Name: VLAN0010
DISTRIBUTED-SWITCH(vlan)#vlan 20
VLAN 20 added:
  Name: VLAN0020
DISTRIBUTED-SWITCH(vlan)#

```

Langkah 2: Mengonfigurasi Mode Trunk untuk menerima semua vlan dari Office Router.

```

DISTRIBUTED-SWITCH(config)#
DISTRIBUTED-SWITCH(config)#int f1/5
DISTRIBUTED-SWITCH(config-if)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH(config-if)#switchport mode trunk
DISTRIBUTED-SWITCH(config-if)#no sh
*Mar 1 00:23:05.463: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk
DISTRIBUTED-SWITCH(config-if)#no sh
DISTRIBUTED-SWITCH(config-if)#

```

Langkah 3: Mengonfigurasi Mode Trunk dan hanya mengijinkan vlan 10 ke departemen IT Control. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Primary, yang berarti switch ini akan menjadi root bridge dalam topologi spanning-tree. Spanning-tree digunakan untuk mencegah looping di jaringan layer 2 dengan menonaktifkan jalur cadangan secara otomatis jika jalur utama aktif. Karena LACP tidak dapat digunakan akibat keterbatasan image switch, redundansi dilakukan melalui mekanisme spanning-tree, sehingga jaringan tetap aman dari loop sekaligus menjaga ketersediaan jalur cadangan.

```

Enter configuration commands, one per line. End with CNTL/Z.
DISTRIBUTED-SWITCH(config)#int range f1/1 - 2
DISTRIBUTED-SWITCH(config-if-range)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH(config-if-range)#switchport mode trunk
DISTRIBUTED-SWITCH(config-if-range)#switchport
*Mar 1 00:27:31.427: %DTP-5-TRUNKPORTON: Port Fa1/1-2 has become dot1q trunk
DISTRIBUTED-SWITCH(config-if-range)#switchport trunk allowed vlan 10
Command rejected: Bad VLAN allowed list. You have to include all default vlans, e.g. 1-2,1002-1005.
Command rejected: Bad VLAN allowed list. You have to include all default vlans, e.g. 1-2,1002-1005.
DISTRIBUTED-SWITCH(config-if-range)#$trunk allowed vlan 10,1-2,1002-1005
DISTRIBUTED-SWITCH(config-if-range)#spanning-tree vlan 10 root primary
VLAN 10 bridge priority set to 8192
VLAN 10 bridge max aging time unchanged at 20
VLAN 10 bridge hello time unchanged at 2
VLAN 10 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH(config)#int range f1/1 - 2
DISTRIBUTED-SWITCH(config-if-range)#no sh
DISTRIBUTED-SWITCH(config-if-range)#

```

Langkah 4: Mengonfigurasi Mode Trunk dan hanya mengijinkan vlan 20 ke departemen Accounting. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Primary, yang berarti switch ini akan menjadi root bridge dalam topologi spanning-tree.

```

DISTRIBUTED-SWITCH(config)#int range f1/3 - 4
DISTRIBUTED-SWITCH(config-if-range)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH(config-if-range)#switchport mode trunk
DISTRIBUTED-SWITCH(config-if-range)#switchport trunk allowed vlan 20
Command rejected: Bad VLAN allowed list. You have to include all default vlans,
Command rejected: Bad VLAN allowed list. You have to include all default vlans,
DISTRIBUTED-SWITCH(config-if-range)#spanning-tree root vlan 20 primary
^
% Invalid input detected at '^' marker.

DISTRIBUTED-SWITCH(config-if-range)#spanning-tree vlan 20 root primary
% This switch is already the root of VLAN20 spanning tree
VLAN 20 bridge priority set to 8192
VLAN 20 bridge max aging time unchanged at 20
VLAN 20 bridge hello time unchanged at 2
VLAN 20 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH(config)#int range f1/3 - 4
DISTRIBUTED-SWITCH(config-if-range)#$trunk allowed vlan 20, 1-2, 1002-1005
switchport trunk allowed vlan 20, 1-2, 1002-1005
^
% Invalid input detected at '^' marker.

DISTRIBUTED-SWITCH(config-if-range)#$trunk allowed vlan 20,1-2,1002-1005
DISTRIBUTED-SWITCH(config-if-range)#no sh
DISTRIBUTED-SWITCH(config-if-range)#

```

6. Konfigurasi Distribusi Switch 1 (Production)

Langkah 1: Membuat Vlan database (vlan 100).

```

DISTRIBUTED-SWITCH-1#vlan database
DISTRIBUTED-SWITCH-1(vlan)#vlan 100
VLAN 100 added:
  Name: VLAN0100
DISTRIBUTED-SWITCH-1(vlan)#

```

Langkah 2: Mengonfigurasi Mode Trunk untuk menerima semua vlan dari Production Router.

```

DISTRIBUTED-SWITCH-1(config)#int f1/0
DISTRIBUTED-SWITCH-1(config-if)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH-1(config-if)#switchport mode trunk
DISTRIBUTED-SWITCH-1(config-if)#switchpo
*Mar 1 00:02:16.199: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
DISTRIBUTED-SWITCH-1(config-if)#spanning-tree vlan 100 root primary
% This switch is already the root of VLAN100 spanning tree
VLAN 100 bridge priority set to 8192
VLAN 100 bridge max aging time unchanged at 20
VLAN 100 bridge hello time unchanged at 2
VLAN 100 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH-1(config)#

```

Langkah 3: Mengonfigurasi Mode Trunk dan hanya mengijinkan vlan 100 ke Area 1. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Primary, yang berarti switch ini akan menjadi root bridge dalam topologi spanning-tree.

```

VLAN 100 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH-1(config)#int range f1/1 - 2
DISTRIBUTED-SWITCH-1(config-if-range)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH-1(config-if-range)#switchport mode trunk
DISTRIBUTED-SWITCH-1(config-if-range)#swit
*Mar 1 00:04:13.435: %DTP-5-TRUNKPORTON: Port Fa1/1-2 has become dot1q trunk
DISTRIBUTED-SWITCH-1(config-if-range)#$trunk allowed vlan 100,1-2,1002-1005
DISTRIBUTED-SWITCH-1(config-if-range)#spanning-tree vlan 100 root primary
% This switch is already the root of VLAN100 spanning tree
VLAN 100 bridge priority unchanged at 8192
VLAN 100 bridge max aging time unchanged at 20
VLAN 100 bridge hello time unchanged at 2
VLAN 100 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH-1(config)#

```

7. Konfigurasi Distribusi Switch 2 (Production)

Langkah 1: Membuat Vlan database (vlan 101).

```

Exiting....
DISTRIBUTED-SWITCH-2#vlan database
DISTRIBUTED-SWITCH-2(vlan)#vlan 101
VLAN 101 added:
    Name: VLAN0101
DISTRIBUTED-SWITCH-2(vlan)#

```

Langkah 2: Mengonfigurasi Mode Trunk untuk menerima semua vlan dari Production Router.

```

Enter configuration commands, one per line. End with CNTL/Z.
DISTRIBUTED-SWITCH-2(config)#int f1/5
DISTRIBUTED-SWITCH-2(config-if)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH-2(config-if)#switchport mode trunk
DISTRIBUTED-SWITCH-2(config-if)#swirchport
*Mar 1 00:02:19.551: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk
DISTRIBUTED-SWITCH-2(config-if)#

```

Langkah 3: Mengonfigurasi Mode Trunk dan hanya mengijinkan vlan 101 ke Area 2. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Primary, yang berarti switch ini akan menjadi root bridge dalam topologi spanning-tree.

