# Campus Networking Workshop
# CIS 399

Dale Smith
University of Oregon & NSRC
dsmith@uoregon.edu

UNIVERSITY OF OREGON

# Course Notes

- Course Participants:
  - US Computer Science Students
  - Undergraduate students from China
  - Network and IT professionals from Africa and South Asia
- Course Grading (US CS Students Only)
  - No exams
  - Attendance and participation is mandatory

# Daily Schedule

- 08:30am-10:00am Morning Session I
- 10:00am-10:30am Morning Break
- 10:30am-12:30pm Morning Session II
- 12:30pm-01:30pm Lunch
- 1:30pm-03:00pm Afternoon Session I
- 03:00pm-03:30pm Afternoon Break
- 03:30pm-05:00pm Afternoon Session II

# Week at a Glance

- Monday: Introduction and Cabling Systems
- Tuesday: Layer 2 (in-building edge)
- Wednesday: Layer 3 (campus core routing)
- Thursday: Advanced routing (border)
- Friday: Network Management and Network Engineering Round Table

# Today

- Morning session 1:

  Campus Network Best Practices

- Morning session 2:

  Cabling Infrastructure Design

- Afternoon session 1 & 2:

  Fiber termination lab (NSRC Students)

  or campus network tour (rest of group)

# 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

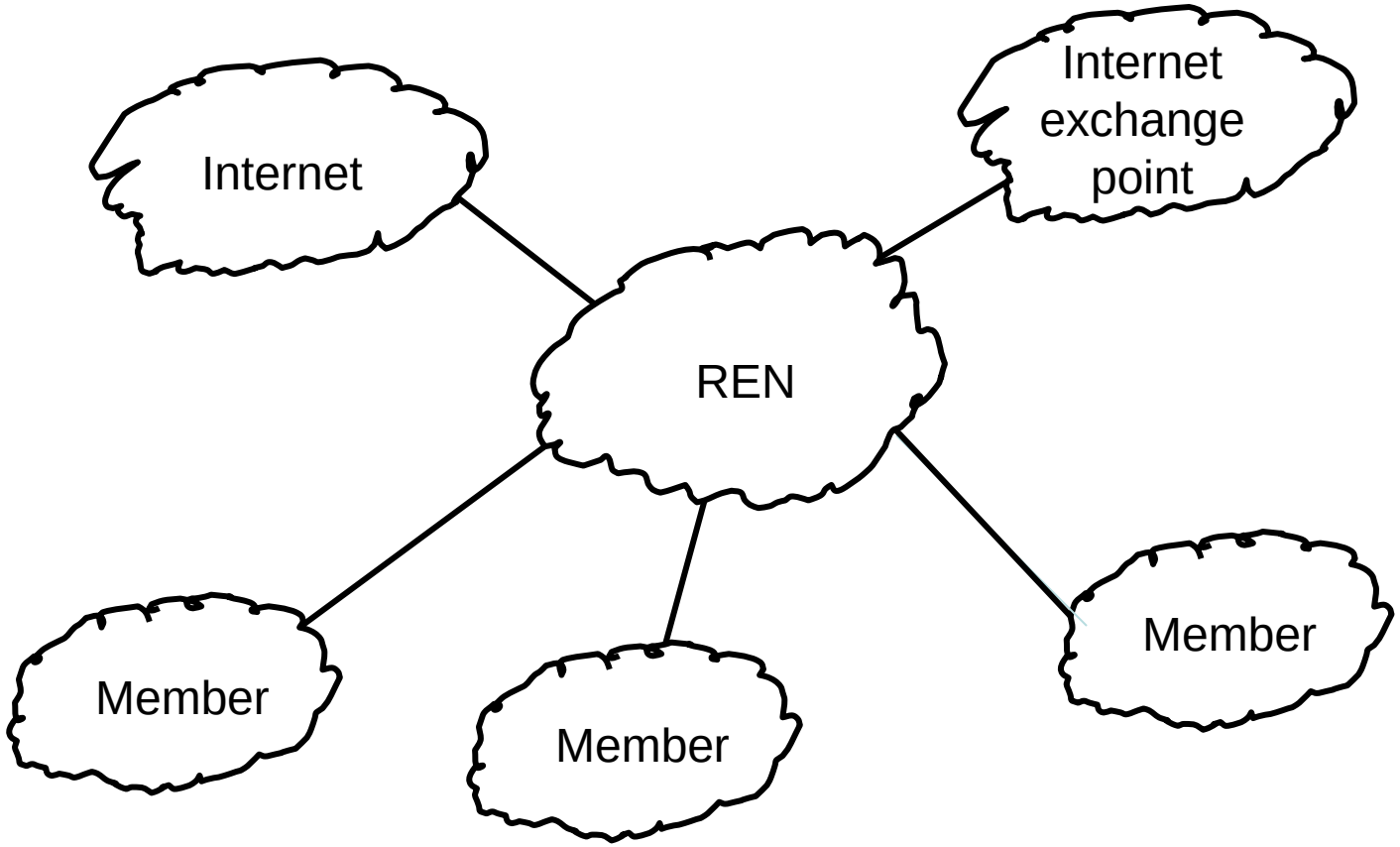
# Why a REN?

