Campus Network Security: High Level Overview

Campus Network Design & Operations Workshop

UNIVERSITY OF OREGON

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NSRC
Network Startup Resource Center

Security Outline

- Policy Framework
- Security Foundation = Network Management
- Appropriate Campus Network Architecture
- Encryption
- Virus Protection
- Role of Authentication and Authorization
- Appropriate Use of Firewalls

Security is Hard

- Securing and monitoring the security of a campus network is difficult
- Campus networks need to be fairly open
- Always will have viruses, attacks, and people generally acting bad

Campus Networks and Security

- Goal: Prepare for problems you **will** have
  - You will have compromises and hackers
  - You will have viruses
- You get a call from your ISP saying that they have a report that one of your hosts is participating in a Denial of Service (DoS) attack
  - What do you do?
  - How do you find the host (very hard if NAT)?

Security is a Process

- You can never achieve security – it is a process that you have to continually work on
  - Assessment – what is at risk
  - Protection – efforts to mitigate risk
  - Detection – detect intrusions or problem
  - Response – respond to intrusion or problem
  - Do it all over again

Policy Framework

Policy Framework

- Why is policy important?
  - How do your users know what is permissible?
  - How do you know what you can do?
    - Can you disconnect users from the network?
    - Can you eavesdrop on network traffic?
- What do you include?
  - Typical policy framework for a University is an "Acceptable Use Policy" or AUP
    - Google "University Acceptable Use Policy"

Writing an AUP

- This is your opportunity to say how you want people to behave on your network
- Keep it short and clear – 1 or 2 pages?
- Feel free to borrow from AUPs at other institutions
- Link to your existing disciplinary procedure
- Tell people where to go for help and advice

Example: Allowed activity

- “You may use the network for reasonable purposes relating to your studies or academic research”
- “You may use the network for limited recreational use between the hours of 8pm and 6am, but must stop if requested to do so by a member of staff”

Example: Disallowed activity

- "You may not use the network for viewing obscene material or for any activity which may bring the university into disrepute"
  - (Intentionally vague. e.g. pornography may be legal in your country, but your AUP can still ban it)
- "Questionable material will be brought to the attention of the Academic Vice Chancellor, whose decision is final"

Example: Disallowed activity

- “You may not access any service or data for which you are not authorized, or attempt to bypass any access controls”
- “You must not use anyone else's account, or allow your account to be used by anyone else”
- “You must keep your password secret. If you suspect someone else knows it, change it immediately”

Example: Monitoring

- “All use of the network and computing facilities is monitored and recorded for the purposes of enforcing this AUP. Your use of university facilities implies that you consent to your activity being monitored”

Example: Consequences

- “Failure to comply with this policy may result in your access to computing facilities being suspended or permanently withdrawn. It may also result in action being taken under the university disciplinary procedure, which could lead to expulsion”

Process

- All users must see, and preferably sign, the AUP
- Include this as part of an existing process (e.g. student enrollment or username/password setup)

Typical Acceptable Use Policy

- Use of University computing and network for University-related use only (prohibits commercial use)
- Shall not interfere with use of computing or network of others (prohibits hogging of resources)
- Copyright must be respected
- Violators can be denied access
- Use of computing and network is not private and can be monitored by IT Staff
- And more. Use Google and find examples
- Make this an official University Policy so that violations of AUP will be treated as violations of University policy

Network Management

Security Foundation

- You must have managed equipment in your network
- You must have some basic network management running
- Network Management is the foundation that virtually all of the security framework operates on

Key Network Management Tools

- Are some devices not responding or responding poorly, possibly because of a DOS attack or breakin?
  - Nagios
  - Smokeping
- Are you seeing unusual levels of traffic?
  - Cacti

Network Traffic Analysis

- It is important to know what traverses your network
  - You learn about a new virus and find out that all infected machines connect to 128.129.130.131
  - Can find out which machines have connected?
- What tools are available?
  - netflow: you will learn about this
  - Snort: open source intrusion detection system that is very useful to find viruses

Log Analysis

- Can be just as important as traffic analysis
- Central syslog server and gather logs from:
  - DHCP server, DNS servers, Mail servers, switches, routers, etc.
  - Now, you have data to look at
  - Given an IP, you can probably find user
- Lots of tools to correlate logs and alarm on critical events