```

DISTRIBUTED-SWITCH-2(config)#int range f1/1 - 2
DISTRIBUTED-SWITCH-2(config-if-range)#switchport trunk encapsulation dot1q
DISTRIBUTED-SWITCH-2(config-if-range)#switchport mode trunk
DISTRIBUTED-SWITCH-2(config-if-range)#switchport
*Mar 1 00:03:27.311: %DTP-5-TRUNKPORTON: Port Fa1/1-2 has become dot1q trunk
DISTRIBUTED-SWITCH-2(config-if-range)#$trunk allowed vlan 101,1-2,1002-1005
DISTRIBUTED-SWITCH-2(config-if-range)#spanning-tree vlan 101 root primary
% This switch is already the root of VLAN101 spanning tree
VLAN 101 bridge priority set to 8192
VLAN 101 bridge max aging time unchanged at 20
VLAN 101 bridge hello time unchanged at 2
VLAN 101 bridge forward delay unchanged at 15
DISTRIBUTED-SWITCH-2(config)#

```

8. Konfigurasi Distribusi Switch 3 (Production)

Langkah 1: Membuat Vlan database (vlan 102).

```
DISTRIBUTED-SWITCH-3#  
DISTRIBUTED-SWITCH-3#vlan database  
DISTRIBUTED-SWITCH-3(vlan)#vlan 102  
VLAN 102 added:  
Name: VLAN0102  
DISTRIBUTED-SWITCH-3(vlan)#
```

Langkah 2: Mengonfigurasi Mode Trunk untuk menerima semua vlan dari Production Router.

```
DISTRIBUTED-SWITCH-3#config t  
Enter configuration commands, one per line. End with CNTL/Z.  
DISTRIBUTED-SWITCH-3(config)#int f1/5  
DISTRIBUTED-SWITCH-3(config-if)#switchport trunk encapsulation dot1q  
DISTRIBUTED-SWITCH-3(config-if)#switchport mode trunk  
DISTRIBUTED-SWITCH-3(config-if)#switchpor  
*Mar 1 00:02:03.791: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk  
DISTRIBUTED-SWITCH-3(config-if)#
```

Langkah 3: Mengonfigurasi Mode Trunk dan hanya mengijinkan vlan 102 ke Area 3. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Primary, yang berarti switch ini akan menjadi root bridge dalam topologi spanning-tree.

```
DISTRIBUTED-SWITCH-3(config)#int range f1/1 - 2  
DISTRIBUTED-SWITCH-3(config-if-range)#switchport trunk encapsulation dot1q  
DISTRIBUTED-SWITCH-3(config-if-range)#switchport mode trunk  
DISTRIBUTED-SWITCH-3(config-if-range)#switc  
*Mar 1 00:03:00.019: %DTP-5-TRUNKPORTON: Port Fa1/1-2 has become dot1q trunk  
DISTRIBUTED-SWITCH-3(config-if-range)#$trunk allowed vlan 102,1-2,1002-1005  
DISTRIBUTED-SWITCH-3(config-if-range)#spanning-tree vlan 102 root primary  
% This switch is already the root of VLAN102 spanning tree  
VLAN 102 bridge priority set to 8192  
VLAN 102 bridge max aging time unchanged at 20  
VLAN 102 bridge hello time unchanged at 2  
VLAN 102 bridge forward delay unchanged at 15  
DISTRIBUTED-SWITCH-3(config)#
```

9. Konfigurasi Managed-Switch (Office - IT Controll)

Langkah 1: Membuat Vlan database (vlan 10).

```
MANAGED-SWITCH#vlan database  
MANAGED-SWITCH(vlan)#vlan 10  
VLAN 10 added:  
Name: VLAN0010  
MANAGED-SWITCH(vlan)#
```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Secondary, yang berarti switch tersebut akan menjadi cadangan utama jika Root Primary (Distributed Switch)

tidak aktif. Ketika Root Primary gagal, managed switch otomatis naik mengambil posisi sebagai Root Bridge.

```
MANAGED-SWITCH(config)#int f1/0
MANAGED-SWITCH(config-if)#switchport trunk encapsulation dot1q
MANAGED-SWITCH(config-if)#switchport mode trunk
MANAGED-SWITCH(config-if)#switch
*Mar 1 00:03:17.383: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
MANAGED-SWITCH(config-if)#switchport trunk allowed vlan 10
Command rejected: Bad VLAN allowed list. You have to include all default vlans, e.g. 1-2,1002-1005.
MANAGED-SWITCH(config-if)#switchport trunk allowed vlan 10,1-2,1002-1005
MANAGED-SWITCH(config-if)#spanning-tree vlan 10 root secondary
VLAN 10 bridge priority set to 16384
VLAN 10 bridge max aging time unchanged at 20
VLAN 10 bridge hello time unchanged at 2
VLAN 10 bridge forward delay unchanged at 15
MANAGED-SWITCH(config-if)#

MANAGED-SWITCH(config)#
MANAGED-SWITCH(config)#int f1/3
MANAGED-SWITCH(config-if)#switchport trunk encapsulation dot1q
MANAGED-SWITCH(config-if)#switchport mode trunk
MANAGED-SWITCH(config-if)#switchpot
*Mar 1 00:05:39.323: %DTP-5-TRUNKPORTON: Port Fa1/3 has become dot1q trunk
MANAGED-SWITCH(config-if)#switchport trunk allowed vlan 10
Command rejected: Bad VLAN allowed list. You have to include all default vlans, e.g. 1-2,1002-1005.
MANAGED-SWITCH(config-if)#switchport trunk allowed vlan 10,1-2,1002-1005
MANAGED-SWITCH(config-if)#spanning-tree vlan 10 root secondary
VLAN 10 bridge priority unchanged at 16384
VLAN 10 bridge max aging time unchanged at 20
VLAN 10 bridge hello time unchanged at 2
VLAN 10 bridge forward delay unchanged at 15
MANAGED-SWITCH(config-if)#
```

Langkah 3: Mengonfigurasi Switch Mode Access ke interface client.

```
MANAGED-SWITCH(config)#int range f1/1 - 2
MANAGED-SWITCH(config-if-range)#switchport mode access
MANAGED-SWITCH(config-if-range)#switchport access vlan 10
^
% Invalid input detected at '^' marker.
MANAGED-SWITCH(config-if-range)#switchport access vlan 10
```

10. Konfigurasi Managed-Switch (Office - Accounting)

Langkah 1: Membuat Vlan database (vlan 20).

```
MANAGED-SWITCH1#vlan database
MANAGED-SWITCH1(vlan)#vlan 20
VLAN 20 added:
  Name: VLAN0020
MANAGED-SWITCH1(vlan)#
```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Secondary, yang berarti switch tersebut akan menjadi cadangan utama jika Root Primary (Distributed Switch) tidak aktif. Ketika Root Primary gagal, managed switch otomatis naik mengambil posisi sebagai Root Bridge.

```
MANAGED-SWITCH1(config)#int range f1/0 - 1
MANAGED-SWITCH1(config-if-range)#switchport trunk encapsulation dot1q
MANAGED-SWITCH1(config-if-range)#switchport mode trunk
MANAGED-SWITCH1(config-if-range)#switchport
*Mar  1 00:03:11.819: %DTP-5-TRUNKPORTON: Port Fa1/0-1 has become dot1q trunk
MANAGED-SWITCH1(config-if-range)#$trunk allowed vlan 20,1-2,1002-1005
MANAGED-SWITCH1(config-if-range)#spanning-tree vlan 20 root secondary
VLAN 20 bridge priority set to 16384
VLAN 20 bridge max aging time unchanged at 20
VLAN 20 bridge hello time unchanged at 2
VLAN 20 bridge forward delay unchanged at 15
MANAGED-SWITCH1(config)#
```

solarwinds | Solar-PuTTY free tool

Langkah 3: Mengonfigurasi Switch Mode Access ke interface client.

```
MANAGED-SWITCH1(config)#int range f1/2 - 3
MANAGED-SWITCH1(config-if-range)#switchport mode access
MANAGED-SWITCH1(config-if-range)#switchport access vlan 20
MANAGED-SWITCH1(config-if-range)#
```

11. Konfigurasi Managed-Switch (Production – Area 1)

Langkah 1: Membuat Vlan database (vlan 100).

```
INDUSTRIAL-SWITCH#vlan database
INDUSTRIAL-SWITCH(vlan)#vlan 100
VLAN 100 added:
  Name: VLAN0100
INDUSTRIAL-SWITCH(vlan)#
```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Secondary, yang berarti switch tersebut akan menjadi cadangan utama jika Root Primary (Distributed Switch) tidak aktif. Ketika Root Primary gagal, managed switch otomatis naik mengambil posisi sebagai Root Bridge.