- **Enable research or services that could not be accomplished otherwise**
- Cost Savings (buyers club)
- Vision of building alliances
- Successful RENs find that there are unanticipated benefits

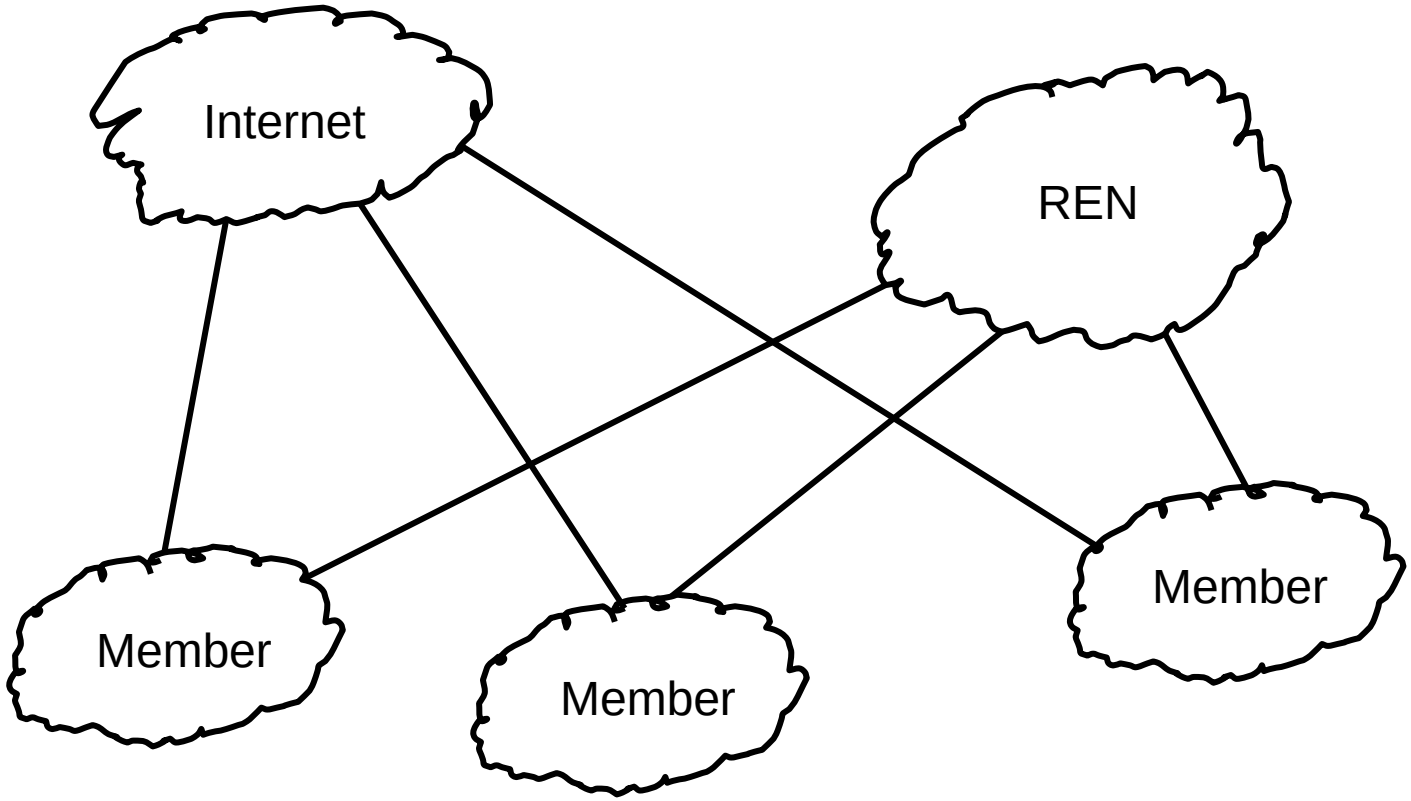
# REN Services

- What services are provisioned? Various models:
  - REN provides all Internet connectivity
  - Peering network to exchange traffic between members
  - Advanced peering network that might
    - Develop or peer with a local commercial exchange
    - Provide international connections (GEANT, etc)
  - Other services (video conferencing)

# REN as Internet Service Provider



# REN as Peering Network



# What model of NREN will you use?

- NREN as Primary Internet Service Provider?
- NREN as local peering between members?
- NREN as local peer plus other peers?
- What are implications from a public IP and Autonomous System Number perspective of these models?

# Who Needs ASN?

- Very Simple:
  - Anyone who is multi-homed (connected to multiple outside networks) needs an ASN
- All RENs need ASN
- Any multi-homed campus needs ASN

# Who Needs Public IP Space?

- **Every campus must have Public IP address space**
- Question is really: Provider dependent or provider independent.
- If provider is REN, then REN must have public IP address space for customers
- Any large campus should have provider independent IP address space

# Provider Independent IP Addresses

- What are provider independent IP addresses?
  - Public IP addresses that are not allocated to you by your Internet Service Provider.
- Can move between service providers without renumbering
- If REN assigns IP, then it is NOT provider independent, your REN is a provider

# To NAT or not to NAT

- NAT is common technique to reduce number of IP addresses required
- NAT makes some things hard.
  - NAT breaks things like SIP (standard-based VoIP), which you have to work around
  - NAT translation device needs to know about applications.  Stifles innovation.
- NAT is probably a reality for some
- Still need some public IP space

# What About 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 uplinks, but moving to high speed external links, they start to fail.

