Live Session 02
Intro to Networking

CS 7349

Spring 2023

World Changers
Shaped Here

SMU®

Contents

- Security News of the Week
- House Keeping – Term Project
- Class Presentation – Special Topic
- Networks
- Network Communications
- Network Challenges and Security

Security News of the Week – kind of

- https://www.zdnet.com/article/updated-kaseya-ransomware-attack-faq-what-we-know-now/
  - A review and timeline of the Kaseya ransomware attack
- https://www.cnet.com/tech/services-and-software/t-mobiles-august-cyberattack-4-quick-and-easy-ways-to-secure-your-data-after-a-breach/
  - “Their security is pretty awful..” said the 21-year old Binns
- https://www.npr.org/2021/08/26/1013501080/chinas-microsoft-hack-may-have-had-a-bigger-purpose-than-just-spying
  - Big exchange server hack – follow up with Power Apps misconfiguration

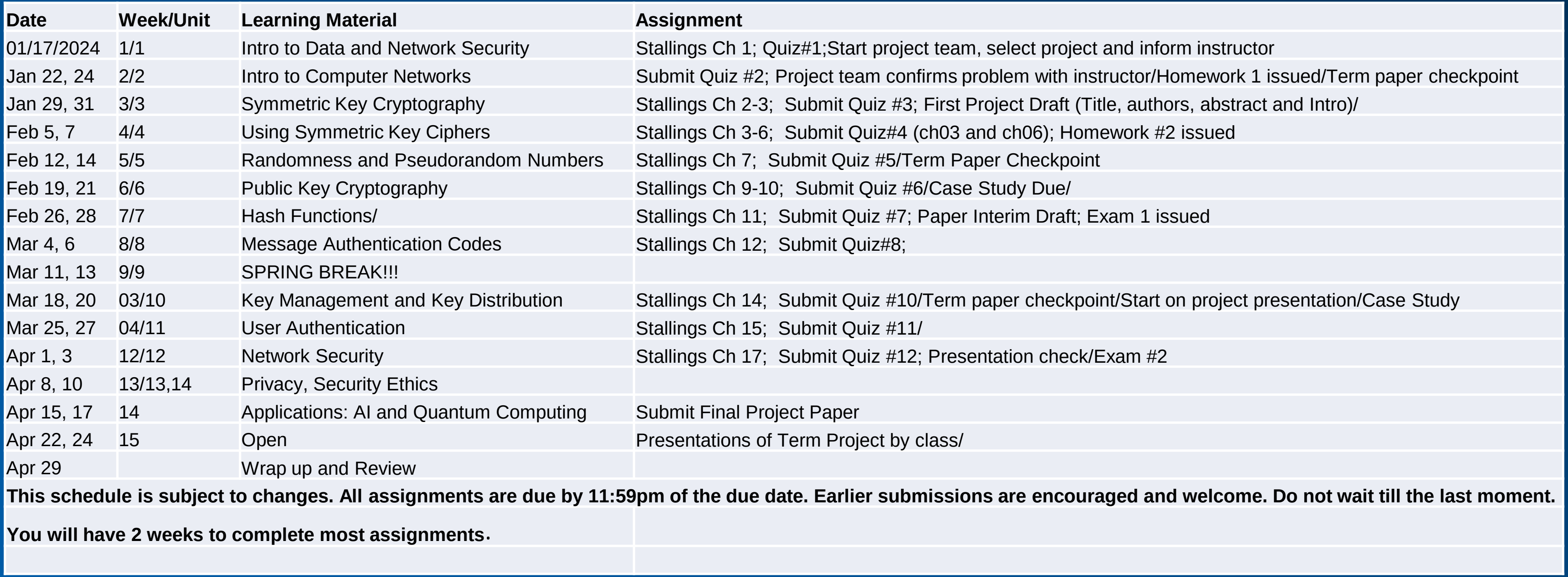
Source: npr.org, cnet.com, zdnet.com

Security News of the Week – Spring 2024

- https://en.wikipedia.org/wiki/British_Post_Office_scandal
  - 1999-2015 over 900 subpostmasters were sent to prison for embezzlement. Turns out it was due to errors in the accounting software
- https://krebsonsecurity.com/2024/01/e-crime-rapper-punchmade-dev-debuts-card-shop/
  - “Punchmade Dev” has rap songs which are cybercrime tutorials
- https://www.wired.com/story/cryptographers-fully-private-internet-searches-cybersecurity-databases-privacy/
  - Holy grail of search privacy with homomorphic encryption

Source: wikipedia.com, krebsonsecurity.com, zdnet.com

Spring schedule



Date	Week/Unit	Learning Material	Assignment
01/17/2024	1/1	Intro to Data and Network Security	Stallings Ch 1; Quiz#1;Start project team, select project and inform instructor
Jan 22, 24	2/2	Intro to Computer Networks	Submit Quiz #2; Project team confirms problem with instructor/Homework 1 issued/Term paper checkpoint
Jan 29, 31	3/3	Symmetric Key Cryptography	Stallings Ch 2-3; Submit Quiz #3; First Project Draft (Title, authors, abstract and Intro)/
Feb 5, 7	4/4	Using Symmetric Key Ciphers	Stallings Ch 3-6; Submit Quiz#4 (ch03 and ch06); Homework #2 issued
Feb 12, 14	5/5	Randomness and Pseudorandom Numbers	Stallings Ch 7; Submit Quiz #5/Term Paper Checkpoint
Feb 19, 21	6/6	Public Key Cryptography	Stallings Ch 9-10; Submit Quiz #6/Case Study Due/
Feb 26, 28	7/7	Hash Functions/	Stallings Ch 11; Submit Quiz #7; Paper Interim Draft; Exam 1 issued
Mar 4, 6	8/8	Message Authentication Codes	Stallings Ch 12; Submit Quiz#8;
Mar 11, 13	9/9	SPRING BREAK!!!	
Mar 18, 20	03/10	Key Management and Key Distribution	Stallings Ch 14; Submit Quiz #10/Term paper checkpoint/Start on project presentation/Case Study
Mar 25, 27	04/11	User Authentication	Stallings Ch 15; Submit Quiz #11/
Apr 1, 3	12/12	Network Security	Stallings Ch 17; Submit Quiz #12; Presentation check/Exam #2
Apr 8, 10	13/13,14	Privacy, Security Ethics	
Apr 15, 17	14	Applications: AI and Quantum Computing	Submit Final Project Paper
Apr 22, 24	15	Open	Presentations of Term Project by class/
Apr 29		Wrap up and Review	
This schedule is subject to changes. All assignments are due by 11:59pm of the due date. Earlier submissions are encouraged and welcome. Do not wait till the last moment.			
You will have 2 weeks to complete most assignments.			

Book: Cryptography and Network Security by William Stallings, 8th edition

Class Presentation - Special Topic

- Any topic of your interest: Work, ~~school~~, play
  - Can be a question/answer, wonderment, information
  - **Security related; NOT term paper related; NO course topic**
  - Strict time limits 5 mins + 3 mins Q&A
- Schedule – as per roster
  - Adu, Aliliele, Blocker, Braden, Brown, Burnett…

House Keeping

- Status of Teams for Term Paper? Topic?
- Term Paper Topic, team, due by 01/28/2024; Checkpoint on 01/29, 01/3
- Quiz 1 and Homework 1 are issued
- Quiz 1, 1 week; Homework 1, 2 weeks
- Presentations start 01/22/2024

Project Timeline (For 9 page paper)

- Jan: First project draft 1 page, basically your Introduction section, plus title, authors and abstract, some references
- Feb: Interim draft 3 pages, basically your intro and related work, plus basic description of your solution
- Mar: Draft 6 pages. Detailed solution, analysis, references
- Apr: Final paper 9 pages. Submit, with presentation

A LaTex template and example paper will be provided

Project – 1st deliverable

- Team projects (3 per team)
- Choose topic (from topic list or your own)*
- Within topic, identify problem to be addressed (no survey projects, only problem solving projects - survey is a part of your problem solution and is contained in the final paper)
- Confirm problem with professor

Project Abstract and Intro

- **Abstract** structure (100 word limit for 6 pages)
  - start with statement of what is presented
  - motivate the problem
  - discuss details of what is done at a high level
  - state the main conclusions
- **Introduction** basic structure (the rest of page 1):
  - motivate the problem further
  - state the problem in detail
  - state the basic work done/approach taken
  - State the contributions of your paper
  - state the outline for the rest of the paper
    - Conclusions are not stated in the introduction.

Project Paper

- **Use the LaTex template** provided for all of your project paper submissions.
- Your paper is expected to be publishable
  - High quality research, well written, reproducible results based on paper contents. 9 pages exactly. No more, no less
  - https://scholar.google.com/ for references (NOT cnn.com, foxnews.com, cnbc.com; YES ietf.org, ieee.org,…itu-t)
  - https://www.overleaf.com/read/brpdfvsxsjww#8886a4 ←Paper template

Unit Review – Networks and the Internet

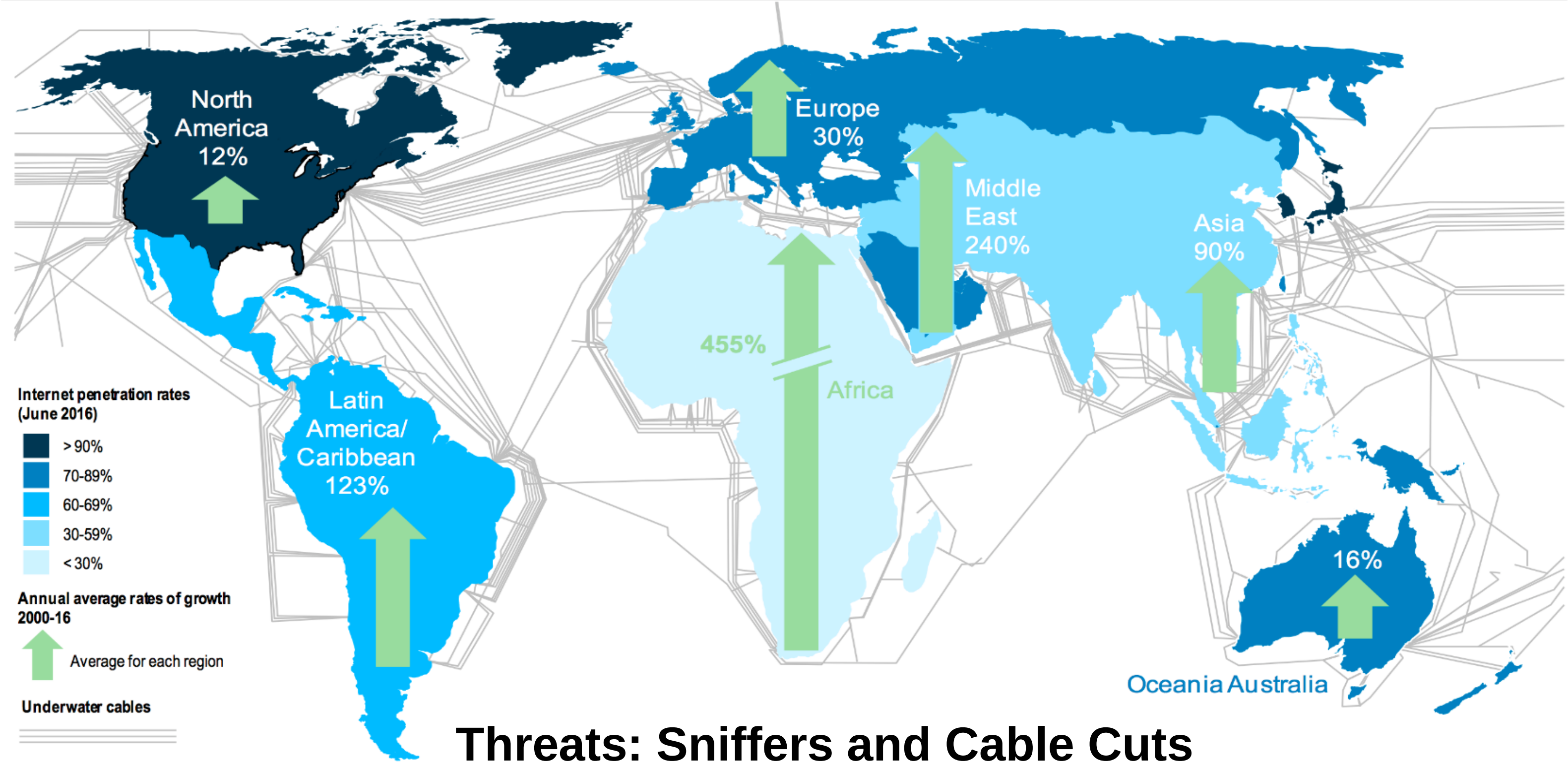
https://sciencenode.org/feature/a-brief-history-of-the-internet-.php

https://www.theguardian.com/technology/2016/jul/15/how-the-internet-was-invented-1976-arpa-kahn-cerf

Source: theguardian.com, sciencenode.org, internetsociety.org, cnnbusiness.com, eff.org, eteknix.com, pexels.com, pixabay.com,