```

INDUSTRIAL-SWITCH(config)#int f1/0
INDUSTRIAL-SWITCH(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH(config-if)#switchport
*Mar 1 00:02:53.779: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
INDUSTRIAL-SWITCH(config-if)#switchport trunk allowed vlan 100,1-2,1002-1005
INDUSTRIAL-SWITCH(config-if)#spanning-tree vlan 100 root secondary
VLAN 100 bridge priority set to 16384
VLAN 100 bridge max aging time unchanged at 20
VLAN 100 bridge hello time unchanged at 2
VLAN 100 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH(config)#int f1/5
INDUSTRIAL-SWITCH(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH(config-if)#swit
*Mar 1 00:03:58.647: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk
INDUSTRIAL-SWITCH(config-if)#switchport trunk allowed vlan 100,1-2,1002-1005
INDUSTRIAL-SWITCH(config-if)#spanning-tree vlan 100 root secondary
VLAN 100 bridge priority unchanged at 16384
VLAN 100 bridge max aging time unchanged at 20
VLAN 100 bridge hello time unchanged at 2
VLAN 100 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH(config)#

```

Langkah 3: Mengonfigurasi Switch Mode Access ke interface client.

```

INDUSTRIAL-SWITCH(config)#int range f1/1 - 4
INDUSTRIAL-SWITCH(config-if-range)#switchport mode access
INDUSTRIAL-SWITCH(config-if-range)#switchport access vlan 100
INDUSTRIAL-SWITCH(config-if-range)#

```

12. Konfigurasi Managed-Switch (Production – Area 2)

Langkah 1: Membuat Vlan database (vlan 101).

```

INDUSTRIAL-SWITCH1#vlan database
INDUSTRIAL-SWITCH1(vlan)#vlan 101
VLAN 101 added:
Name: VLAN0101
INDUSTRIAL-SWITCH1(vlan)#

```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Secondary, yang berarti switch tersebut akan menjadi cadangan utama jika Root Primary (Distributed Switch) tidak aktif. Ketika Root Primary gagal, managed switch otomatis naik mengambil posisi sebagai Root Bridge.

```

INDUSTRIAL-SWITCH1(config)#int f1/0
INDUSTRIAL-SWITCH1(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH1(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH1(config-if)#switchport t
*Mar 1 00:02:05.355: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
INDUSTRIAL-SWITCH1(config-if)#switchport trunk allowed vlan 101,1-2,1002-1005
INDUSTRIAL-SWITCH1(config-if)#spanning-tree vlan 101 root secondary
VLAN 101 bridge priority set to 16384
VLAN 101 bridge max aging time unchanged at 20
VLAN 101 bridge hello time unchanged at 2
VLAN 101 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH1(config)#int f1/5
INDUSTRIAL-SWITCH1(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH1(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH1(config-if)#s
*Mar 1 00:02:51.795: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk
INDUSTRIAL-SWITCH1(config-if)#switchport trunk allowed vlan 101,1-2,1002-1005
INDUSTRIAL-SWITCH1(config-if)#spanning-tree vlan 101 root secondary
VLAN 101 bridge priority unchanged at 16384
VLAN 101 bridge max aging time unchanged at 20
VLAN 101 bridge hello time unchanged at 2
VLAN 101 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH1(config)#

```

Langkah 3: Mengonfigurasi Switch Mode Access ke interface client.

```

INDUSTRIAL-SWITCH1(config)#int range f1/1 - 4
INDUSTRIAL-SWITCH1(config-if-range)#switchport mode access
INDUSTRIAL-SWITCH1(config-if-range)#switchport access vlan 101
INDUSTRIAL-SWITCH1(config-if-range)#

```

13. Konfigurasi Managed-Switch (Production – Area 3)

Langkah 1: Membuat Vlan database (vlan 102).

```

INDUSTRIAL-SWITCH2#vlan database
INDUSTRIAL-SWITCH2(vlan)#vlan 102
VLAN 102 added:
  Name: VLAN0102
INDUSTRIAL-SWITCH2(vlan)#exit
APPLY completed.
Exiting...

```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch. Selanjutnya, dilakukan konfigurasi Spanning-Tree Root Secondary, yang berarti switch tersebut akan menjadi cadangan utama jika Root Primary (Distributed Switch) tidak aktif. Ketika Root Primary gagal, managed switch otomatis naik mengambil posisi sebagai Root Bridge.

```

INDUSTRIAL-SWITCH2(config)#int f1/0
INDUSTRIAL-SWITCH2(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH2(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH2(config-if)#switchport trunk
*Mar 1 00:02:27.215: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
INDUSTRIAL-SWITCH2(config-if)#switchport trunk allowed 102,1-2,1002-1005
^
% Invalid input detected at '^' marker.

INDUSTRIAL-SWITCH2(config-if)#switchport trunk allowed vlan 102,1-2,1002-1005
INDUSTRIAL-SWITCH2(config-if)#spanning-tree vlan 102 root secondary
VLAN 102 bridge priority set to 16384
VLAN 102 bridge max aging time unchanged at 20
VLAN 102 bridge hello time unchanged at 2
VLAN 102 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH2(config)#int f1/5
INDUSTRIAL-SWITCH2(config-if)#switchport trunk encapsulation dot1q
INDUSTRIAL-SWITCH2(config-if)#switchport mode trunk
INDUSTRIAL-SWITCH2(config-if)#switch
*Mar 1 00:03:18.895: %DTP-5-TRUNKPORTON: Port Fa1/5 has become dot1q trunk
INDUSTRIAL-SWITCH2(config-if)#switchport trunk allowed vlan 102,1-2,1002-1005
INDUSTRIAL-SWITCH2(config-if)#spanning-tree vlan 102 root secondary
^
% Invalid input detected at '^' marker.

INDUSTRIAL-SWITCH2(config-if)#spanning-tree vlan 102 root secondary
VLAN 102 bridge priority unchanged at 16384
VLAN 102 bridge max aging time unchanged at 20
VLAN 102 bridge hello time unchanged at 2
VLAN 102 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH2(config)#

```

Langkah 3: Mengonfigurasi Switch Mode Access ke interface client.

```

VLAN 102 bridge forward delay unchanged at 15
INDUSTRIAL-SWITCH2(config)#int range f1/1 - 4
INDUSTRIAL-SWITCH2(config-if-range)#switchport mode access
INDUSTRIAL-SWITCH2(config-if-range)#switchport access vlan 102
INDUSTRIAL-SWITCH2(config-if-range)#

```

14. Konfigurasi Managed-Switch (Servers)

Langkah 1: Membuat Vlan database (vlan 90, vlan 91, dan vlan 92).

```

MANAGED-SWITCH2#vlan database
MANAGED-SWITCH2(vlan)#vlan 90
VLAN 90 added:
  Name: VLAN0090
MANAGED-SWITCH2(vlan)#vlan 91
VLAN 91 added:
  Name: VLAN0091
MANAGED-SWITCH2(vlan)#vlan 92
VLAN 92 added:
  Name: VLAN0092
MANAGED-SWITCH2(vlan)#

```

Langkah 2: Melakukan konfigurasi Mode Trunk pada interface yang terhubung ke Distributed Switch.

```
MANAGED-SWITCH2(config)#int f1/0
MANAGED-SWITCH2(config-if)#switchport trunk encapsulation dot1q
MANAGED-SWITCH2(config-if)#switchport mode trunk
MANAGED-SWITCH2(config-if)#exit
*Mar 1 00:05:27.363: %DTP-5-TRUNKPORTON: Port Fa1/0 has become dot1q trunk
MANAGED-SWITCH2(config-if)#exit
MANAGED-SWITCH2(config)#int f1/4
MANAGED-SWITCH2(config-if)#switchport trunk encapsulation dot1q
MANAGED-SWITCH2(config-if)#switchport mode trunk
MANAGED-SWITCH2(config-if)#exit
*Mar 1 00:05:59.835: %DTP-5-TRUNKPORTON: Port Fa1/4 has become dot1q trunk
MANAGED-SWITCH2(config-if)#exit
MANAGED-SWITCH2(config)#
```

Langkah 3: Mengonfigurasi mode access pada interface yang terhubung ke masing-masing server.

