

Campus Network Best Practices: Campus Network Design Principles

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Why Are We Doing This?

- Our goal is to build networking capacity to support Research and Education
 - Remember: University = Research & Education
- The end game is regional, national, and larger Research and Education Networks (RENs)
- All RENs start with campus networks – they are the foundation of the REN



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Why Focus on Campus Networks?

- The Campus Network is the foundation for all Research and Education activity
- Without a good campus network, the Research and Education Network can't work as well as it should
- Ad-hoc campus networks work OK with VSAT or low speed uplinks, but moving to high speed external links, they start to fail.



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Why Focus on Campus Networks?

- Your campus network is the foundation that all services are provisioned on
- Ad hoc networks just don't work well. They are unreliable and hard to maintain.
- If you don't have a plan, how will you know where are going?



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What are Our Goals?

- Network Design Goals
 - Reliability/Resiliency
 - Performance
 - Manageability
 - Must have this to find problems and viruses
 - Scalability
 - Need to be able to grow as needs grow
- Need this in the campus and the REN



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Campus Network Rules

- Separate layers of your network
- Minimize number of network devices in any path
- Use standard solutions for common situations
- Provision central services near the core
- Route near the core, switch at the edges
- Separate core router functions from border router functions
- Use DHCP centrally
- Separate DNS server duties



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Campus Network Design

- A good network design is modular and hierarchical, with a clear separation of functions:
 - **Core:** Resilient, few changes, few features, high link and high CPU capacity
 - **Distribution:** Aggregation, redundancy
 - **Access:** Port density, affordability, security features, many adds, moves and changes



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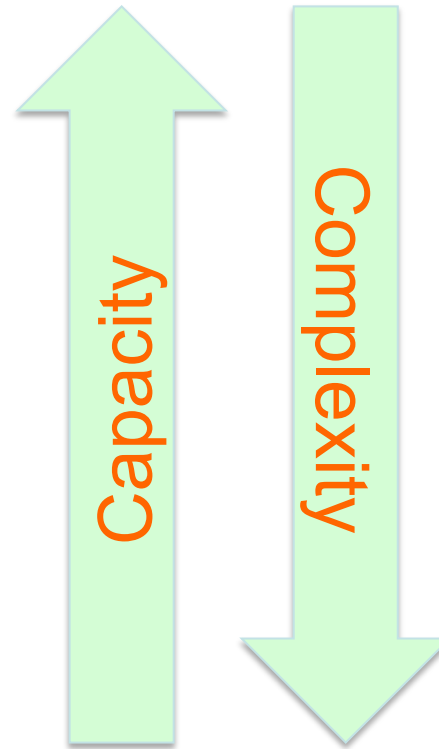


Layers Features

Core

Distribution

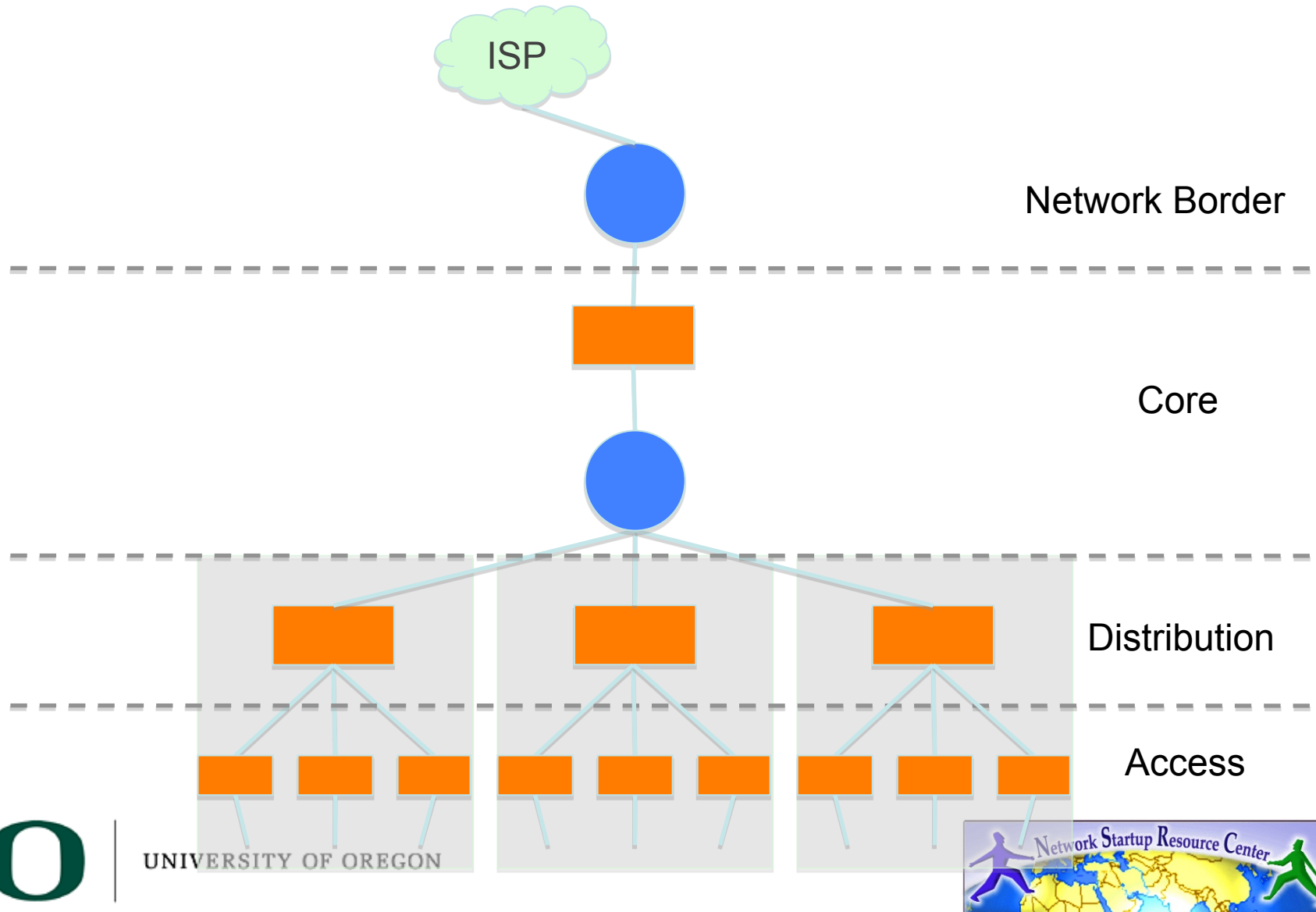
Access



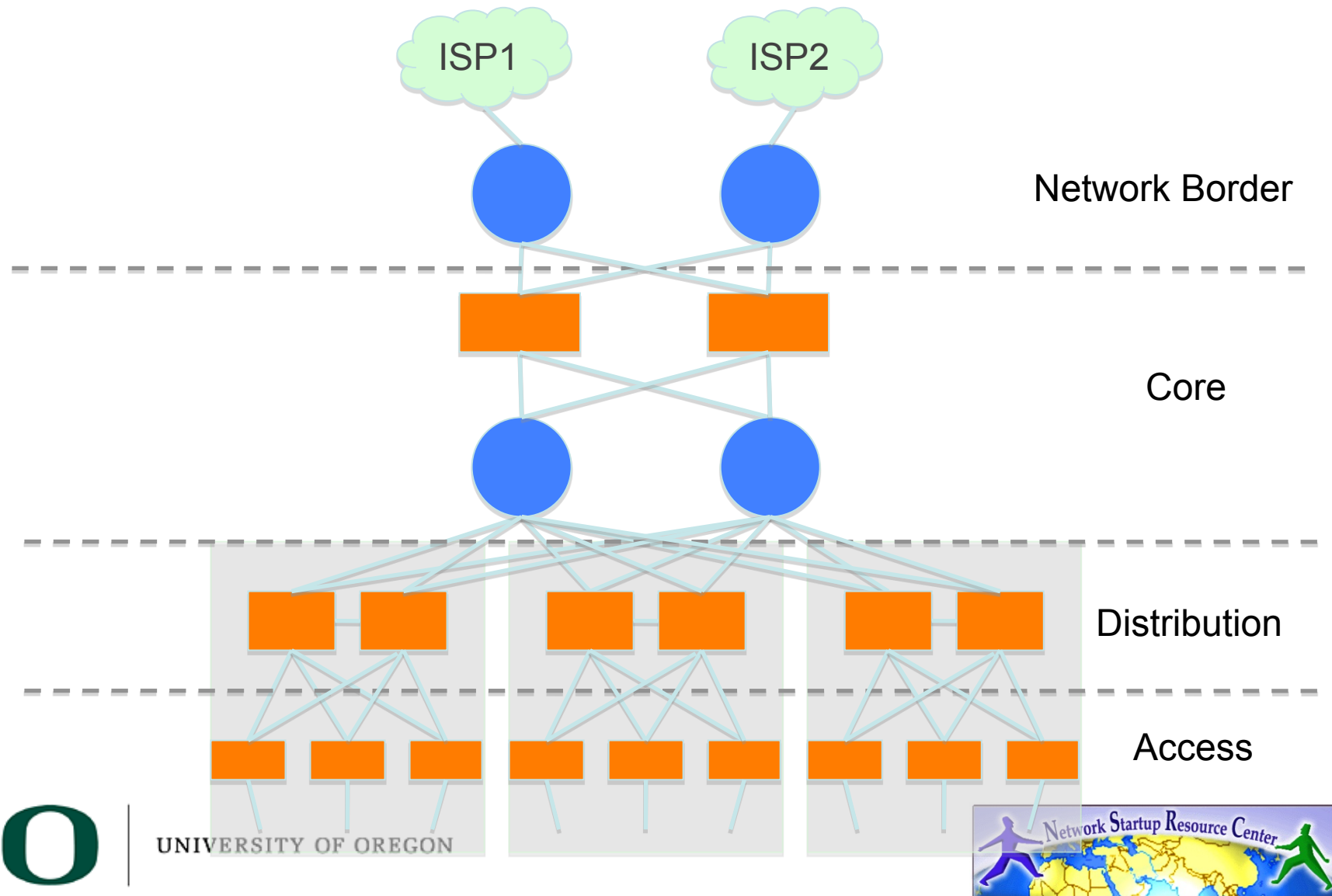
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Campus Network Design - Simple