Unit Review – Networks and the Internet

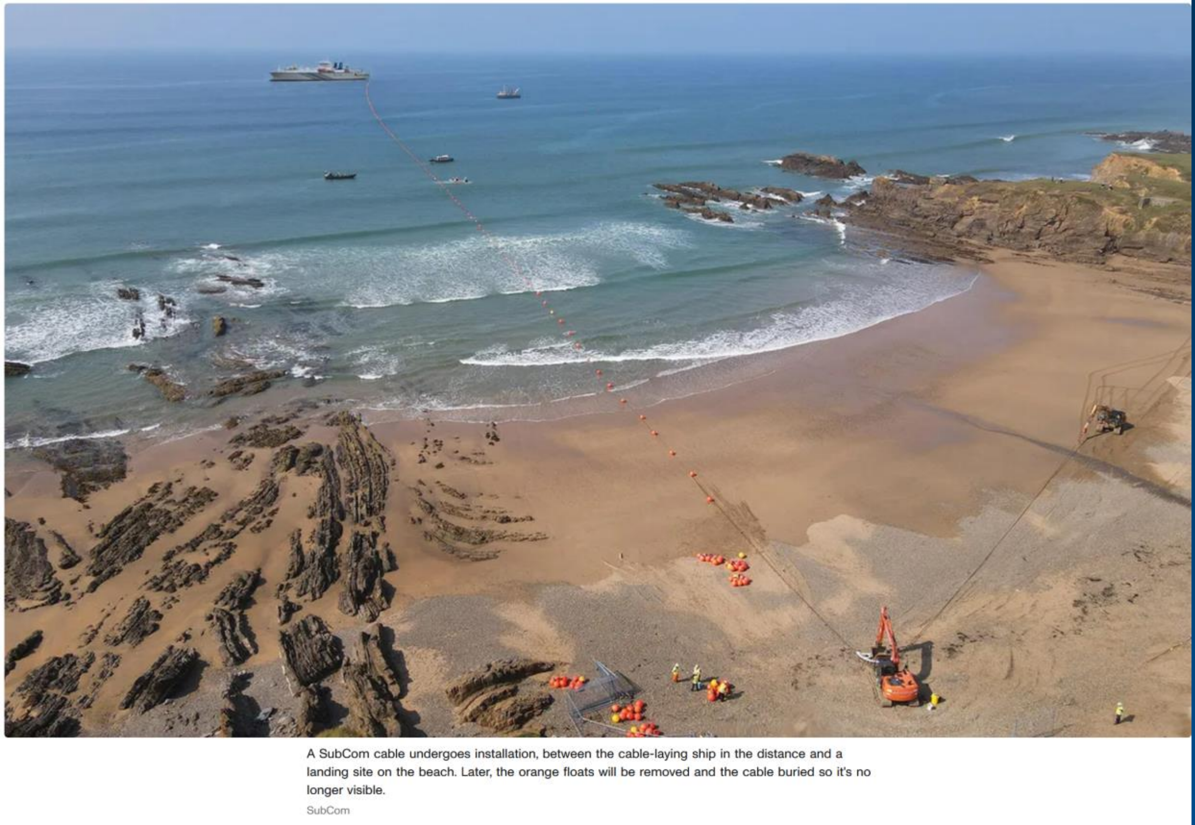
Figures as of June 2016



Threats: Sniffers and Cable Cuts

Source: Telegeography, InternetWorldStats.com, Standard Chartered Research – Note : submarine cables are a visual representation

Subsea Networks



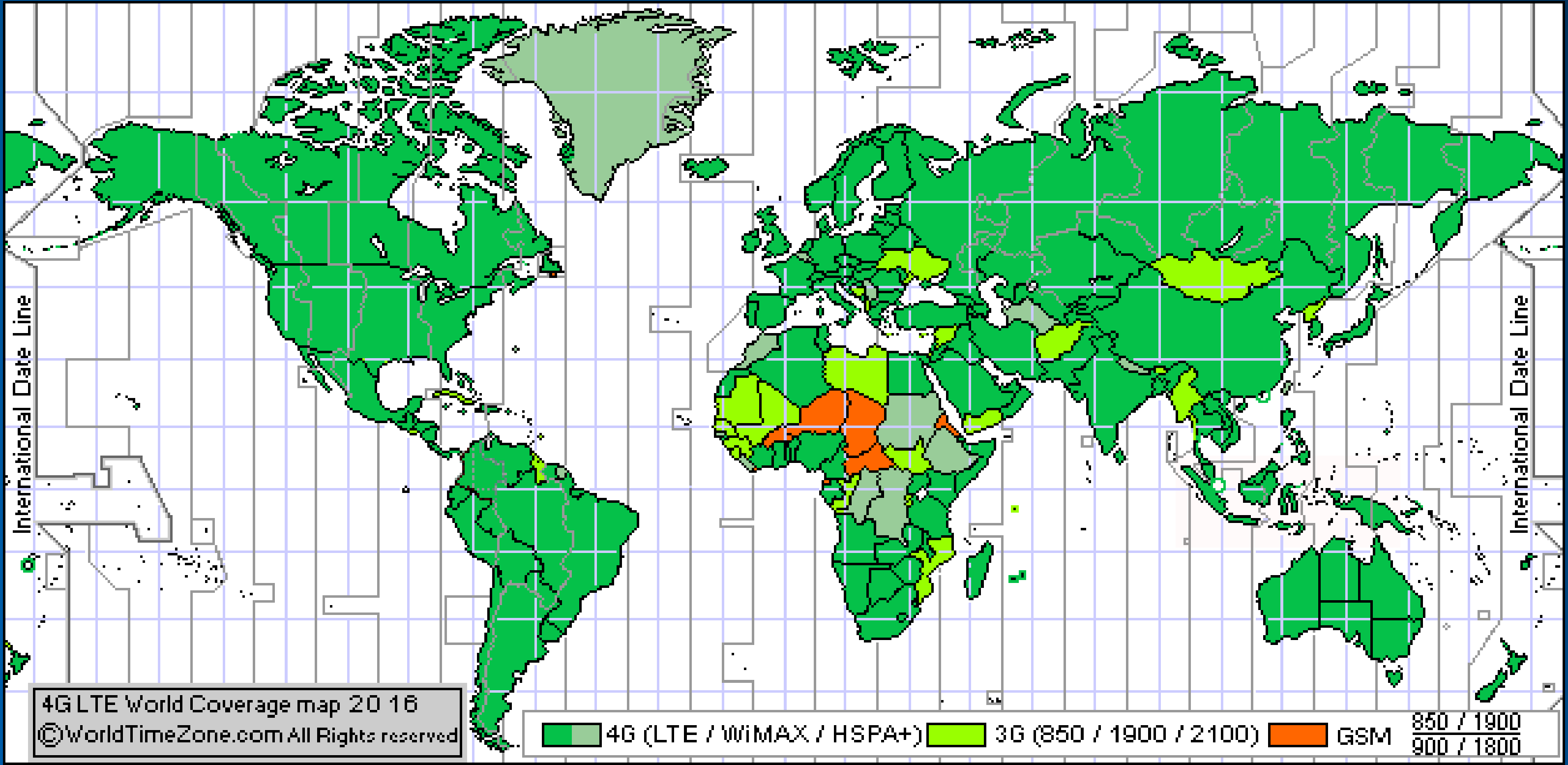
A SubCom cable undergoes installation, between the cable-laying ship in the distance and a landing site on the beach. Later, the orange floats will be removed and the cable buried so it's no longer visible.

SubCom

Source: https://www.cnet.com/home/internet/features/the-secret-life-of-the-500-cables-that-run-the-internet/?utm_source=pocket_collection_story

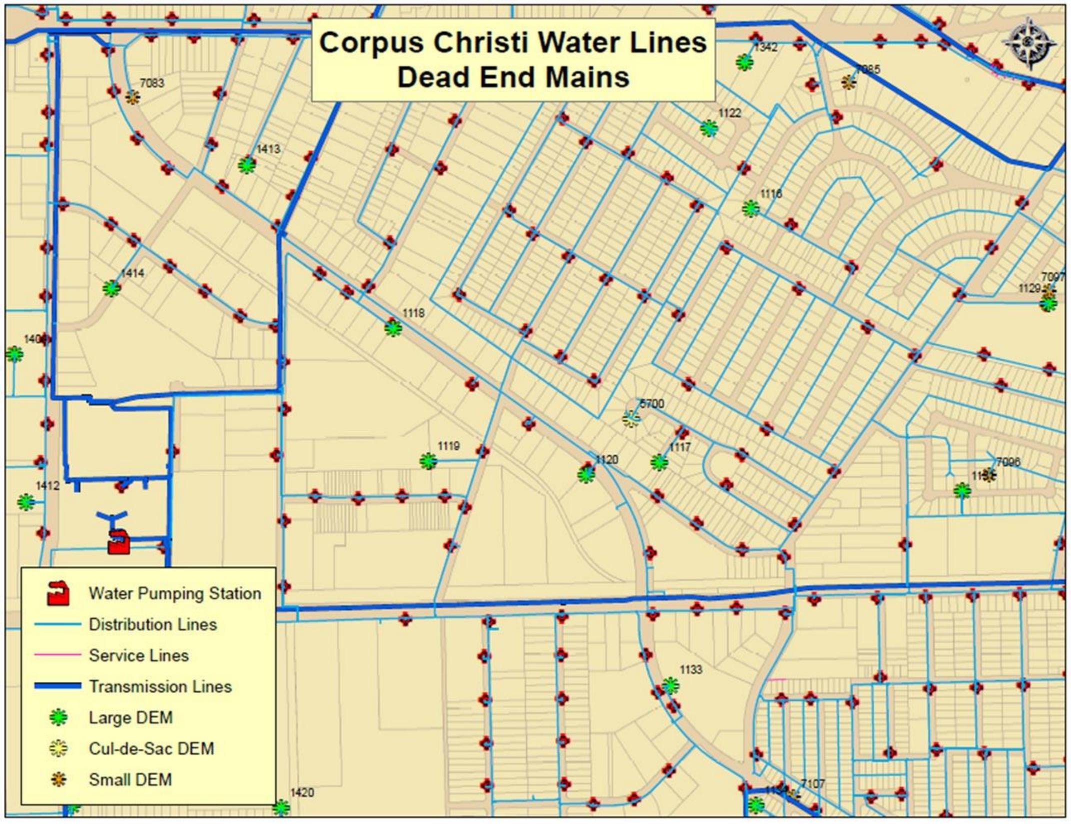
Telecom Networks

4G LTE World Coverage Map - LTE, WiMAX, HSPA+, 3G, GSM Country List


International Date Line
International Date Line
4G LTE World Coverage map 20 16
©WorldTimeZone.com All Rights reserved
🟩 4G (LTE / WiMAX / HSPA+)
🟩 3G (850 / 1900 / 2100)
🟧 GSM 850 / 1900 900 / 1800

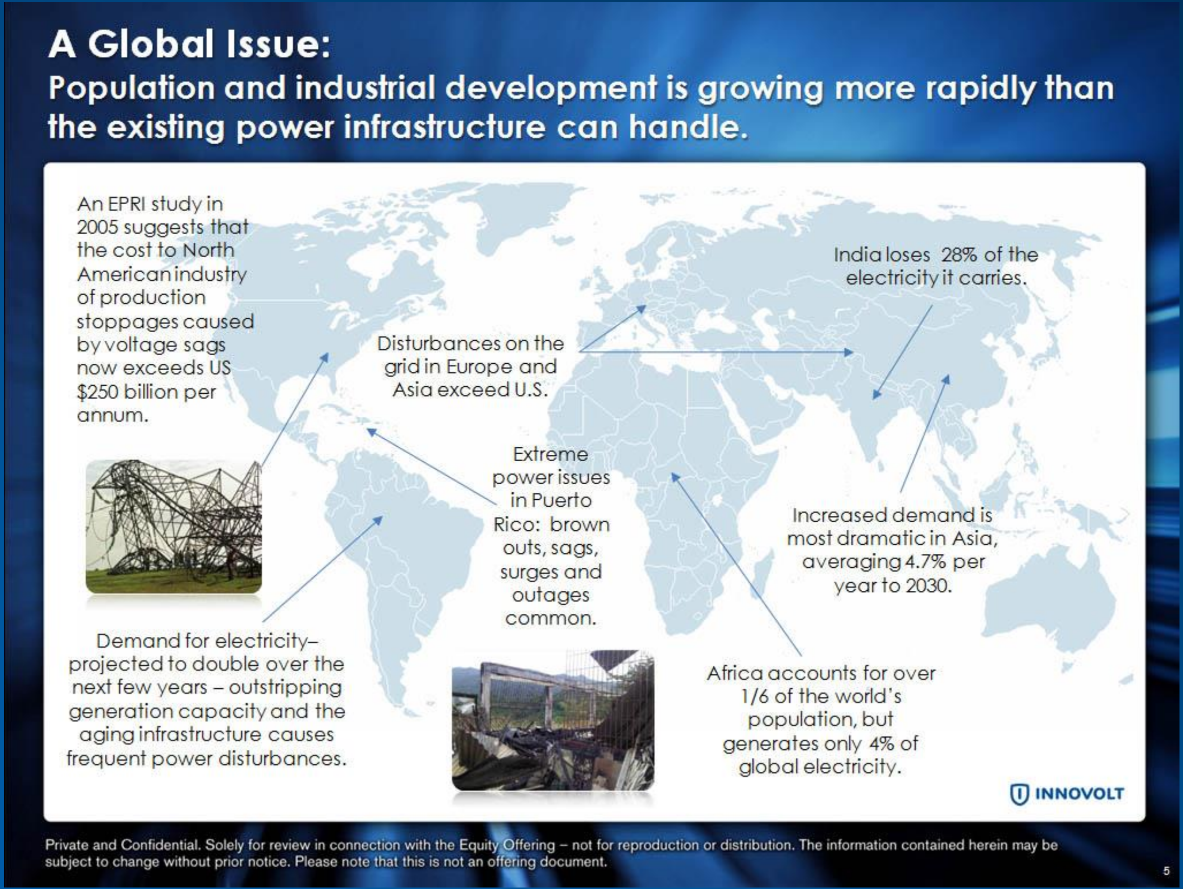
Current Threats?