```
MANAGED-SWITCH2(config)#int f1/1
MANAGED-SWITCH2(config-if)#switchport mode access
MANAGED-SWITCH2(config-if)#switchport access vlan 90
MANAGED-SWITCH2(config-if)#exit
MANAGED-SWITCH2(config)#int f1/2
MANAGED-SWITCH2(config-if)#switchport mode access
MANAGED-SWITCH2(config-if)#switchport access vlan 91
MANAGED-SWITCH2(config-if)#exit
MANAGED-SWITCH2(config)#int f1/3
MANAGED-SWITCH2(config-if)#switchport mode access
MANAGED-SWITCH2(config-if)#switchport access vlan 92
MANAGED-SWITCH2(config-if)#
```

4. PENGUJIAN

4.1 Pengujian DHCP dan Alokasi IP

Pengujian dilakukan pada sisi client untuk memastikan bahwa DHCP Server berfungsi dengan benar dan mampu memberikan alamat IP sesuai konfigurasi yang telah ditetapkan.

1. Pengujian pertama dilakukan pada seluruh client di area Production. Hasilnya menunjukkan bahwa alokasi IP sudah sesuai dengan konfigurasi DHCP Pool serta pembagian alamat VLAN pada masing-masing area.

Area 2

```
PC5> ip dhcp -r
DDORA IP 10.20.101.2/27 GW 10.20.101.1
PC5> █
```

Area 3

```
PC12> ip dhcp -r
DDORA IP 10.20.102.2/27 GW 10.20.102.1
PC12> █
```

Area 1

```
PC6> ip dhcp -r
DDORA IP 10.20.100.2/27 GW 10.20.100.1
PC6> █
```

2. Pengujian kedua dilakukan pada seluruh client di area Office. Hasilnya menunjukkan bahwa alokasi IP sudah sesuai dengan konfigurasi DHCP Pool serta pembagian alamat VLAN pada masing-masing area.

IT Controll

```
PC1> ip dhcp -r
DORA IP 10.10.10.2/26 GW 10.10.10.1
PC1> █
```

Accounting & Finance

```
PC3> ip dhcp -r
DORA IP 10.10.20.2/26 GW 10.10.20.1

PC3> █
```

3. Alokasi IP Address static pada masing-masing server.

DB-Server

```
DB-SERVER> sh

NAME      IP/MASK      GATEWAY      MAC      LPORT  RHOST:PORT
DB-SERV1  10.30.91.3/29  10.30.91.6    00:50:79:66:68:0b  20272  127.0.0.1:20273
          fe80::250:79ff:fe66:680b/64

DB-SERVER> █
```

NAS-Storage

```
NAS-STORAGE> sh

NAME      IP/MASK      GATEWAY      MAC      LPORT  RHOST:PORT
NAS-STO1  10.30.90.3/29  10.30.90.6    00:50:79:66:68:0a  20270  127.0.0.1:20271
          fe80::250:79ff:fe66:680a/64

NAS-STORAGE> █
```

MES-Server

```
MES-SERVER> sh

NAME      IP/MASK      GATEWAY      MAC      LPORT  RHOST:PORT
MES-SER1  10.30.92.3/29  10.30.92.6    00:50:79:66:68:0c  20274  127.0.0.1:20275
          fe80::250:79ff:fe66:680c/64
          fd00:acad:92::3/64

MES-SERVER> █
```

4.2 Pengujian Rute OSPF pada Setiap Router

Pengujian dilakukan pada seluruh router yang telah dikonfigurasi menggunakan OSPF untuk memastikan bahwa masing-masing perangkat berhasil mempelajari seluruh rute yang diperlukan untuk berkomunikasi ke seluruh jaringan dalam topologi.

1. Pengujian pertama dilakukan pada Office Router. Hasilnya menunjukkan bahwa router tersebut telah mempelajari seluruh rute menuju router-router lain yang tergabung dalam proses OSPF.

```

0      10.0.20.0/30 [110/3] via 10.1.10.1, 00:03:19, GigabitEthernet0/3
                        [110/3] via 10.0.10.1, 00:03:19, GigabitEthernet0/0
0      10.0.200.0/30 [110/2] via 10.1.10.1, 00:03:29, GigabitEthernet0/3
                        [110/2] via 10.0.10.1, 00:03:40, GigabitEthernet0/0
0      10.1.20.0/30 [110/3] via 10.1.10.1, 00:03:19, GigabitEthernet0/3
                        [110/3] via 10.0.10.1, 00:03:19, GigabitEthernet0/0
0      10.1.200.0/30 [110/2] via 10.1.10.1, 00:03:29, GigabitEthernet0/3
                        [110/2] via 10.0.10.1, 00:03:40, GigabitEthernet0/0
0      10.20.100.0/27 [110/4] via 10.1.10.1, 00:03:19, GigabitEthernet0/3
                        [110/4] via 10.0.10.1, 00:03:19, GigabitEthernet0/0
0      10.20.101.0/27 [110/4] via 10.1.10.1, 00:03:19, GigabitEthernet0/3
                        [110/4] via 10.0.10.1, 00:03:19, GigabitEthernet0/0
0      10.20.102.0/27 [110/4] via 10.1.10.1, 00:03:19, GigabitEthernet0/3
                        [110/4] via 10.0.10.1, 00:03:19, GigabitEthernet0/0
0      10.30.90.0/29 [110/2] via 10.1.10.1, 00:03:29, GigabitEthernet0/3
                        [110/2] via 10.0.10.1, 00:03:40, GigabitEthernet0/0
0      10.30.91.0/29 [110/2] via 10.1.10.1, 00:03:29, GigabitEthernet0/3
                        [110/2] via 10.0.10.1, 00:03:40, GigabitEthernet0/0
0      10.30.92.0/29 [110/2] via 10.1.10.1, 00:03:29, GigabitEthernet0/3
                        [110/2] via 10.0.10.1, 00:03:40, GigabitEthernet0/0
OFFICE-ROUTER#
OFFICE-ROUTER#

```

- Pengujian kedua dilakukan pada Office Core Router. Hasilnya menunjukkan bahwa router tersebut telah mempelajari seluruh rute menuju router-router lain yang tergabung dalam proses OSPF.

```

0      10.0.0.0/8 is variably subnetted, 21 subnets, 5 masks
0      10.0.20.0/30 [110/2] via 10.30.91.2, 00:04:01, GigabitEthernet0/4.91
                        [110/2] via 10.30.90.2, 00:04:01, GigabitEthernet0/4.90
                        [110/2] via 10.1.200.2, 00:04:01, GigabitEthernet0/6
                        [110/2] via 10.0.200.2, 00:04:01, GigabitEthernet0/5
0      10.1.20.0/30 [110/2] via 10.30.91.2, 00:04:01, GigabitEthernet0/4.91
                        [110/2] via 10.30.90.2, 00:04:01, GigabitEthernet0/4.90
                        [110/2] via 10.1.200.2, 00:04:01, GigabitEthernet0/6
                        [110/2] via 10.0.200.2, 00:04:01, GigabitEthernet0/5
0      10.10.10.0/26 [110/2] via 10.1.10.2, 00:04:11, GigabitEthernet0/3
                        [110/2] via 10.0.10.2, 00:04:11, GigabitEthernet0/2
0      10.10.20.0/26 [110/2] via 10.1.10.2, 00:04:11, GigabitEthernet0/3
                        [110/2] via 10.0.10.2, 00:04:11, GigabitEthernet0/2
0      10.20.100.0/27 [110/3] via 10.30.91.2, 00:04:01, GigabitEthernet0/4.91
                        [110/3] via 10.30.90.2, 00:04:01, GigabitEthernet0/4.90
                        [110/3] via 10.1.200.2, 00:04:01, GigabitEthernet0/6
                        [110/3] via 10.0.200.2, 00:04:01, GigabitEthernet0/5
0      10.20.101.0/27 [110/3] via 10.30.91.2, 00:04:01, GigabitEthernet0/4.91
                        [110/3] via 10.30.90.2, 00:04:01, GigabitEthernet0/4.90
                        [110/3] via 10.1.200.2, 00:04:01, GigabitEthernet0/6
                        [110/3] via 10.0.200.2, 00:04:01, GigabitEthernet0/5
0      10.20.102.0/27 [110/3] via 10.30.91.2, 00:04:01, GigabitEthernet0/4.91
                        [110/3] via 10.30.90.2, 00:04:01, GigabitEthernet0/4.90
                        [110/3] via 10.1.200.2, 00:04:01, GigabitEthernet0/6
                        [110/3] via 10.0.200.2, 00:04:01, GigabitEthernet0/5
OFFICE-CORE-ROUTER#
OFFICE-CORE-ROUTER#

```

- Pengujian ketiga dilakukan pada Production Router. Hasilnya menunjukkan bahwa router tersebut telah mempelajari seluruh rute menuju router-router lain yang tergabung dalam proses OSPF.