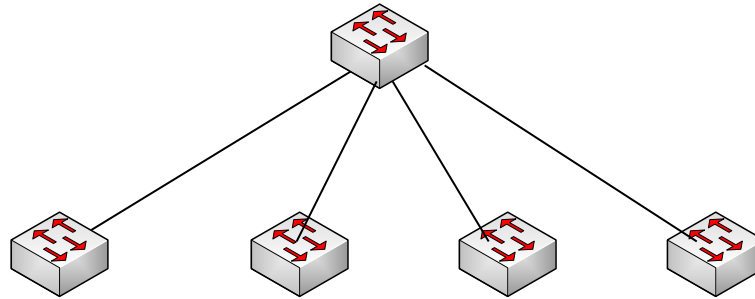


Campus Network Design - Redundant

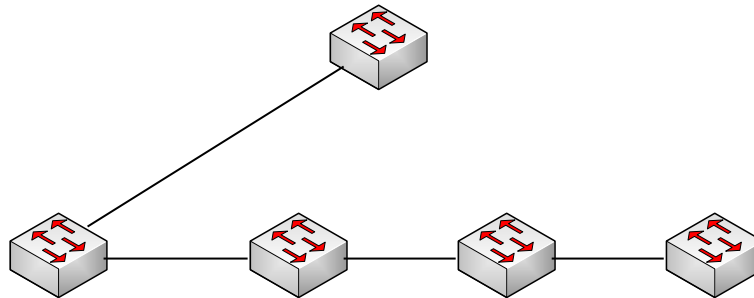


Minimize Number of Network Devices in the Path

- Build star networks



- Not daisy chained networks



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Edge Networks (Layer 2 LANs)

- Provides Service to end users
- Each of these networks will be an IP subnet
- Plan for no more than 250 Computers at maximum
- Should be one of these for every reasonable sized building
- This network should only be switched
- **Always buy switches that are managed – no unmanaged switches!**

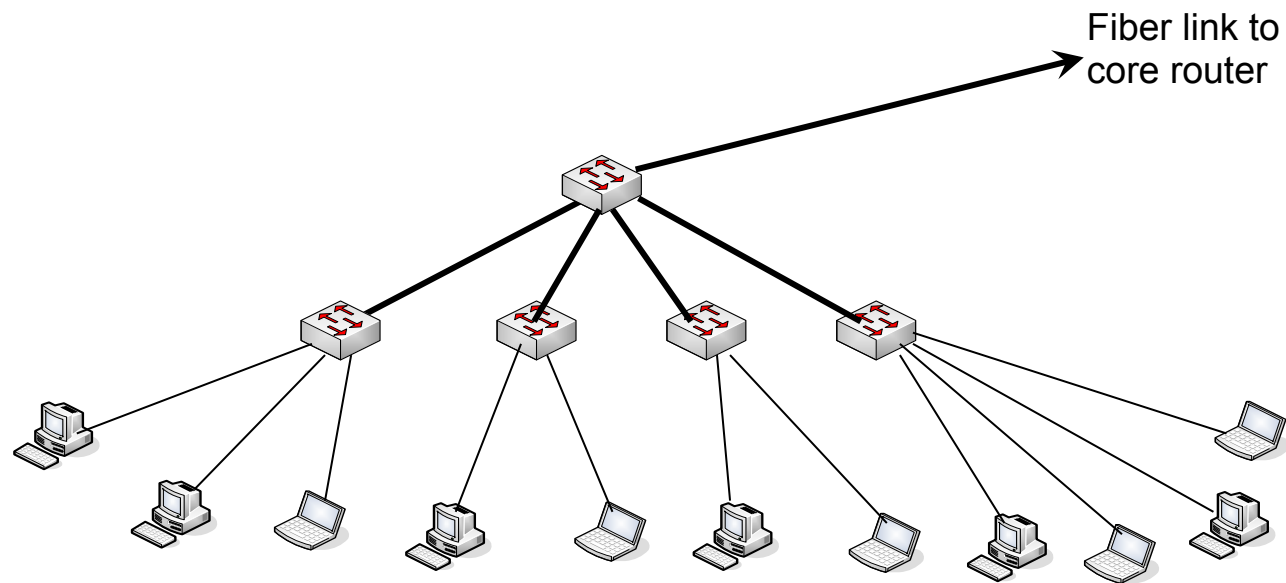


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Edge Networks

- Make every network look like this:

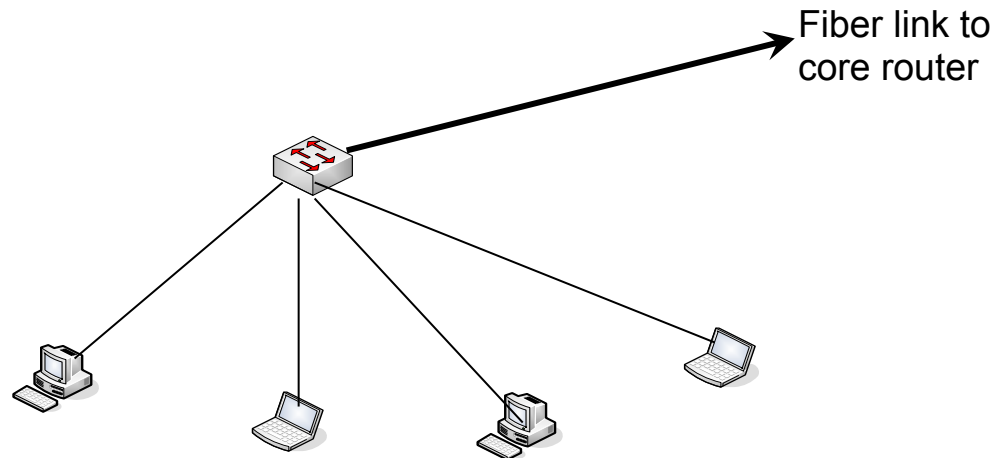


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Edge Networks Continued

- Build Edge network incrementally as you have demand and money
- Start Small:

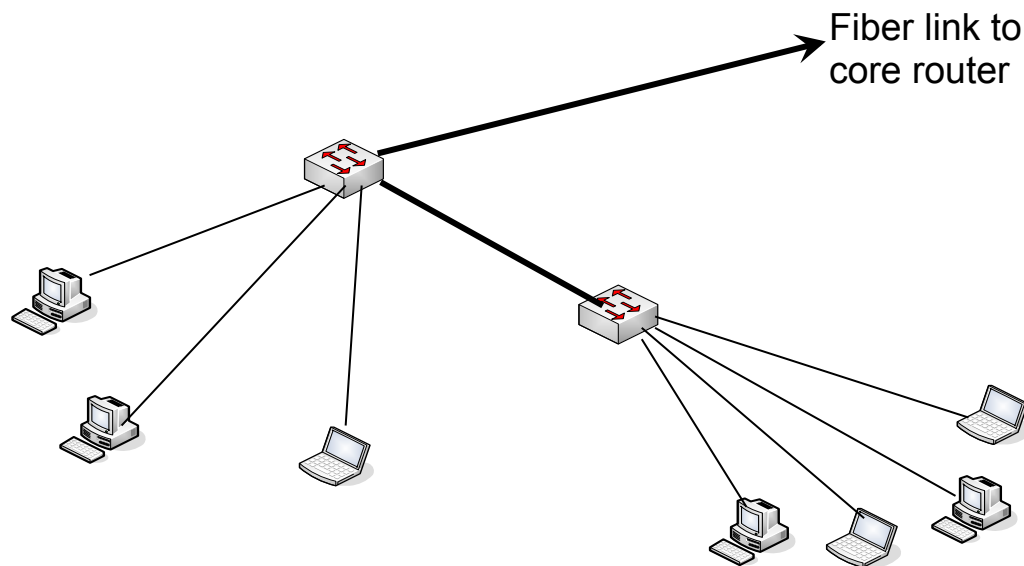


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Edge Networks Continued

- Then as you need to add machines to the network, add a switch to get this:

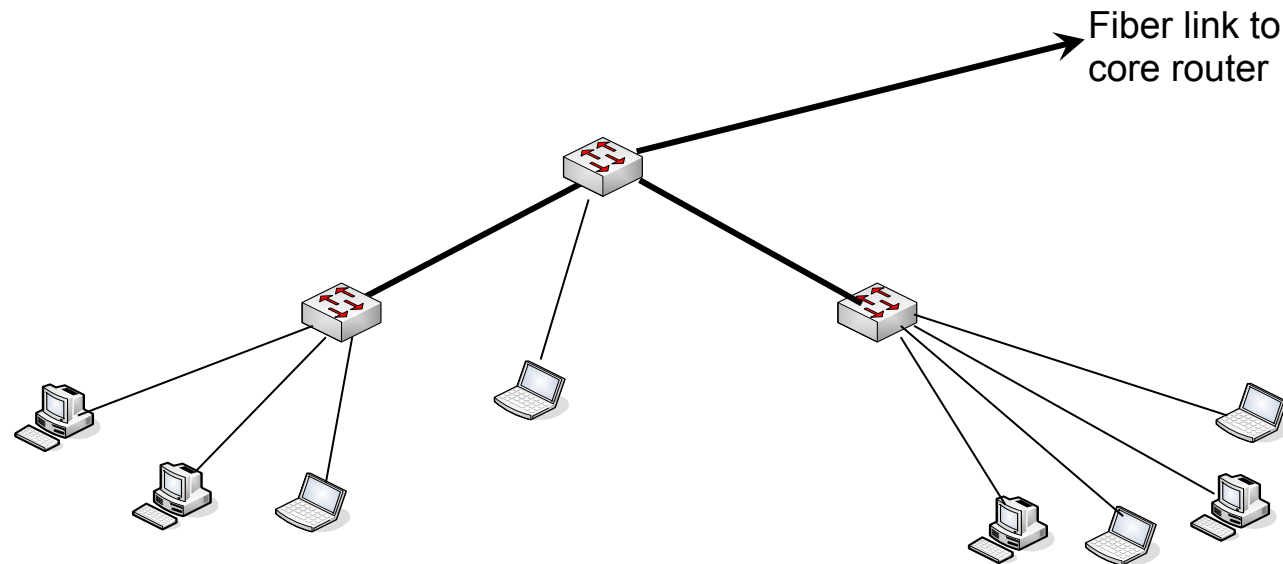


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Edge Networks Continued

- And keep adding switches to get to the final configuration

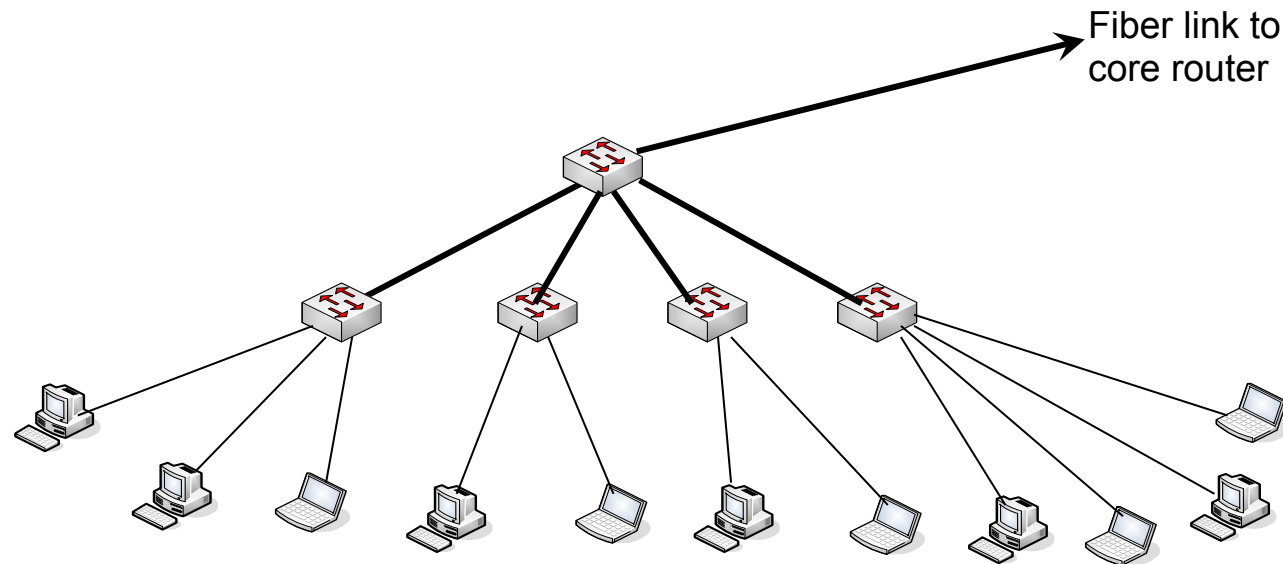


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Edge Networks Continued

- And keep adding switches to get to the final configuration

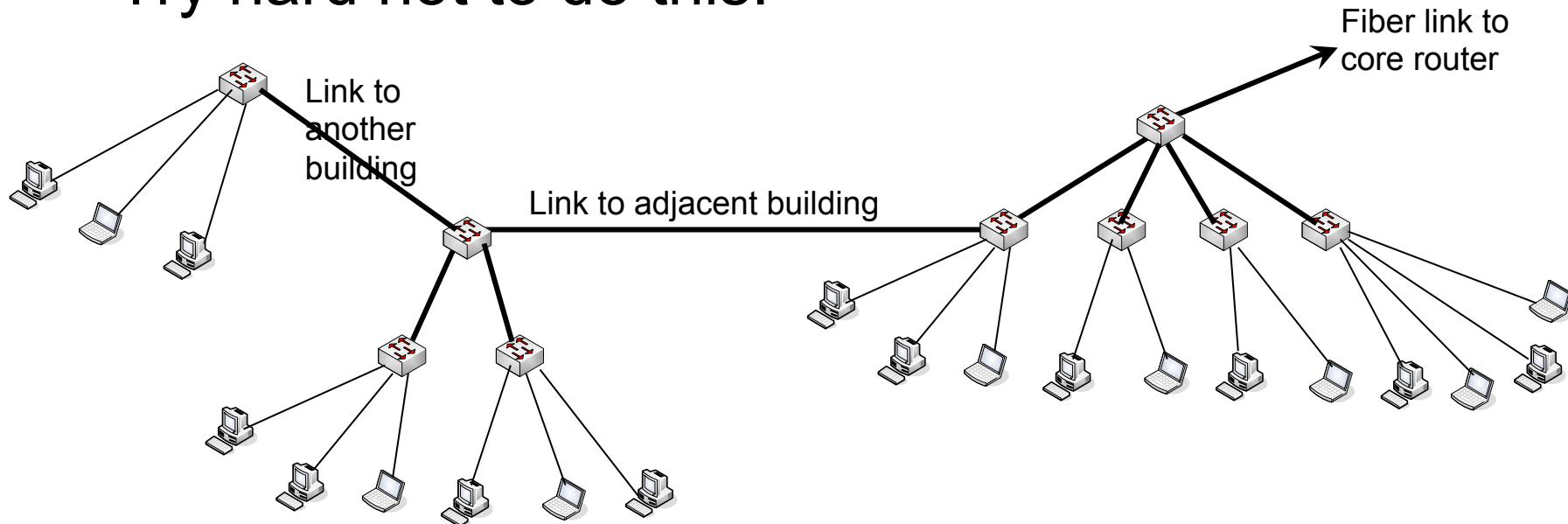


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Edge Networks Continued

- Resist the urge to save money by breaking this model and daisy chaining networks or buildings together
- Try hard not to do this:

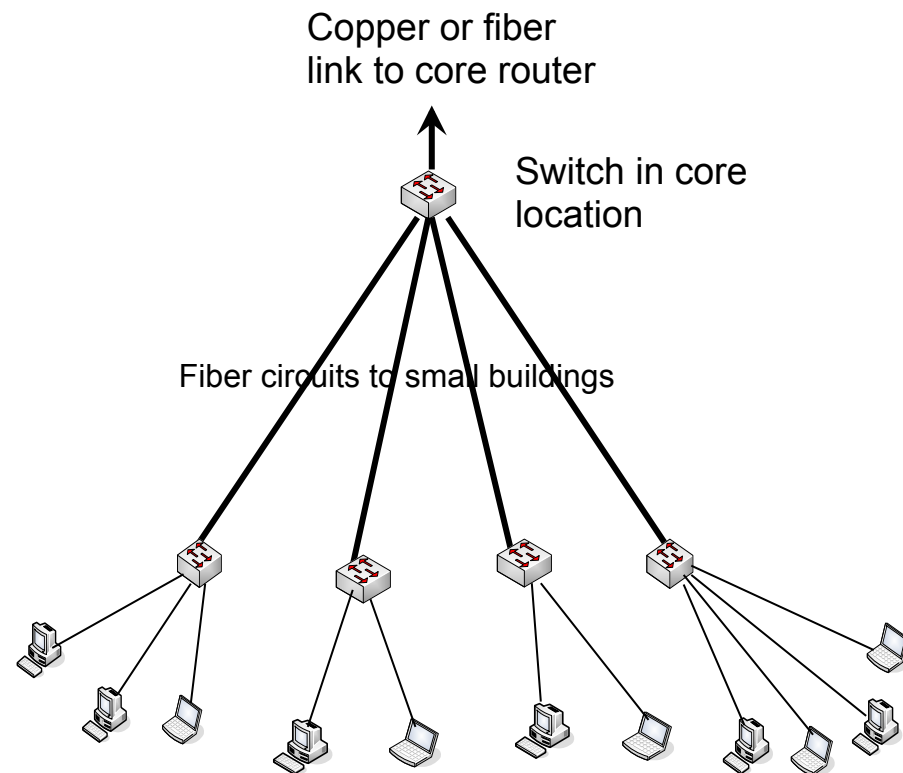
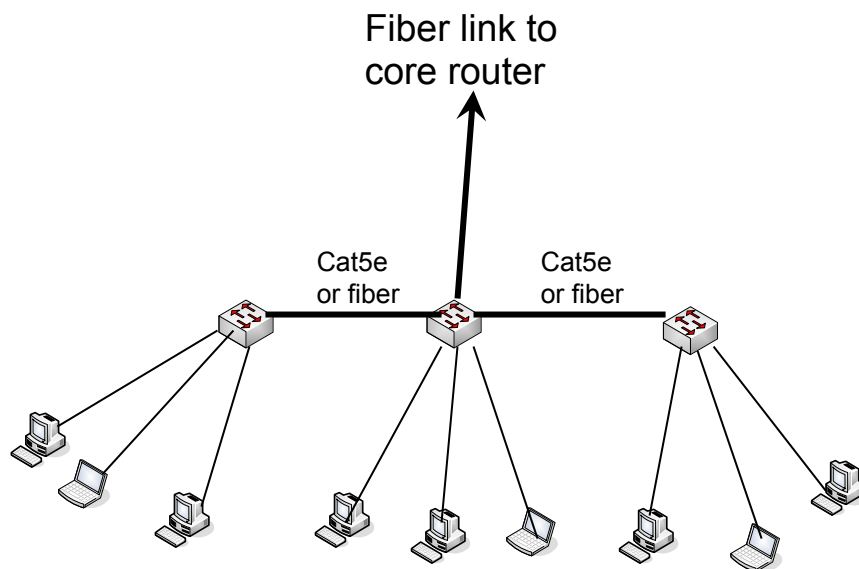


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Edge Networks Continued

- There are cases where you can serve multiple small buildings with one subnet.
- Do it carefully.
- Two basic models:



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Core Network



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Core Layer

- Core network is the “core” of your network
 - Reliability is key
 - Keep it simple!
 - Always route (not switch) in the core
 - Reliable power and air conditioning
 - As you grow:
 - Add more devices for redundancy or better performance
 - Use dual power supplies fed from separate UPSs



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Routing versus Switching

Layer 2 versus Layer 3

- Routers provide more isolation between devices (they stop broadcasts)
- Routing is more complicated, but also more sophisticated and can make more efficient use of the network, particularly if there are redundancy elements such as loops

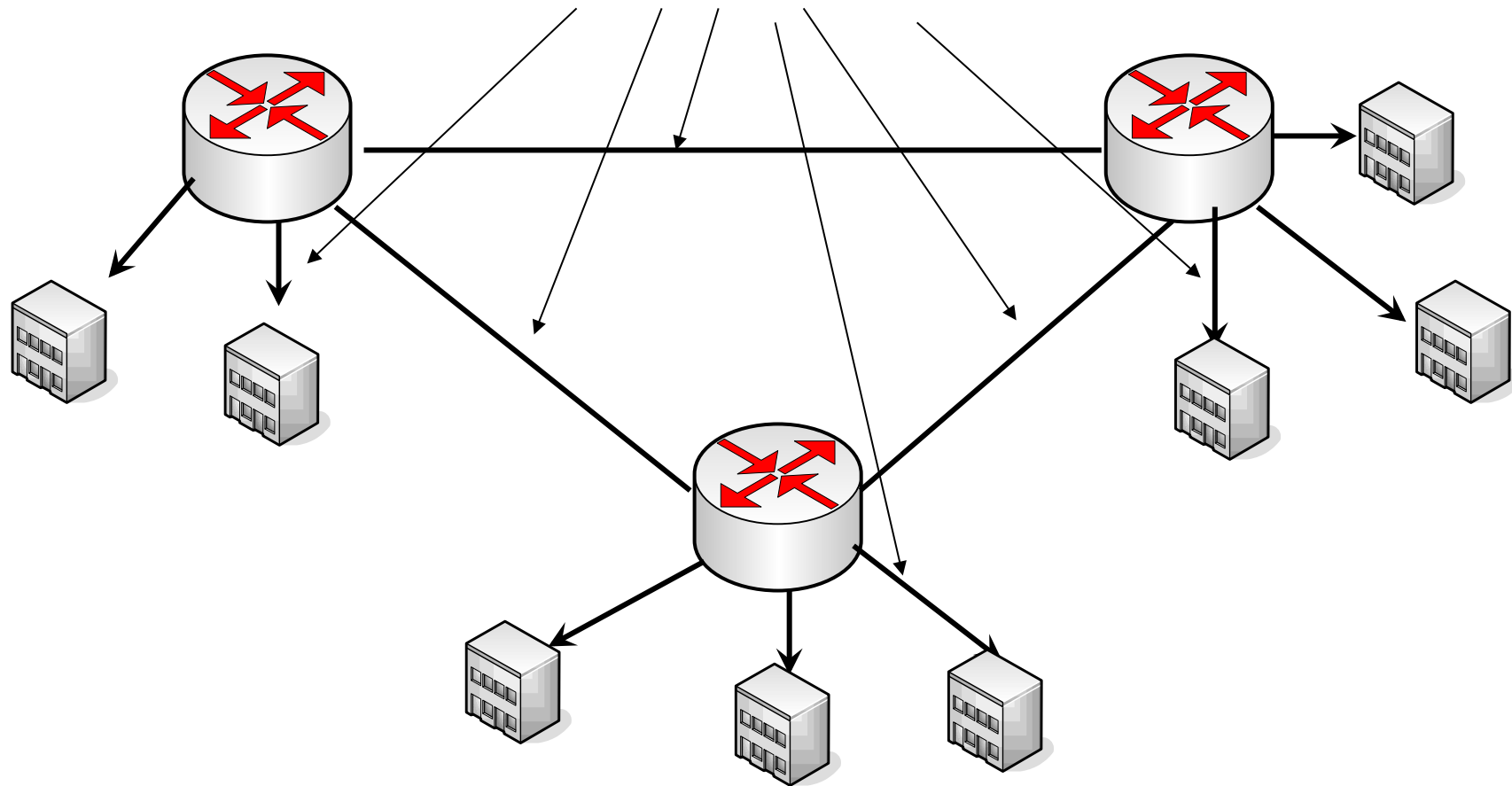


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Switching versus Routing

These links must be routed, not switched

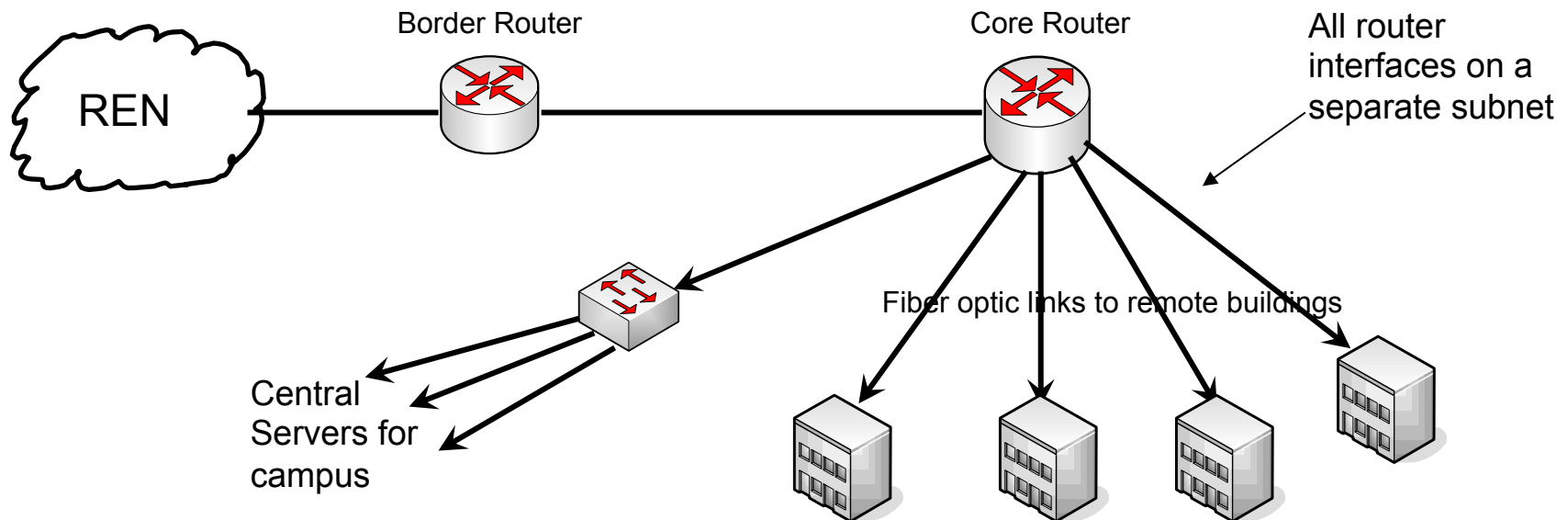


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Core Network

- At the core of your network should be routers – you must route, not switch.
- Routers give isolation between subnets
- A simple core:

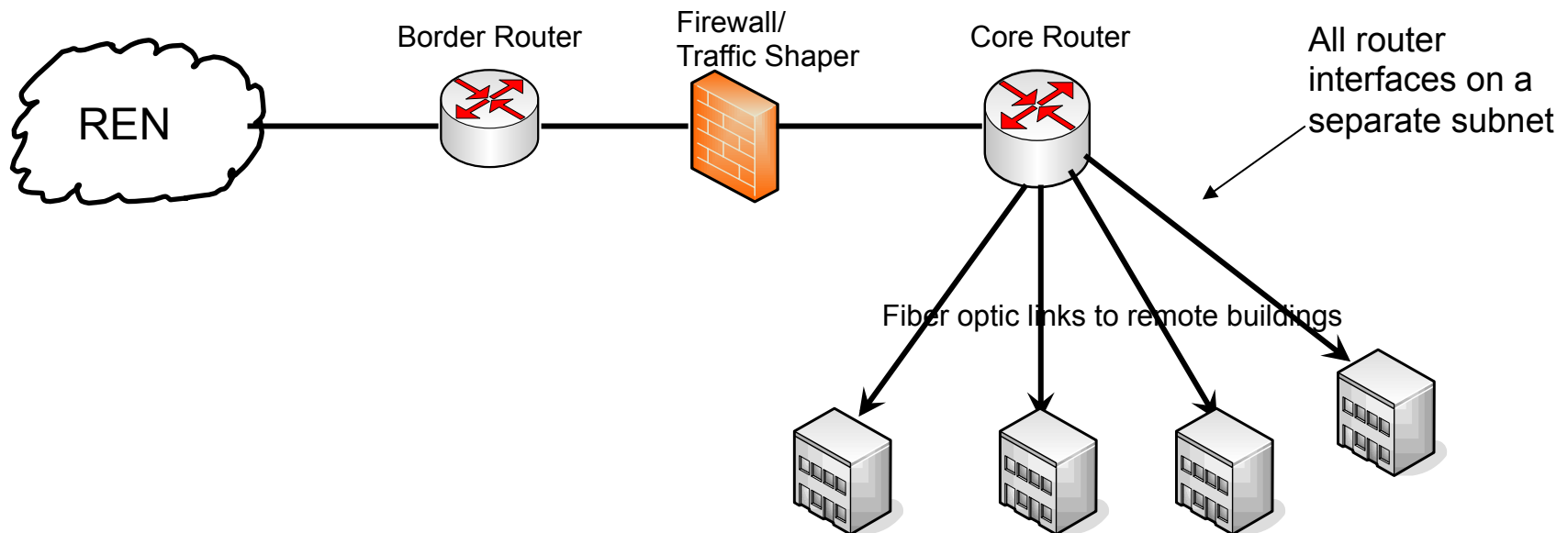


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Where to put Firewalls or NAT

- Firewalls or NAT devices must be placed “in line”
- This means that the speed of this device affects access to the outside world
- This is a typical design, but think about alternatives

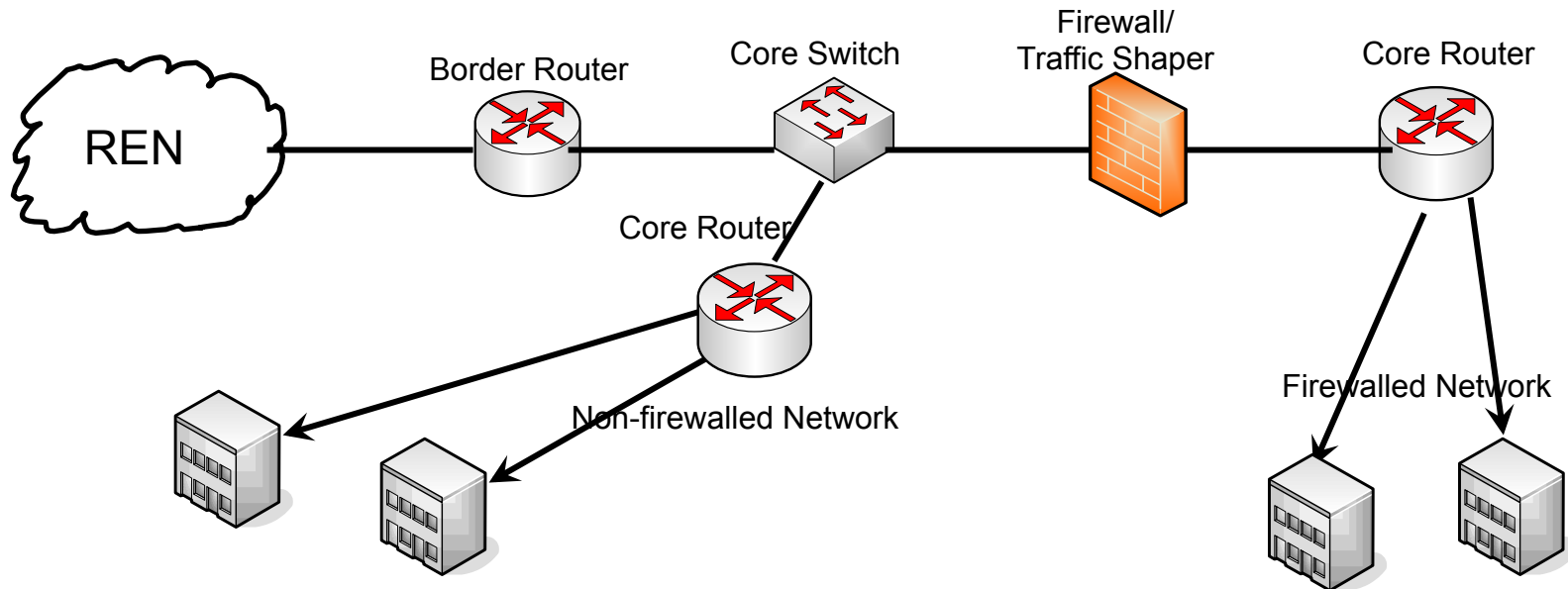


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Where to put Firewalls

- Try to have parts of your network non-firewalled, non NATed
- This will allow full bandwidth, un-filtered access to the Internet
- Simple configuration:

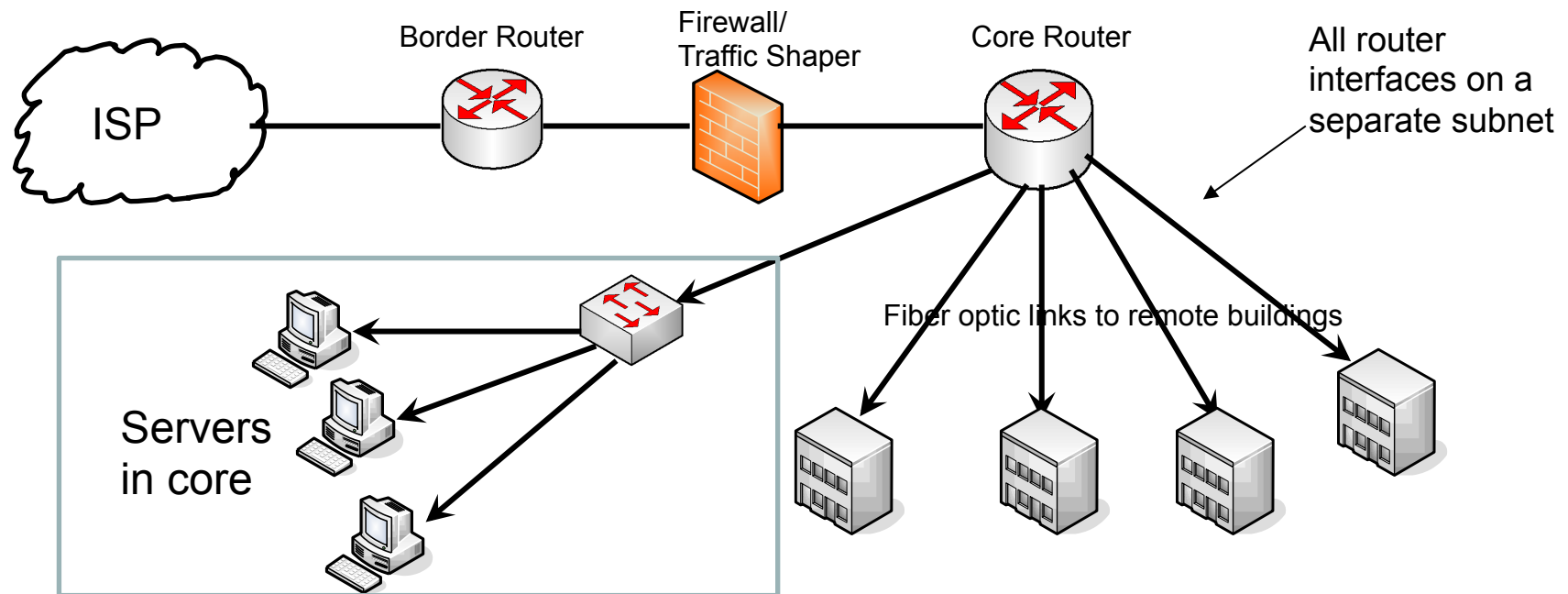


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Where to put Servers?

