Datacenter Rack Switch Redundancy Models

Server Access Ethernet Switch Connectivity Options

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Introductions

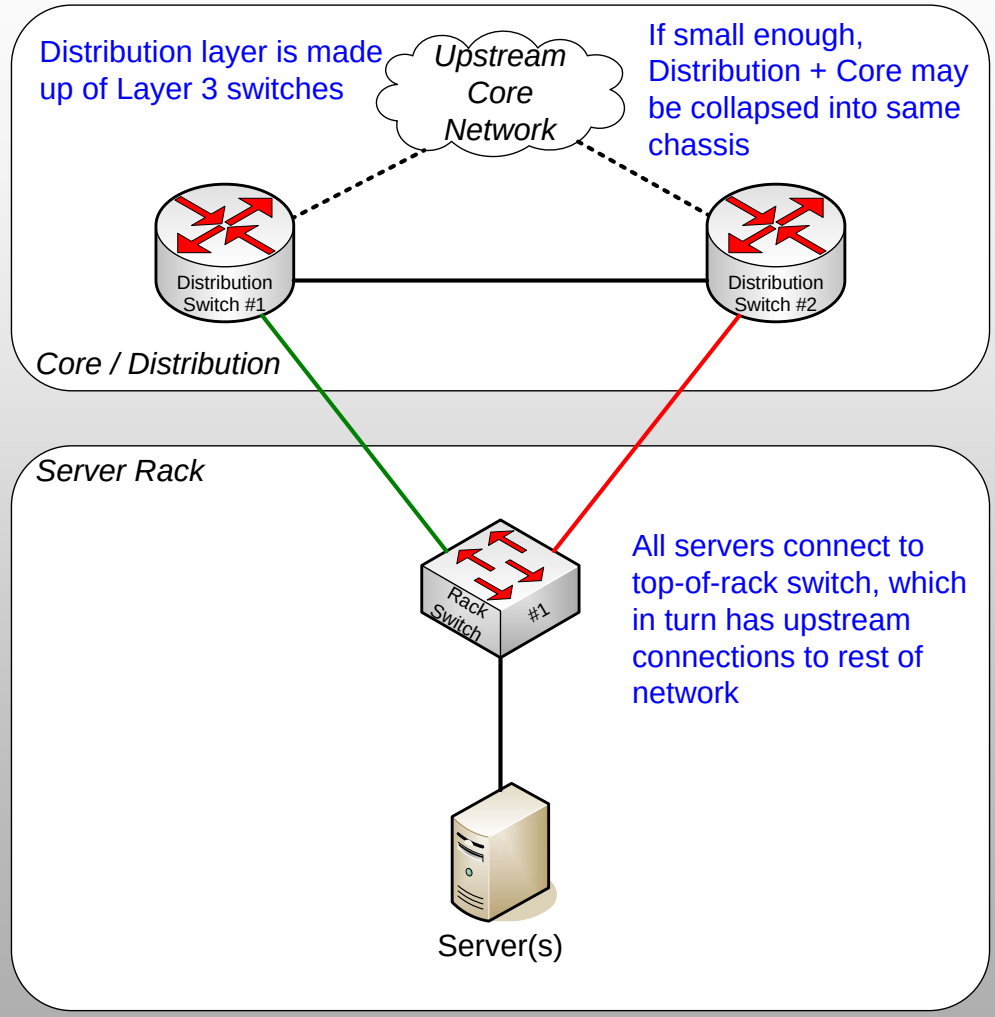
Server Access Explained

- Enterprise and Content datacenters are home to racks full of servers, providing connectivity via Ethernet
- Typically, an Ethernet switch is located within the rack to aggregate all access connectivity for local servers, then uplinked to a network core
- There are multiple ways in which to provide redundant connectivity to this “top-of-rack” switch, each with their own benefits and drawbacks

Who May Be Interested?

- Network operators responsible for server connectivity to multiple racks – these design options scale from one rack switch to hundreds of rack switches in a datacenter
- Folks whose jobs rely upon undisrupted connectivity to servers throughout their datacenter
- Organizations battling with network redundancy versus stability trade-offs

Reference: Sample Network

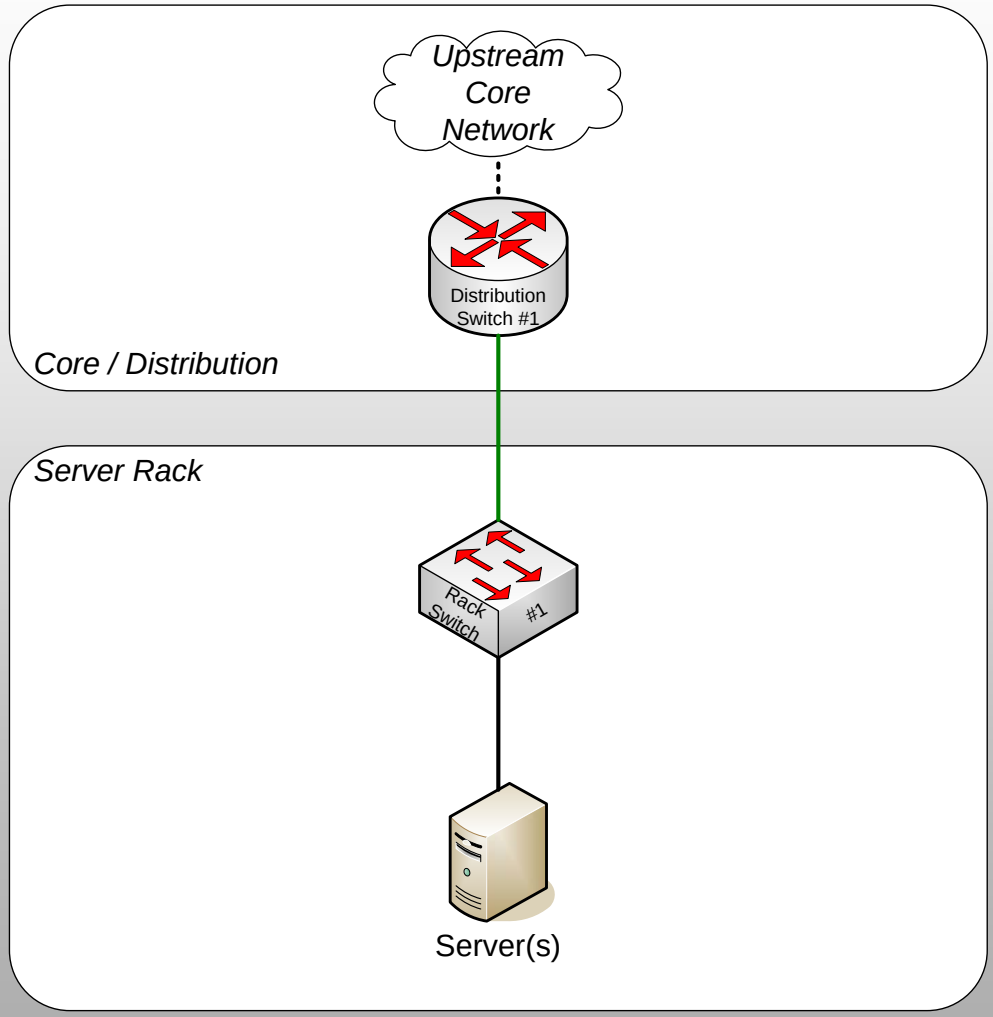


Basic Definitions

- “Layer 1” - physical cabling infrastructure, physical link, patch panels, Ethernet cords etc.
- “Layer 2” - switching and bridging, VLANs etc.
- “Layer 3” - IP routing, using static or dynamic protocols such as RIP, EIGRP, OSPF, BGP, etc.
- “Distribution” - provides upstream path to rest of the network (sometimes collapsed with Core)
- “Rack Switch” a.k.a. Top-of-Rack Switch - all servers within a rack connect to this switch, and this switch in turn has uplinks to the distribution equipment (often mounted at *middle* of rack)