```

0      10.0.0.0/8 is variably subnetted, 19 subnets, 5 masks
0      10.0.10.0/30 [110/3] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/3] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.0.200.0/30 [110/2] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/2] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.1.10.0/30 [110/3] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/3] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.1.200.0/30 [110/2] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/2] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.10.10.0/26 [110/4] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/4] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.10.20.0/26 [110/4] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/4] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.30.90.0/29 [110/2] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/2] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.30.91.0/29 [110/2] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/2] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
0      10.30.92.0/29 [110/2] via 10.1.20.1, 00:06:13, GigabitEthernet0/7
                        [110/2] via 10.0.20.1, 00:06:13, GigabitEthernet0/0
PRODUCTION-ROUTER#
PRODUCTION-ROUTER#
PRODUCTION-ROUTER#

```

4. Pengujian keempat dilakukan pada Production Core Router. Hasilnya menunjukkan bahwa router tersebut telah mempelajari seluruh rute menuju router-router lain yang tergabung dalam proses OSPF.

```

10.0.0.0/8 is variably subnetted, 21 subnets, 5 masks
0    10.0.10.0/30 [110/2] via 10.30.91.1, 00:04:49, GigabitEthernet0/4.91
    [110/2] via 10.30.90.1, 00:04:49, GigabitEthernet0/4.90
    [110/2] via 10.1.200.1, 00:04:49, GigabitEthernet0/6
    [110/2] via 10.0.200.1, 00:04:49, GigabitEthernet0/5
0    10.1.10.0/30 [110/2] via 10.30.91.1, 00:04:49, GigabitEthernet0/4.91
    [110/2] via 10.30.90.1, 00:04:49, GigabitEthernet0/4.90
    [110/2] via 10.1.200.1, 00:04:49, GigabitEthernet0/6
    [110/2] via 10.0.200.1, 00:04:49, GigabitEthernet0/5
0    10.10.10.0/26 [110/3] via 10.30.91.1, 00:04:49, GigabitEthernet0/4.91
    [110/3] via 10.30.90.1, 00:04:49, GigabitEthernet0/4.90
    [110/3] via 10.1.200.1, 00:04:49, GigabitEthernet0/6
    [110/3] via 10.0.200.1, 00:04:49, GigabitEthernet0/5
0    10.10.20.0/26 [110/3] via 10.30.91.1, 00:04:49, GigabitEthernet0/4.91
    [110/3] via 10.30.90.1, 00:04:49, GigabitEthernet0/4.90
    [110/3] via 10.1.200.1, 00:04:49, GigabitEthernet0/6
    [110/3] via 10.0.200.1, 00:04:49, GigabitEthernet0/5
0    10.20.100.0/27 [110/2] via 10.1.20.2, 00:04:59, GigabitEthernet0/3
    [110/2] via 10.0.20.2, 00:04:59, GigabitEthernet0/2
0    10.20.101.0/27 [110/2] via 10.1.20.2, 00:04:59, GigabitEthernet0/3
    [110/2] via 10.0.20.2, 00:04:59, GigabitEthernet0/2
0    10.20.102.0/27 [110/2] via 10.1.20.2, 00:04:59, GigabitEthernet0/3
    [110/2] via 10.0.20.2, 00:04:59, GigabitEthernet0/2
PRODUCTION-CORE-ROUTER#
PRODUCTION-CORE-ROUTER#
PRODUCTION-CORE-ROUTER#

```

4.3 Pengujian Inter-VLAN Routing

Pengujian dilakukan pada masing-masing departemen atau area di setiap divisi, baik Office maupun Production, untuk memastikan bahwa proses inter-VLAN routing berjalan sesuai konfigurasi dan tiap VLAN dapat saling berkomunikasi sesuai ketentuan.

1. Pengujian pertama dilakukan pada Office. Hasilnya menunjukkan bahwa vlan 10 dan vlan 20 dapat saling terhubung.

vlan 10 test ping ke vlan 20

```

PC1> ping 10.10.20.2
84 bytes from 10.10.20.2 icmp_seq=1 ttl=63 time=30.782 ms
84 bytes from 10.10.20.2 icmp_seq=2 ttl=63 time=2.802 ms
84 bytes from 10.10.20.2 icmp_seq=3 ttl=63 time=3.891 ms
84 bytes from 10.10.20.2 icmp_seq=4 ttl=63 time=10.099 ms
84 bytes from 10.10.20.2 icmp_seq=5 ttl=63 time=2.327 ms

```

vlan 20 test ping ke vlan 10

```

PC3> ping 10.10.10.2
84 bytes from 10.10.10.2 icmp_seq=1 ttl=63 time=3.534 ms
84 bytes from 10.10.10.2 icmp_seq=2 ttl=63 time=2.728 ms
84 bytes from 10.10.10.2 icmp_seq=3 ttl=63 time=8.236 ms
84 bytes from 10.10.10.2 icmp_seq=4 ttl=63 time=36.101 ms
84 bytes from 10.10.10.2 icmp_seq=5 ttl=63 time=46.478 ms
PC3> █

```

2. Pengujian kedua dilakukan pada Production. Hasilnya menunjukkan bahwa vlan 100, vlan 101 dan vlan 102 dapat saling terhubung.

vlan 100 test ping ke vlan 101, vlan 102

```
PC6> ping 10.20.101.2
84 bytes from 10.20.101.2 icmp_seq=1 ttl=63 time=38.214 ms
84 bytes from 10.20.101.2 icmp_seq=2 ttl=63 time=14.048 ms
84 bytes from 10.20.101.2 icmp_seq=3 ttl=63 time=16.854 ms
^C
PC6> ping 10.20.102.2
84 bytes from 10.20.102.2 icmp_seq=1 ttl=63 time=5.645 ms
84 bytes from 10.20.102.2 icmp_seq=2 ttl=63 time=2.103 ms
84 bytes from 10.20.102.2 icmp_seq=3 ttl=63 time=9.624 ms
^C
PC6> █
```

vlan 101 test ping ke vlan 100, vlan 102

```
PC5> ping 10.20.100.2
84 bytes from 10.20.100.2 icmp_seq=1 ttl=63 time=201.160 ms
84 bytes from 10.20.100.2 icmp_seq=2 ttl=63 time=2.185 ms
84 bytes from 10.20.100.2 icmp_seq=3 ttl=63 time=3.752 ms
^C
PC5> ping 10.20.102.2
84 bytes from 10.20.102.2 icmp_seq=1 ttl=63 time=46.952 ms
84 bytes from 10.20.102.2 icmp_seq=2 ttl=63 time=2.698 ms
84 bytes from 10.20.102.2 icmp_seq=3 ttl=63 time=2.627 ms
^C
PC5> █
```

vlan 102 test ping ke vlan 100, vlan 101