- Servers should be on a high speed interface off of your core router
- Servers should be at your core location where there is good power and air conditioning

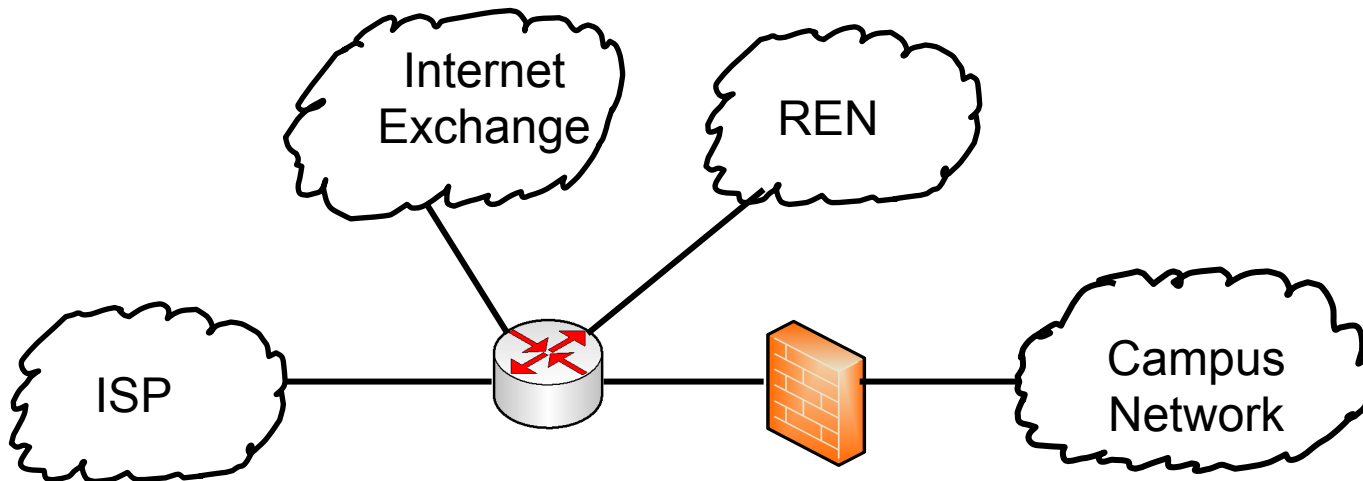


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Border Router

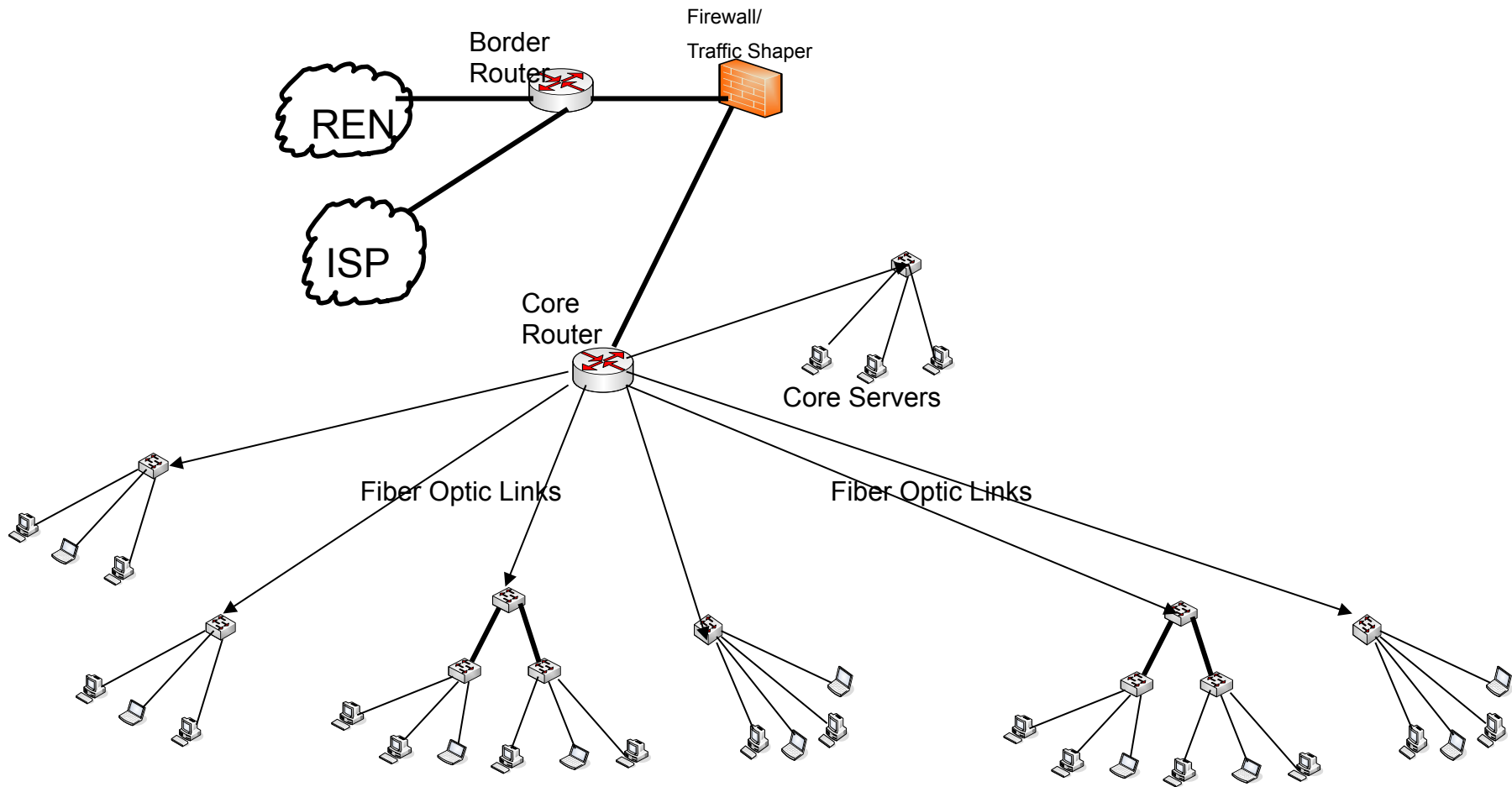
- Connects to outside world
- RENs and Peering are the reason you need them
- Must get Provider Independent IP address space and Autonomous System Number and run BGP to really make this work right



