Designing and building the infrastructure
Introduction

CSCI E 45a: The Cyber World – part A

Learning Goals

- Understand how connectivity happens from a network jack to top tier ISPs
- Compare residential, and enterprise environments
- Understand the infrastructure needed to support enterprise services

Infrastructure to support services

- Service – in this context is what users need/ask for/expect/experience
- Infrastructure to support the services
  - Network connectivity – local and Internet
  - Systems - On or off premise

Assessing the needs

- Defining the technical requirements of the service
  - Compute, and storage needs
  - Network needs
  - Security needs
  - Needs today, tomorrow, seasonal demands, etc.

Tussle #1

- Optimizing resource allocation to demand
  - Not enough resources, result in poor performance or the inability to support all users
  - Too many resources, means over spend for under-utilized resources

Tussle #2

- Reconciling resiliency, complexity and security
  - Resiliency - "Two is one, and one is none"
  - Reducing/removing single points of failure adds to the complexity
  - The more complex the infrastructure:
    - The more expensive it is
    - The harder it is to manage, and to secure

Topics

- Residential infrastructure – R
  Connectivity, network, and services in the home
- Enterprise infrastructure – R
  Connectivity, network, and services in the enterprise

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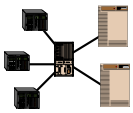
Topics



- The datacenter – R
  The infrastructure needed to run enterprise services
- ISPs – R
  The basic structure of an ISP's network and services

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Slide#	credit
7	http://pagemill.org/compost/mefi/ethernet/IMG_3622.JPG
8	TIA 942 logo

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Designing and building the infrastructure
Residential infrastructure

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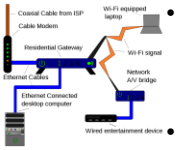
Residential infrastructure



- Connection
  - How does one get their home connected to the Internet
- Network structure
  - What are some key characteristics of home infrastructures
- Services
  - Running Internet services from home

Home connectivity – the "last mile"

- Shared infrastructure
  - Many end points share the same "wire" to the ISP
  - Cable modems, Passive Optical Network (PON) Fiber To The Home (FTTH)
- Dedicated infrastructure
  - Each end point has its own "wire" to the ISP
  - DSL, Home Run FTTH, T1

Home connectivity – in the home

- Option 1 – One Ethernet line from Modem
  - Resident provides own local network infrastructure: Ethernet switch and/or WiFi access point
  - Resident needs to install NAT if there is more than one device

Home connectivity – in the home

- Option 2 – Gateway provided by ISP
  - Private IP address range
  - Provides WiFi and/or Ethernet for the local network
  - Integrated NAT

Home connectivity – in the home

- Often kept with default configurations!
  - Open wireless
  - Default passwords for the gateway device
  - Legality of using a neighbor's WiFi – it's fuzzy

Residential IP addresses

- ISP home services typically offer one dynamic IP address per account
- Home network - Typically private IP addresses, and no subnet structure

Network structure



- These days, many more than one device
  - Desktops/laptops, gaming consoles, smart phones, tablets, media centers, medical monitors, home control systems, etc.
- Connectivity via Ethernet and/or WiFi

Home based services

- Most IPSs don't allow you to run services from a consumer account
  - Some ISPs will not enforce this actively and let you use dynamic DNS
  - Some ISPs will lease static IP addresses to run services from home
- Putting services behind a NAT adds complexity

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3	ISP logos
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9	Ben's basement setup

Designing and building the infrastructure
Enterprise infrastructure

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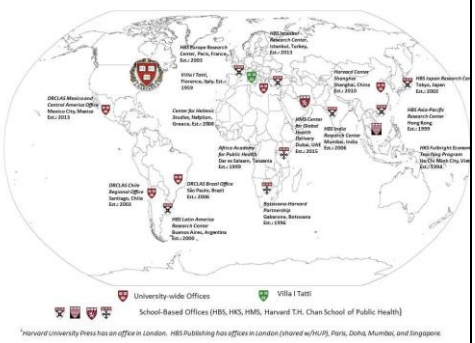
Enterprise infrastructure

- Connection
  - How small and large enterprise connect to the Internet
- Network structure
  - Key characteristics of enterprise infrastructures
- Services
  - Running enterprise Internet services

Enterprise structure and connectivity

- Large enterprises can have one or more site(s)/campus(es)
- Connectivity usually done as many individual sites
- Can connect sites to create a virtual enterprise-wide network
  - Using PPVPN to inter-connect sites

Harvard locations around the globe



*Harvard University Press has an office in London. HBS Publishing has offices in London (shared w/HUP), Paris, Doha, Mumbai, and Singapore.