Networks of Water Supply



Source: Corpus Christi, Texas, Municipal Water Supply;
https://www.cybersecuritydive.com/news/authorities-threats-water-other-critical-sectors/701431/

Networks of Electrical Grids



A Global Issue:

Population and industrial development is growing more rapidly than the existing power infrastructure can handle.

An EPRI study in 2005 suggests that the cost to North American industry of production stoppages caused by voltage sags now exceeds US $250 billion per annum.

Disturbances on the grid in Europe and Asia exceed U.S.

India loses 28% of the electricity it carries.

Extreme power issues in Puerto Rico: brown outs, sags, surges and outages common.

Increased demand is most dramatic in Asia, averaging 4.7% per year to 2030.

Demand for electricity– projected to double over the next few years – outstripping generation capacity and the aging infrastructure causes frequent power disturbances.

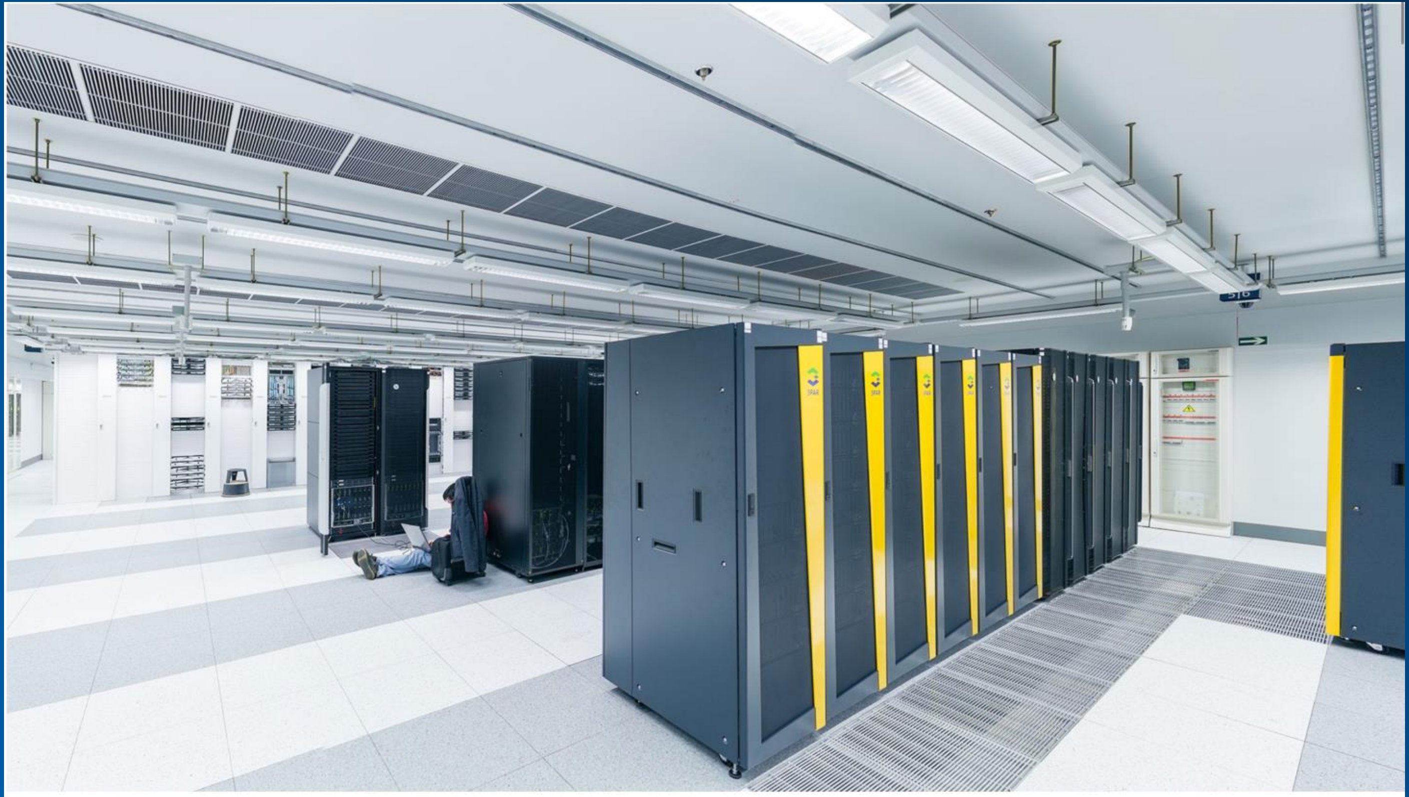
Africa accounts for over 1/6 of the world's population, but generates only 4% of global electricity.

INNOVOLT

Private and Confidential. Solely for review in connection with the Equity Offering – not for reproduction or distribution. The information contained herein may be subject to change without prior notice. Please note that this is not an offering document.

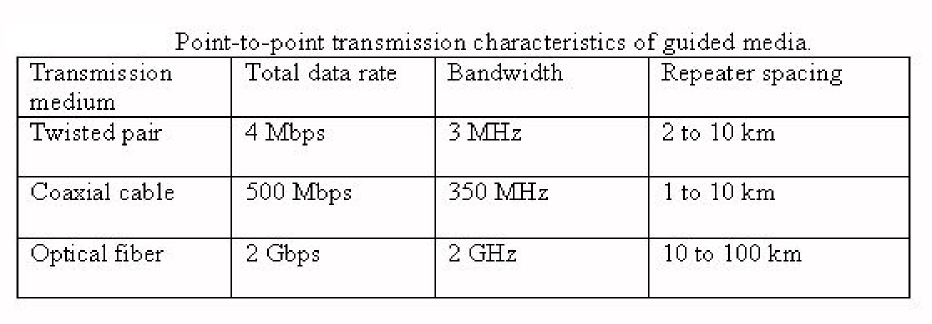
Source: Innovolt

The Internet: Hardware and Protocols



Source: http://www.elasticspace.com/2014/05/internet-machine; Timo Arnall

Media



Point-to-point transmission characteristics of guided media.

Transmission medium	Total data rate	Bandwidth	Repeater spacing
Twisted pair	4 Mbps	3 MHz	2 to 10 km
Coaxial cable	500 Mbps	350 MHz	1 to 10 km
Optical fiber	2 Gbps	2 GHz	10 to 100 km

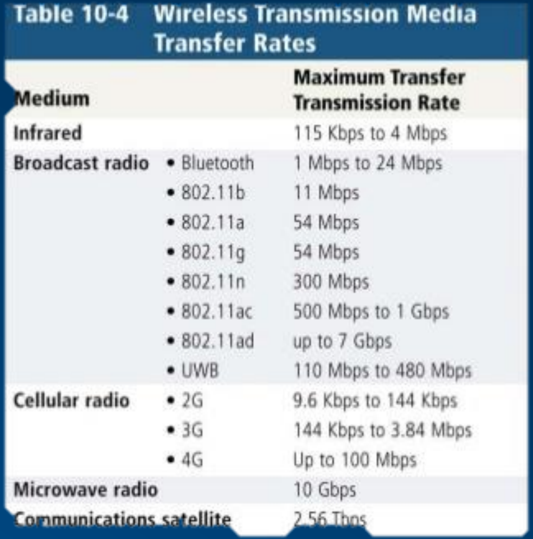
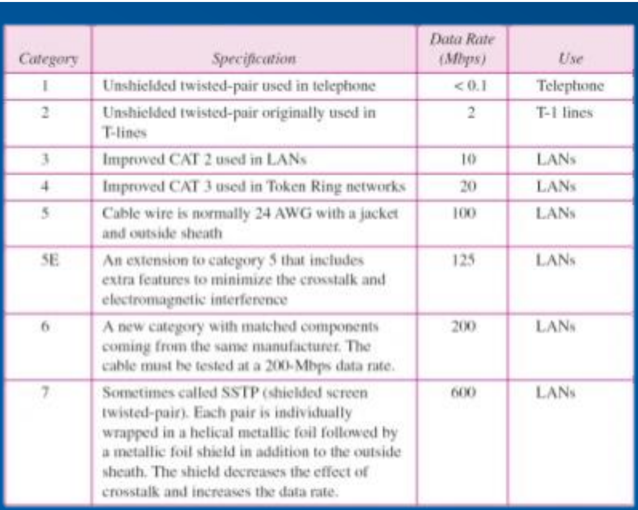
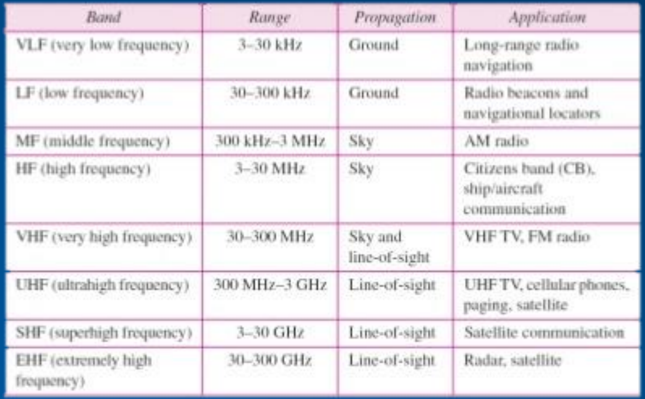


Table 10-4 Wireless Transmission Media Transfer Rates

Medium		Maximum Transfer Transmission Rate
Infrared		115 Kbps to 4 Mbps
Broadcast radio	• Bluetooth	1 Mbps to 24 Mbps
	• 802.11b	11 Mbps
	• 802.11a	54 Mbps
	• 802.11g	54 Mbps
	• 802.11n	300 Mbps
	• 802.11ac	500 Mbps to 1 Gbps
	• 802.11ad	up to 7 Gbps
	• UWB	110 Mbps to 480 Mbps
Cellular radio	• 2G	9.6 Kbps to 144 Kbps
	• 3G	144 Kbps to 3.84 Mbps
	• 4G	Up to 100 Mbps
Microwave radio		10 Gbps
Communications satellite		2.56 Tbps



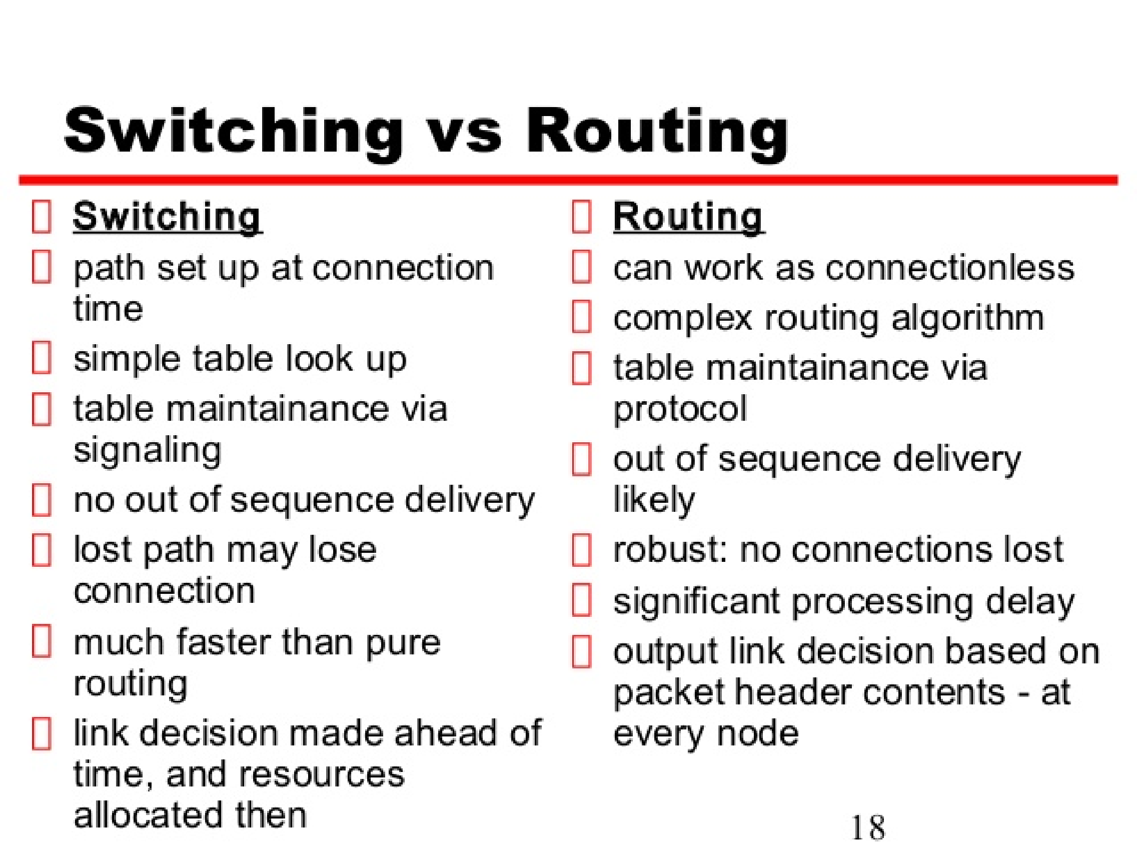
Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs



Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

Source: Cenage Learning; https://www.slideshare.net/shafaan/chapter-7-transmission-media

Circuit Switching vs Packet Routing

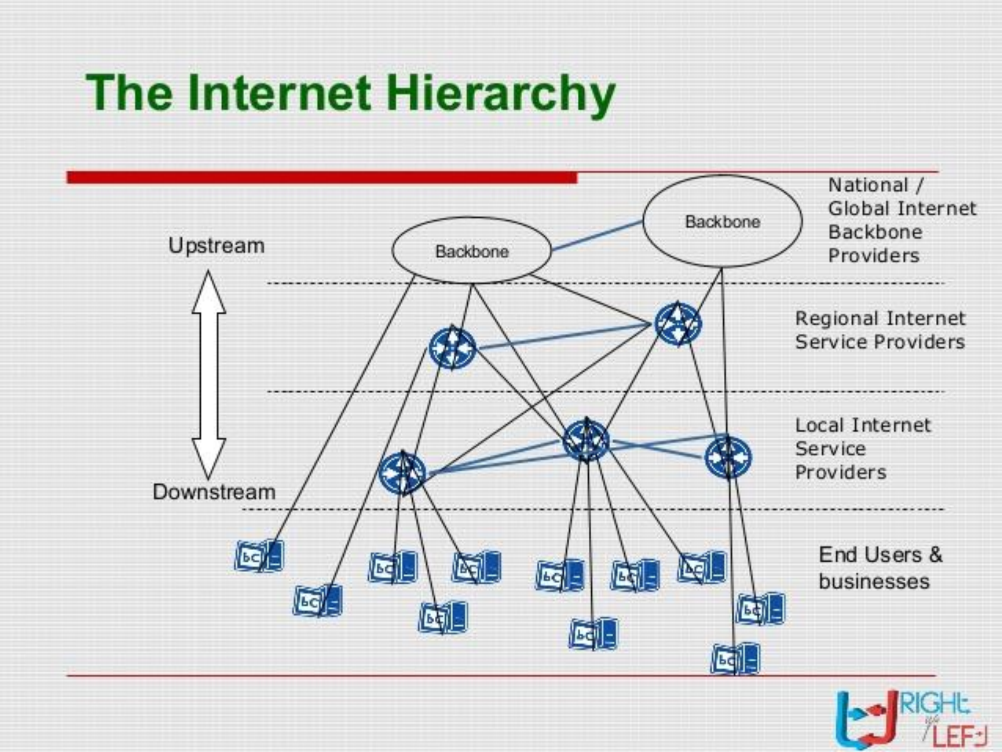


Switching vs Routing

- **Switching**
- path set up at connection time
- simple table look up
- table maintainance via signaling
- no out of sequence delivery
- lost path may lose connection
- much faster than pure routing
- link decision made ahead of time, and resources allocated then

- **Routing**
- can work as connectionless
- complex routing algorithm
- table maintainance via protocol
- out of sequence delivery likely
- robust: no connections lost
- significant processing delay
- output link decision based on packet header contents - at every node

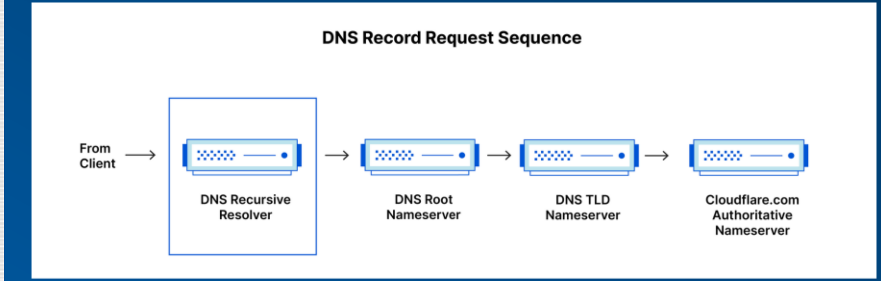
Internet structure today - kinda



The Internet Hierarchy
Backbone
Backbone
National / Global Internet Backbone Providers
Upstream
Downstream
Regional Internet Service Providers
Local Internet Service Providers
End Users & businesses
RIGHt LEFt

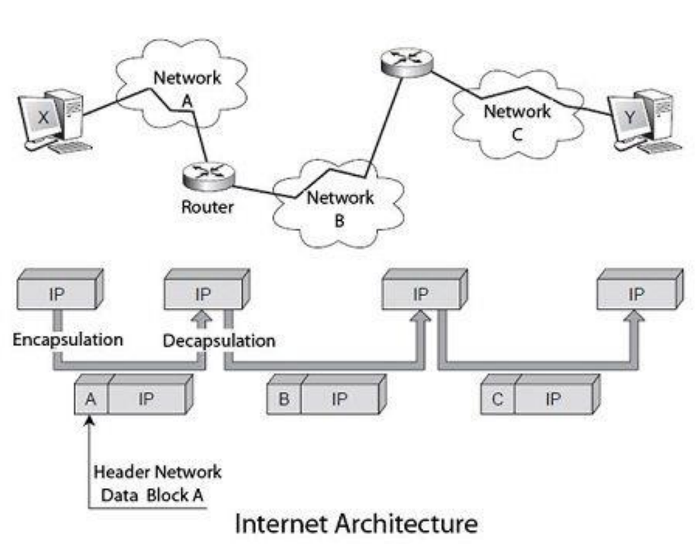
http://www.nanog.org
North American Network Operators Group

- China Mobile: largest by revenue
- Level3: 95% of internet traffic
- Comcast: Largest internet provider USA



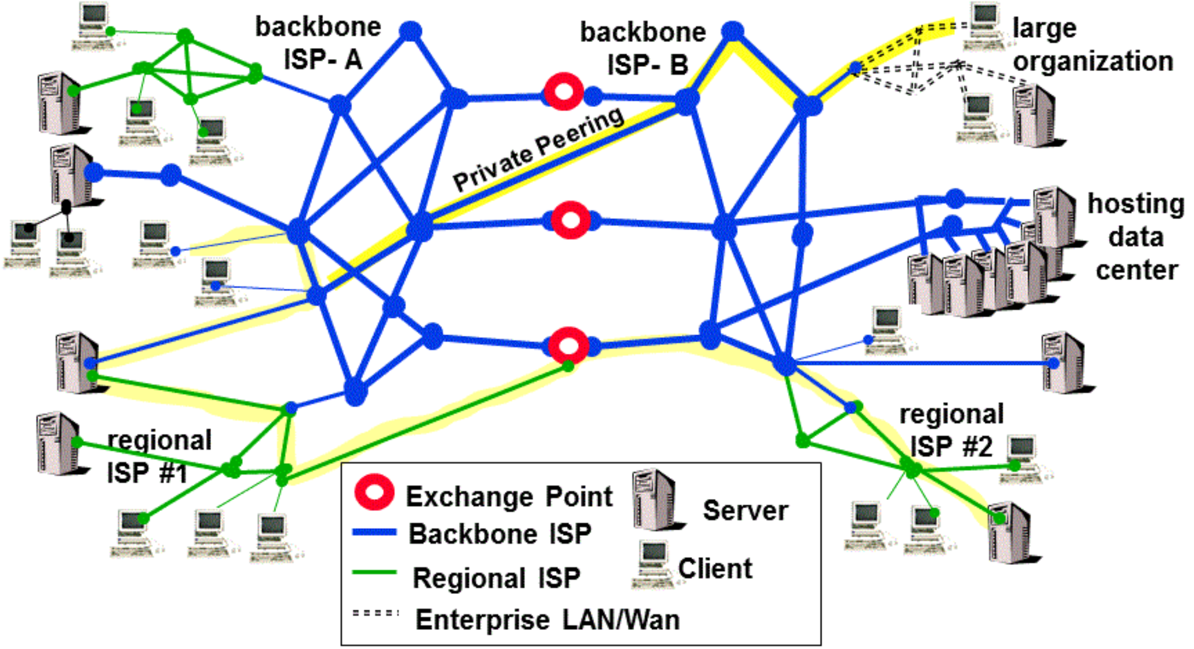
Source: https://www.cloudflare.com/learning/network-layer/how-does-the-internet-work/; https://www.cloudflare.com/learning/dns/what-is-dns/

Internet structure – High Level

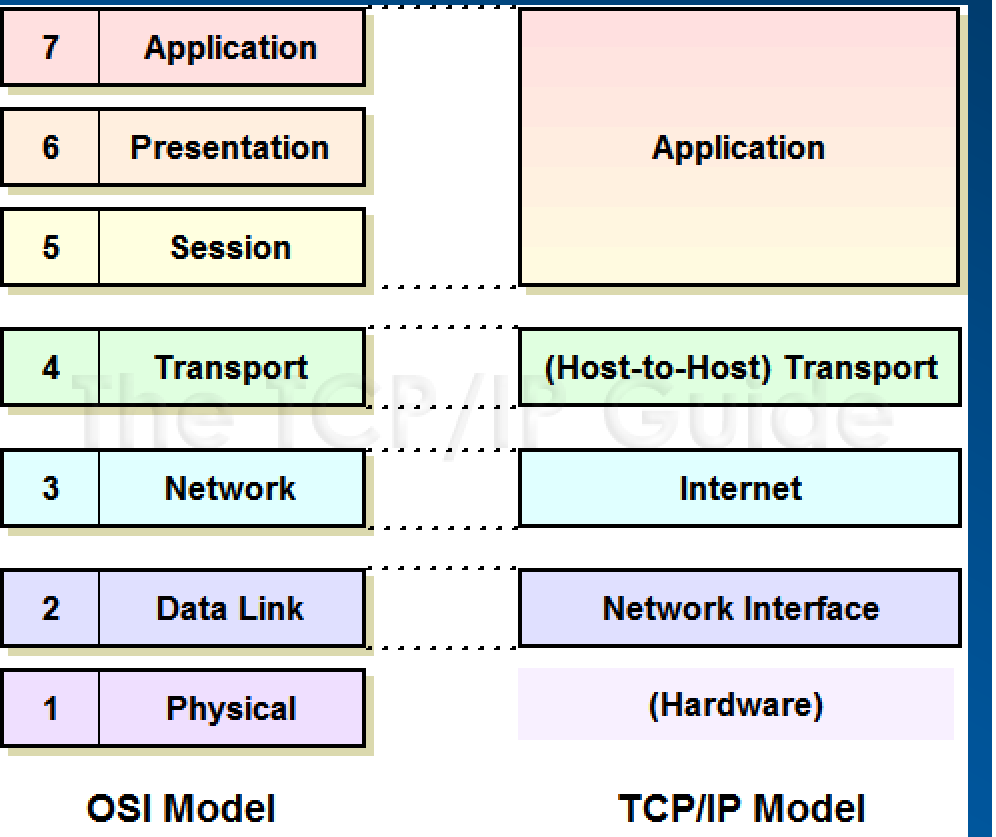


Internet Architecture

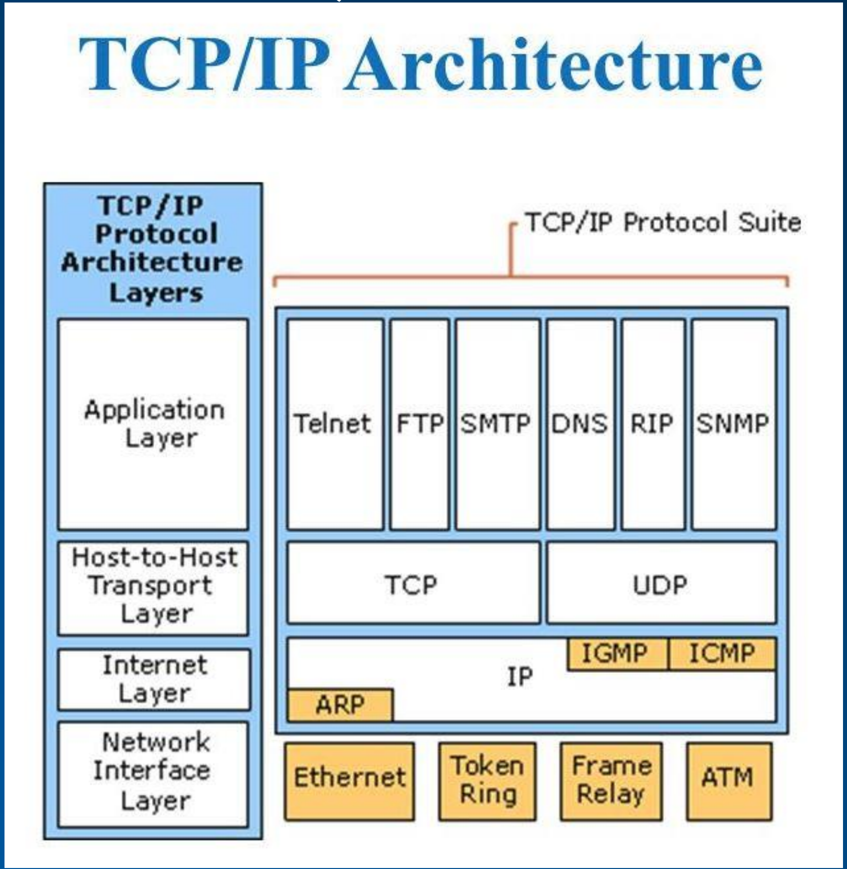
For a complete picture, initiate traceroutes from within several different backbones