# Campus Network Personnel

- Every campus should have at least one person who does nothing but work on the network. Not email systems, not course management systems. Just networks.
- Larger campuses will need more
- University of Oregon has 8 people just doing networking plus 3 doing security
  - Started small 20 years ago with 2 people

# Why is This Stuff Important

- The campus network is the foundation that all services are provisioned on
- Ad hoc networks just don't work well
- Without a plan, how will you know where to make investments?
- You must develop a plan to get Provider Independent Public IP address space

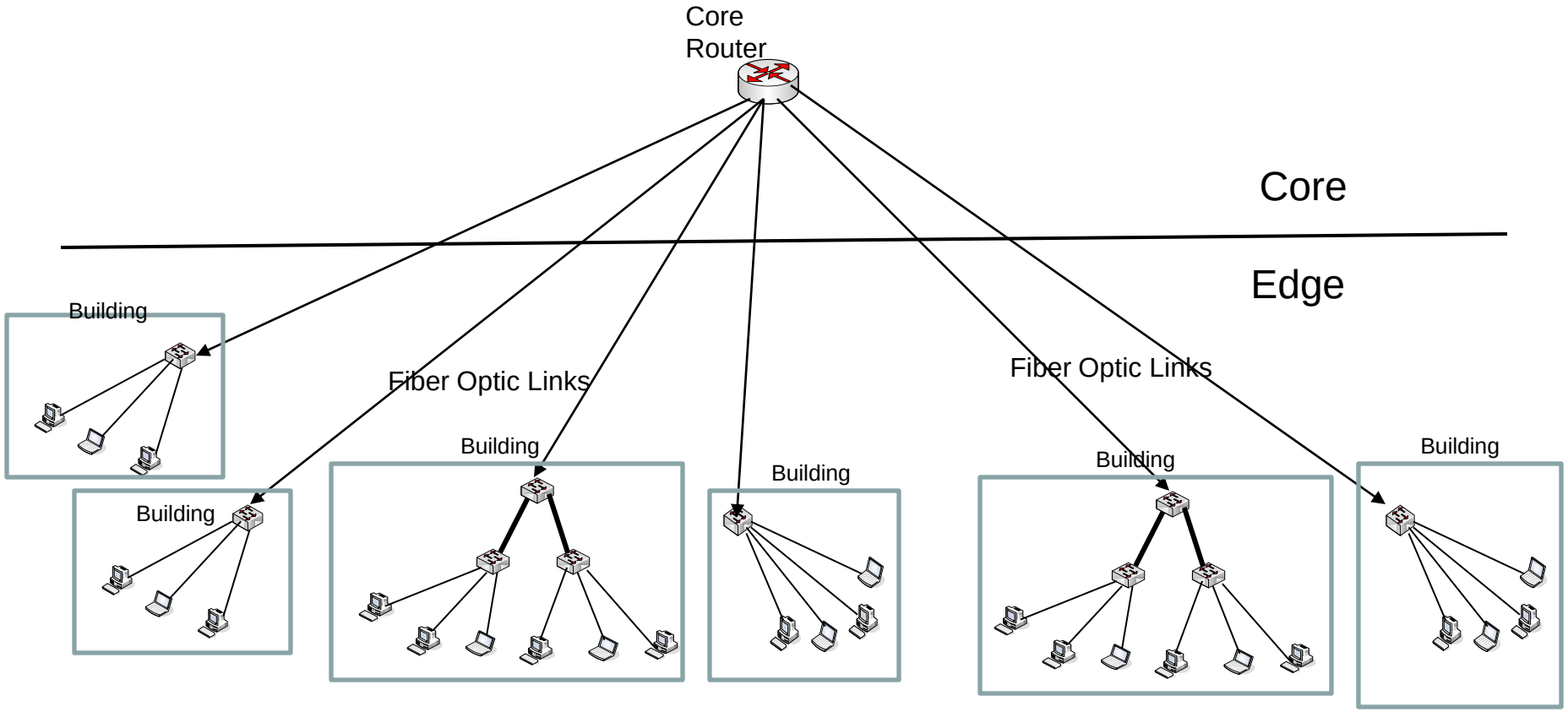
# Campus Network Rules

- Build Separate Core and Edge Networks
- Minimize number of network devices in any path
- Use standard solutions for common situations
- Provide services near the core
- Separate border routers from core
- Provide opportunities to firewall and shape network traffic

# Core versus Edge

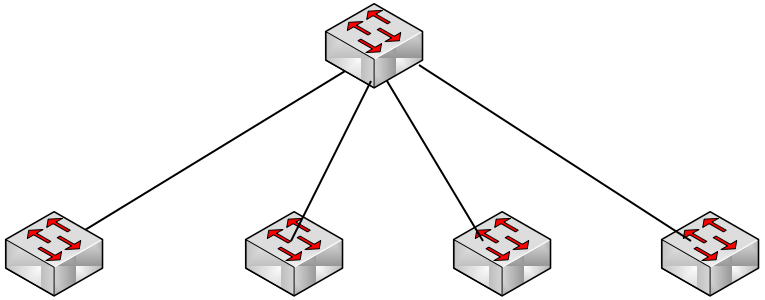
- Core network is the “core” of your network
  - Provides service between buildings
  - Must have reliable power and air conditioning
  - May have multiple cores
  - Always route in the core
- Edge is toward the edges of your network
  - Edge is inside of individual buildings to individual computers
  - Always switch at the edge