Enforcing the AUP

- You need to be able to monitor what your users are doing
- Sometimes this is really simple
  - in a public computer lab or hostel, someone "shoulder surfing" may be sufficient deterrent
- But there are useful technical tools too
- Getting to know what's normal helps you identify when things are abnormal

Netflow

- Routers can generate summary records about every traffic session seen
  - src addr, src port, dst addr, dst port, bytes/packets
- Software to record and analyze this data
  - e.g. nfdump + nfsen
- Easily identify the top bandwidth users
- Drill down to find out what they were doing

Beware: Netflow and NAT

- You need to see the real (internal) source IP addresses, not the shared external address
- If you are doing NAT on the border router that's not a problem
  - Generate Netflow on the interface before the NAT translation
- If you are doing NAT on a firewall then you need to generate netflow data from the firewall, or from some device behind the firewall

Anomalous Traffic

- Intrusion Detection Systems (e.g. Snort) can identify suspicious traffic patterns, e.g.
  - machines using Bittorrent
  - machines infected with certain viruses/worms
  - some network-based attacks
- Typically connect IDS to a mirror port
- Risk of false positives, need to tune the rules
- Starting point for further investigation

Associating IP address to user

- ARP/DHCP logs map IP to MAC address
- Bridge tables map MAC address to switch port
  - Several tools can do this, e.g. Netdot, LibreNMS
- 802.1x/RADIUS logs for wireless users
- AD logs for domain logins to workstations
- Network Access Control
  - e.g. PacketFence, forces wired users to login

Using Net Management

- BAYU: "Be Aware You're Uploading"
- Detect P2P like Bittorrent and automatically send a warning E-mail telling the user to check whether what they're doing is legal
- Amazingly effective when people realize they're being watched!
- Some users may not be aware they had Bittorrent installed, and will uninstall it
- We did this at the U of O and bittorrent use is now virtually non-existent.

Let's re-state the key problems

- Some people are using excessive amounts of limited resources, e.g. bandwidth
- Some people are using the network for purposes not related to their studies
- Some people are using the network for undesirable or even illegal activities
- Put like this, it's a question of behavior and discipline, not technology
- That is why policy is important
  - Treat violations same as any other violation of University policies.

Campus Network Architecture

Architecture to Help With Security

- Key architectural issue to help with security is segmentation and IP addressing schemes
  - Follow campus network best practices
  - Route in the core
  - One IP Subnet per building
  - Put campus-level servers on IP subnet that is separate from users
  - Servers with sensitive information might be on a different subnet as something like Moodle

Encryption

Encryption

- Encryption is important to prevent eavesdropping by bad actors
  - Protect sensitive data
  - Protect passwords
- Disable clear-text password protocols
  - Disable telnet, ftp (and use ssh, scp)
  - Only allow TLS based POP and IMAP
  - Move all web traffic that involves passwords or sensitive data to HTTPS

SSL Certificates

- Don’t use self-signed for public services
  - They teach users bad habits (that it is OK to click through an unknown certificate dialogue)
- Get certificates from well known certificate authorities (CA)
  - Let’s Encrypt is a new Certificate Authority providing free, automated and open certificates:
  - https://letsencrypt.org/
- Larger campuses may want to provide certificate service

Virus Protection

Virus Protection

- Most viruses are spread through the action of users
  - Clicking “OK” or “Install” when they shouldn’t
  - Firewalls generally won’t help
  - Windows needs virus protection software (is MS Security Essentials enough?)
- Server-based viruses or intrusions are typically caused from external attacks
  - Firewalls might help

Authentication and Authorization

Centralized Authentication

- How do you know who is using your network?
- AAA: Authentication, Authorization, and Accounting
- Central database of users
  - Can be a single system that everyone has a login (or password file entry)
  - LDAP or Microsoft Active Directory
- Systems and Devices use database
  - Protocols: Radius, LDAP, Kerberos, LDAP with Active Directory

Wireless

- Best practice is to authenticate users
  - This allows you to know who your users are
  - Requires central AAA database
  - Log the access to your central syslog server
- How to do this
  - Captive Portal
  - 802.1x WPA2 Enterprise
- Who can install access points (AUP)?