Communications Protocol stacks (OSI vs TCP/IP)



OSI Model		TCP/IP Model
7	Application	Application
6	Presentation	
5	Session	
4	Transport	(Host-to-Host) Transport
3	Network	Internet
2	Data Link	Network Interface
1	Physical	(Hardware)



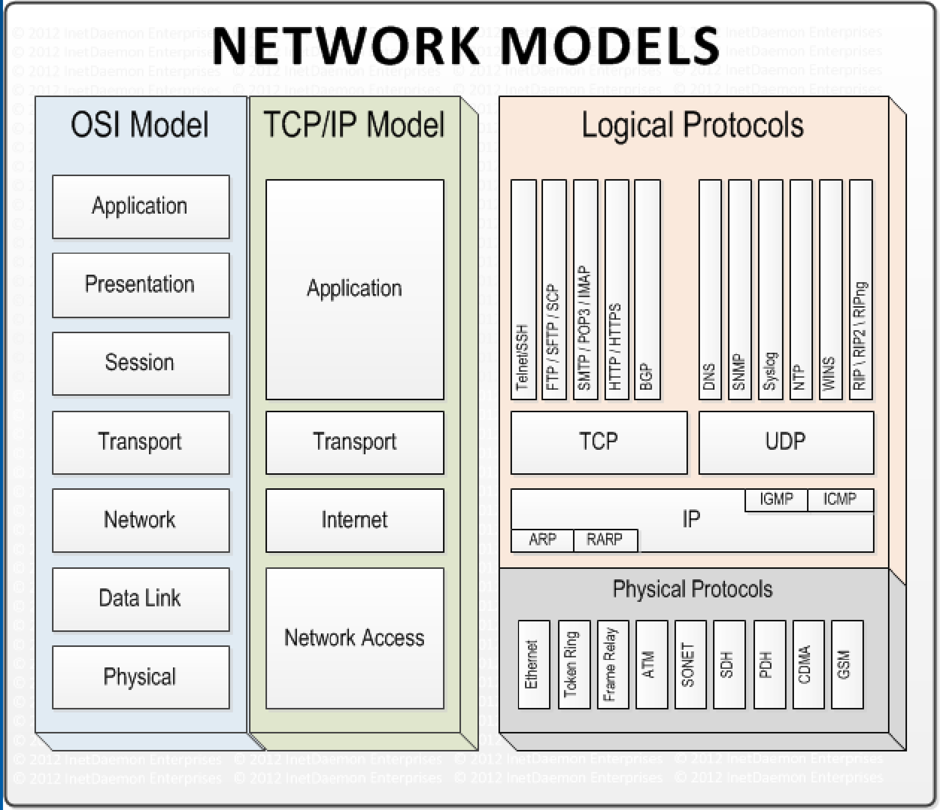
TCP/IP Architecture

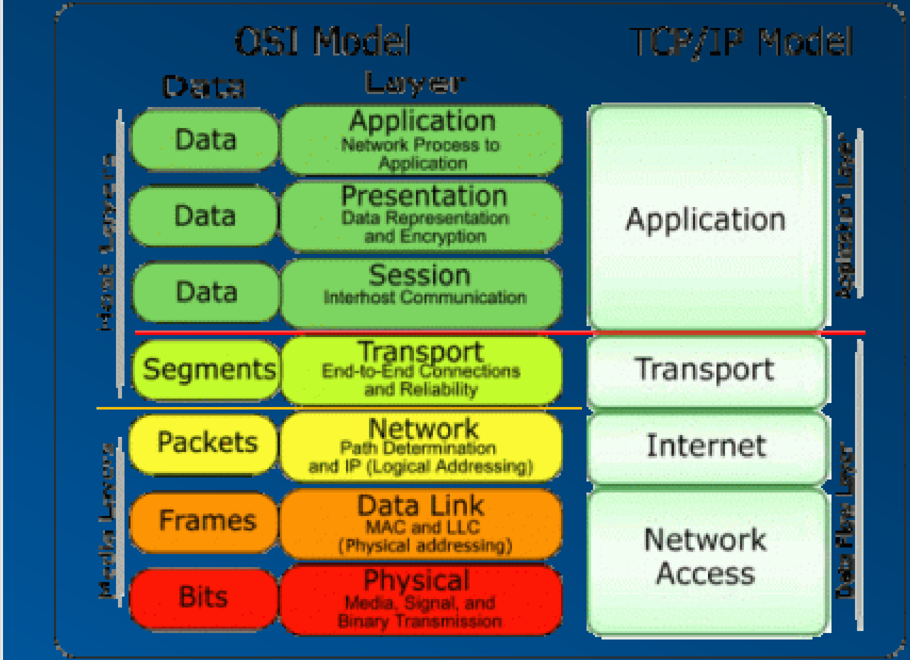
TCP/IP Protocol Architecture Layers

- Application Layer: Telnet, FTP, SMTP, DNS, RIP, SNMP
- Host-to-Host Transport Layer: TCP, UDP
- Internet Layer: IP, IGMP, ICMP, ARP
- Network Interface Layer: Ethernet, Token Ring, Frame Relay, ATM

Source: https://armagedonid.blogspot.com/2018/04/tcpip-architecture-model.html; www.tcpipguide.com

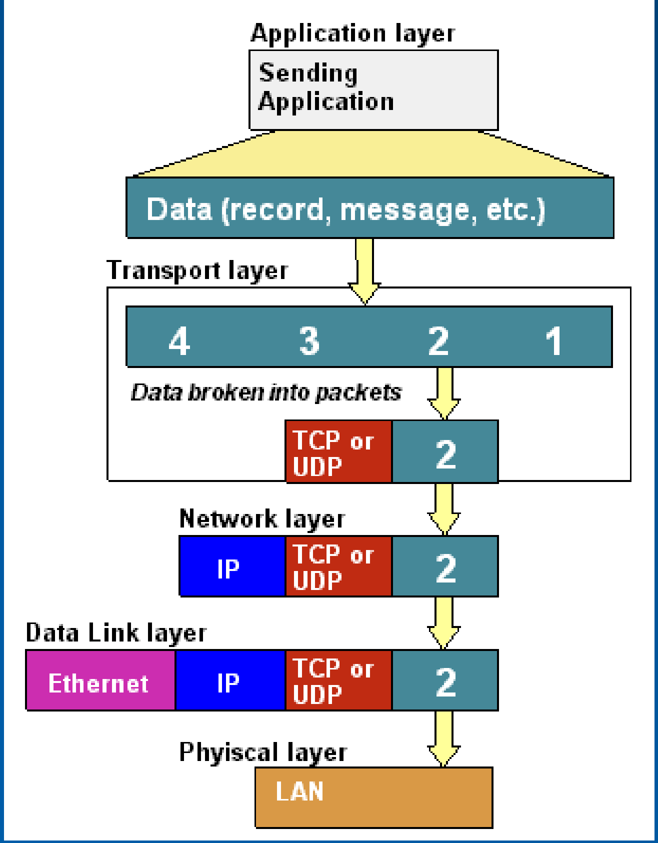
Protocols: OSI vs TCP/IP model

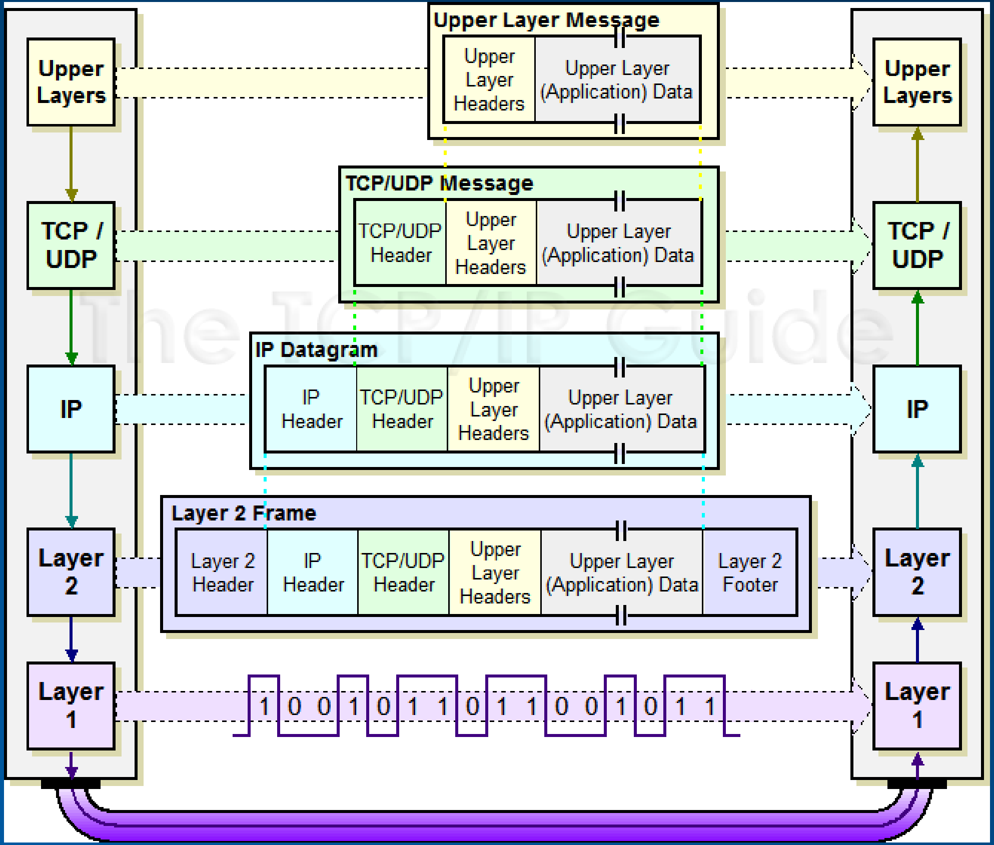




Source: InetDaemon and Durban Institute of Technology

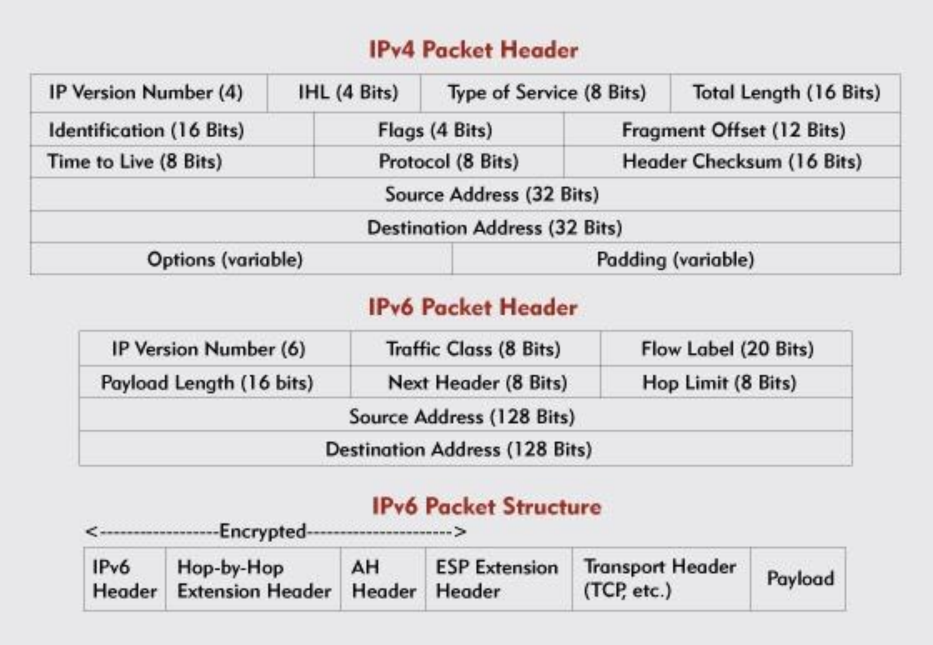
Data Packets and Encapsulation





Source: http://www.tcpipguide.com/free/t_IPDatagramEncapsulation.htm

Packet Structure (IP and 802.11 WLAN)



IPv4 Packet Header

IP Version Number (4)	IHL (4 Bits)	Type of Service (8 Bits)	Total Length (16 Bits)
Identification (16 Bits)	Flags (4 Bits)	Fragment Offset (12 Bits)	
Time to Live (8 Bits)	Protocol (8 Bits)	Header Checksum (16 Bits)	
Source Address (32 Bits)			
Destination Address (32 Bits)			
Options (variable)	Padding (variable)		

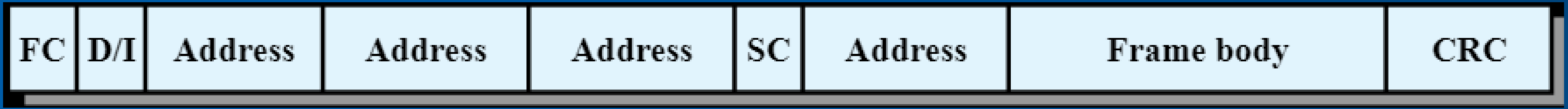
IPv6 Packet Header

IP Version Number (6)	Traffic Class (8 Bits)	Flow Label (20 Bits)
Payload Length (16 bits)	Next Header (8 Bits)	Hop Limit (8 Bits)
Source Address (128 Bits)		
Destination Address (128 Bits)		

