# Inter-VLAN Routing Configuration

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**004 So, inter-VLAN routing.
Inter-VLAN Routing Operation

What is Inter-VLAN routing?

- Layer 2 switches cannot forward traffic between VLANs without the assistance of a router.
- Inter-VLAN routing is a process for forwarding network traffic from one VLAN to another, using a router.

**In the good old days when there were no layer three routers, or layer three switches, and there were no VLAN trunks and stuff like that, if you wanted to go between two VLANs, what you did was you took VLAN10, and you passed it up. And you took a VLAN10 interface and stuck it into a router interface. You took VLAN20, stuck it into another router interface and said, "Go ahead, route us."

So, it went out of the switch, up to the router, back down to the switch, and out again. It worked. And back in the time that this was developed, network speeds weren’t that great
anyway. So, there wasn't really a big speed impact.

The biggest problem we had on this one is, what if I had ten VLANs?

Student: You had to buy multiple routers.

Instructor: Then I've got to find a router with ten VLAN interfaces, or ten interfaces. Or, if I don't, and I find four or five routers that have all the interfaces I need, then those routers have to be connected to other routers above them and above them so that I can get to any of the ten. I've got to go up some tree and back down again to have enough routers across the bottom connected to enough other routers to go where I want to go. So, functional but not scalable.
The router-on-a-stick approach uses a different path to route between VLANs.

One of the router’s physical interfaces is configured as a 802.1Q trunk port so it can understand VLAN tags.

Logical subinterfaces are created; one subinterface per VLAN.

Each subinterface is configured with an IP address from the VLAN it represents.

VLAN members (hosts) are configured to use the subinterface address as a default gateway.

Only one of the router’s physical interface is used.

**007 So, router-on-a-stick became the next way of doing it. Router-on-a-stick is kind of interesting and fun. And you’re going to learn a new technology.
Multilayer switches can perform Layer 2 and Layer 3 functions, replacing the need for dedicated routers.

Multilayer switches support dynamic routing and inter-VLAN routing.

The multilayer switch must have IP routing enabled.

A switch virtual interface (SVI) exists for VLAN 1 by default. On a multilayer switch, a logical (layer 3) interface can be configured for any VLAN.

The switch understands network-layer PDUs; therefore, can route between its SVIs, just as a router routes between its interfaces.

With a multilayer switch, traffic is routed internal to the switch device.

This routing process is a suitable and scalable solution.

**008 Router-on-a-stick is the ability to actually take a VLAN trunk up to a router and let the router route from that single VLAN trunk. Then there's multilayer switch inter-VLAN routing. And what that means is multilayer switch means we actually started installing routing protocol and routing engines inside of switches. Now, that got really cool because as soon as you put the routing inside the switch, now the packets are all moving at switch speed, not going up to the router and operating at router speed, not limited by the bandwidth of the interfaces between the switch and the router. They're not limited to like by a fast
Ethernet link. They can route at whatever speed the inside of the switch is running at. So, guess what we like to do now? We like to do, whenever possible, multilayer switch inter-VLAN routing.

Configure Router-on-a-Stick Preparation

An alternative to legacy inter-VLAN routing is to use VLAN trunking and subinterfaces.

VLAN trunking allows a single physical router interface to route traffic for multiple VLANs.

The physical interface of the router must be connected to a trunk link on the adjacent switch.

On the router, subinterfaces are created for each unique VLAN.

Each subinterface is assigned an IP address specific to its subnet or VLAN and is also configured to tag frames for that VLAN.

**009 Let’s take a look at VLAN trunking for router-on-a-stick.
**010 This is the idea. I've got VLAN10. I've got VLAN30. And notice I only have one connection to the router. If I have multiple VLANs, and I want to connect all the VLANs to a single device that way, what am I going to do? How am I going to connect multiple VLANs on the same cable on one interface?

Student: On the router side?

Instructor: On the switch side or the router side, it doesn’t matter.

Student: I’d trunk it out of the switch.

Instructor: Right. You’re going to have to use a VLAN trunk. The only
way to put more than one VLAN on the same single interface is to use a VLAN trunk. So, we’re going to actually turn on on F0/5, we’re going to turn on trunking. Everything’s going to go up to the router and be frame tagged on its way up. The router is going to have to read the frame tags and keep the two VLANs separated, correct?

Okay, let’s see how they do that. So, down here, made VLAN10, made VLAN 30, went to interface five, set switch port mode trunk and end.