```
PC12> ping 10.20.100.2
84 bytes from 10.20.100.2 icmp_seq=1 ttl=63 time=16.072 ms
84 bytes from 10.20.100.2 icmp_seq=2 ttl=63 time=34.359 ms
^C
PC12> ping 10.20.101.2
84 bytes from 10.20.101.2 icmp_seq=1 ttl=63 time=94.298 ms
84 bytes from 10.20.101.2 icmp_seq=2 ttl=63 time=13.119 ms
84 bytes from 10.20.101.2 icmp_seq=3 ttl=63 time=16.025 ms
^C
PC12> █
```

4.4 Pengujian Ping Antar Divisi dan Penerapan Access-List

Pengujian dilakukan pada setiap departemen atau area di kedua divisi, baik Office maupun Production, untuk memastikan bahwa seluruh koneksi antar VLAN telah berjalan sesuai dengan aturan access-list yang telah diterapkan. Pengujian ini bertujuan memverifikasi apakah tiap area hanya dapat mengakses resource yang memang diizinkan oleh kebijakan jaringan.

1. Pengujian pertama dilakukan pada departemen IT Control di divisi Office. Hasilnya menunjukkan bahwa VLAN 10 (IT Control) dapat terhubung ke server serta ke seluruh area di Production sesuai dengan ketentuan access-list yang berlaku.

Test ping ke servers

```

PC1> sh
NAME      IP/MASK      GATEWAY      MAC      LPORT  RHOST:PORT
PC1      10.10.10.2/26  10.10.10.1    00:50:79:66:68:0d  20284  127.0.0.1:20285
fe80::250:79ff:fe66:680d/64
fd00::acad:10:0:2050:79ff:fe66:680d/64  eui-64

PC1> ping 10.30.90.3

84 bytes from 10.30.90.3 icmp_seq=1 ttl=62 time=33.641 ms
84 bytes from 10.30.90.3 icmp_seq=2 ttl=62 time=29.435 ms
84 bytes from 10.30.90.3 icmp_seq=3 ttl=62 time=20.717 ms
^C
PC1> ping 10.30.91.3

84 bytes from 10.30.91.3 icmp_seq=1 ttl=62 time=449.116 ms
84 bytes from 10.30.91.3 icmp_seq=2 ttl=62 time=86.570 ms
84 bytes from 10.30.91.3 icmp_seq=3 ttl=62 time=52.239 ms
^C
PC1> ping 10.30.92.3

84 bytes from 10.30.92.3 icmp_seq=1 ttl=62 time=834.734 ms
84 bytes from 10.30.92.3 icmp_seq=2 ttl=62 time=37.487 ms
84 bytes from 10.30.92.3 icmp_seq=3 ttl=62 time=38.192 ms
^C

```

Test ping ke production

```

PC1> ping 10.20.100.2

84 bytes from 10.20.100.2 icmp_seq=1 ttl=60 time=308.135 ms
84 bytes from 10.20.100.2 icmp_seq=2 ttl=60 time=85.765 ms
^C
PC1> ping 10.20.101.2

84 bytes from 10.20.101.2 icmp_seq=1 ttl=60 time=213.151 ms
84 bytes from 10.20.101.2 icmp_seq=2 ttl=60 time=140.426 ms
^C[[A
PC1> ping 10.20.102.2

84 bytes from 10.20.102.2 icmp_seq=1 ttl=60 time=353.167 ms
84 bytes from 10.20.102.2 icmp_seq=2 ttl=60 time=148.857 ms
84 bytes from 10.20.102.2 icmp_seq=3 ttl=60 time=112.963 ms
^C

```

2. Pengujian kedua dilakukan pada departemen Accounting dan Finance di divisi Office. Hasilnya menunjukkan bahwa VLAN 20 (Accounting) hanya dapat terhubung ke DB server.

Test ping ke servers

```

PC3> ping 10.30.90.3

*10.10.20.1 icmp_seq=1 ttl=255 time=50.459 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=2 ttl=255 time=332.868 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=3 ttl=255 time=53.969 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC3> ping 10.30.91.3

84 bytes from 10.30.91.3 icmp_seq=1 ttl=62 time=892.224 ms
84 bytes from 10.30.91.3 icmp_seq=2 ttl=62 time=15.645 ms
84 bytes from 10.30.91.3 icmp_seq=3 ttl=62 time=48.057 ms
^C
PC3> ping 10.30.92.3

*10.10.20.1 icmp_seq=1 ttl=255 time=137.194 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=2 ttl=255 time=267.900 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=3 ttl=255 time=621.988 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC3> 

```

Test ping ke production

```

PC3>
PC3> ping 10.20.100.2

*10.10.20.1 icmp_seq=1 ttl=255 time=299.516 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=2 ttl=255 time=230.178 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC3> ping 10.20.101.2

*10.10.20.1 icmp_seq=1 ttl=255 time=75.529 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=2 ttl=255 time=152.723 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC3> ping 10.20.102.2

*10.10.20.1 icmp_seq=1 ttl=255 time=93.320 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.10.20.1 icmp_seq=2 ttl=255 time=62.628 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC3> 

```

3. Pengujian ketiga dilakukan pada seluruh area pada divisi Production karena aturan access-listnya sama. Hasilnya menunjukkan bahwa seluruh area hanya dapat terhubung ke DB server dan MES Server.

Test ping Area 1 ke servers

```
PC6> ping 10.30.90.3
*10.20.100.1 icmp_seq=1 ttl=255 time=35.843 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.100.1 icmp_seq=2 ttl=255 time=4.807 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC6> ping 10.30.91.3
84 bytes from 10.30.91.3 icmp_seq=1 ttl=61 time=480.171 ms
84 bytes from 10.30.91.3 icmp_seq=2 ttl=61 time=282.309 ms
^C
PC6> ping 10.30.92.3
84 bytes from 10.30.92.3 icmp_seq=1 ttl=61 time=611.350 ms
84 bytes from 10.30.92.3 icmp_seq=2 ttl=61 time=47.619 ms
^C
PC6> █
```

Test ping Area 1 ke office

```
^C
PC6> ping 10.10.10.2
*10.20.100.1 icmp_seq=1 ttl=255 time=52.579 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.100.1 icmp_seq=2 ttl=255 time=16.161 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC6> ping 10.10.20.2
*10.20.100.1 icmp_seq=1 ttl=255 time=14.307 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.100.1 icmp_seq=2 ttl=255 time=18.552 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC6> █
```

Test ping Area 2 ke servers

```
PC5> ping 10.30.90.3
*10.20.101.1 icmp_seq=1 ttl=255 time=55.244 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.101.1 icmp_seq=2 ttl=255 time=54.495 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC5> ping 10.30.91.3
84 bytes from 10.30.91.3 icmp_seq=1 ttl=61 time=26.530 ms
84 bytes from 10.30.91.3 icmp_seq=2 ttl=61 time=91.066 ms
^C
PC5> ping 10.30.92.3
84 bytes from 10.30.92.3 icmp_seq=1 ttl=61 time=36.262 ms
84 bytes from 10.30.92.3 icmp_seq=2 ttl=61 time=93.055 ms
^C
PC5> █
```

Test ping Area 2 ke office

```
^C
PC5> ping 10.10.10.2
*10.20.101.1 icmp_seq=1 ttl=255 time=48.897 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.101.1 icmp_seq=2 ttl=255 time=15.924 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC5> ping 10.10.20.2
*10.20.101.1 icmp_seq=1 ttl=255 time=16.078 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.101.1 icmp_seq=2 ttl=255 time=32.999 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC5> █
```

Test ping Area 3 ke servers

```
PC12> ping 10.30.90.3
*10.20.102.1 icmp_seq=1 ttl=255 time=30.462 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.102.1 icmp_seq=2 ttl=255 time=2.971 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC12> ping 10.30.91.3
84 bytes from 10.30.91.3 icmp_seq=1 ttl=61 time=115.458 ms
84 bytes from 10.30.91.3 icmp_seq=2 ttl=61 time=64.721 ms
^C
PC12> ping 10.30.92.3
84 bytes from 10.30.92.3 icmp_seq=1 ttl=61 time=132.245 ms
84 bytes from 10.30.92.3 icmp_seq=2 ttl=61 time=53.632 ms
^C
PC12> █
```

Test ping Area 3 ke office