Appropriate Use of Firewalls

How useful are firewalls?

- A long time ago, client machines used to get infected through direct network attacks
- Windows (since XP SP2) has built-in firewall
- This is no longer an issue
- However, people still design networks as if it were still a problem

Actual methods of infection

- Opening malicious E-mail attachments
- Clicking malicious links
- Gmail and the like all use HTTPS by default
- Your firewall cannot inspect this traffic!
- All your firewall does in this case is act as a bottleneck for legitimate traffic

When a machine is p0wned…

- It may connect outbound to a command-and-control center
  - Firewall will almost certainly permit this
- It may attack other machines inside your network
  - This traffic does not go through the firewall
- It may start spewing spam
  - Looks like the machine owner sending E-mail so the firewall may not stop it (see SMTP discussion)
- Firewall does not stop the infection.

Countermeasures

- Keep all your systems up-to-date with patches
- Get rid of obsolete operating systems (esp. WinXP)
- Use the security features built into the hosts
  - Such as the built-in Windows firewall (Do not turn it off)
- Deploy anti-virus and keep it up-to-date
- Use strong authentication and crypto where possible
  - e.g. RSA keys instead of passwords for ssh authentication
- Network-based detection and/or containment
  - Allows cleaning up machines once they are infected
- User education. No quick fix

Aside: NAT != Firewall

- And NAT != Security
  - Did you know that a cone NAT (one-to-one NAT) allows anyone on the Internet to connect inbound to a port that you are using outbound?
- NAT and firewalling are two different concepts and can be separated
- NAT overload (port address translation/PAT) makes it harder to identify bad actors on your network

Outbound port blocking

- Port block seriously inconveniences users and visitors
  - Many sites block lots of TCP ports.
  - Even simple things like email may need ports 465, 587, 993, 995 to send and receive mail
  - Remember, you want as open of a network as possible
- Blocking mostly doesn't help your security or policy
  - e.g. Bittorrent can tunnel through port 80 or 443

Exceptions to Blocking

- There are some ports that are recommended to be blocked. These include:
  - 25 TCP – Unauthenticated SMTP (see slide discussing SMTP)
  - 123 UDP – Network Time Protocol (must allow campus NTP servers)
  - 135 through 139 both TCP and UDP – Microsoft netbios
  - 161 and 162 UDP – SNMP
  - 1025 TCP – Microsoft RPC exploit
  - 1433 TCP – Microsoft SQL worm
  - 1434 UDP – Microsoft SQL worm
  - 2049 UDP – Sun NFS
- Don't need a firewall for this. An Access Control List on the border router is just as effective
  - It costs less, is less complicated, and doesn't impact performance

SMTP notes

- Blocking TCP port 25 outbound recommended for all users
  - You will need to allow port 25 outbound for your campus email servers.
- Forces users to relay mail via your local SMTP server (or use 465 or 587 authenticated SMTP)
  - Local SMTP server will log all emails and can apply a rate limit on number of emails sent per user (e.g. exim) can do this.
- Easier to detect and control virus-infected machines which are sending spam and affecting your network's reputation

Block YouTube / Facebook etc?

- There are many valuable educational videos on YouTube
- Staff have legitimate uses for Facebook to maintain professional connections
- Clever students will find ways around
  - Universities are designed to attract clever people

Bandwidth shaping

- Give your users (say) 1M each? It only takes 50 abusers to burn 50M between them
- Give them much less and you are penalizing everyone
- There are legitimate users of large amounts of bandwidth (e.g. research datasets)
- Shaping and prioritization won't fix not having enough bandwidth to meet demand

Deep Packet Inspection (DPI)

- Classify, shape, or even block traffic by content
- Much traffic is HTTPS and therefore can't be inspectd
- No DPI box can distinguish between humorous cat videos and veterinary medicine videos
- In-line control products are very expensive and cause significant bottlenecks
- Out-of-line (e.g. Snort) much more useful for detecting malicious activity

Performance

- Any device you put in-line with all your traffic can become a bottleneck
- You may only have 10M today, but soon it will be 100M, then 1G, then 10G
- Traffic filtering / inspection / shaping at higher rates is extremely expensive
- Search for “science DMZ” – many sites now bypassing firewall entirely