Configure Router-on-a-Stick Router Subinterface Configuration

Configure Router-on-a-Stick
Router Subinterface Configuration

R1(config)# interface g0/0.10
R1(config-subif)# encapulation dot1q 10
R1(config-subif)# ip address 172.17.10.1 255.255.255.0
R1(config-subif)# interface g0/0.30
R1(config-subif)# encapulation dot1q 30
R1(config-subif)# ip address 172.17.30.1 255.255.255.0
R1(config)# interface g0/0
R1(config-if)# no shutdown

**011 Up here, what did we do? We went to interface--**
Configure Router-on-a-Stick Switch Configuration

**010 Gig zero zero, you see that?**
Went to interface gig zero zero.
**011 And we said let's make it gig zero zero dot ten. Where is gig zero zero dot ten?

Student: Sub interface of gig zero zero.

Instructor: It's a sub interface of gig zero zero. That's easy to say. What's a sub interface? A sub interface is another one of those logical interfaces like we were making on the switches that we can say, "Hi, you are now an interface because I told you you were." So, we can make a logical interface that doesn't really exist physically. And we can make it just because we say we did.
So, notice right here this says gig zero zero dot ten. And then right after that it says what?

Student: Encapsulation.

Instructor: Encapsulation dot one Q ten. What would encapsulation dot one Q ten mean?

Student: It means that anything coming in is encapsulated for trunk deformation, and anything that's tagged with ten is going to be on that dot ten sub interface.

Instructor: Correct. In other words, anything that comes in 802.1q tagged as VLAN10 is going to go to that interface. Now, let me tell you. The two numbers don't have to match. That could be gig zero zero dot one. And it could go to dot one Q ten. And some people will do that. They'll do sub interface dot one dot two dot three dot four and assign them to VLAN numbers. Making the sub interface number does not tell you what VLAN it's going to be listening to. The encapsulation dot one Q line is what tells you what interface you're going to be listening to, or what VLAN you're going to listen to.

And then it does what? It gives it a default gateway with a mask for that subnet, or gateway for that subnet. Then it does another one, 0.0.30, gives it another dot one Q statement that says now all interfaces tagged thirty go here, and gives it another IP address that's another gateway.
Notice interface gig zero zero has no IP address and no encapsulation. What it means is what? Which addresses, if any, which packets, if any, would go to the main interface gig zero zero?

Student: Native VLAN.

Instructor: Right, the native VLAN that's not tagged. It won't be caught by either of the tagged calls. It will go straight to the main interface. What this is assuming right now is that there is nothing on the native VLAN. The native VLAN's not used.

So, dot one Q, 172.17.10.1, dot one Q thirty, 172.17.31, and now what's going to happen?

Really kind of simple looking if you were to diagram this. VLAN10, VLAN30, trunk, router, interface, sub interfaces, like that. So, all the traffic will come up. The traffic going between .10 and .30 will do what? It will come up .10. When it hits this core interface, it's going to keep on coming. When it gets to the .10 interface, what's it going to do? It's going to take the entire Ethernet frame, including the .10 VLAN trunk component, throw it away. And like the magician pulling it out of its hat, what's it going to pull out?

Student: Ethernet frame.

Instructor: Nope. It's going to pull out the IP packet, right? It's going to throw away the Ethernet frame, pull out the IP packet. The IP packet's
going to say I want to go to something on the thirty network. So, it's going to say, "Well, heck. Thirty network, I know where that is." And it's going to take it from this sub interface through the routing and drop it on that sub interface. When it gets into that sub interface, what's it going to do?

Student: Send it back down.

Instructor: It's going to be re-encapsulated. This time it's going to have a what? .30 frame tag on it because now I'm in VLAN30, and send it back down here where it's going to come down and jump into VLAN30. So, to get between VLAN10 and VLAN30, I went up through and back down. That's why it's called router-on-a-stick. It goes up the stick, down the stick. It gets from VLAN10 to VLAN30.

So, yes you can create sub interfaces in a router. Yes, you can create them for multiple reasons. This is one of them. And this is what you do with them in this reason. Later on, when you learn about frame relay, you find we create sub interfaces for frame relay also. But that's all that is, create the two logical interfaces to handle two tagged frame packets, and then just passed it from one logical interface to the other. And it got delivered back through the physical interface, through the trunk, back down to the switch.

Questions? Anybody ever done this? It does work, doesn't it?
Student: Yeah.

Instructor: What’s the downside to doing it?

