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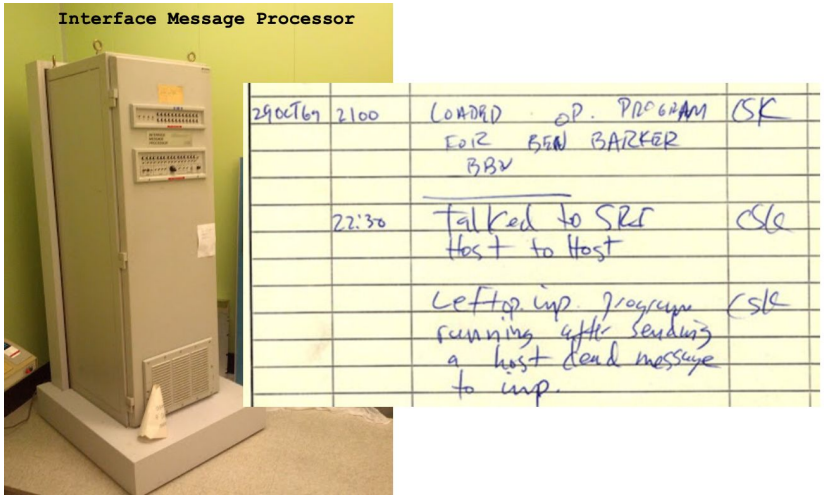
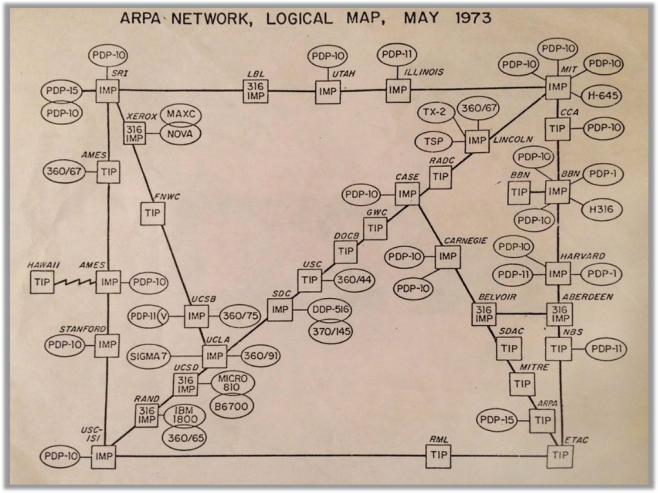
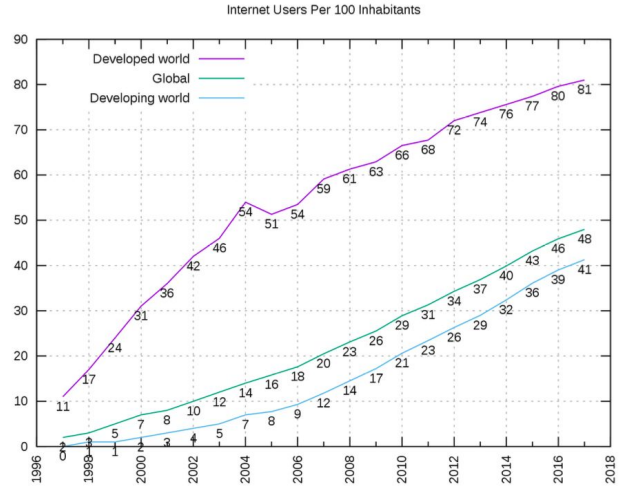
Origins of Internet



Origins of Internet



Origins of Internet



Impacts of Internet

- Design of Internet
  - Is the reason for its impact?

Impacts of Internet

- Design of Internet
  - Supports growth and fosters innovation?

Impacts of Internet

- Internet is a tense place

Search **Bloomberg**

Cybersecurity

Cyber-Attack Hits U.S. Health Agency Amid Covid-19 Outbreak

By Shira Stein and Jennifer Jacobs
March 16, 2020, 8:37 AM EDT *Updated on March 16, 2020, 4:35 PM EDT*

- NSC tweet on disinformation Sunday was connected to attack
- Cyber intrusion comes as U.S. battles the coronavirus pandemic

2018:

Impacts of Internet

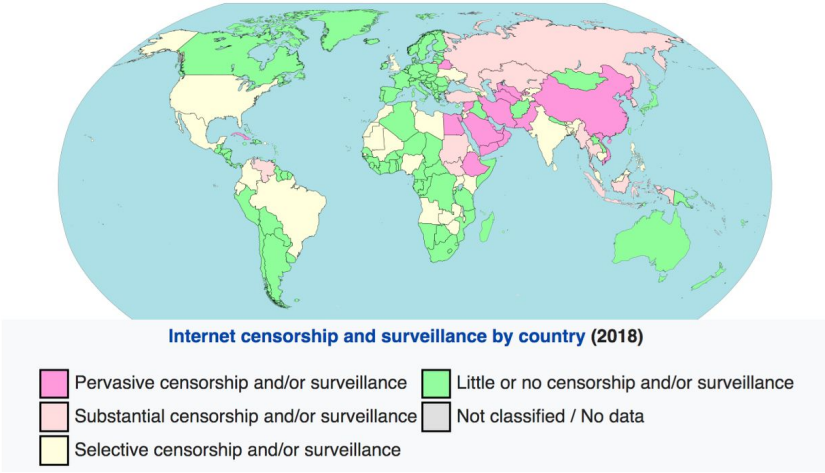
- Internet is a tense place

Impacts of Internet

- Internet is a tense place

Impacts of Internet

- Internet is a tense place



Impacts of Internet

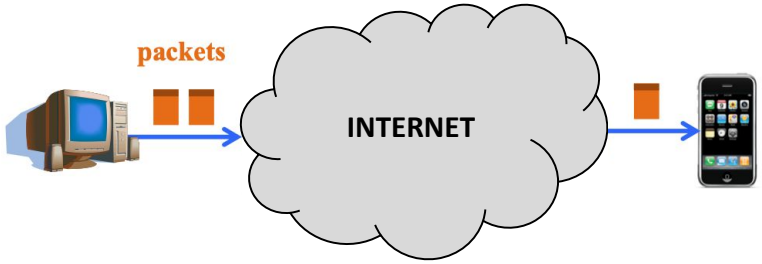
- Design of Internet
  - Creates or exacerbates these tensions?

What is Internet?

- Internet is a
  - **Publicly accessible** network of **interconnected** computer networks
    - Transmit data by **packet switching** using standard Internet Protocol
  - **Network of networks**
    - Consists of many smaller domestic/academic/business/govt networks
      - Carry various **information** and **services**

What is Internet?

- Best-effort packet delivery service

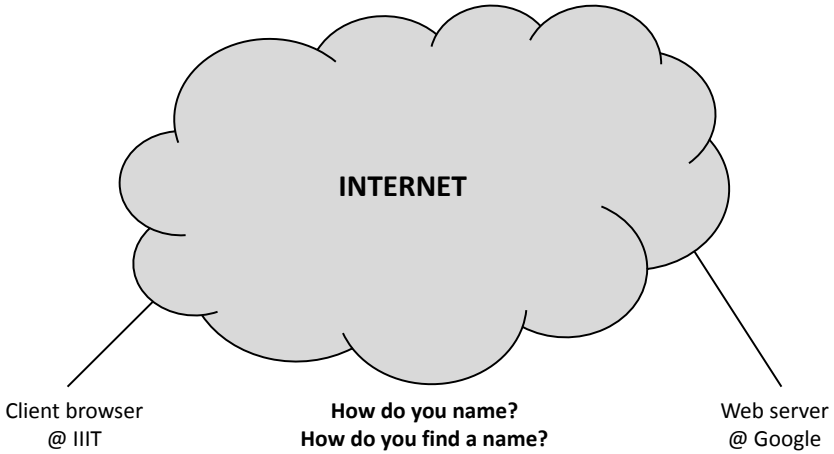


What is Internet?

- Power at edge
  - End-to-end principle
    - Communication/protocol operations should occur at endpoints
      - Whenever possible
  - Programmability
    - New network services can be added at any time, by anyone
      - With programmable end hosts
        - Eventually, end hosts became powerful and ubiquitous

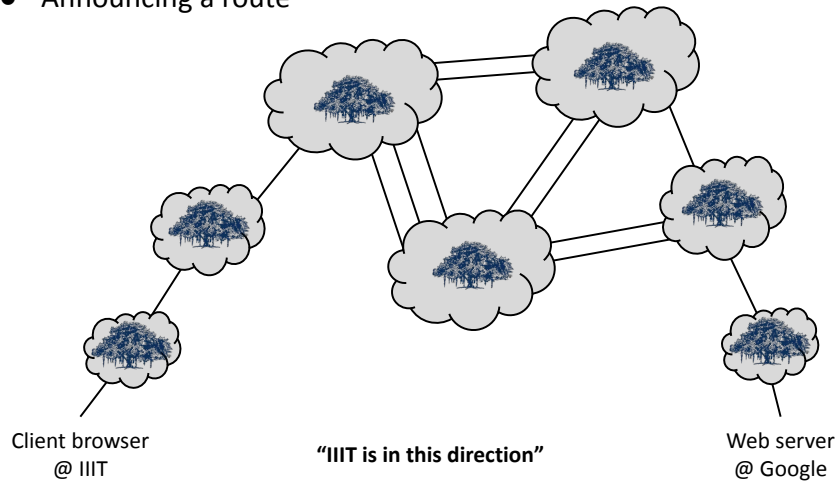
What is Internet?