Executive summary so far

- Firewalls are useless
- Bandwidth shaping is useless
- DPI is useless
- What do we do now? ▮▮

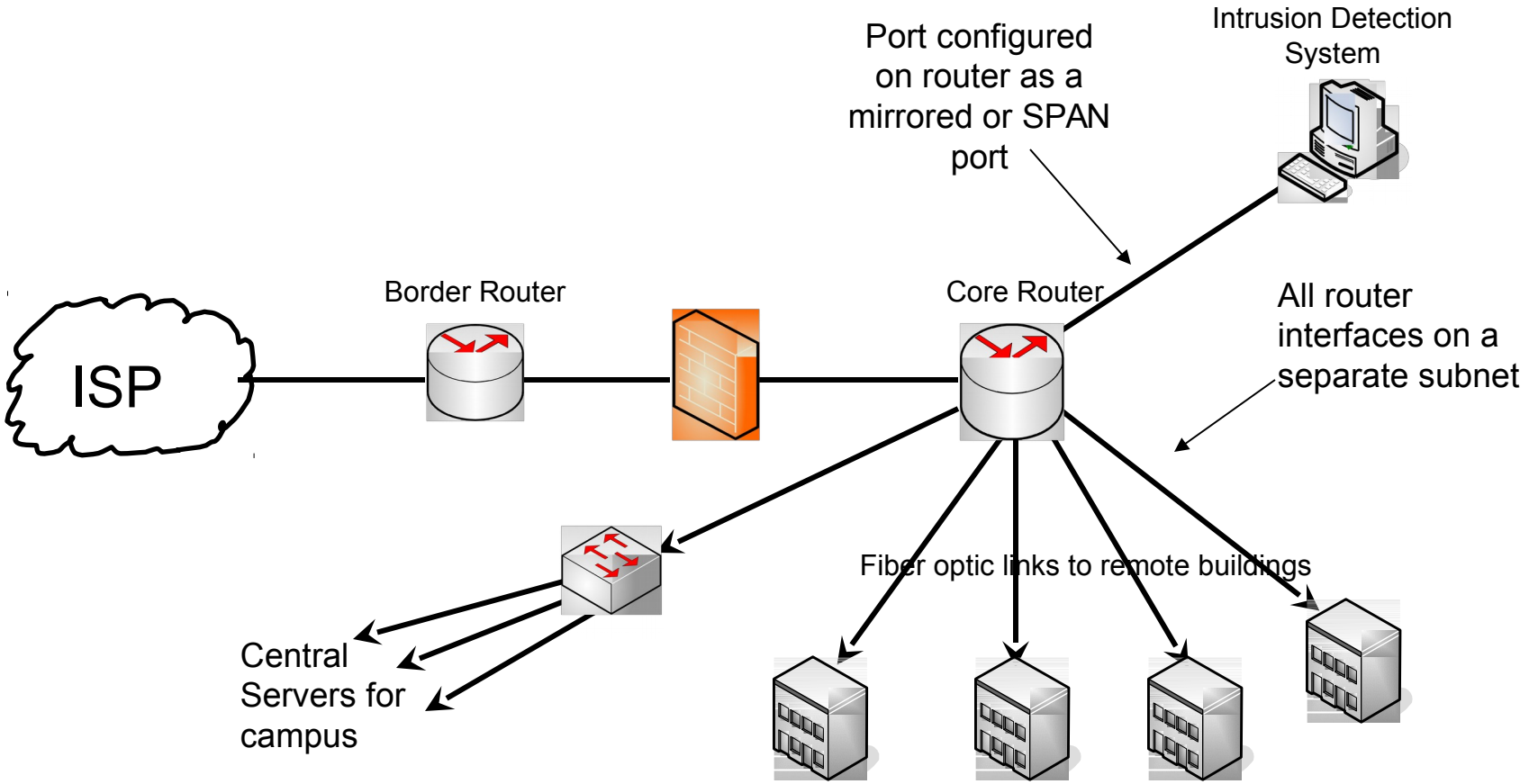
Where to put Firewalls

- Traditional recommendation for firewalls is based on old experience with Windows prior to XP service pack 2
  - Windows machines would get infected from the Internet just by being on the network
- Firewalls were placed to do NAT and to protect entire campus
- This is a very “Corporate” approach and doesn’t allow for innovation by users

Firewall Placement

- Firewalls don't protect users from getting viruses that come via two mechanisms
  - "clicked links" while web browsing
  - Email attachments
  - Both are encrypted and firewalls won't help
- As bandwidth increases, in-line firewalls limit performance for all users. This gets to be a bigger problem at higher speeds.