# Core versus Edge

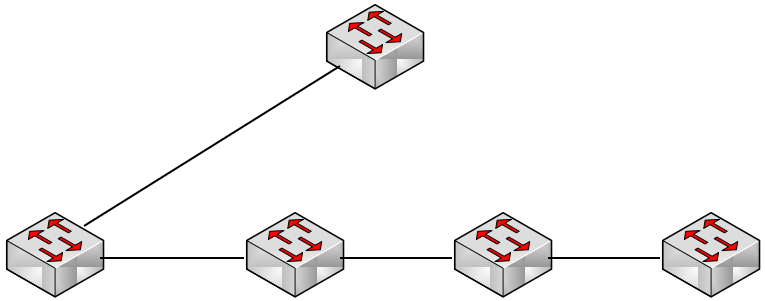


# Minimize Number of Network Devices in the Path

- Build star networks

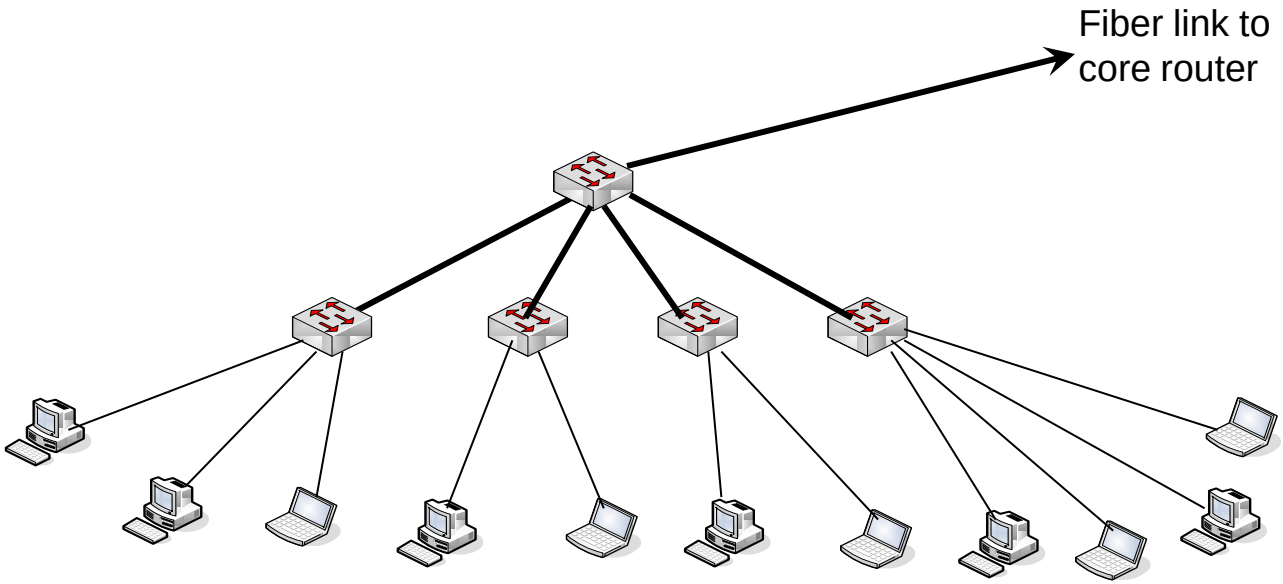


- Not daisy chained networks



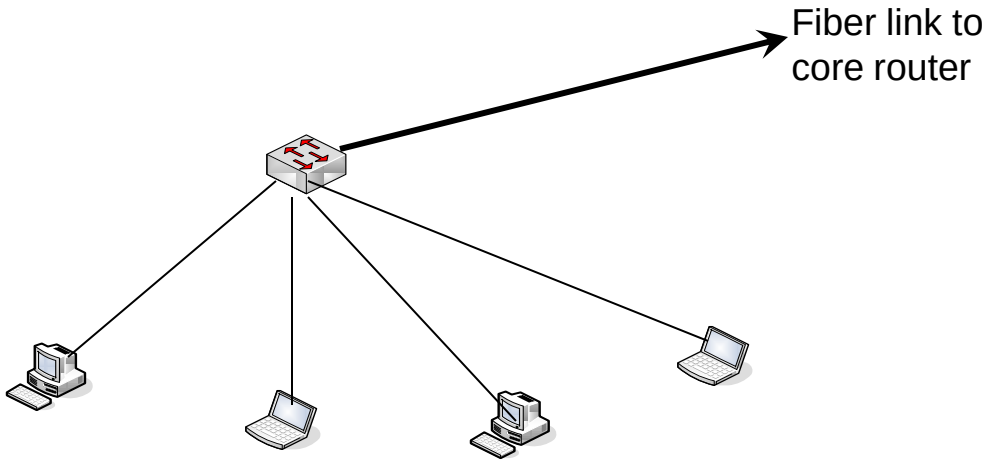
# Edge Networks

- Make every network look like this:



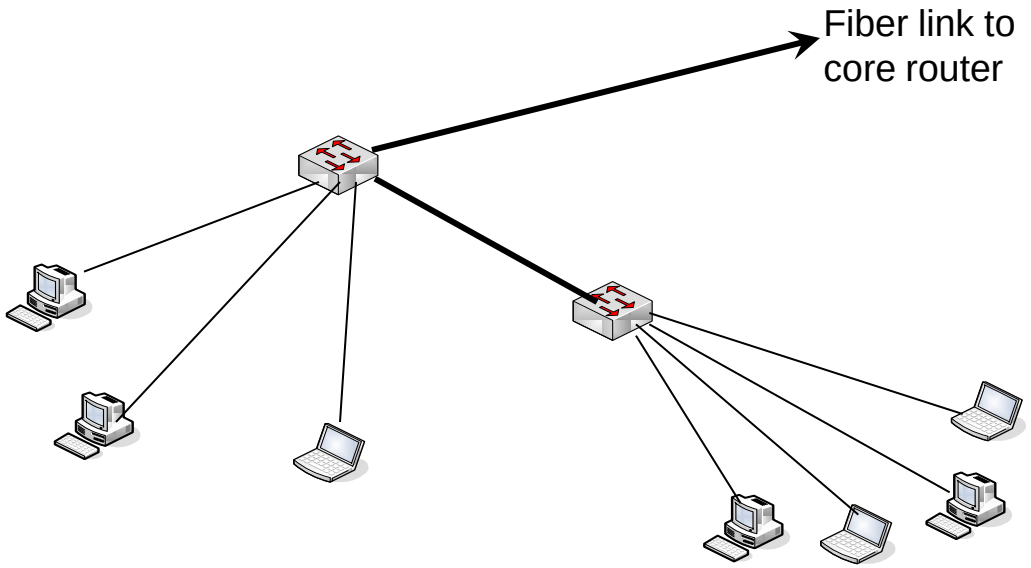
# Edge Networks Continued

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



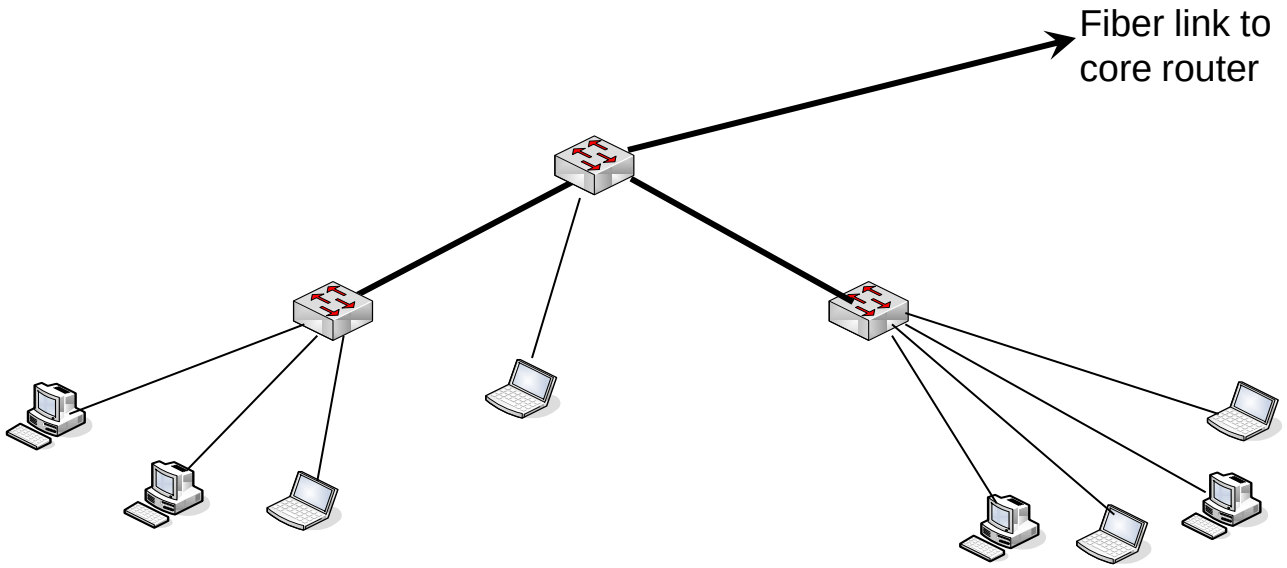
# Edge Networks Continued

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



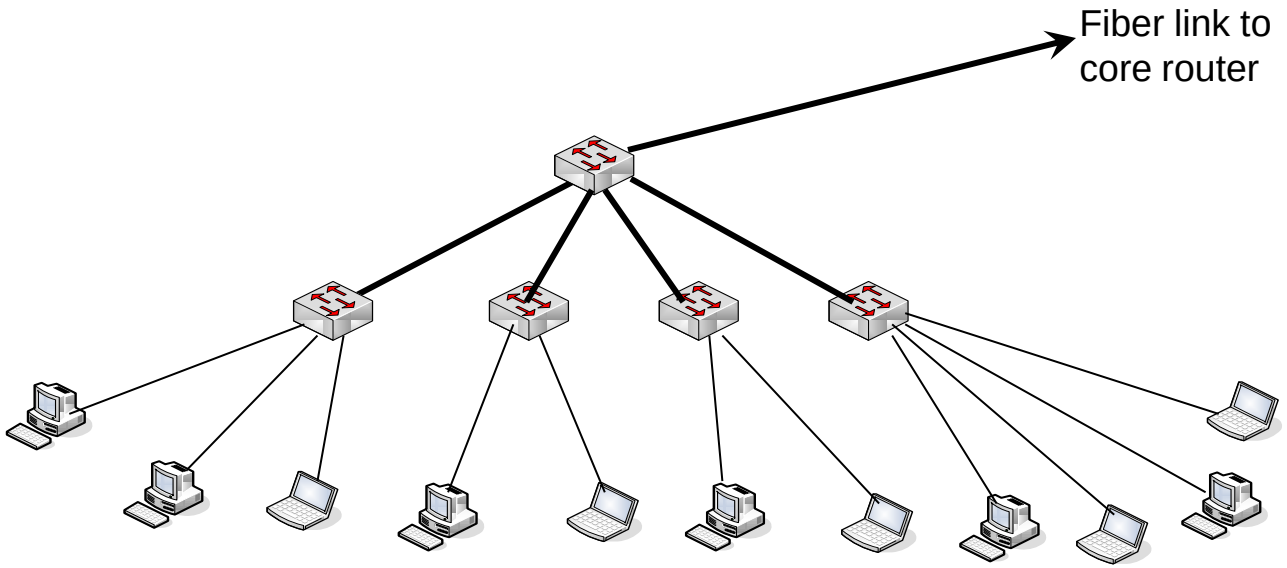
# Edge Networks Continued

- And keep adding switches to get to the final configuration