IPv6 Packet Structure

<------------------Encrypted--------------------->

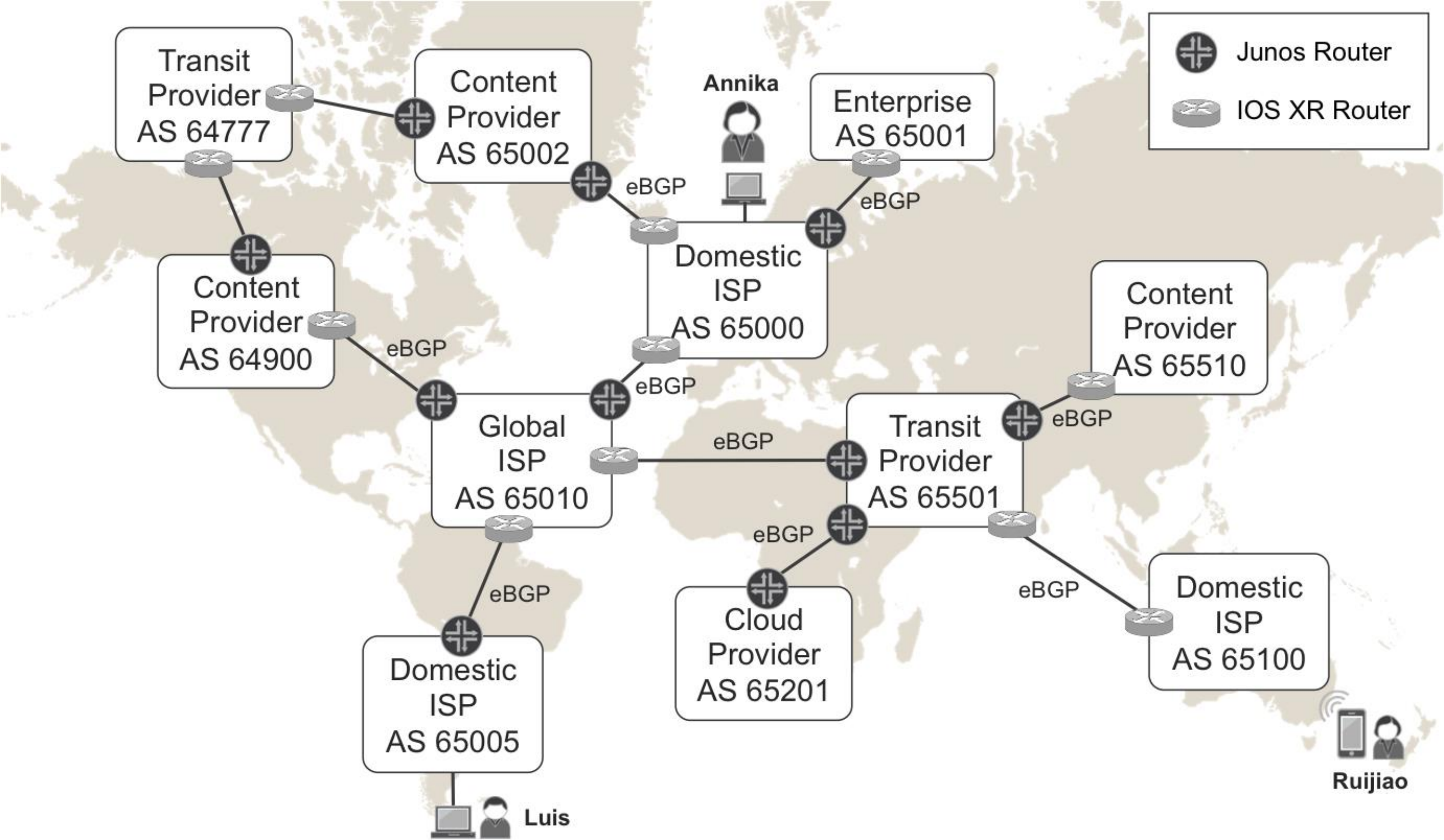
IPv6 Header	Hop-by-Hop Extension Header	AH Header	ESP Extension Header	Transport Header (TCP, etc.)	Payload



FC	D/I	Address	Address	Address	SC	Address	Frame body	CRC

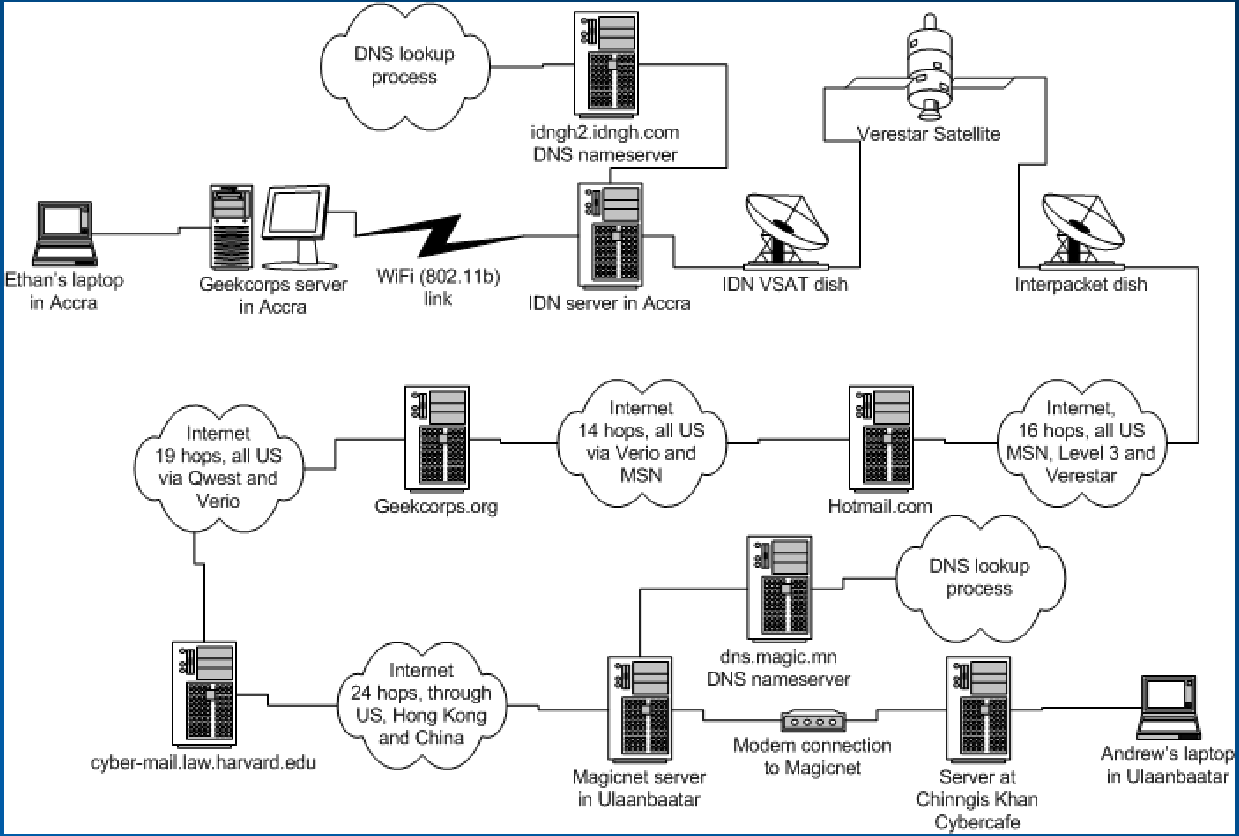
Source: https://skminhaj.wordpress.com/2016/02/15/fragmentation-in-ipv4-and-ipv6/

One day in the life of Annika



Source: Safari Books online

Internet architecture


DNS lookup process
idngh2.idngh.com DNS nameserver
Verestar Satellite
Ethan's laptop in Accra
Geekcorps server in Accra
WiFi (802.11b) link
IDN server in Accra
IDN VSAT dish
Interpacket dish
Internet 19 hops, all US via Qwest and Verio
Geekcorps.org
Internet 14 hops, all US via Verio and MSN
Hotmail.com
Internet, 16 hops, all US MSN, Level 3 and Verestar
dns.magic.mn DNS nameserver
DNS lookup process
cyber-mail.law.harvard.edu
Internet 24 hops, through US, Hong Kong and China
Magicnet server in Ulaanbaatar
Modem connection to Magicnet
Server at Chinngis Khan Cybercafe
Andrew's laptop in Ulaanbaatar

Source: https://cyber.harvard.edu/digitaldemocracy/internetarchitecture.html

Packet Communication

- STORE and FORWARD concept of packet communications developed by Paul Baran, Don Davies and Leonard Kleinrock

  https://www.rand.org/content/dam/rand/pubs/research_memoranda/2006/RM3420.pdf

  On Distributed Communications by Paul Baran

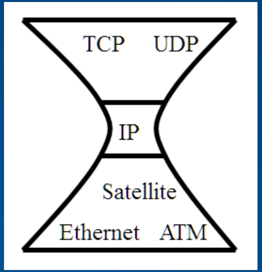
  http://internethalloffame.org/blog/2012/10/01/leonard-kleinrock-tx-2-and-seeds-internet

  - The work of Leonard Kleinrock on packet switching

- TCP/IP Protocol Architecture: https://technet.microsoft.com/en-us/library/cc958821.aspx

Design Principles

- http://cs.binghamton.edu/~nael/classes/cs428-528-f11/deeper/clark-sigcomm88.pdf
  - The Design Philosophy of the DARPA Internet Protocols, David Clarke
- https://www.vox.com/a/internet-maps
  - From DARPA to now, 40 maps that explain the Internet growth
- https://www.caida.org/research/security/



Standards – some majors

- International Telecommunications Union(ITU-T): http://www.itu.int
- Internet Engineering Task Force (IETF): https://tools.ietf.org
- 3rd Generation Partnership Project (3GPP, 3GPP2):
  http://www.3gpp2.org/ ; http://www.3gpp.org
- Institute of Electrical and Electronics Engineers (IEEE): http://www.ieee.org
- ANSI, NIST (North American); IEC, ISO (International); ETSI (European); Japanese, Korean, Chinese, etc. etc. etc.

Network Security - 1

- **Functionality** first. Security later
- Security across layers and at ALL layers
- **Malware**
  - Virus: human interaction
  - Worms: self-replicating. The Morris internet worm https://en.wikipedia.org/wiki/Morris_worm
- **Spyware**: key-logging, malicious and accidental
  - http://www.wired.co.uk/article/what-is-a-keylogger HP laptops were shipped with a Conexant audio driver keylogger, by accident. Generally malicious. Windows 10 keylogger with installation of the Technical Preview.

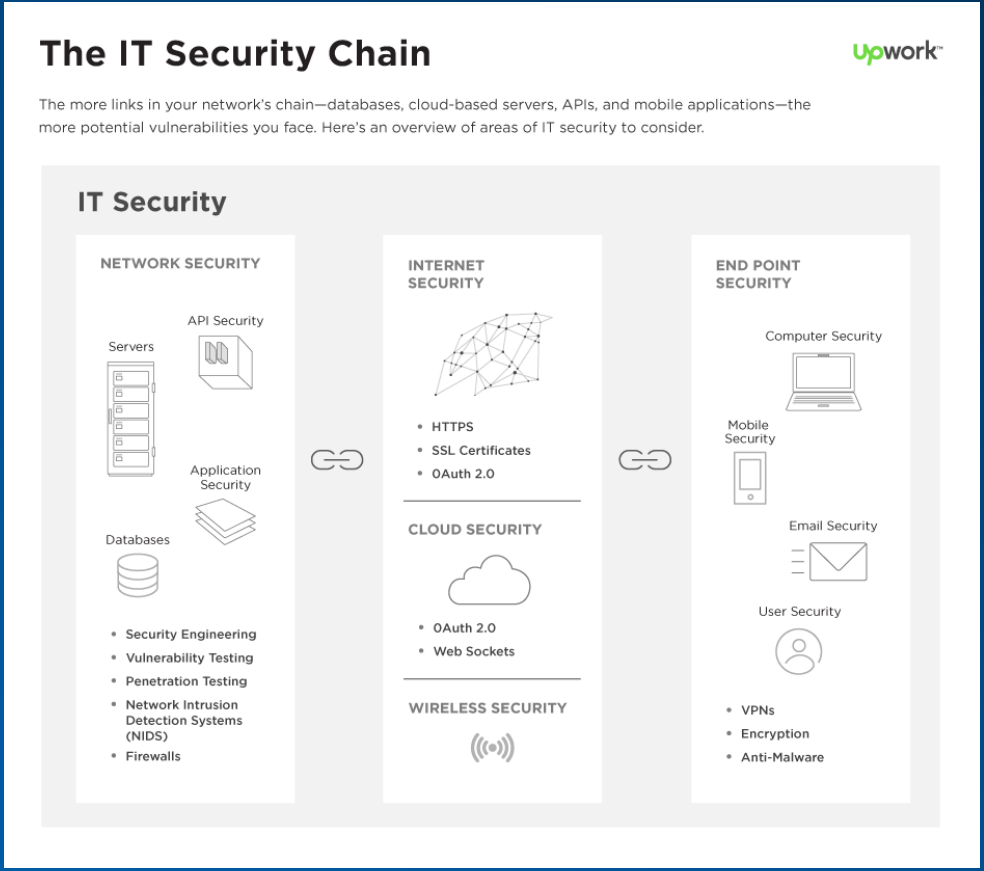
Network Security - 2

- **Botnet**: used for sending out spam. Used for DoS attack. What is a DoS attack?. The price of taking down a website? Example botnet
- **Ransomware**: Lockey
- **Packet Sniffing**: Traffic Analysis. DPI (deep packet inspection); example WiFi open; Routing thru the adversary (WifiKill for robbing houses)
- **IP Spoofing**: fake address, trick the system

Network Security

Greatest protection for least cost against these threats

Network Security Basics



The IT Security Chain

Upwork™

The more links in your network's chain—databases, cloud-based servers, APIs, and mobile applications—the more potential vulnerabilities you face. Here's an overview of areas of IT security to consider.