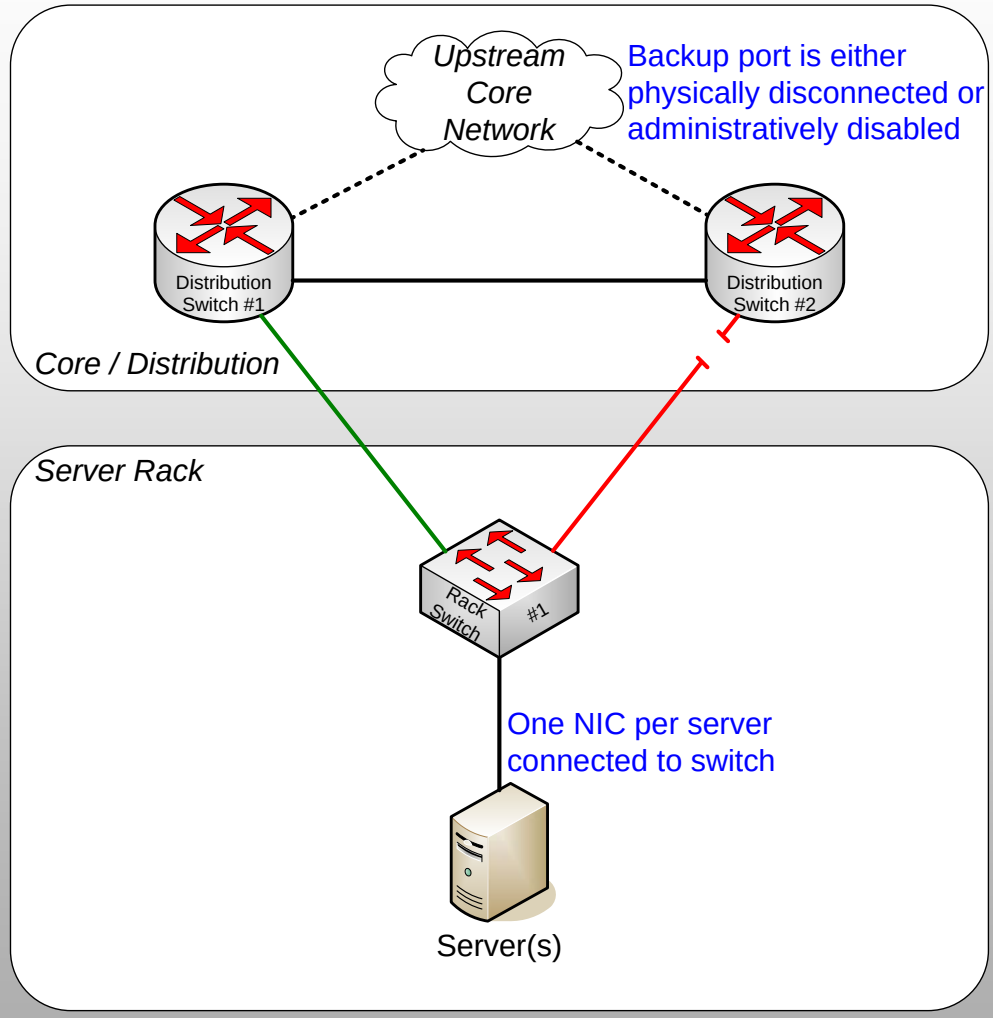
Model 0
No Redundancy

No Redundancy



Model 0.5
Manual Activation

Manual Activation

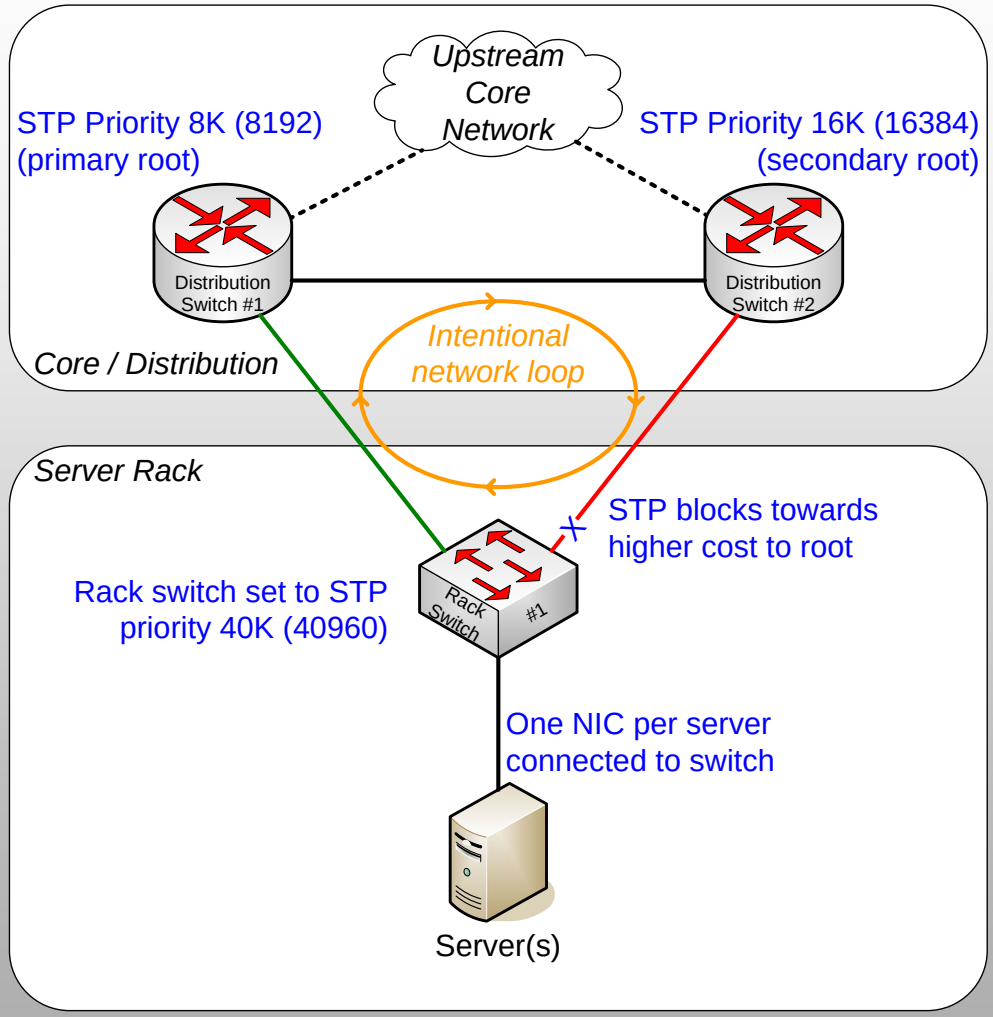


Manual Activation Explained

- Pretty simple – configure typical L2 redundant environment, say “I’m afraid of L2 loops,” and then shut down one of the uplinks
- In response to an primary link outage, requires manual intervention to enable the backup port
- Do yourself a favor, shut down at the distribution side
- Do yourself another favor, shut down the primary before enabling the backup
- Do yourself a third favor, stay away from this model