For a given site

- Commercial grade of same services as for residential
  - Higher data rate
  - Fixed IP addresses
  - Likely less filtering (not forcing the use of the ISPs middleware - e.g. DNS, SMTP relays, etc.)
- Can be multi-homed for increased reliability/resiliency
  - To the same or different ISPs

Enterprise Internet identifiers

IP

NRO

- Getting your own public IP addresses
  - Through the ISP for smaller organizations
  - Through Regional Internet Registries (RIRs) for larger businesses
    - If you can justify a /20 or more

Enterprise Internet identifiers

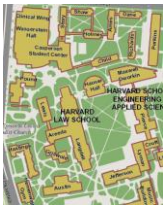
AS

- Autonomous System (AS)
  - Collection of routers under same administration
  - Assigned by RIRs to entities within its territory

Connectivity reliability options

- Single homed
  - Single link to one ISP
  - Use default route on the link to the ISP
- Multi-homed
  - More than one link to one or more ISPs
  - Uses one or more edge routers
  - Uses BGP to decide which ISP to use for a destination

The site/campus



- Multiple interconnected buildings
- Level of interconnection dependent on physical layout, bandwidth, and resiliency needs

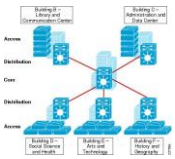
Enterprise network architecture

- Many small/medium enterprises are similar to residential setups
  - One or two levels as described
- Larger or more complex enterprises divide their address space into subnets

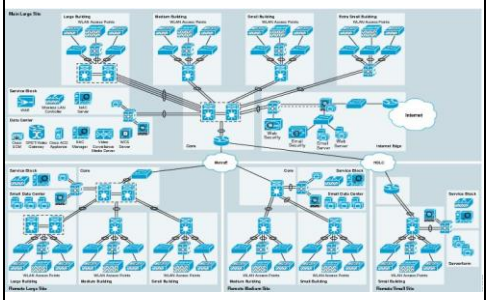
Enterprise network architecture

- Subnets
  - Per building, per region, per network technology, etc.
  - Subnets connected together with routers
  - Two or more levels of hierarchy
    - Backbone plus any number of levels as needed

Hierarchical network structure



- Core
  - The backbone of the enterprise and connection point(s) to ISPs
- Distribution
  - "Distributes" the network to different physical sub-sections
- Access
  - The structure within a physical sub-section to support end-point access to the network



The building

- Floor level switches are connected to aggregation switches for the building
- Resiliency
  - Two jacks side by side connect to different switches
    - Voice/Data A/Data B
  - Two network links into the switch
  - Building power redundancy for switches unusual – but emergency power may be used

The closet

- Point of aggregation for a subset of a building (typically a floor) or a small building
- All network jacks and wireless access points on the floor connect into the switch
- Wires are run throughout the building

End-point connectivity

- RJ45 network jacks
- Wireless Access Point (WAP)
  - Laid out to provide overlap, continuous coverage

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Cables

Type	Characteristics
CAT3	Up to 10Mbps for up to 100 m
CAT5	Up to 100Mbits for up to 100 m
CAT5e	Up to 1 Gbps for up to 100 m
CAT6	Up to 10 Gbps for up to 55 m
CAT6a	Up to 10 Gbps for up to 100 m

- What the numbers mean
  - 10 Mbps - ~1 hour to download a DVD (4.7GB)
  - 100 Mbps - ~1 hour to download 10 DVDs
  - 1 Gbps - ~1 hour to download 100 DVDs
  - 10 Gbps - ~1 hour to download 1,000 DVDs

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Enterprise services

- Enterprises run three categories of services
  - Services aimed at their customers/partners
    - Website, data integration, etc.
  - Business systems for the enterprise
    - Email, financial systems, Intranets, etc.
  - Technology services for the enterprise
    - DNS, end-point management, etc.
- Enterprise services are typically run in a datacenter or in the cloud

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6	NRO logo
8	Icons from http://all-free-download.com/free-icon/
9	map.harvard.edu
12	http://www.cisco.com/c/dam/en/us/td/i/200001-300000/220001-230000/227001-228000/227530.eps/_jcr_content/renditions/227530.jpg
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16	http://pagemill.org/compost/mefi/ethernet/IMG_3622.JPG
16	http://img.directindustry.com/images_di/photo-g/rf-wireless-access-point-61398-3133227.jpg
16	WiFi logo

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Designing and building the infrastructure
The datacenter

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Enterprise services

- The datacenter or the cloud
- Datacenters considerations
  - Site location
  - Space considerations
  - Power considerations
  - Cooling
  - Fire protection
  - Technology design
  - Security

Site location

- Not just anywhere
- Some considerations:
  - Easy access, but limited number of access points
  - Away from physical problems: floods, earthquakes, etc.
  - Access to redundant power, connectivity
  - Cost of labor, power, connectivity, etc.