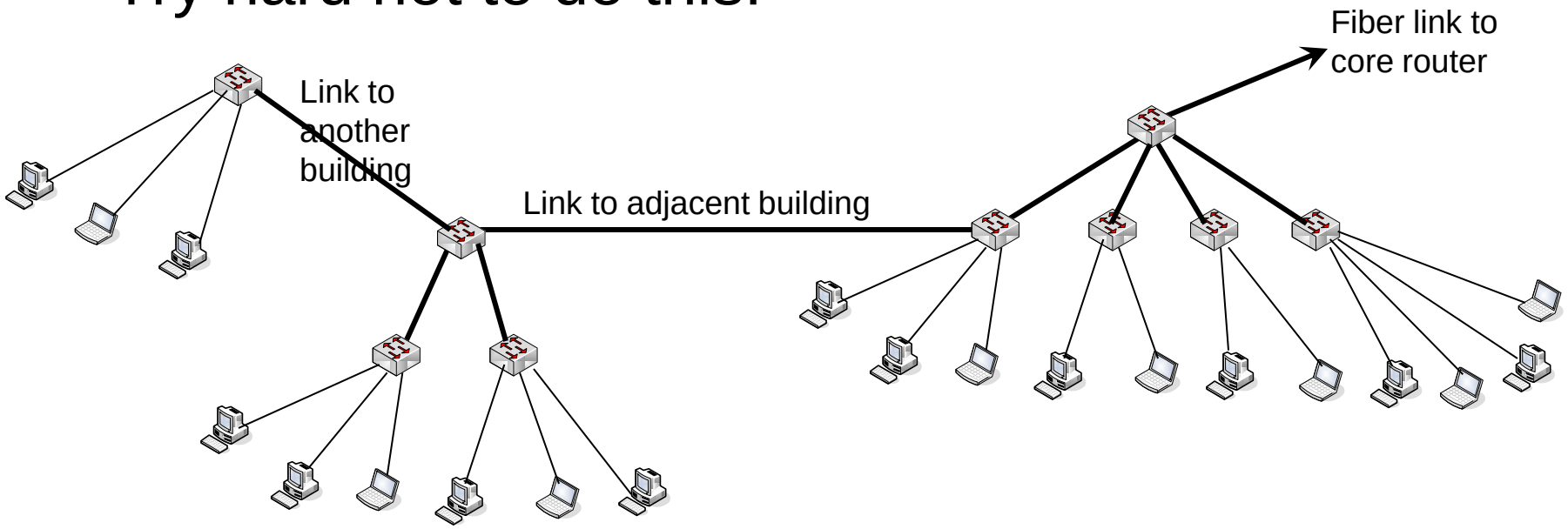
# Edge Networks Continued

- And keep adding switches to get to the final configuration



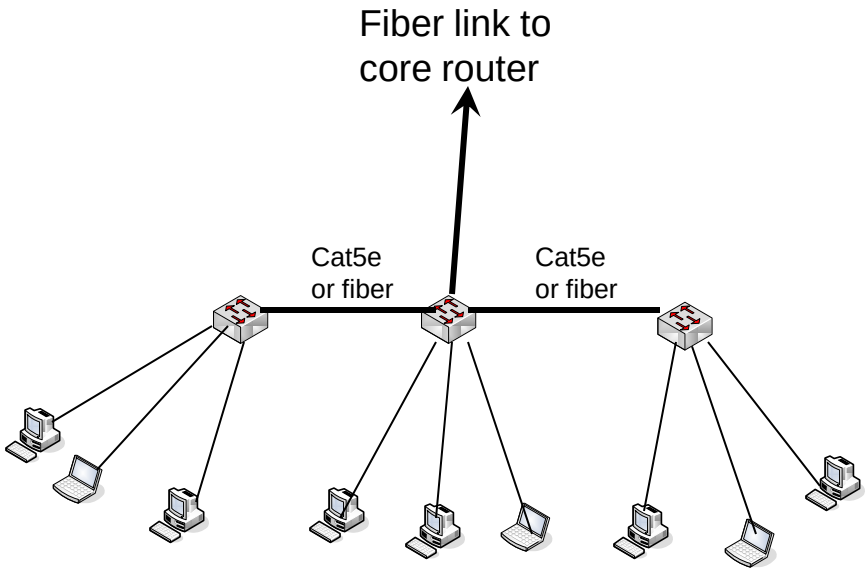
# Edge Networks Continued

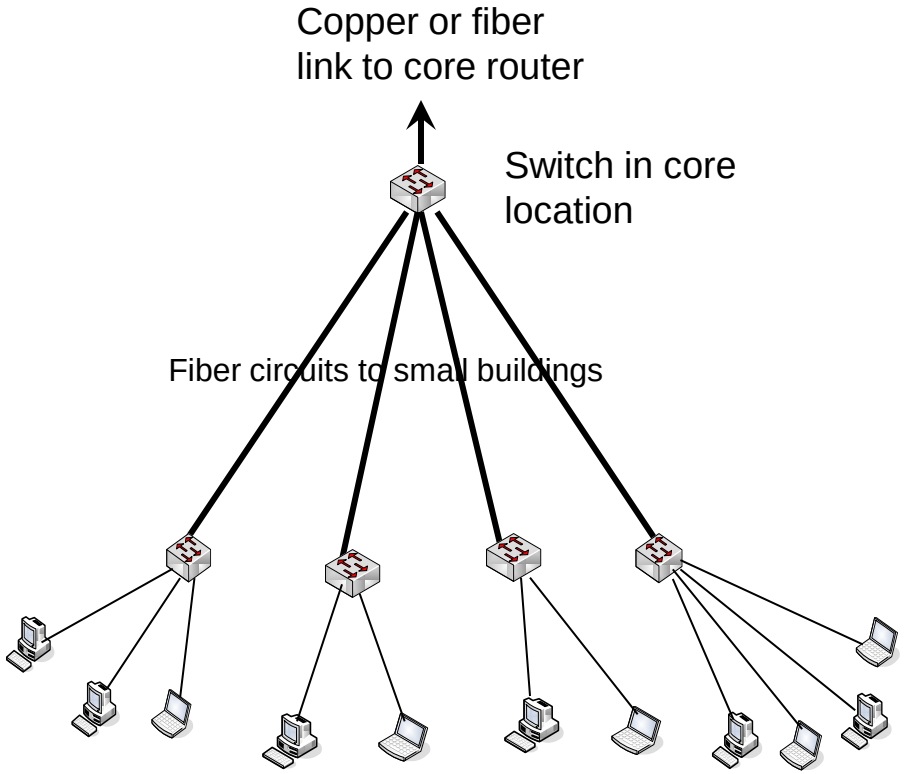
- Resist the urge to save money by breaking this model and daisy chaining networks or buildings together
- Try hard not to do this:



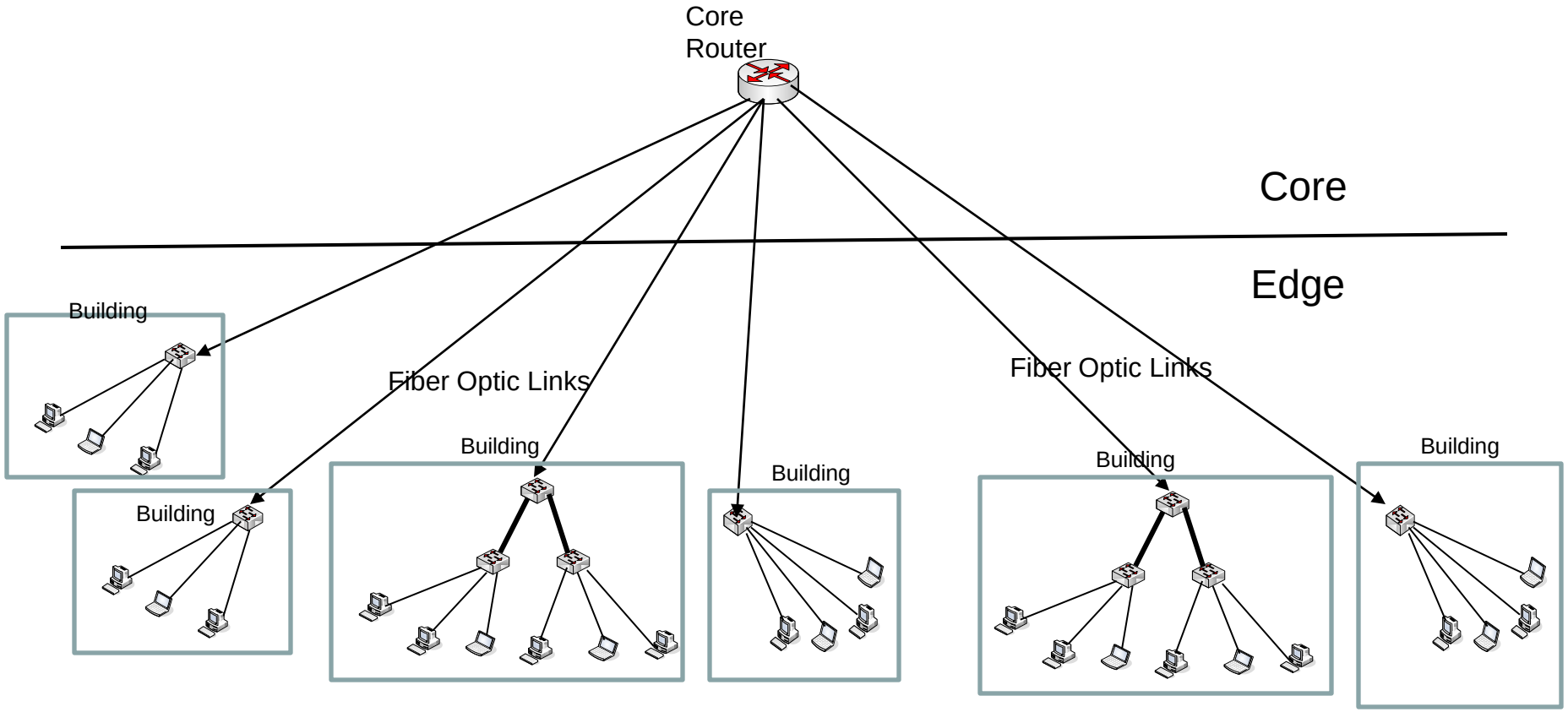
# Edge Networks Continued

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



# Core Networks

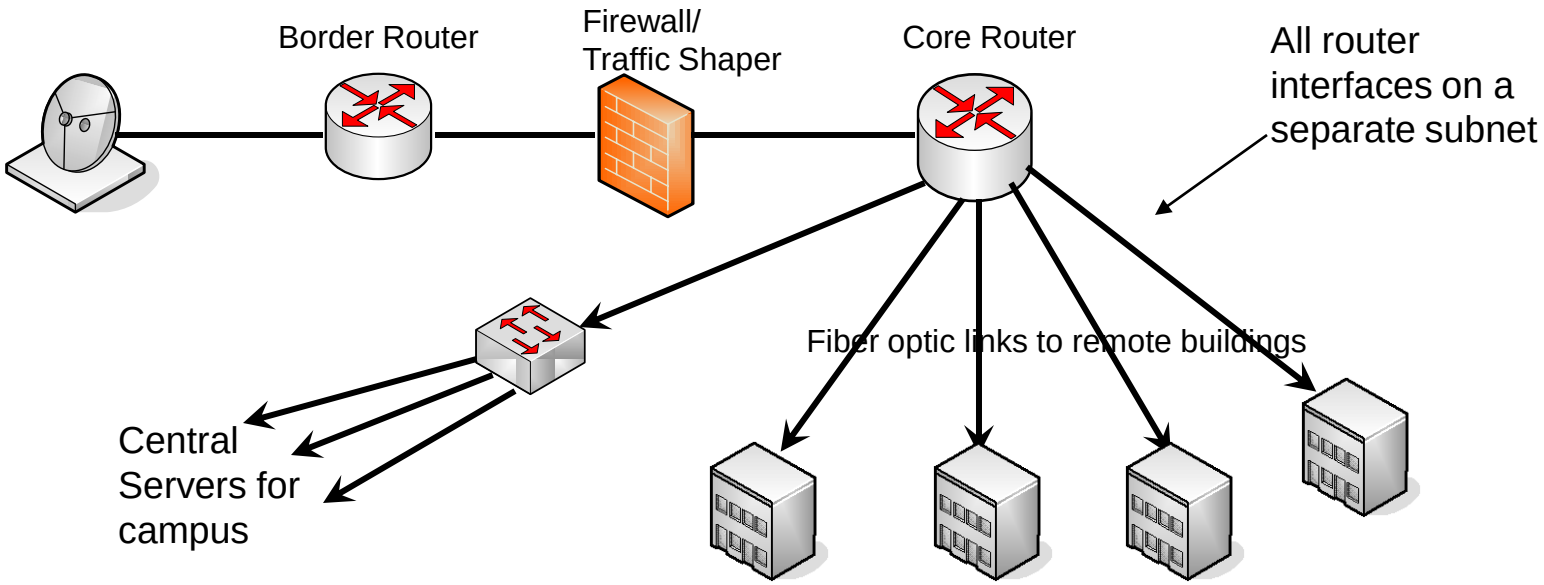


# Core Network

- Reliability is the key
  - remember many users and possibly your whole network relies on the core
- May have one or more network core locations
- Core location must have reliable power
  - UPS battery backup (redundant UPS as your network evolves)
  - Generator
- Core location must have reliable air conditioning
- As your network evolves, core equipment should be equipped with dual power supplies, each powered from separate UPS