Model 1
“The Cliché” Layer2 + STP

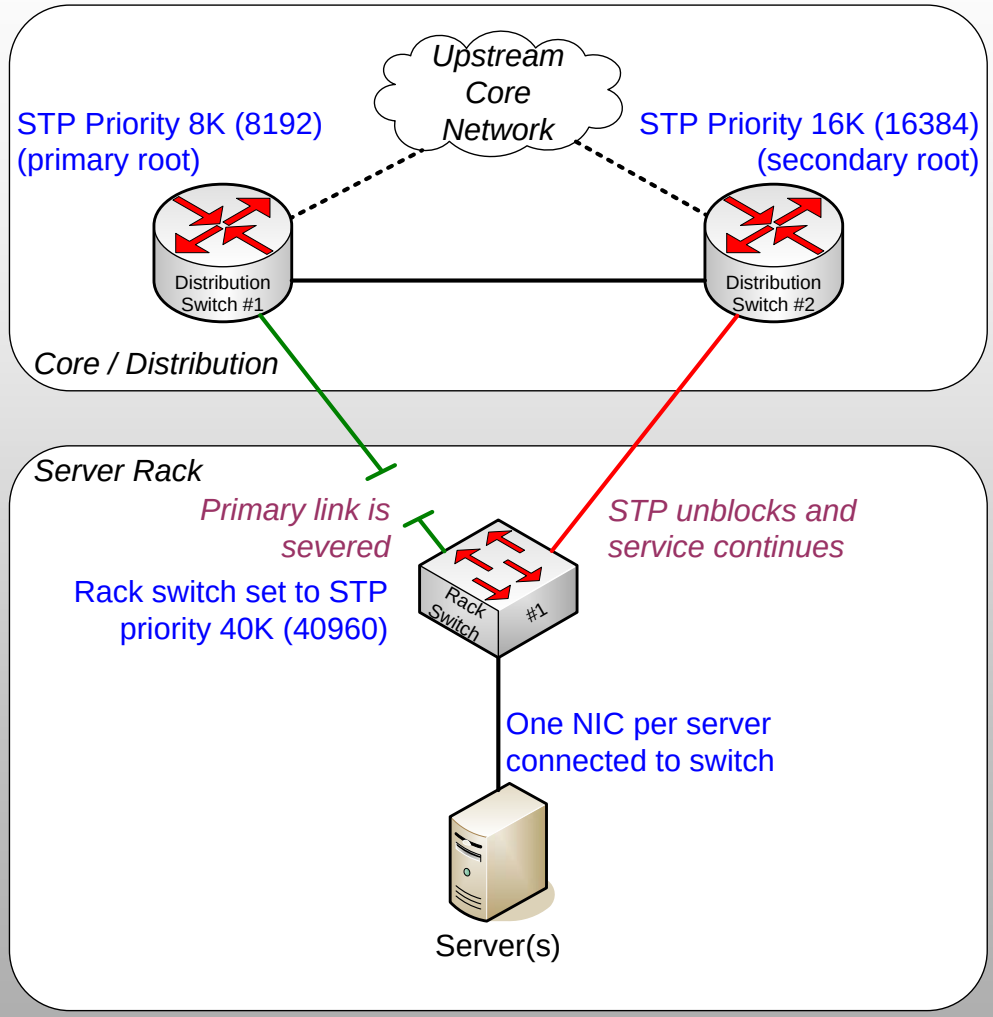
“The Cliché” Layer2 + STP



L2 + STP Explained

- Network loops are intentionally created to provide redundant paths
- Utilizes spanning-tree protocol, 802.1d or preferably RSTP 802.1w, may utilize MST (802.1s) depending on equipment vendor and network size
- STP will automatically detect and block loops during normal conditions, and will unblock to provide failover during an outage
- Relies upon receipt and processing of BPDUs to decide where to block loops

L2 + STP Redundancy



L2 + STP Benefits

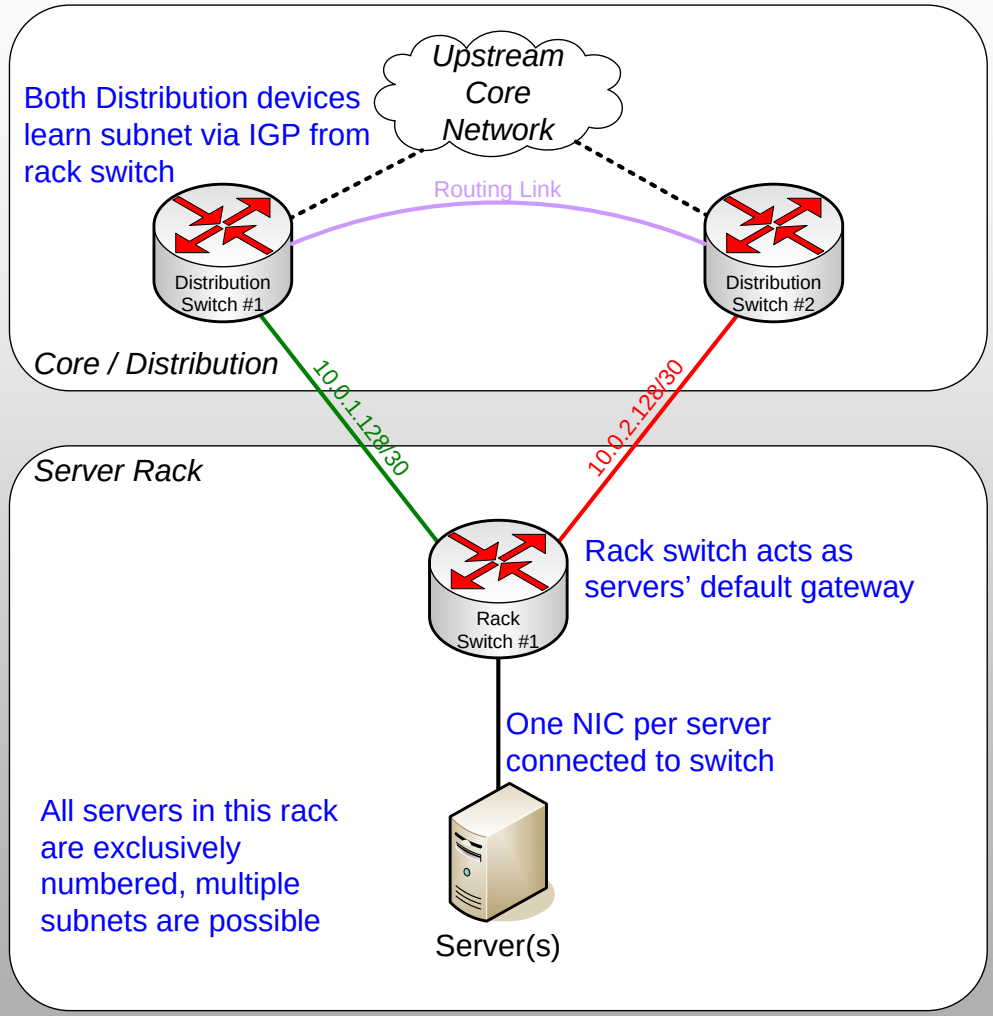
- Extremely common model, simple to use and understand
- Easy to verify backup connectivity and available redundancy (via STP blocking state)
- Most flexible option, any subnet can be extended to any server in any rack via VLAN tagging, easy server mobility (e.g. VM)
- Allows for centralized “services” to be deployed in transparent mode (SLB, firewalling, etc.)
- Helps conserve public IPv4 addresses

L2 + STP Drawbacks

- Stability varies based vendor and device model
- Limitations to interoperations in a multi-vendor environment
- Configuration errors, cabling errors, hardware failure can cause entire datacenter shut downs
- Some network troubles may be difficult to trace
- Heavily depends on rack switch CPU health
- Often requires extra tweaks to achieve desired performance / stability
- May not be able to utilize backup capacity