```
^C
PC12> ping 10.10.10.2
*10.20.102.1 icmp_seq=1 ttl=255 time=51.438 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.102.1 icmp_seq=2 ttl=255 time=31.743 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC12> ping 10.10.20.2
*10.20.102.1 icmp_seq=1 ttl=255 time=47.165 ms (ICMP type:3, code:13, Communication administratively prohibited)
*10.20.102.1 icmp_seq=2 ttl=255 time=38.203 ms (ICMP type:3, code:13, Communication administratively prohibited)
^C
PC12> █
```

4.5 Pengujian Akses Internet

Pengujian dilakukan pada setiap departemen atau area di kedua divisi, baik Office maupun Production, termasuk seluruh server. Tujuannya untuk memastikan bahwa perangkat yang diizinkan mengakses internet dapat terhubung dengan baik, sementara perangkat yang tidak memiliki izin benar-benar tidak dapat mengakses internet sesuai kebijakan access-list dan konfigurasi NAT yang telah diterapkan.

1. Pengujian pertama dilakukan pada divisi Office. Hasilnya menunjukkan bahwa VLAN 10 (IT Control) dan VLAN 20 (Accounting) dapat terhubung ke internet.

Ping IT Control ke Internet

```
^C
PC1> ping 8.8.8.8
84 bytes from 8.8.8.8 icmp_seq=1 ttl=125 time=40.937 ms
84 bytes from 8.8.8.8 icmp_seq=2 ttl=125 time=45.810 ms
84 bytes from 8.8.8.8 icmp_seq=3 ttl=125 time=40.087 ms
^C
PC1> ping google.com
google.com resolved to 74.125.24.139
84 bytes from 74.125.24.139 icmp_seq=1 ttl=125 time=43.883 ms
84 bytes from 74.125.24.139 icmp_seq=2 ttl=125 time=39.142 ms
84 bytes from 74.125.24.139 icmp_seq=3 ttl=125 time=166.312 ms
^C
PC1> █
```

Ping Accounting ke Internet

```
PC3> ping 8.8.8.8
84 bytes from 8.8.8.8 icmp_seq=1 ttl=125 time=54.076 ms
84 bytes from 8.8.8.8 icmp_seq=2 ttl=125 time=42.392 ms
^C
PC3> ping google.com
google.com resolved to 74.125.24.113
84 bytes from 74.125.24.113 icmp_seq=1 ttl=125 time=42.846 ms
84 bytes from 74.125.24.113 icmp_seq=2 ttl=125 time=42.911 ms
84 bytes from 74.125.24.113 icmp_seq=3 ttl=125 time=46.766 ms
^C
PC3> █
```

2. Pengujian kedua dilakukan pada divisi Production. Hasilnya menunjukkan bahwa VLAN 100 (Area 1), VLAN 101 (Area 2) dan VLAN 102 (Area 3) dapat terhubung ke internet.

Ping Area 1 ke Internet

```
PC6>
PC6> ping google.com
google.com resolved to 74.125.24.113
84 bytes from 74.125.24.113 icmp_seq=1 ttl=125 time=106.651 ms
84 bytes from 74.125.24.113 icmp_seq=2 ttl=125 time=192.928 ms
84 bytes from 74.125.24.113 icmp_seq=3 ttl=125 time=165.916 ms
84 bytes from 74.125.24.113 icmp_seq=4 ttl=125 time=106.067 ms
^C
PC6> ping 8.8.8.8
84 bytes from 8.8.8.8 icmp_seq=1 ttl=125 time=123.032 ms
84 bytes from 8.8.8.8 icmp_seq=2 ttl=125 time=92.883 ms
84 bytes from 8.8.8.8 icmp_seq=3 ttl=125 time=292.476 ms
^C
PC6> █
```

Ping Area 2 ke Internet

```
PC5> ping 8.8.8.8
84 bytes from 8.8.8.8 icmp_seq=1 ttl=125 time=110.370 ms
84 bytes from 8.8.8.8 icmp_seq=2 ttl=125 time=91.287 ms
84 bytes from 8.8.8.8 icmp_seq=3 ttl=125 time=128.672 ms
^C
PC5> ping google.com
google.com resolved to 74.125.24.100
84 bytes from 74.125.24.100 icmp_seq=1 ttl=125 time=157.570 ms
84 bytes from 74.125.24.100 icmp_seq=2 ttl=125 time=390.031 ms
84 bytes from 74.125.24.100 icmp_seq=3 ttl=125 time=94.209 ms
^C
PC5> █
```

Ping Area 3 ke Internet

```
PC12> ping 8.8.8.8
84 bytes from 8.8.8.8 icmp_seq=1 ttl=125 time=150.155 ms
84 bytes from 8.8.8.8 icmp_seq=2 ttl=125 time=209.692 ms
84 bytes from 8.8.8.8 icmp_seq=3 ttl=125 time=117.121 ms
^C
PC12> ping google.com
google.com resolved to 74.125.24.138
84 bytes from 74.125.24.138 icmp_seq=1 ttl=125 time=138.635 ms
84 bytes from 74.125.24.138 icmp_seq=2 ttl=125 time=123.696 ms
84 bytes from 74.125.24.138 icmp_seq=3 ttl=125 time=105.743 ms
^C
PC12> █
```

3. Pengujian ketiga dilakukan pada Servers. Hasilnya menunjukkan bahwa seluruh server tidak dapat terhubung ke internet sesuai dengan aturan access-list yang telah diimplementasikan.

Ping NAS Storage ke Internet

```
NAS-STORAGE> ping 8.8.8.8
8.8.8.8 icmp_seq=1 timeout
8.8.8.8 icmp_seq=2 timeout
8.8.8.8 icmp_seq=3 timeout
^C
NAS-STORAGE> █
```

Ping DB Server ke Internet

```
DB-SERVER> ping 8.8.8.8
8.8.8.8 icmp_seq=1 timeout
8.8.8.8 icmp_seq=2 timeout
8.8.8.8 icmp_seq=3 timeout
^C
DB-SERVER> █
```

Ping MES Server ke Internet

```
MES-SERVER> ping 8.8.8.8
8.8.8.8 icmp_seq=1 timeout
8.8.8.8 icmp_seq=2 timeout
8.8.8.8 icmp_seq=3 timeout
^C
MES-SERVER> █
```

4.6 Pengujian SLACC IPv6

Pengujian dilakukan pada setiap departemen atau area di kedua divisi, baik Office maupun Production.

1. Pengujian pertama dilakukan pada divisi Office. Hasilnya menunjukkan bahwa VLAN 10 (IT Control) dan VLAN 20 (Accounting) mendapatkan IPv6 secara otomatis.

Vlan 10

```
PC1> ip auto
GLOBAL SCOPE      : fd00:acad:10:0:2050:79ff:fe66:680d/64
ROUTER LINK-LAYER : 0c:77:c7:a3:00:02
```

Vlan 20

```
PC3> ip auto
GLOBAL SCOPE      : fd00:acad:20:0:2050:79ff:fe66:6802/64
ROUTER LINK-LAYER : 0c:77:c7:a3:00:02
```

2. Pengujian kedua dilakukan pada divisi Production. Hasilnya menunjukkan bahwa VLAN 100 (Area 1), VLAN 101 (Area 2) dan VLAN 102 (Area 3) mendapatkan IPv6 secara otomatis.

Vlan 100

```
PC6> ip auto
GLOBAL SCOPE      : fd00:cccc:100:0:2050:79ff:fe66:6805/64
ROUTER LINK-LAYER : 0c:92:4e:3c:00:01
PC6> █
```

Vlan 101

```
PC5> ip auto
GLOBAL SCOPE      : fd00:cccc:101:0:2050:79ff:fe66:6806/64
ROUTER LINK-LAYER : 0c:92:4e:3c:00:04
PC5> █
```

Vlan 102