IT Security

NETWORK SECURITY

- Security Engineering
- Vulnerability Testing
- Penetration Testing
- Network Intrusion Detection Systems (NIDS)
- Firewalls

INTERNET SECURITY

- HTTPS
- SSL Certificates
- OAuth 2.0

CLOUD SECURITY

- OAuth 2.0
- Web Sockets

WIRELESS SECURITY

END POINT SECURITY

- VPNs
- Encryption
- Anti-Malware

Source: Upwork Global, Inc

Network Utilities - traceroute

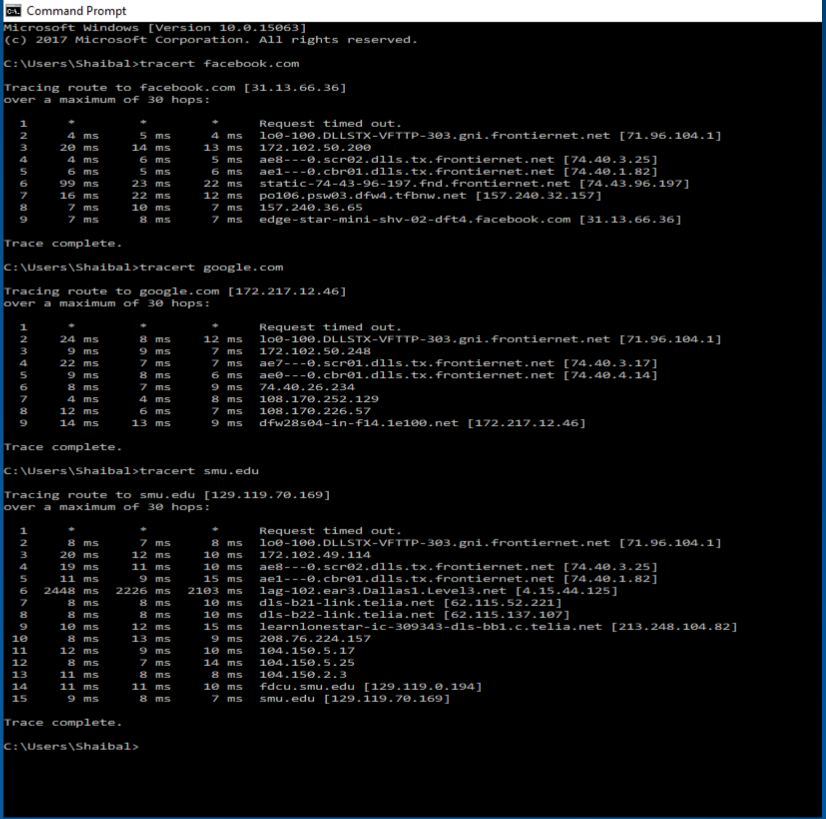
- Linux: tracerte <IP address or domain name>
- Windows: tracert <IP address or domain name>
- MAC: traceroute (in network utilities)

Traceroute is a network utility that shows a path (of routers) between your device and an endpoint, using ICMP pings (see slide 19, and identify ICMP utility).

  - Please experiment with the command on your computer. (command line).

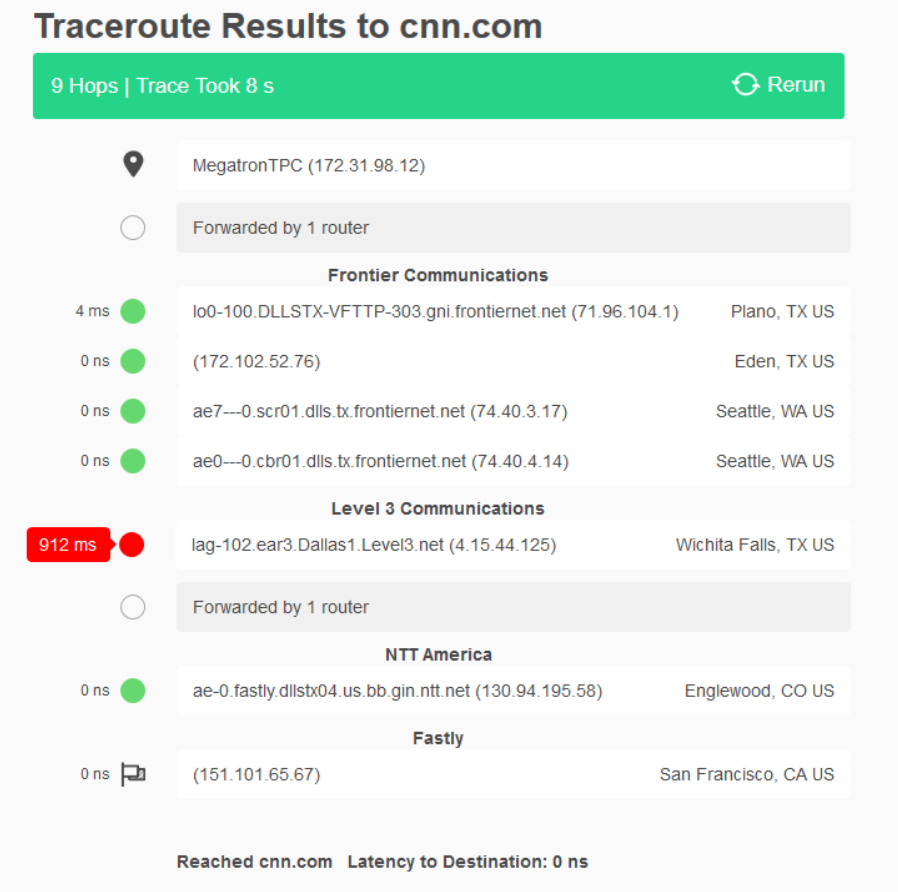
- https://community.spiceworks.com/networking/articles/2531-traceroute-request-timed-out-why-traceroute-is-broken
  - Nicely explained traceroute workings and alternate traceroute tool using TCP
  - All of these methods provide vulnerabilities that can be exploited

Traceroute demo



```
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\Shaibal>tracert facebook.com

Tracing route to facebook.com [31.13.66.36]
over a maximum of 30 hops:

  1     *        *        *     Request timed out.
  2     4 ms     5 ms     4 ms  lo0-100.DLLSTX-VFTTP-303.gni.frontiernet.net [71.96.104.1]
  3    20 ms    14 ms    13 ms  172.102.50.200
  4     4 ms     6 ms     5 ms  ae8---0.scr02.dlls.tx.frontiernet.net [74.40.3.25]
  5     6 ms     5 ms     6 ms  ae1---0.cbr01.dlls.tx.frontiernet.net [74.40.1.82]
  6    99 ms    23 ms    22 ms  static-74-43-96-197.fnd.frontiernet.net [74.43.96.197]
  7    16 ms    22 ms    12 ms  po106.psw03.dfw4.tfbnw.net [157.240.32.157]
  8     7 ms    10 ms     7 ms  157.240.36.65
  9     7 ms     8 ms     7 ms  edge-star-mini-shv-02-dft4.facebook.com [31.13.66.36]

Trace complete.

C:\Users\Shaibal>tracert google.com

Tracing route to google.com [172.217.12.46]
over a maximum of 30 hops:

  1     *        *        *     Request timed out.
  2    24 ms     8 ms    12 ms  lo0-100.DLLSTX-VFTTP-303.gni.frontiernet.net [71.96.104.1]
  3     9 ms     9 ms     7 ms  172.102.50.248
  4    22 ms     7 ms     7 ms  ae7---0.scr01.dlls.tx.frontiernet.net [74.40.3.17]
  5     9 ms     8 ms     6 ms  ae0---0.cbr01.dlls.tx.frontiernet.net [74.40.4.14]
  6     8 ms     7 ms     9 ms  74.40.26.234
  7     4 ms     4 ms     8 ms  108.170.252.129
  8    12 ms     6 ms     7 ms  108.170.226.57
  9    14 ms    13 ms     9 ms  dfw28s04-in-f14.1e100.net [172.217.12.46]

Trace complete.

C:\Users\Shaibal>tracert smu.edu

Tracing route to smu.edu [129.119.70.169]
over a maximum of 30 hops:

  1     *        *        *     Request timed out.
  2     8 ms     7 ms     8 ms  lo0-100.DLLSTX-VFTTP-303.gni.frontiernet.net [71.96.104.1]
  3    20 ms    12 ms    10 ms  172.102.49.114
  4    19 ms    11 ms    10 ms  ae8---0.scr02.dlls.tx.frontiernet.net [74.40.3.25]
  5    11 ms     9 ms    15 ms  ae1---0.cbr01.dlls.tx.frontiernet.net [74.40.1.82]
  6  2448 ms  2226 ms  2103 ms  lag-102.ear3.Dallas1.Level3.net [4.15.44.125]
  7     8 ms     8 ms    10 ms  dls-b21-link.telia.net [62.115.52.221]
  8     8 ms     8 ms    10 ms  dls-b22-link.telia.net [62.115.137.107]
  9    10 ms    12 ms    15 ms  learnlonestar-ic-309343-dls-bb1.c.telia.net [213.248.104.82]
 10     8 ms    13 ms     9 ms  208.76.224.157
 11    12 ms     9 ms    10 ms  104.150.5.17
 12     8 ms     7 ms    14 ms  104.150.5.25
 13    11 ms     8 ms     8 ms  104.150.2.3
 14    11 ms    11 ms    10 ms  fdcu.smu.edu [129.119.0.194]
 15     9 ms     8 ms     7 ms  smu.edu [129.119.70.169]

Trace complete.

C:\Users\Shaibal>
```

Regular traceroute – using ICMP Echo
Firewall blocks the ping – router security



Traceroute Results to cnn.com

9 Hops | Trace Took 8 s

MegatronTPC (172.31.98.12)