Model 2
Full Layer 3

Full Layer 3


Upstream
Core
Network
Both Distribution devices learn subnet via IGP from rack switch
Routing Link
Distribution Switch #1
Distribution Switch #2
Core / Distribution
10.0.1.128/30
10.0.2.128/30
Server Rack
Rack Switch #1
Rack switch acts as servers' default gateway
One NIC per server connected to switch
All servers in this rack are exclusively numbered, multiple subnets are possible
Server(s)

Full L3 Explained

- Distribution ⇔ rack switch ports are configured as Layer 3 on both sides
- Distribution ⇔ rack switch links are point-to-point routing links
- Default gateway for servers is rack switch
- Routing protocol is run between rack switch and distribution (typically IGP such as OSPF)
- Redundancy is based on standard routing protocols, e.g. link state, metric/cost

Full L3 Benefits

- Simple to use and understand
- No L2 loops, no STP or associated risks
- Works very well for managed hosting environments with many small customer subnets
- Extremely robust, configuration errors will impact only single rack in worst case
- Easy to verify backup connectivity and available redundancy (via routing adjacencies)
- Supports multi-path to take advantage of all capacity

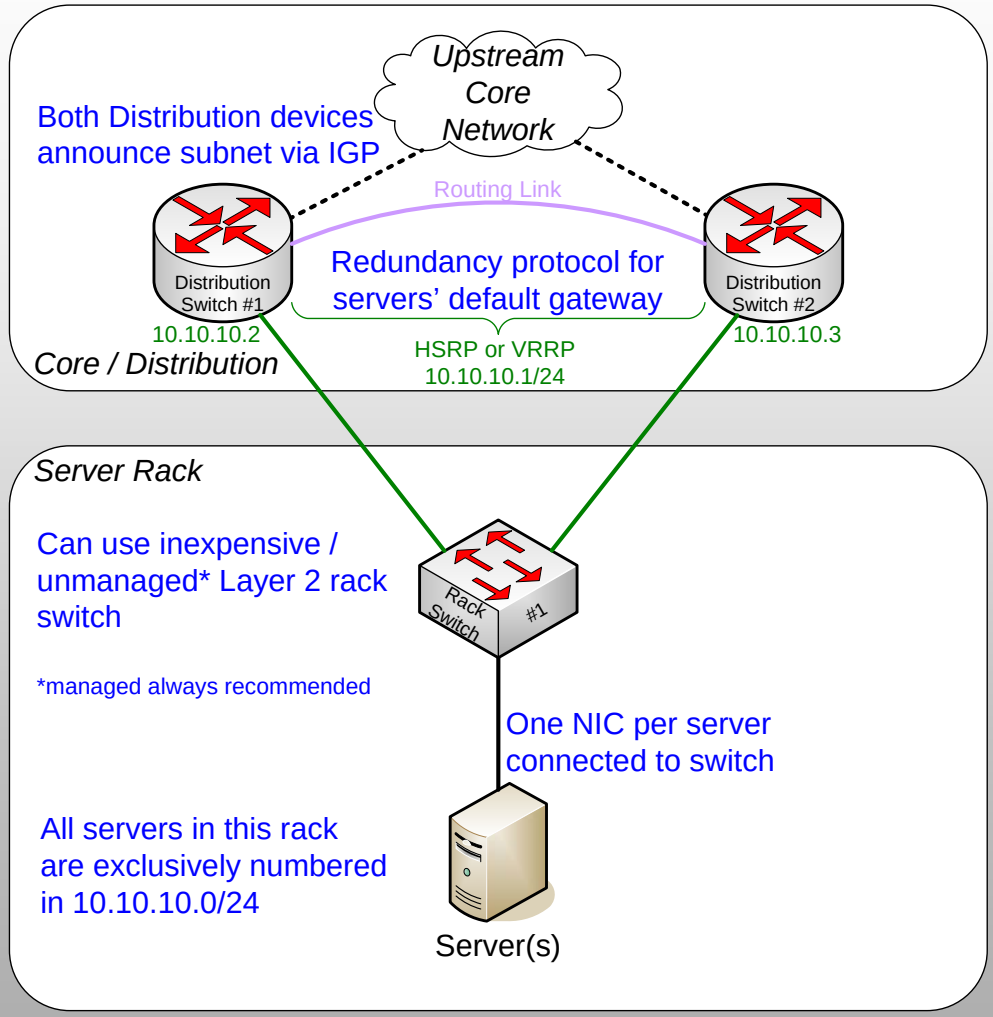
Full L3 Drawbacks

- Significantly increases cost of rack switches
- Racks must be *exclusively* numbered, which means unique subnet(s) per rack
- Inefficient use of public IPv4 address space, one subnet must be allocated per rack

  /28 = 13 servers, /27 = 29 servers, /26 = 61 servers
- Relocating a server (or VM) to another rack means renumbering, limits NIC teaming
- Additional “services” must run in Layer3 mode (e.g. SLB, firewall), may require fancy routing tricks, PBR, etc.

Model 3
Layer 3 Dist with Layer 2 RS

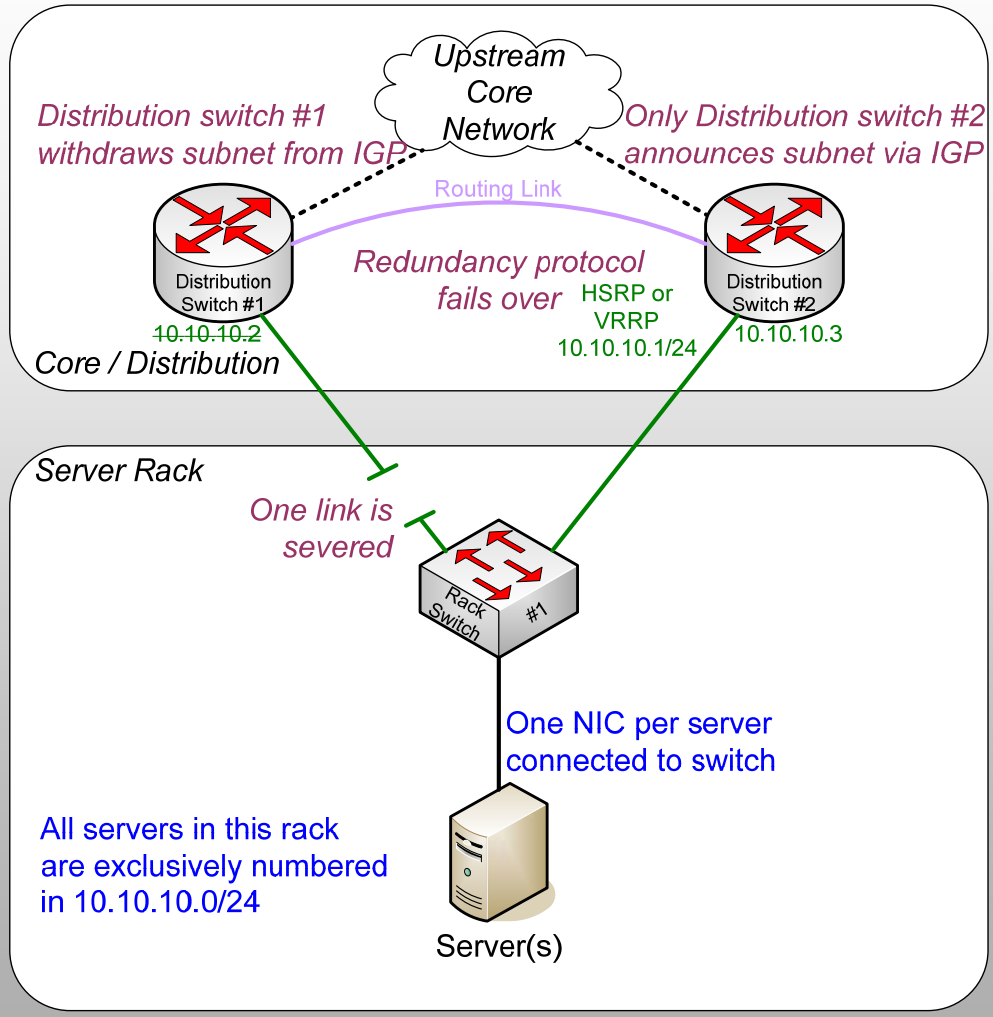
Layer 3 Dist with Layer 2 RS



L3 Dist with L2 RS Explained

- Distribution ports are configured as Layer 3 (a.k.a. "routed ports”)
- Default gateway for servers on distribution using a redundancy protocol such as HSRP or VRRP
- Layer 2 adjacency is formed through the rack switch (a.k.a. “V-shaped”)
- Distribution switches announce reachability via IGP, as with standard L2 model
- Multiple subnets available via 802.1q tagged sub-interfaces from distribution to rack switch