Traditional Design



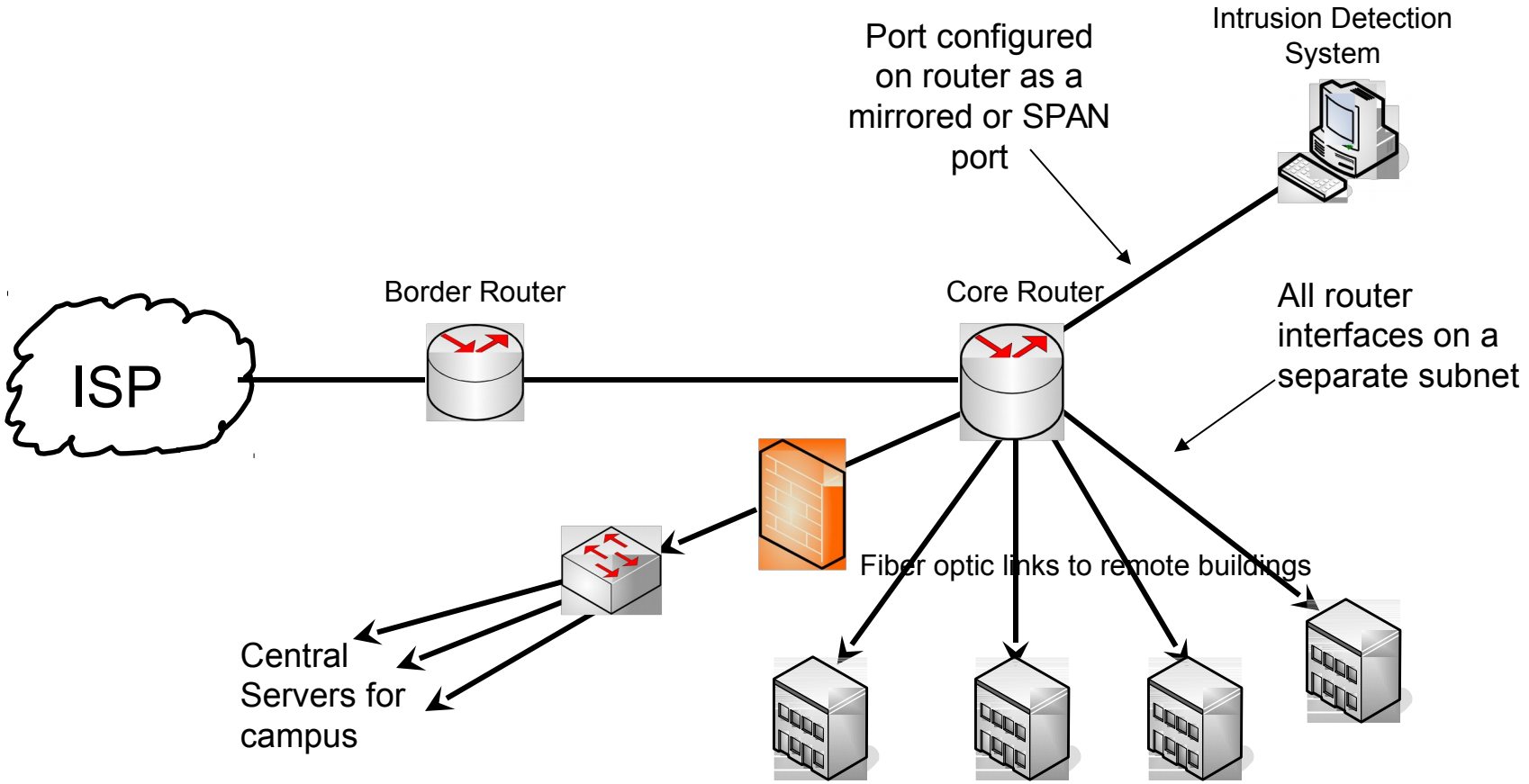
A Newer Approach to Firewalls

- All desktop machines have built-in firewalls that protect them from being attacked from the network
- Firewalls limit performance and cause bottlenecks.
- This drives a new approach to firewalls
  - Firewalls should only protect critical assets
  - This allows firewalls to more tightly protect the critical assets even from attacks from “inside”