Forwarded by 1 router

Frontier Communications

4 ms lo0-100.DLLSTX-VFTTP-303.gni.frontiernet.net (71.96.104.1) Plano, TX US

0 ns (172.102.52.76) Eden, TX US

0 ns ae7---0.scr01.dlls.tx.frontiernet.net (74.40.3.17) Seattle, WA US

0 ns ae0---0.cbr01.dlls.tx.frontiernet.net (74.40.4.14) Seattle, WA US

Level 3 Communications

912 ms lag-102.ear3.Dallas1.Level3.net (4.15.44.125) Wichita Falls, TX US

Forwarded by 1 router

NTT America

0 ns ae-0.fastly.dllstx04.us.bb.gin.ntt.net (130.94.195.58) Englewood, CO US

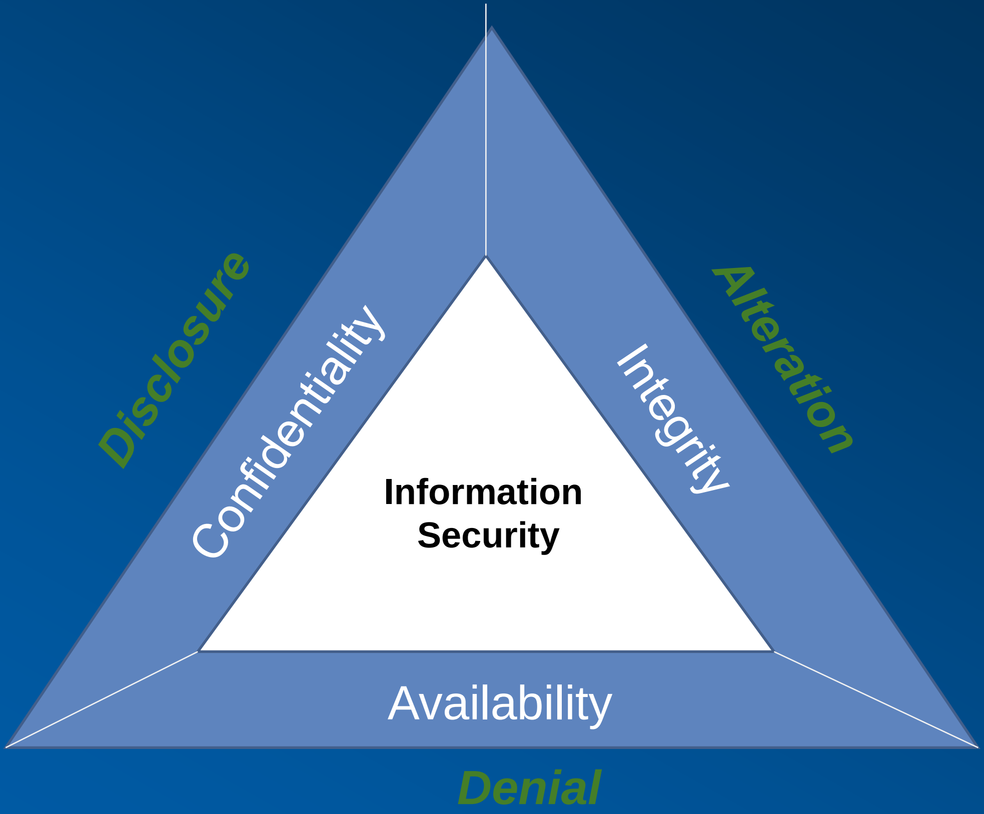
Fastly

0 ns (151.101.65.67) San Francisco, CA US

Reached cnn.com   Latency to Destination: 0 ns

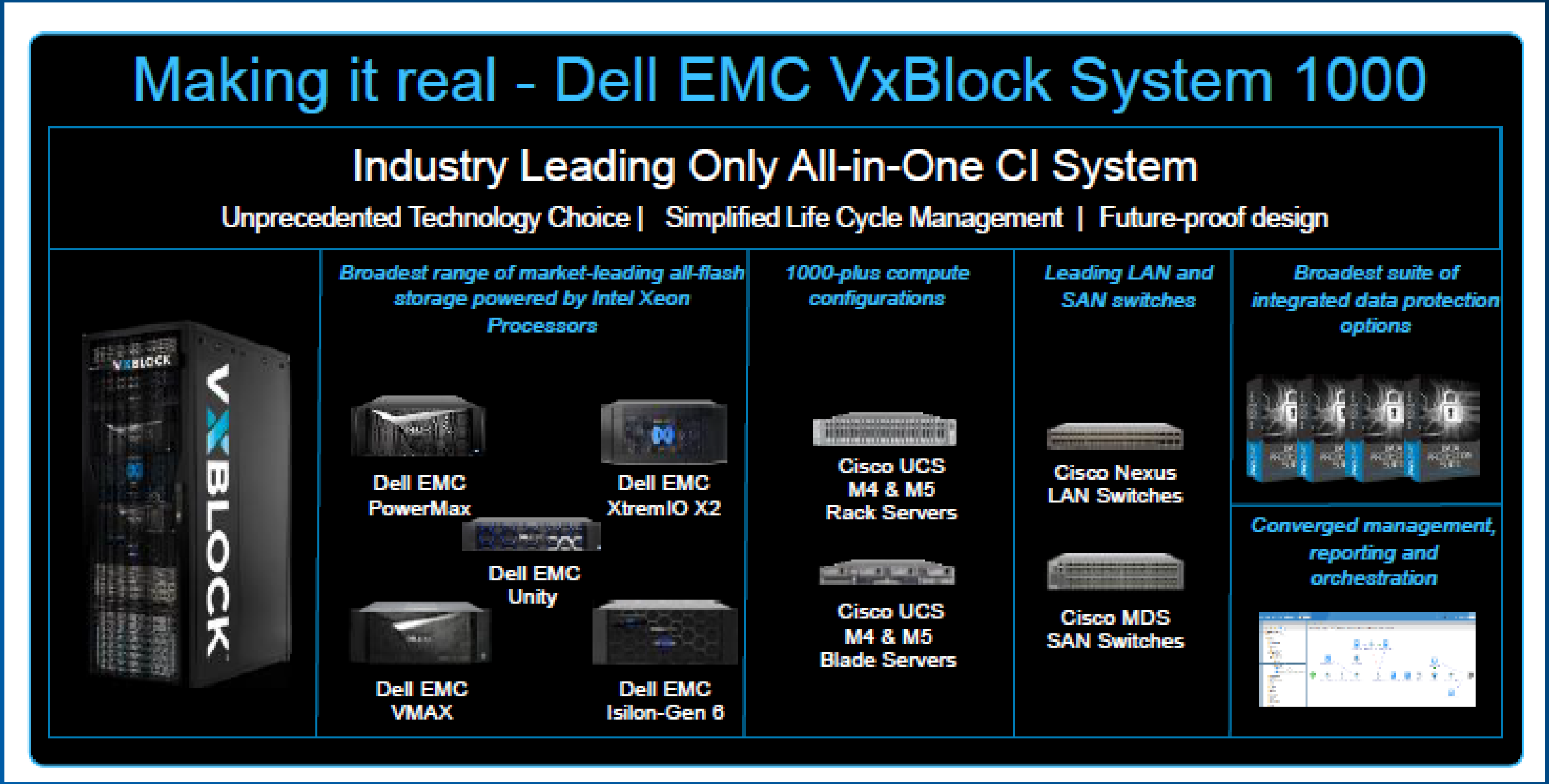
Enhanced traceroute – using TCP SYN
Firewall leaves TCP/IP port open

InfoSec, CIA, Threats



Source: “Information Security Illuminated”, Solomon and Chapple, 2005, Sudbury, MA:Jones and Bartlett.

Cloud Infrastructure basics



Making it real - Dell EMC VxBlock System 1000

Industry Leading Only All-in-One CI System

Unprecedented Technology Choice | Simplified Life Cycle Management | Future-proof design

Broadest range of market-leading all-flash storage powered by Intel Xeon Processors

Dell EMC PowerMax

Dell EMC XtremIO X2

Dell EMC Unity

Dell EMC VMAX

Dell EMC Isilon-Gen 6

1000-plus compute configurations

Cisco UCS M4 & M5 Rack Servers

Cisco UCS M4 & M5 Blade Servers

Leading LAN and SAN switches

Cisco Nexus LAN Switches

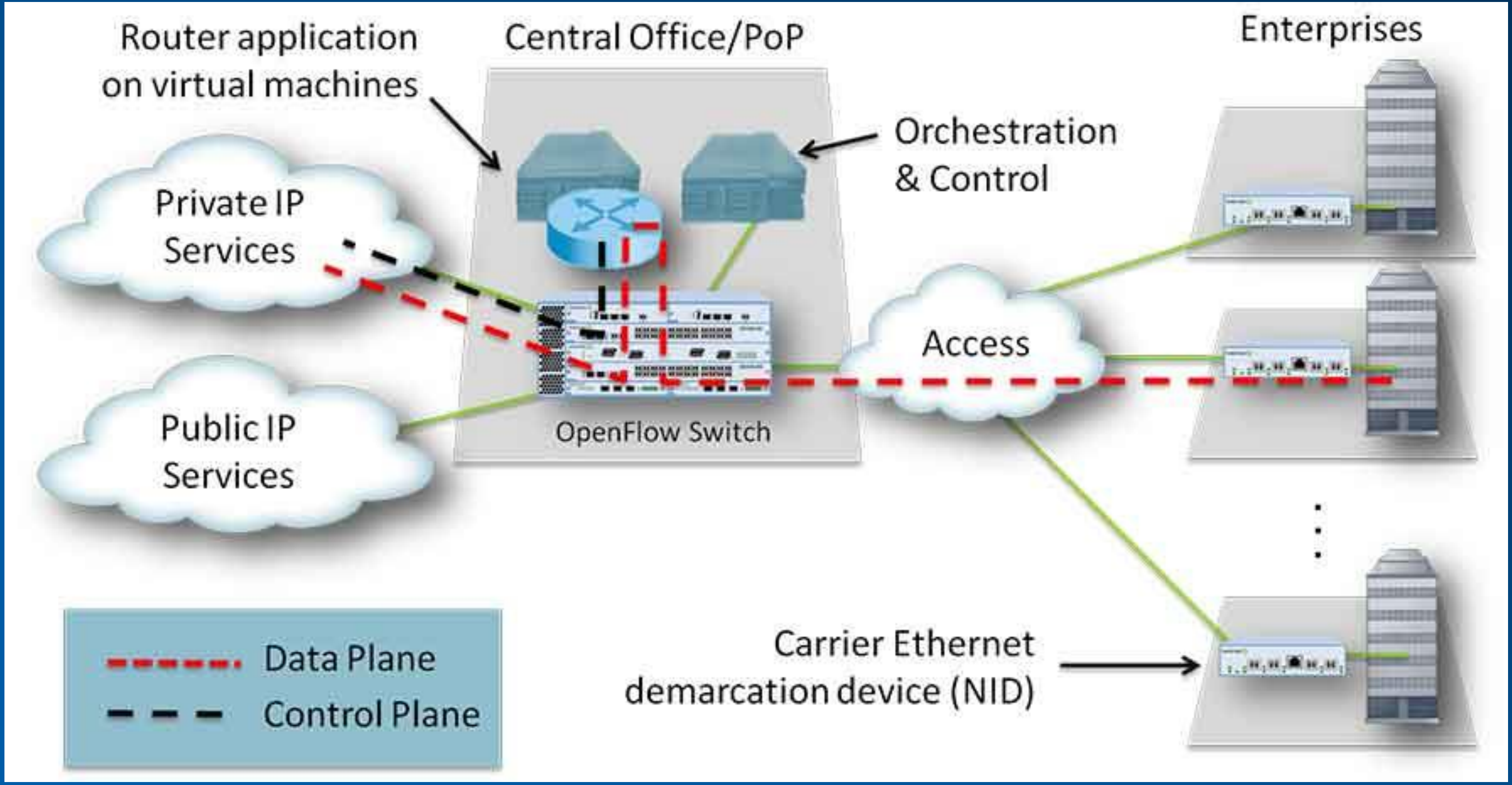
Cisco MDS SAN Switches

Broadest suite of integrated data protection options

Converged management, reporting and orchestration

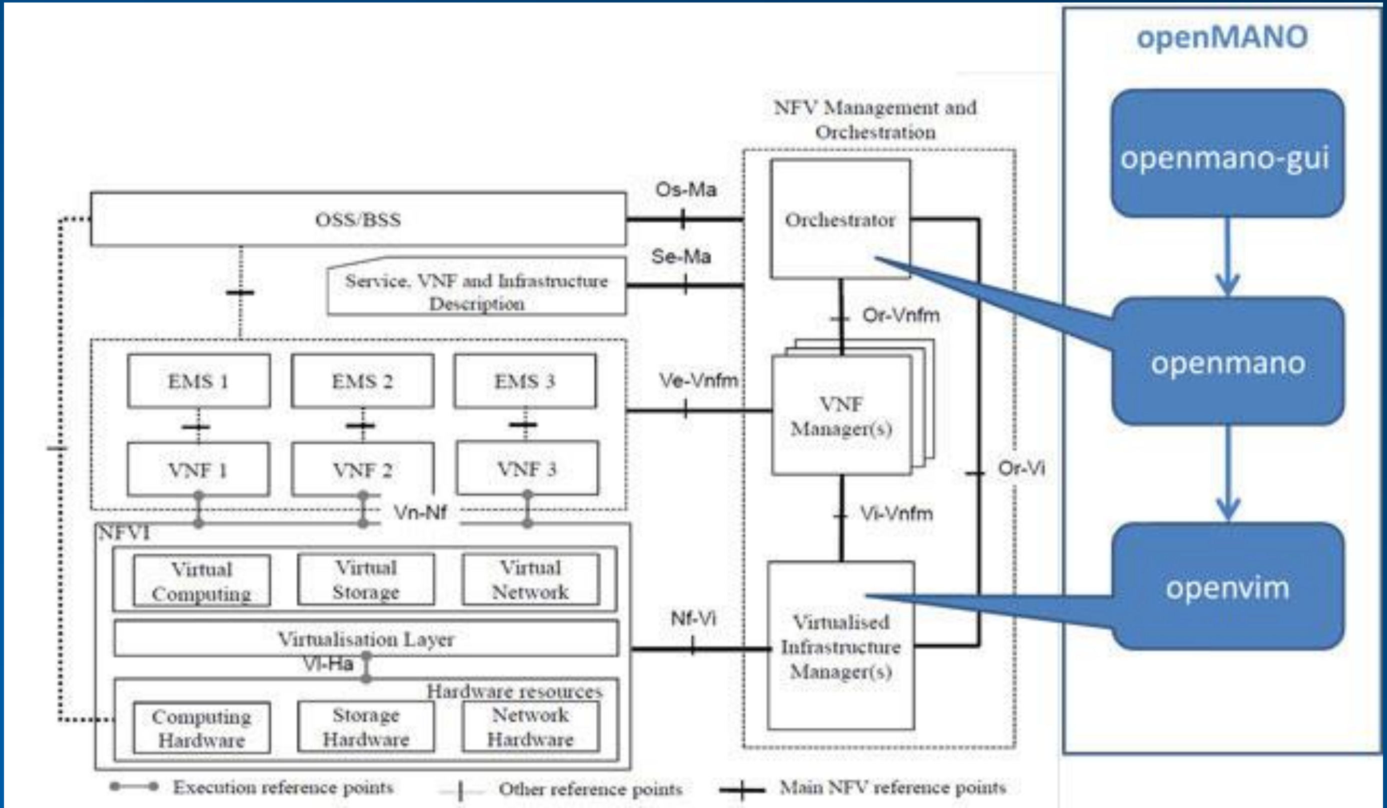
Source: Dell-EMC VCE VBlock

Software Defined Networking



Source: Dell-EMC VCE VBlock

Network Functions Virtualization



Source: ETSI (European Telecommunications Standards Institute)

Thank You!

World Changers
Shaped Here

SMU®