Layer 3 with Layer 2 RS Redundancy



L3 Dist with L2 RS Benefits

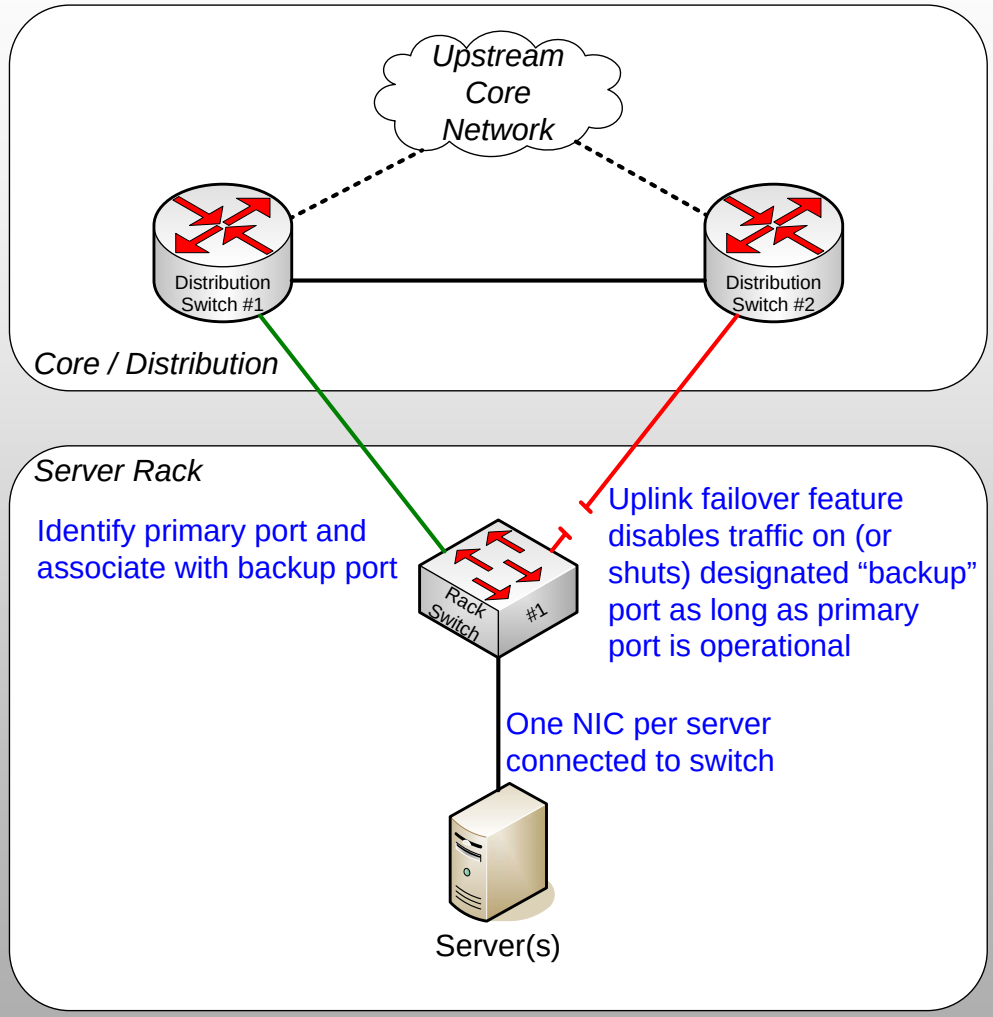
- STP elimination as with full L3 model
- Lower cost than full L3 model, since rack switches are L2 only
- In fact, can run ultra-cheap commodity switches, e.g. not even manageable

L3 Dist with L2 Drawbacks

- As with full L3 model, requires *exclusive* numbering, which means subnet can only exist on that one rack, as well as public IPv4 inefficiencies
- Cannot use upstream backup link capacity without additional configurations (e.g. multiple HSRP/VRRP groups w/alternating priorities and alternating default gateways on servers)
- May impose multi-netting if multiple subnets are required and 802.1q sub-if is not available
- Not very common or straightforward

Model 4
Link Failover

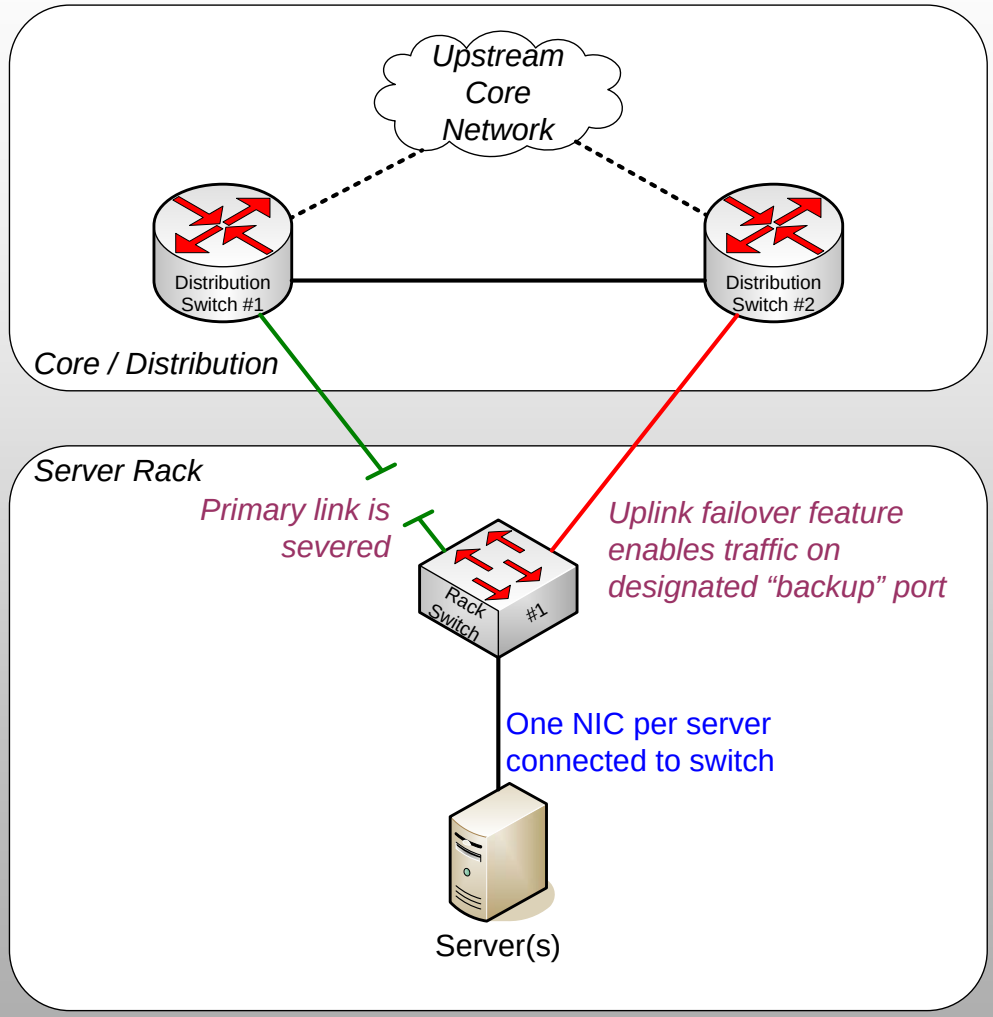
Link Failover



Link Failover Explained

- This model uses switches connected similarly to the L2 model, but with an L1 redundancy
- Instead of creating a loop for backup and blocking using STP, the RS automatically disables all forwarding on (or shuts down) the backup link
- Many vendors support this:
  - Cisco calls this “Flex Link”
  - Foundry calls this “Protected Link Groups”
  - Juniper (EX) calls this “Redundant Trunk Links”
  - Force10 calls this “Redundant Pairs”