Space considerations

- How big a space do you need?
  - Lots of big equipment
  - Room to maneuver between pieces of equipment
- Factoring in growth
  - May be limited - Moore's Law, virtualization, off-premise
- Security considerations: limited number of controllable entry points

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Computer racks

- Servers are "slabs" stacked in the rack
- Racks will often include a KVM (Keyboard, Video, Mouse) switch
- Modern setups have Over The Rack (OTR) connectivity
- Need to access both the front and the back of the rack

5

Power - Redundancy

- High availability data center generally have two separate power feeds
- Power Distribution Units (PDUs) bring these separate sources on either side of a rack
- PDUs can be networked to monitor power consumption, and remote on/off control

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Power – Backup power

- In-line Uninterruptible Power Supply (UPS)
  - Like a "battery pack" for a computer room
  - Primarily used for two things:
    - Provide power continuity for short electrical outages
    - Provide power continuity to allow for proper shut-down in case of longer, un-scheduled outages
- Generator power

7

Cooling and air conditioning

Backup CRAC Fans

- Equipment generates a lot of heat which could lead to equipment failure
- Computer Room Air Conditioning (CRAC)
- Fans to create air flow

8

Fire detection and suppression

- Smoke detectors and fire alarm switches at key locations
- Fire suppression can be with:
  - Water (the city of Cambridge in the US requires the use of water)
  - Gaseous HFC-227ea, FM-200, etc.

9

Securing the facility

- Only authorized personnel can enter the data center
- Every access must be logged and monitored
- Multi-tenant facilities use cages to keep tenants isolated

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2	TIA 942 logo
3	Diane Alber "Time to relocate"
4	http://static.spiceworks.com/shared/project/0000/8692/MGHPCC_Server_room_medium.jpg
5-10	Datacenter pictures from Sherif Hashem

Designing and building the infrastructure
Internet Service Providers (ISPs)

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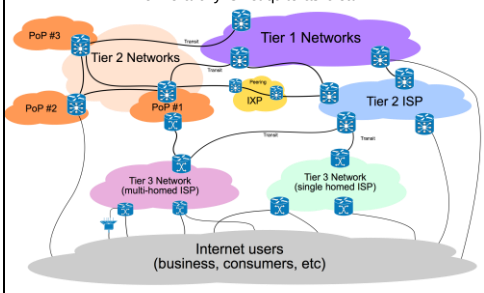
1

Tiered structure of the Internet

Not reality, but useful visualization
The hierarchy is not quite as clean



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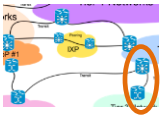
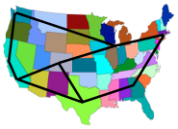
ISP interconnectivity



- Peering – is the exchange of routing information between two ISPs to allow traffic to be exchanged
- The actual flow of traffic between peers is based on business arrangements
- Access ISPs
- Transit ISPs, IXPs – just pass through

3

Our sample ISP



- Big Internet Service Provider (ISP)
- Assume
  - National in scope
  - Peers with other ISPs
  - Has customers ☺

4

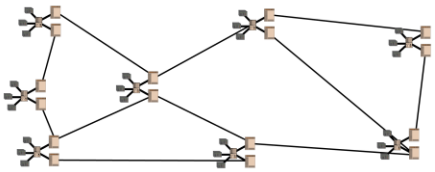
Breaking down the structure

- Regional hubs, and metropolitan areas (metros)
- COs, POPs
  - May be in a facility with other ISPs
    - Colo's, carrier hotels, "meet me" rooms
- Head-ends and local aggregation points

5

ISP network

- Multiple POPs
- Interconnected with backbone links



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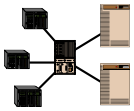
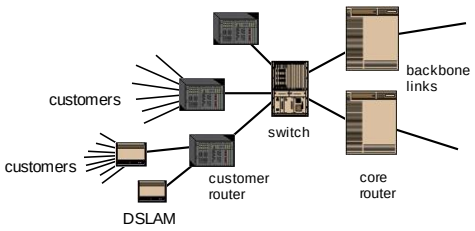
Point of Presence (POP)



- Point of presence (POP) e.g., in a city
- Aggregates local traffic to route on its backbone
- Parts
  - Core routers
  - Customer routers
  - DSLAMs etc

Point of Presence (POP), contd.



ISP provided services

- Routing services
- Middleware services
  - DNS, NTP, firewall services, etc.
- Value added services
  - Email, web hosting, etc.

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Designing and building the infrastructure
Conclusion

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In summary…

- Residential and enterprise infrastructures
  - Use similar technologies
  - Enterprises tend to use more, higher grade versions
  - Some large enterprises also have global networks of their own
- The Internet's traffic is:
  - Distributed through hierarchies combining ISPs traffic routing and site level distribution

In summary…

- Datacenters are:
  - Enterprise infrastructures for enterprise services…
  - …and the cloud is starting to impact that
- Larger ISPs:
  - Manage networks that span bigger geographies
  - Peer with other ISPs to exchange routing information, and network traffic

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3	National network map https://en.wikipedia.org/wiki/File:Network-map.jpg