Recommended Firewall Use

- We recommend that you firewall just the servers with sensitive data
- Always use two levels of defense: hardware firewall and host based firewall. If one fails, you are still protected
- Firewall should protect
  - Limit inbound access to servers to only those ports needed for access to the application (e.g. HTTPS).
  - Limit access from server to rest of network – if compromised, further attacks are contained ("DMZ")
  - Block sensitive servers from Internet and require VPN authentication+encryption to access
- But beware that stateful firewalls are themselves vulnerable to DDoS / exhaustion attacks

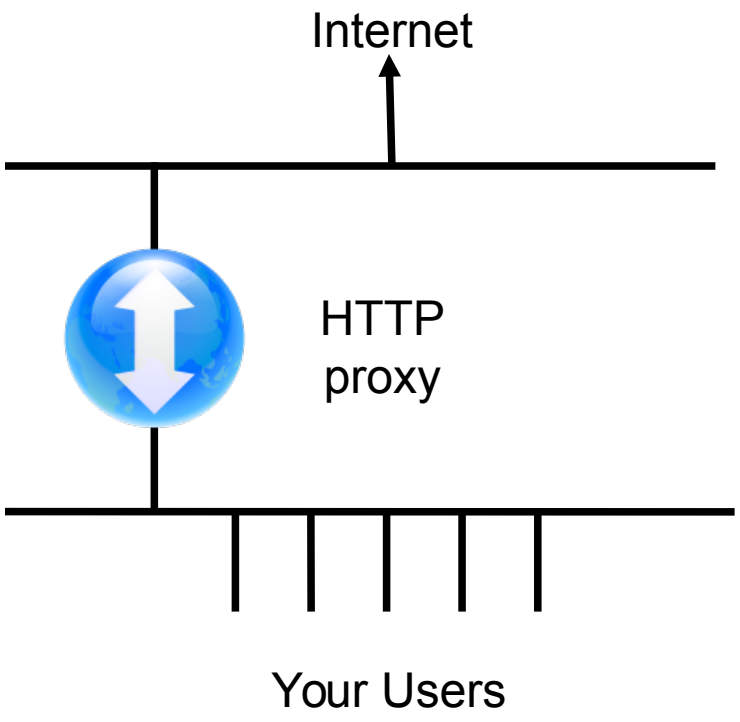
Newer Design



Other Bad Things We've Seen

2. Forcing all access via proxy

- Attempt to save bandwidth (proxy cache) and block undesirable traffic (e.g. torrents)



Well-intentioned, but…

- The Internet is much more than the Web
  - Severe inconvenience caused by not being able to reach other services
- Much content these days is dynamic and hence non-cacheable
  - Many websites use cache-busting techniques to track visitors and increase page impressions
  - Facebook can't be cached with typical web proxy
- Since the Snowden revelations, more and more of all web traffic is encrypted so it can't be cached

Alternative Approach

- Route IP properly
- Have a proxy cache, but keep it to one side
- Use proxy auto-configuration so most users use it automatically
  - WPAD, PAC
  - Just some entries in DNS and a web page
- Allows people to opt-out if they need to
- As more web traffic is encrypted, this becomes less and less useful
- We actually question whether a local web cache is worth the expense and effort

Summary

- Policy is important
- Network management tools are used for security
- Take action on specific issues
  - Encryption
  - Virus Protection
  - Authentication and Authorization
- Use firewalls only to protect sensitive servers

Resources

- Lots of resources on the Internet
  - www.sans.org – subscribe to the SANS newsletter
  - http://www.team-cymru.org/templates.html a great set of templates for secure configuration of routers and some services
  - www.cert.org – a good resource for lists of vulnerabilities
  - www.google.com – having a problem? Seeing an error message? Google it.

Questions/Discussion?