Link Failover Redundancy



Link Failover Benefits

- Not based on health of distribution and rack switch CPUs, may be more reliable
- No complex “state machines” as with STP
- No loops during steady-state, backup link never passes production traffic while primary is up
- May provide rapid failover (depends on certain conditions)
- Reduced interoperability concerns, if the RS provides this feature, there is nothing needed from the distribution equipment
- Same server mobility & subnet flexibility as L2

Link Failover Drawbacks

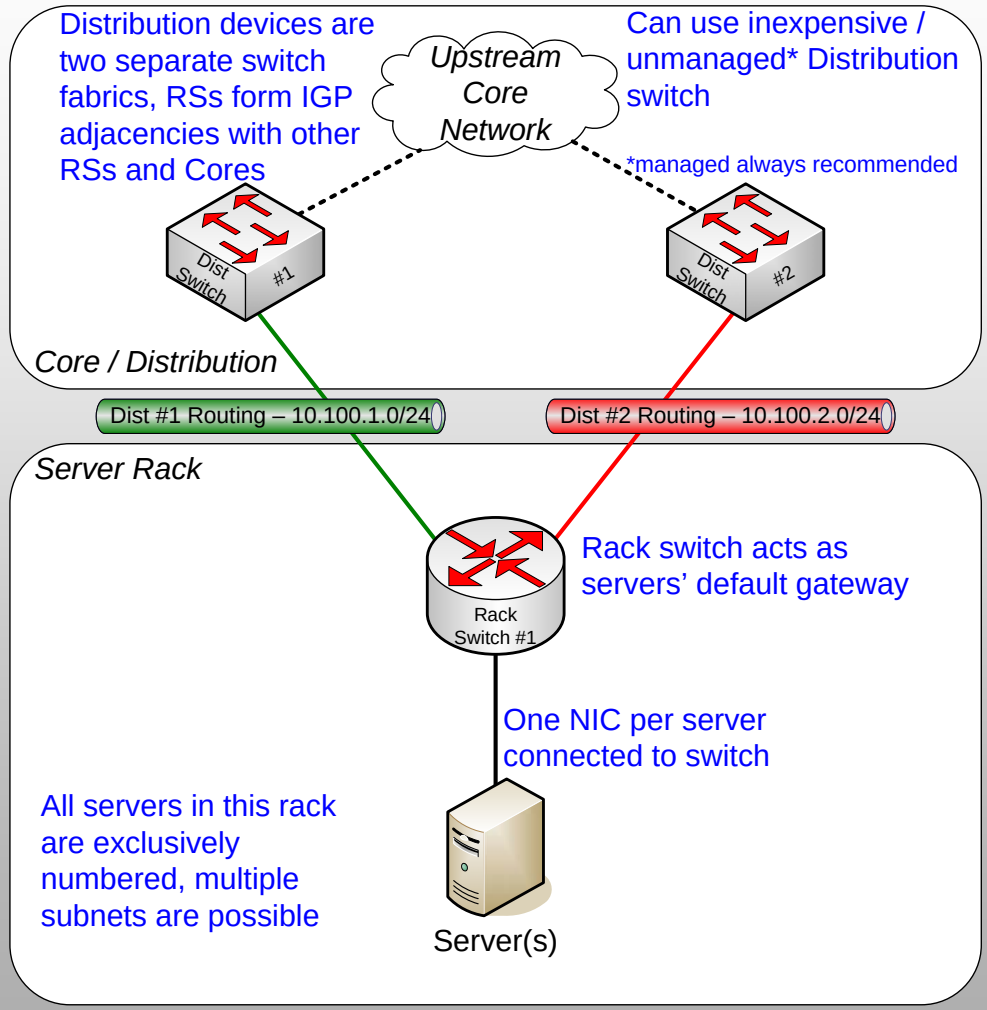
- Some vendors place the backup port in a “down” state:
  - link is always shown as “down” therefore cannot confirm interface health or guarantee redundancy without actually testing failover
  - cannot map backup interfaces using LLDP/CDP/FDP
  - may cause delays in failover due to STP discovery as link in distribution needs to transition to forwarding
- Lack of protocol (STP / IGP) limits knowledge, redundancy may not be complete – surprise!
- Cannot load-balance traffic over redundant link
- STP usually disabled, may cause loops!

Link Failover Questions

- Is anyone using this?
- Really though – using it widely (all racks in a datacenter)?
- Why not?
- Sure, it’s not as flexible as STP, but doesn’t it provide exactly what we need at the dual-uplinked rack switch?