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Putting it all Together

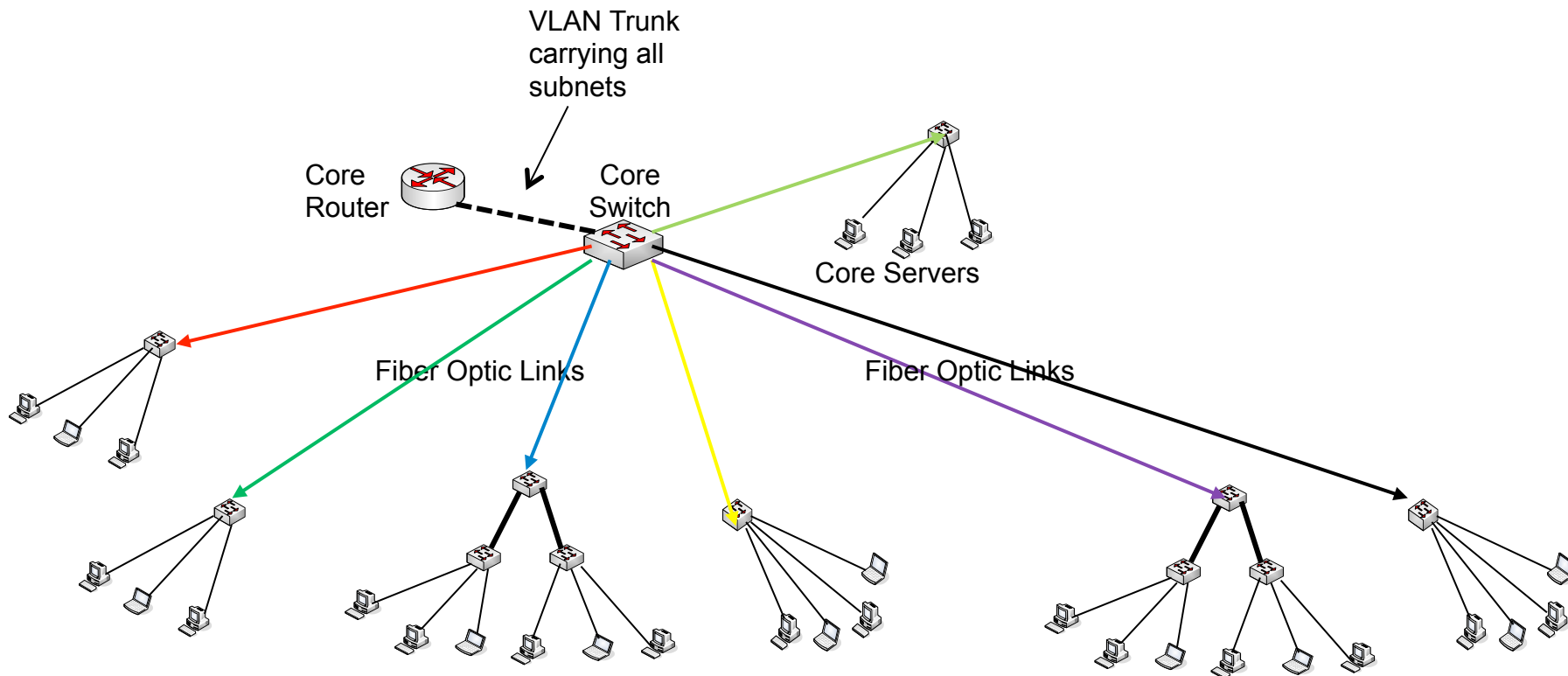


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Alternative Core Designs

- One Armed Router for Core

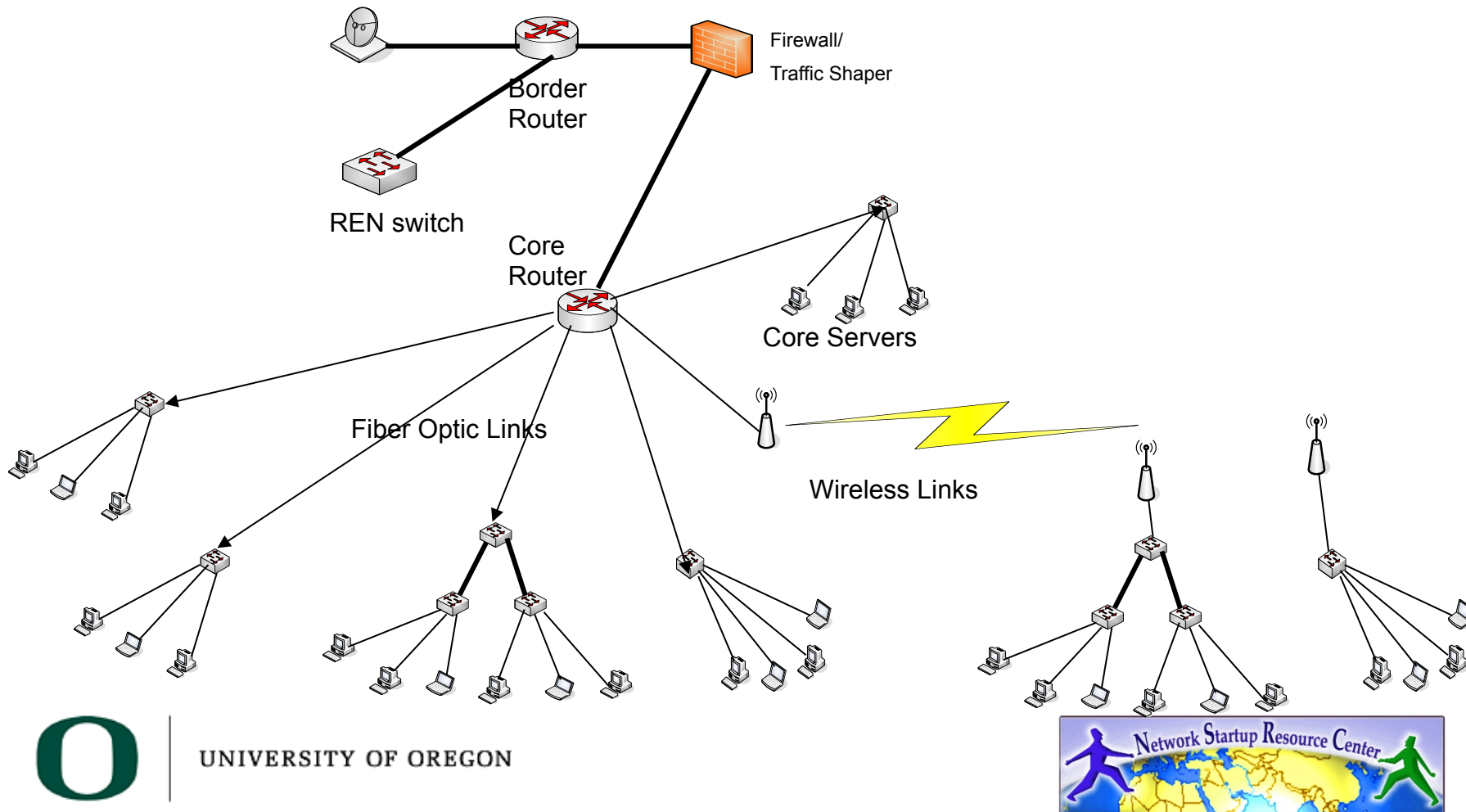


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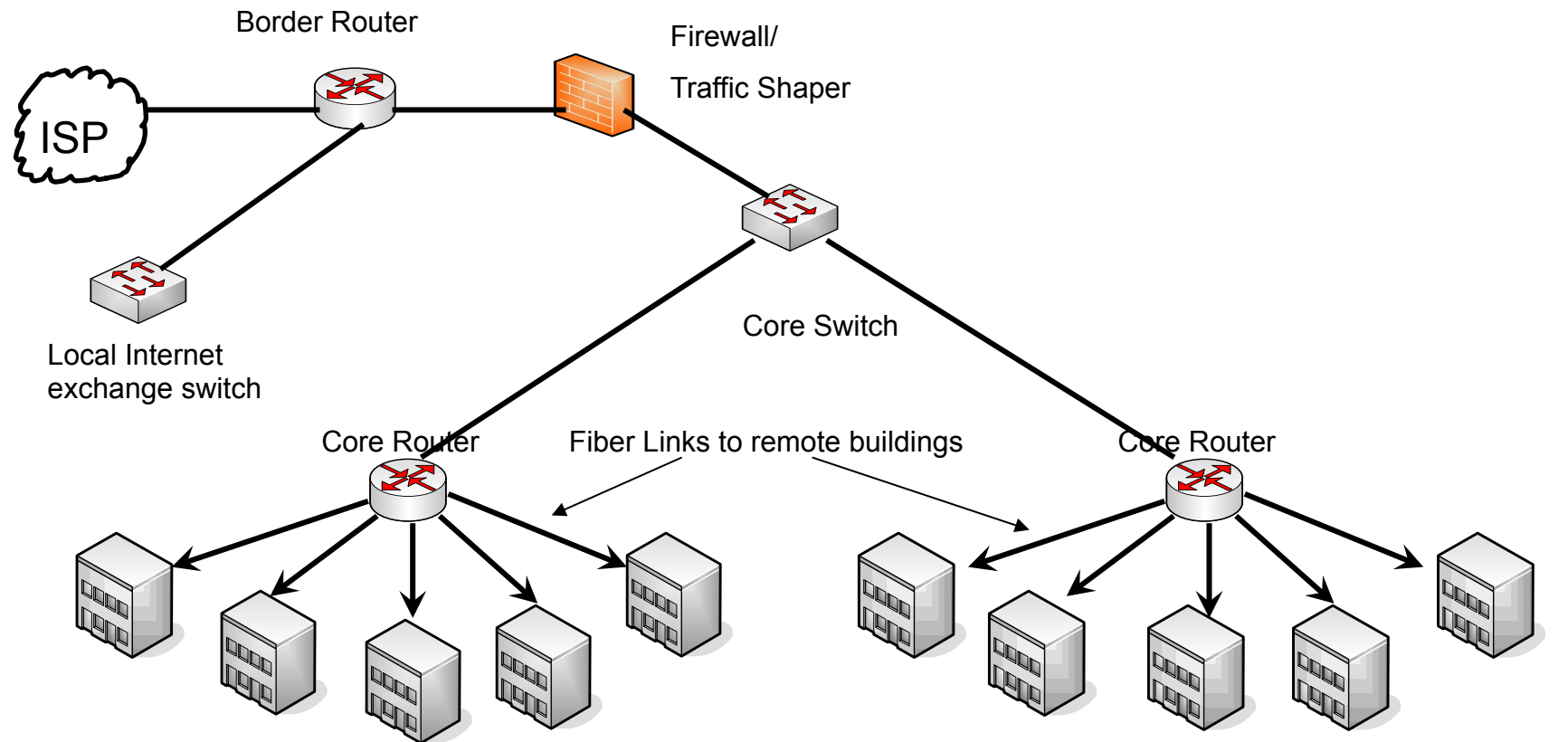
Alternative Core Designs