```
PC12> ip auto
GLOBAL SCOPE      : fd00:cccc:102:0:2050:79ff:fe66:6808/64
ROUTER LINK-LAYER : 0c:92:4e:3c:00:06
PC12> █
```

4.7 Pengujian Tunnel GRE

Pengujian ini dilakukan pada Host di sisi Office maupun Production. Tujuannya untuk memverifikasi apakah Tunnel GRE yang sudah dikonfigurasi benar-benar berfungsi mengalirkan trafik IPv6 antar kedua lokasi tersebut.

1. Pengujian pertama dilakukan dari sisi Office. Hasilnya sukses, di mana VLAN 10 (IT Control) dan VLAN 20 (Accounting) terbukti dapat terhubung ke seluruh area di Production menggunakan jaringan IPv6.

VLAN 10

```
PC1> trace fd00:cccc:100:0:2050:79ff:fe66:6805

trace to fd00:cccc:100:0:2050:79ff:fe66:6805, 64 hops max
 1 fd00:acad:10::1 123.625 ms 31.487 ms 27.249 ms
 2 fd00:1111:1::2 175.590 ms 704.939 ms 559.857 ms
 3 fd00:cccc:100:0:2050:79ff:fe66:6805 168.912 ms 127.287 ms 68.300 ms

PC1> trace fd00:cccc:101:0:2050:79ff:fe66:6806

trace to fd00:cccc:101:0:2050:79ff:fe66:6806, 64 hops max
 1 fd00:acad:10::1 91.844 ms 28.023 ms 13.502 ms
 2 fd00:1111:1::2 299.667 ms 146.087 ms 843.025 ms
 3 * * 316.144 ms

PC1> trace fd00:cccc:101:0:2050:79ff:fe66:6806

trace to fd00:cccc:101:0:2050:79ff:fe66:6806, 64 hops max
 1 fd00:acad:10::1 77.038 ms 19.106 ms 17.741 ms
 2 fd00:1111:1::2 423.878 ms 570.427 ms 99.698 ms
 3 fd00:cccc:101:0:2050:79ff:fe66:6806 102.235 ms 111.069 ms 78.977 ms

PC1> trace fd00:cccc:102:0:2050:79ff:fe66:6808

trace to fd00:cccc:102:0:2050:79ff:fe66:6808, 64 hops max
 1 fd00:acad:10::1 202.997 ms 31.094 ms 30.919 ms
 2 fd00:1111:1::2 444.747 ms 230.547 ms 967.103 ms
 3 fd00:cccc:102:0:2050:79ff:fe66:6808 263.684 ms 98.998 ms 95.190 ms

PC1> █
```

VLAN 20

```
PC3> trace fd00:cccc:100:0:2050:79ff:fe66:6805

trace to fd00:cccc:100:0:2050:79ff:fe66:6805, 64 hops max
 1 fd00:acad:20::1 281.000 ms 25.821 ms 18.837 ms
 2 fd00:1111:1::2 215.931 ms 450.185 ms 464.492 ms
 3 fd00:cccc:100:0:2050:79ff:fe66:6805 551.579 ms 109.313 ms 103.794 ms

PC3> trace fd00:cccc:101:0:2050:79ff:fe66:6806

trace to fd00:cccc:101:0:2050:79ff:fe66:6806, 64 hops max
 1 fd00:acad:20::1 282.180 ms 32.614 ms 12.128 ms
 2 fd00:1111:1::2 299.712 ms 660.493 ms 514.042 ms
 3 fd00:cccc:101:0:2050:79ff:fe66:6806 170.844 ms 79.787 ms 84.398 ms

PC3> trace fd00:cccc:102:0:2050:79ff:fe66:6808

trace to fd00:cccc:102:0:2050:79ff:fe66:6808, 64 hops max
 1 fd00:acad:20::1 321.859 ms 16.085 ms 13.647 ms
 2 fd00:1111:1::2 428.844 ms 537.506 ms 525.029 ms
 3 fd00:cccc:102:0:2050:79ff:fe66:6808 90.930 ms 100.704 ms 110.829 ms

PC3> █
```

2. Pengujian kedua dilakukan dari sisi Production. Hasilnya sukses, di mana VLAN 100 (Area 1), VLAN 101 (Area 2) dan VLAN 102 (Area 3) terbukti dapat terhubung ke seluruh area di Office menggunakan jaringan IPv6.

VLAN 100

```
PC6> trace fd00:acad:10:0:2050:79ff:fe66:680d

trace to fd00:acad:10:0:2050:79ff:fe66:680d, 64 hops max
 1 fd00:cccc:100::1 167.226 ms 29.082 ms 39.618 ms
 2 fd00:1111:1::1 250.223 ms 194.593 ms 457.265 ms
 3 fd00:acad:10:0:2050:79ff:fe66:680d 543.730 ms 264.052 ms 147.900 ms

PC6> trace fd00:acad:20:0:2050:79ff:fe66:6802

trace to fd00:acad:20:0:2050:79ff:fe66:6802, 64 hops max
 1 fd00:cccc:100::1 402.942 ms 26.453 ms 52.234 ms
 2 fd00:1111:1::1 554.340 ms 718.709 ms 562.421 ms
 3 fd00:acad:20:0:2050:79ff:fe66:6802 77.709 ms 144.201 ms 70.246 ms

PC6> █
```

VLAN 101

```
PC5> trace fd00:acad:10:0:2050:79ff:fe66:680d

trace to fd00:acad:10:0:2050:79ff:fe66:680d, 64 hops max
 1 fd00:cccc:101::1 530.948 ms 42.702 ms 82.532 ms
 2 fd00:1111:1::1 306.371 ms 536.333 ms 685.844 ms
 3 fd00:acad:10:0:2050:79ff:fe66:680d 108.834 ms 114.713 ms 219.247 ms

PC5> trace fd00:acad:20:0:2050:79ff:fe66:6802

trace to fd00:acad:20:0:2050:79ff:fe66:6802, 64 hops max
 1 fd00:cccc:101::1 332.673 ms 25.574 ms 18.348 ms
 2 fd00:1111:1::1 356.462 ms 527.131 ms 531.704 ms
 3 fd00:acad:20:0:2050:79ff:fe66:6802 571.530 ms 116.873 ms 208.757 ms

PC5> █
```

VLAN 102

```
PC12> trace fd00:acad:10:0:2050:79ff:fe66:680d

trace to fd00:acad:10:0:2050:79ff:fe66:680d, 64 hops max
 1 fd00:cccc:102::1 259.788 ms 30.824 ms 37.007 ms
 2 fd00:1111:1::1 146.767 ms 683.114 ms 112.416 ms
 3 fd00:acad:10:0:2050:79ff:fe66:680d 154.326 ms 152.562 ms 95.699 ms

PC12> trace fd00:acad:20:0:2050:79ff:fe66:6802

trace to fd00:acad:20:0:2050:79ff:fe66:6802, 64 hops max
 1 fd00:cccc:102::1 205.146 ms 20.768 ms 31.851 ms
 2 fd00:1111:1::1 561.998 ms 826.045 ms 660.345 ms
 3 fd00:acad:20:0:2050:79ff:fe66:6802 258.433 ms 69.273 ms 178.888 ms

PC12> █
```

5. DAFTAR PUSTAKA

Cisco, Panduit, & Rockwell Automation. (2023). *Physical Infrastructure for the Converged Plantwide Ethernet Architecture* (Publikasi No. ENET-TD020B-EN-P).

Pickard, J., Linn, J. B., Awojana, T. B., & Lunsford II, P. J. (2018). *Designing a Converged Plant-wide Ethernet/IP Lab for Hands-on Distance Learning: An Interdisciplinary Graduate Project*. 2018 ASEE Annual Conference & Exposition, Salt Lake City, UT, United States.

Santoso, I., Nursiaga, R., Firmansyah, H., Rantina, M., Asbari, M., & Santoso, G. (2025). Desain Sistem Jaringan Untuk Smart Factory Berbasis Industrial Internet of Things (iiot). *JAREKOM: Jurnal Jaringan dan Rekayasa Komputer*, 01(1), 74–80.