Model 5
Layer 2 Dist with Layer 3 RS

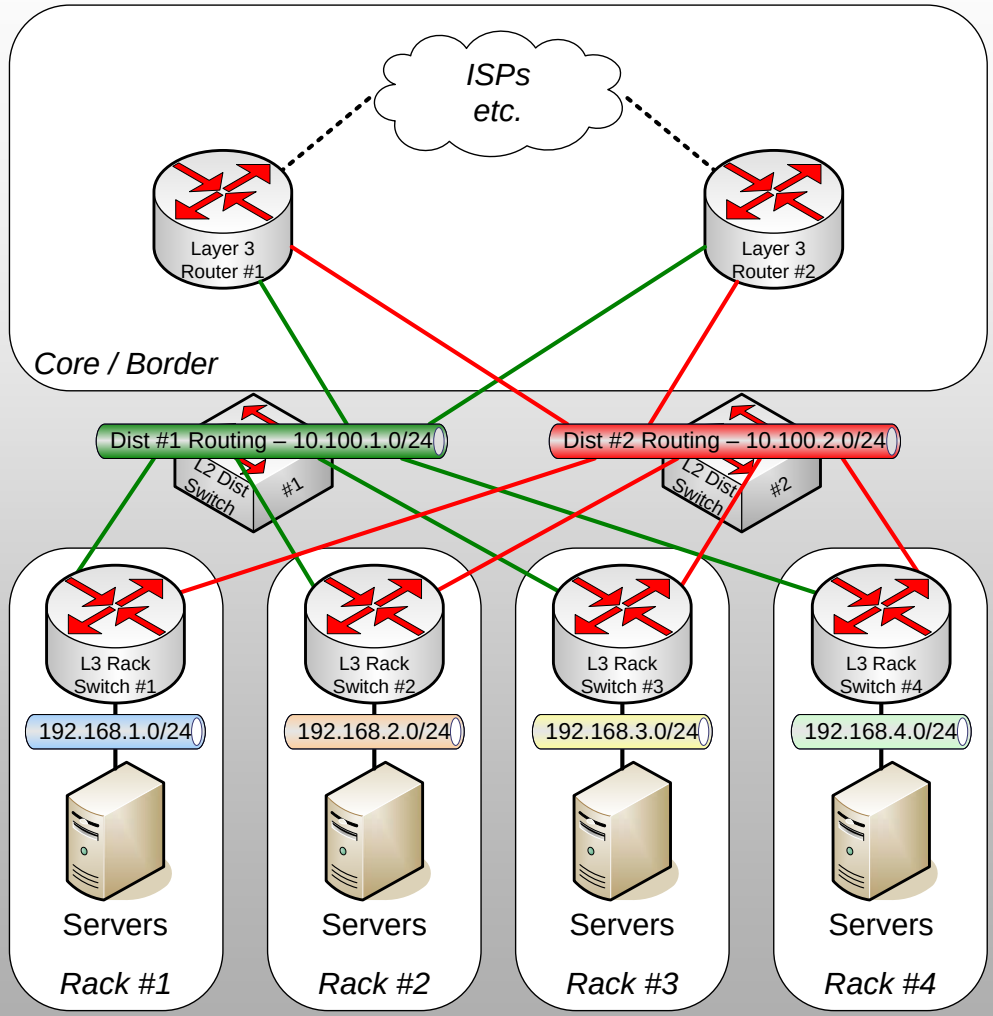
Layer 2 Dist with Layer 3 RS



L2 Dist With L3 RS Explained

- Each distribution switch acts as a switch fabric for a unique multi-access routing subnet, dumb switch with no routing functionality
- Layer 3 RSs form IGP adjacencies with all other RSs and Layer 3 cores over two diverse subnets
- RS uplink ports are configured as Layer 3 ports
- Default gateway for servers is rack switch
- Redundancy is based on standard routing protocols, e.g. link state, metric/cost

Expanded L2 Dist with L3 RS



L2 Dist With L3 RS Benefits

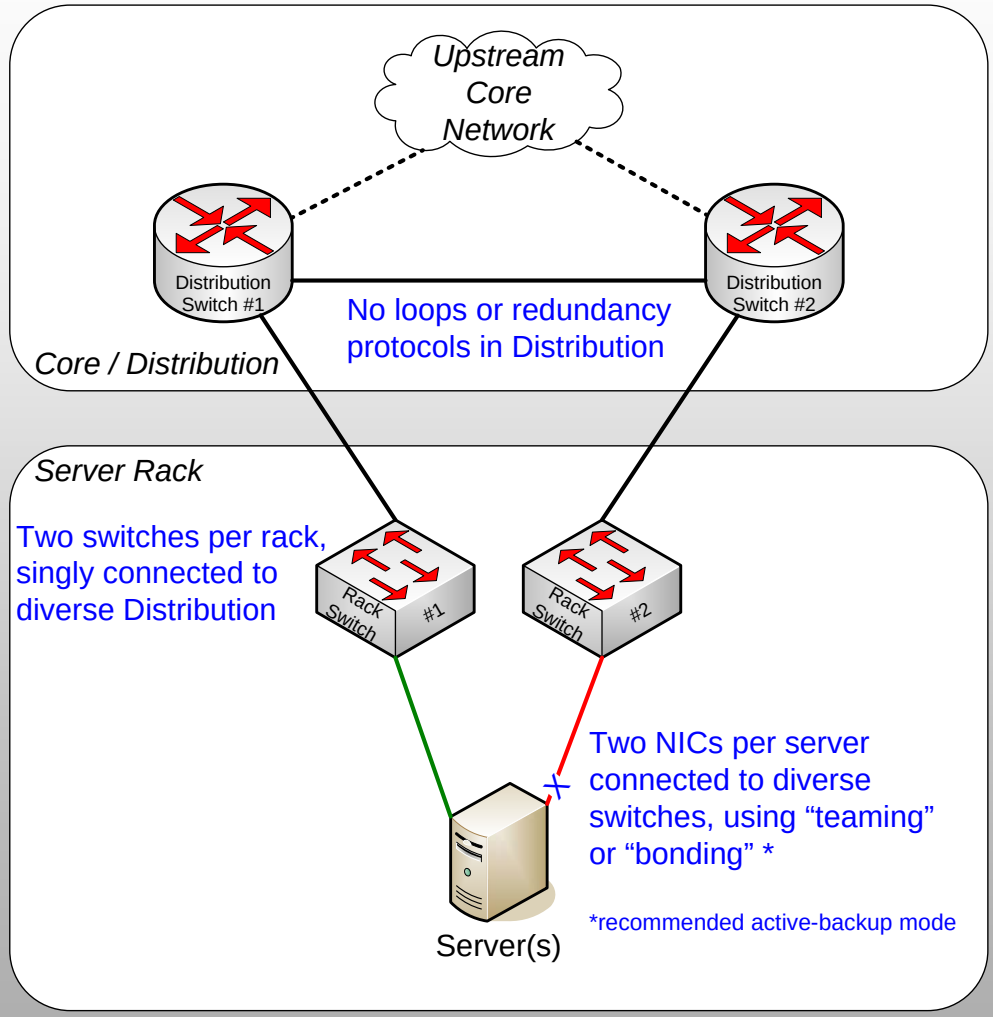
- All the benefits of full L3, such as no loops or STP, ability to utilize redundant uplinks for additional capacity during steady-state
- If application/product requirements require Layer3 access devices, will allow for some economy in the distribution hardware (don’t even need VLAN support in the L2 distribution)
- Introduces a novel any-to-any routing over L2 switching fabric model into the datacenter

L2 Dist With L3 RS Drawbacks

- As with full L3 model, more expensive RSs
- As with full L3 model, requires *exclusive* numbering, which means subnet can only exist on that one rack, as well as public IPv4 inefficiencies
- Since uplinks are not point-to-point, far-end outages are only detected after hold or keepalive timer expiration, may experience short-term blackhole during link failover
- Not very common or straightforward

Model 6
Server-Based (Multi NIC)

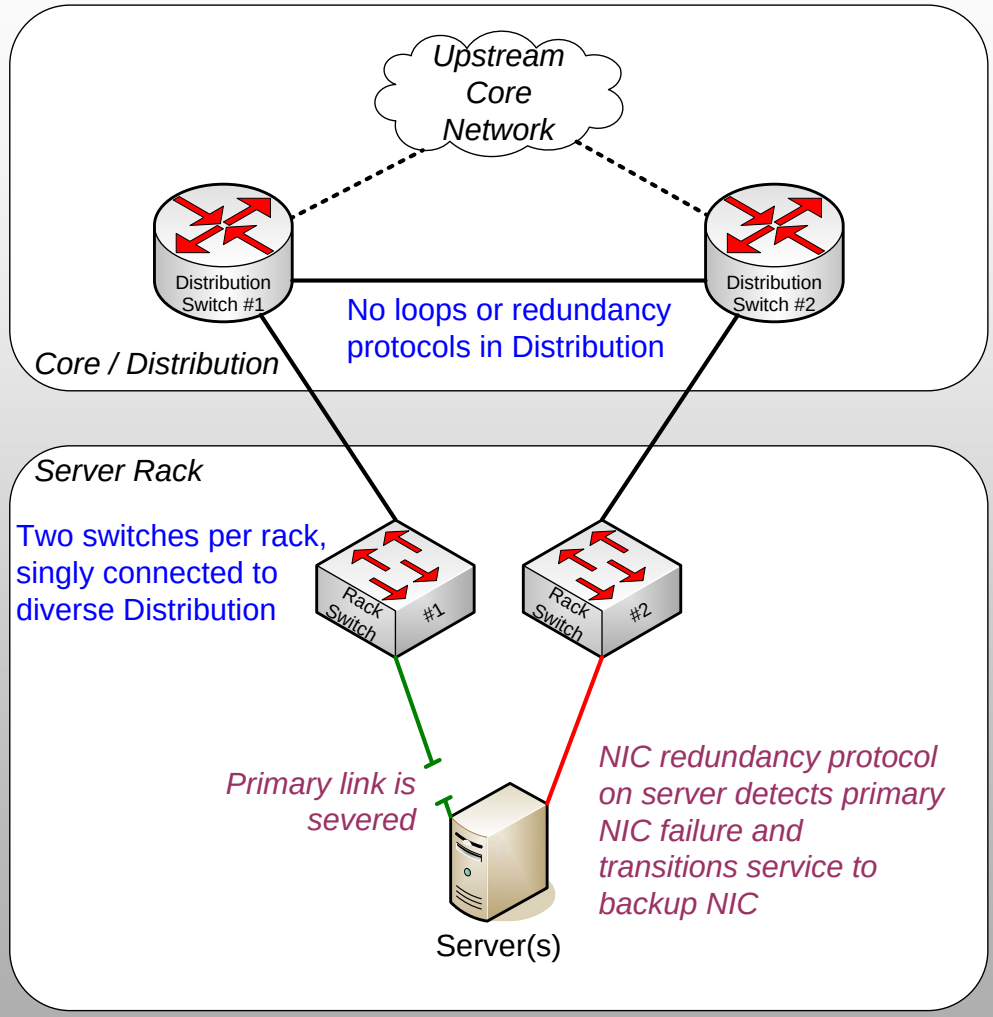
Server-Based (Multi NIC)