- Wireless Links versus Fiber



Complex Core Designs

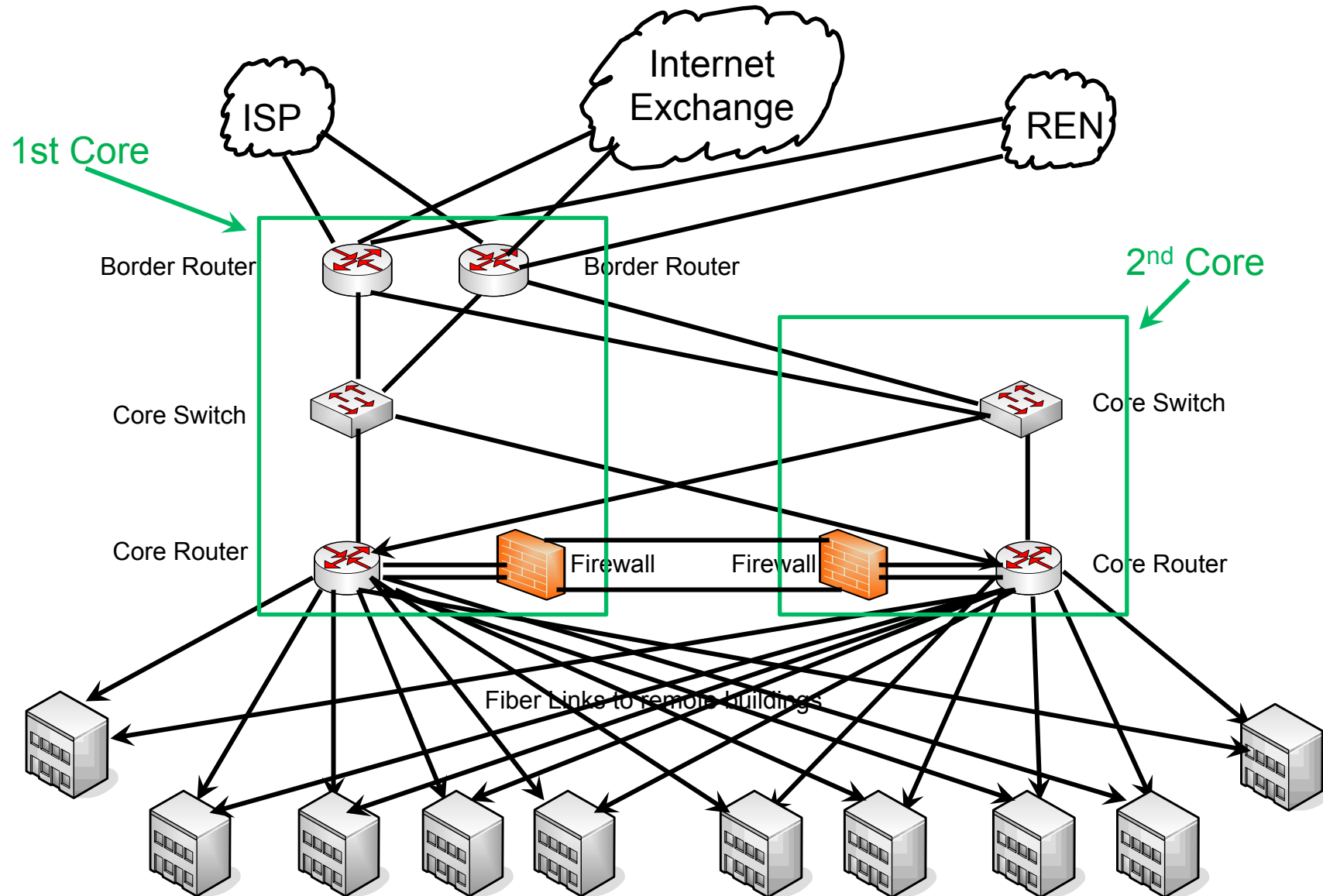
- Multiple Core Routers



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More Complex Core Designs



Layer 2 and 3 Summary

- Route in the core
- Switch at the edge
- Build star networks – don't daisy chain
- Buy only managed switches – re-purpose your old unmanaged switches for labs



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DHCP

- Dynamic Host Configuration Protocol
 - Used to assign IP address and provide basic IP configuration to a host.
- Simplifies your life greatly
 - Faster
 - Fewer mistakes
 - Easier renumbering
- Should be provisioned centrally
 - Requires relaying across layer 3 networks



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Central DHCP

- In order to centralize your DHCP service, you need a DHCP relay on each subnet
 - Most routers provide this feature
 - Also possible on Linux routers using ISC DHCPD as relay
 - The central server knows which subnet queries are coming from, and assigns addresses from the right pool
- As you grow, add another server and run as a failover pair



DNS

- DNS reliability is essential to your network
 - No DNS == No services
- Server location
 - On different subnets, off of different routers
 - Air conditioned, dual power supplies, etc.
- Separate duties
 - Authoritative and recursive on different machines



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DNS Authoritative vs. Recursive

Server Function	Information	Target audience
Authoritative	Your domains	The Internet
Recursive	All other domains	Your users



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Questions?

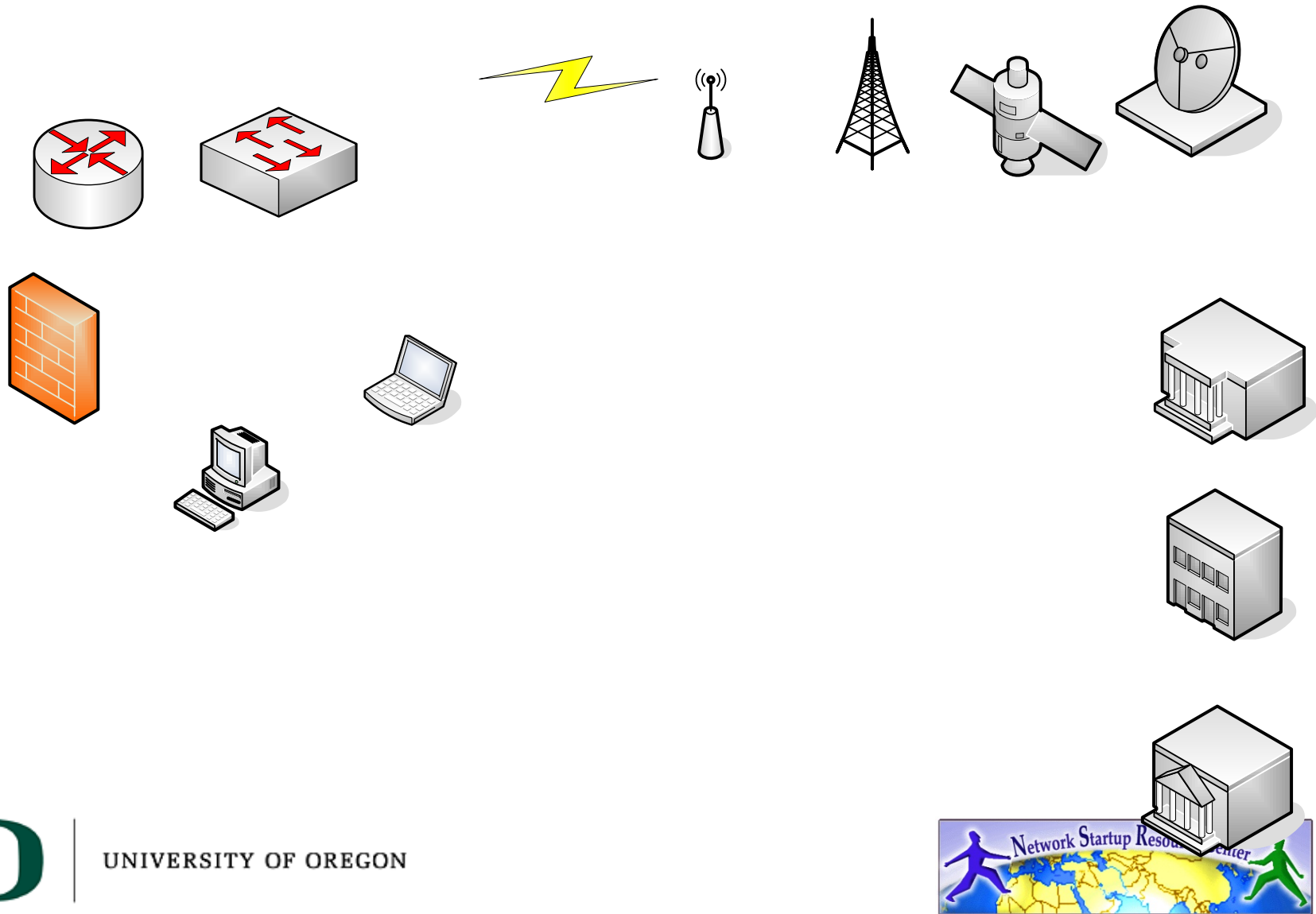
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Symbols to use for diagrams



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