Student: Performance.

Instructor: Yeah, what's the performance hit?

Student: You're going to max out at half speed because you've got to go up and then down the same wire.

Instructor: Right, if you send it up and down the same wire, it’s traversed the same wire twice, if a bunch of traffic goes through, you’re limited by the bandwidth of the interface, right? Where if we could have kept it down here in the switch, we wouldn’t have had those limitations.

Student: What’s the maximum number of sub interfaces you can create?

Instructor: Sixteen point seven million, I believe. It’s a twenty-four bit value. Nobody uses them all. But I feel pretty good I knew the answer.
**012 So, here I am. If I do show IP route, you see the 0.0.10, 0.0.30 over on the side. It's looking at them, calls each one, each subinterface, a virtual or complete interface on its own, which it is, and uses that interface to route the traffic in or out.
Access to devices on remote VLANs can be tested using the ping command.

The ping command sends an ICMP echo request to the destination address.

When a host receives an ICMP echo request, it responds with an ICMP echo reply.

Traceroute is a useful utility for confirming the routed path taken between two devices.
Inter-VLAN Configuration Issues Verify Router Configuration

- With router-on-a-stick configurations, a common problem is assigning the wrong VLAN ID to the subinterface.
- The `show interface` command can help detect this problem.
- If this is the case, use the `encapsulation dot1q <vlan_id>` interface command to fix the problem.

**015 If I’m going to do it inside a switch, what’s the difference going to be?**

If I do it inside the switch, the only difference I get is when I throw this away, I go into the switch. Notice how the switch got bigger. And I made interface, and another interface, and I assigned the addresses to the interfaces. I turned on IP routing. And now, VLAN10 and VLAN30, how do they route? VLAN10 goes up to the interface VLAN10 with the 172.17.10.1.

The switch has a routing table now. The switch routing table says send it
over to this guy. This guy sends it through that virtual interface, sends it back down to VLAN30, just like if you did router-on-a-stick, except we moved the router into the switch. And now, the stick is inside the switch essentially.

So, interfaces get made inside the switch. And the routing goes between the two sub interfaces inside the switch because the switch now has a layer three capability to route.

Student: Does that mean that you don’t have any port set as trunk if they’re not leaving this area?

Instructor: Correct.

Student: Okay.

Instructor: It just goes VLAN interface to VLAN interface. No trunk required. And the funny part is it doesn’t take much of a switch to do that. This little switch right here, it’s more the model number than anything. This is a 3560 switch. Because it’s a 3560 switch, it does layer three, even though it’s only an eight port switch. So, I can have multiple VLANs in here, route between them, and do the whole thing. It doesn’t have to be a twenty-five thousand dollar switch. It doesn’t have to sit in a rack. All it has to do is have layer three software and layer three A6, application specific integrated chips. So, that’s all it takes. Most switches you look at these days are layer there switches.
People who use layer two switches generally know their environment really well. And they have a layer three core or a layer three distribution. And they use layer two switches at the edge just because they're cheaper.

But it doesn't take much now to get into layer three switching. And these switches, by the way, support routing protocols. So, depending on how much money you spent and what software you put in, you definitely get RIP, OSPF, EIGRP. Whether they support BGP, some other things, is dependent on the software and the hardware of the switch itself. But they do support it.
IP Addressing Issues Errors with IP Address and Subnet Masks

- When using legacy inter-VLAN routing, ensure that the router has the correct IP address and mask on the interfaces connecting to the switch.
- Ensure that the network devices are configured with the correct IP address and mask.
- In the router, use the `ip address` command to fix any erroneous IP assignments.
- In the PCs, refer to the installed operating system documentation to properly change IP information.

**016 So, when something goes wrong, what’s wrong, right? Things that go wrong, what can go wrong? IP addresses can be make wrong. Subnet masks can be made wrong. Most of these aren’t switch problems. They’re configuration issues. So, if the IP addresses and masks aren’t right, then the routing doesn’t work.**
IP Addressing Issues
Verifying IP Address and Subnet Mask Configuration Issues

- Use the `show ip interface` command to verify if the correct IP address is configured in the router.
- Use the `show running-config` when troubleshooting router-related problems.
- When troubleshooting addressing issues, ensure that the subinterface is configured with the correct address for that VLAN.
- Subinterface IDs are often configured to match the VLAN number, which makes it easier to manage inter-VLAN configuration, but this is not a requirement.

**017 So, show IP interface helps. Show running config can help.**