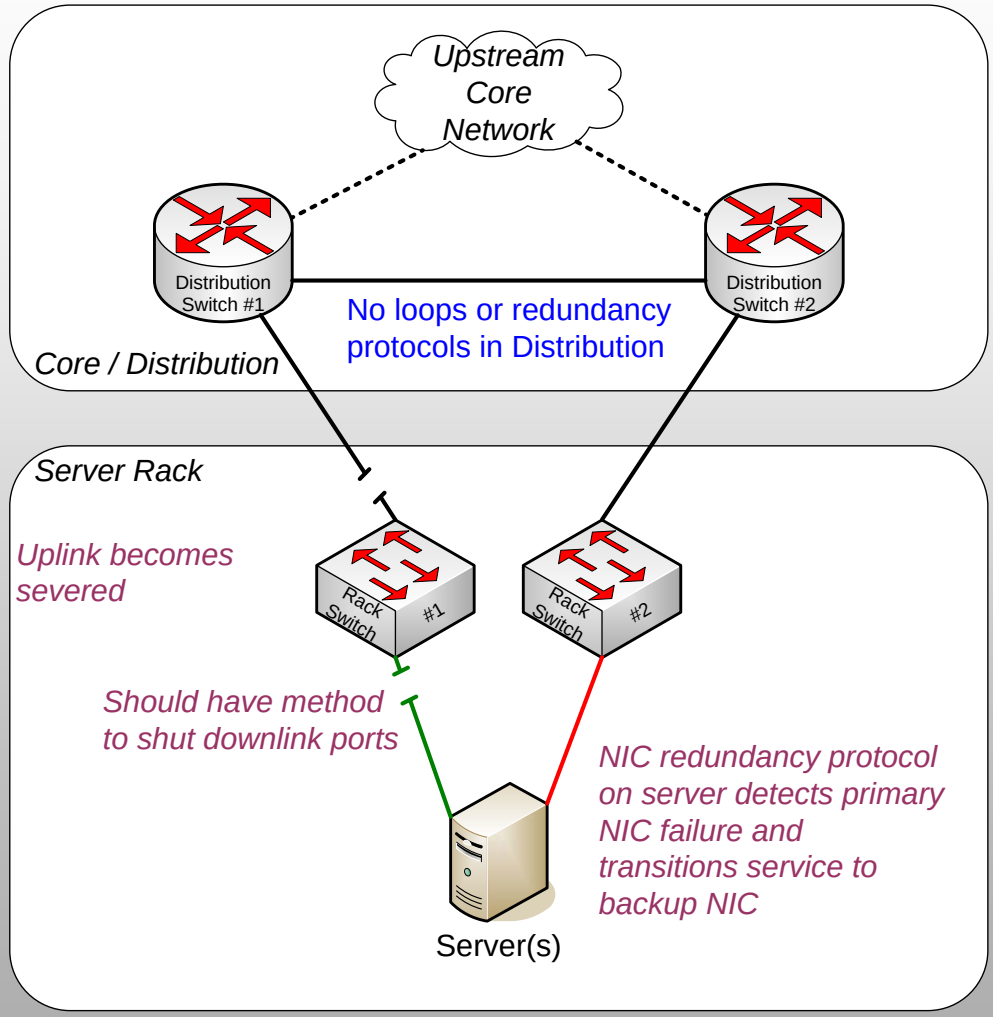
Server-Based Explained

- This model assigns redundancy burden to the servers
- Supply two rack switches for server access, each with diverse uplinks
- May be the best bet when using blade chassis with integrated switches
- Different methods available for servers to determine NIC usability:
  - Link state
  - ARP queries for default gateway
  - Ping default gateway

Server-Based Redundancy 1



Server-Based Redundancy 2



Server-Based Benefits

- Will work with pretty much any switch –if your budget is tight you can shift some $$ from the rack access layer back to the dist / core / border layer where you need it more
- Same IP/subnet/VLAN flexibility as L2 models
- Network requires minimal attention, good for organizations that have more sysadmin skill, requiring less network engineering
- Network has less risk of Layer 2 or Layer 3 troubles, no worry of STP / IGP meltdowns due to misconfiguration or operator error

Server-Based Drawbacks

- Increases complexity of server configuration
- No good centralized way of assuring 100% redundancy (have to check at each server)
- Uses twice the number of NICs on each server
- Uses twice the number of RSs (but, you may want this anyway, to eliminate RS SPOF)
- Should have way to signal server “downlink” ports of RS “uplink” failure, otherwise may blackhole server traffic
- Redundant capacity is not utilized (if configured as recommended)

Extras

Extra Redundancy Helpers

- Most failover schemes rely upon discovery of link status changes (port up / down), which sometimes may be delayed or not properly reported
- Remote fault signaling (link negotiation)
- Unidirectional Dead Link Detection (UDLD) is useful especially with fiber links, but beware buggy implementations
- Bidirectional Forwarding Detection (BFD) is more promising than UDLD, maybe even performed in port ASIC, but stable/reliable implementations are still few

Extra Models

- There are some new models surfacing that are based on link aggregation at the rack server side, running to diverse equipment in the distribution layer:
  - Link aggregation across different members of a switch stack (multi-vendor)
  - Multi-chassis EtherChannel (“MEC” - Cisco VSS), kind of like different members of a switch stack
  - Virtual Port Channel (“vPC” - Cisco Nexus 7000)
- Ink is still drying for some of these, the models included in this talk have been well-baked

Summary

Layer 3 versus Layer 2

- Great quote from Cisco design document which summarizes the difference between Layer 3 and Layer 2:
  - *A routing protocol identifies where to send packets*
  - *STP identifies where not to send frames*

- Source:

http://www.cisco.com/en/US/docs/solutions/Enterprise/Data_Center/DC_3_0/DC-3_0_IPInfra.html

Summary

- We have deployed and operated the preceding models over the past 12 years
- Different datacenter environments, application and security requirements, and equipment capabilities will lead to different solutions
- This list may not be exhaustive, come find me if you have other ways you've done this – both successes and failures!
- Is the L2/STP model seeing a comeback due to server virtualization?

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Any Questions?

Thank you for listening

Peak Web Consulting is available to assist

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