- Border routers separate from Core
- Firewalls and Traffic Shaping Devices
- Intrusion Detection
- Intrusion Prevention
- Network Address Translation

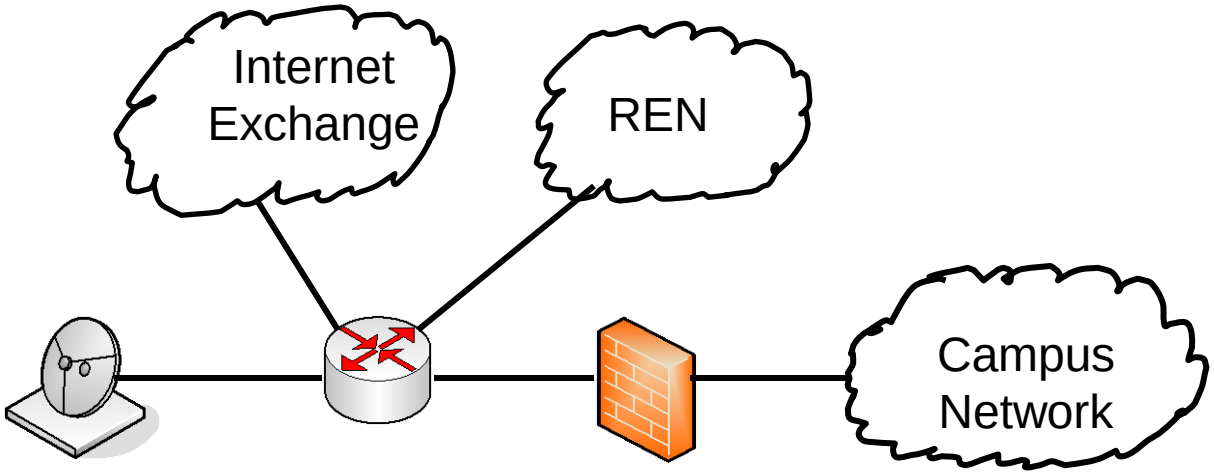
# Core Network

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



# Border Router

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



# Remember the Rules

- Build star networks – don't daisy chain
- Use managed switches
  - You can't do a lot of things I've talked about with unmanaged switches
  - re-purpose your old unmanaged switches for labs
- Route in the core
- Switch at the edge