- Internet is a network of networks



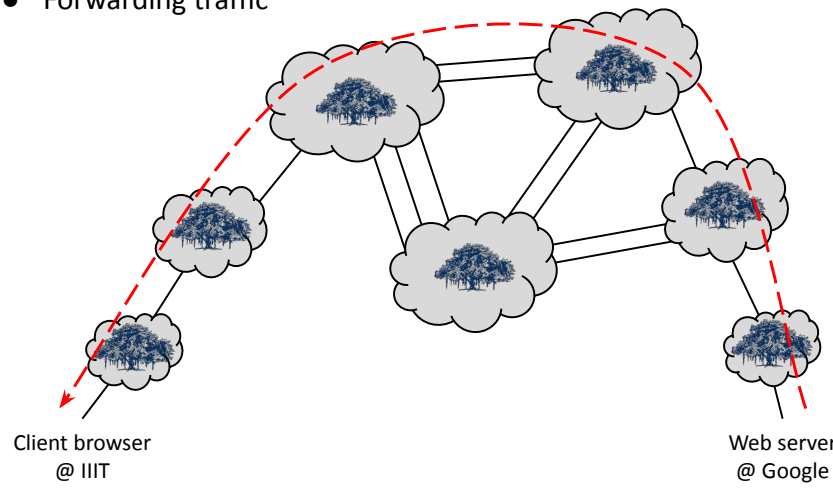
What is Internet?

- Announcing a route



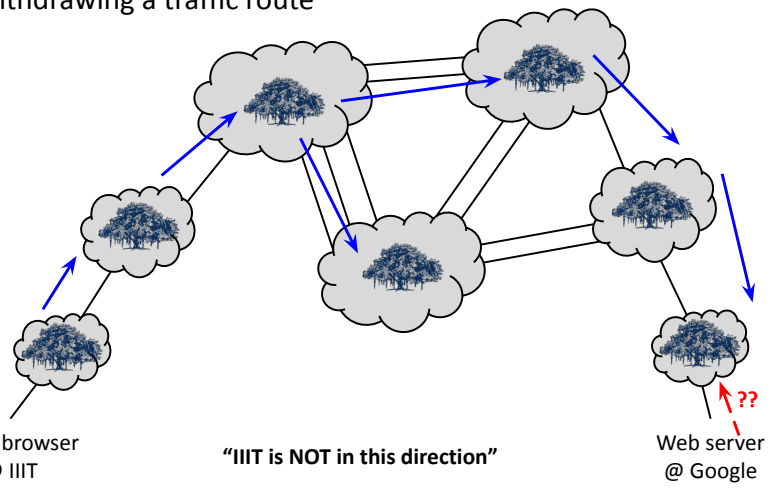
What is Internet?

- Forwarding traffic



What is Internet?

- Withdrawing a traffic route



What is Internet?

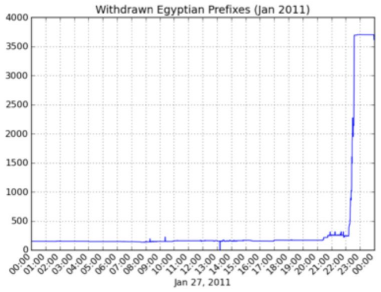
- Withdrawing a traffic route

renesys | blog

Egypt Leaves the Internet

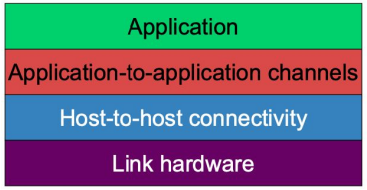
By James Cowie on January 27, 2011 7:56 PM

At 22:34 UTC (00:34am local time), Renesys observed the virtually simultaneous withdrawal of all routes to Egyptian networks in the Internet's global routing table. Approximately 3,500 individual BGP routes were withdrawn, leaving no valid paths by which the rest of the world could continue to exchange Internet traffic with Egypt's service providers. Virtually all of Egypt's Internet addresses are now unreachable, worldwide.



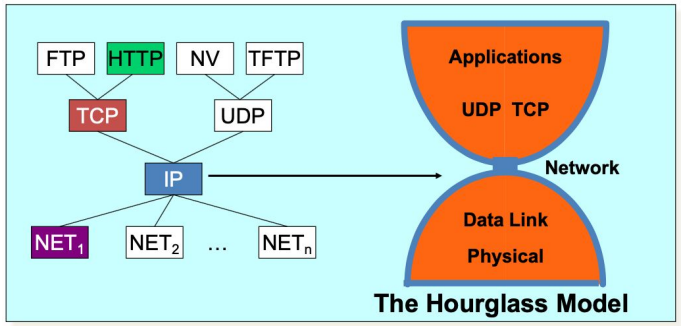
Key concepts in networking

- Abstraction through protocol layering
  - Layers partition system
    - Each layer **solely** relies on services from layer below
    - Each layer **solely** exports services to layer above
  - Interface between layers defines interaction
    - Hides implementation details
    - Layers can change without disturbing other layers



Key concepts in networking

- Internet Protocol (IP) suite
  - Thin Network layer facilitates interoperability



Key concepts in networking

- Application: HyperText Transfer Protocol

```
GET /path/to/resource/ HTTP/1.1
Host: www.cs.xyz.edu
User-Agent: Mozilla/5.0
CRLF
```

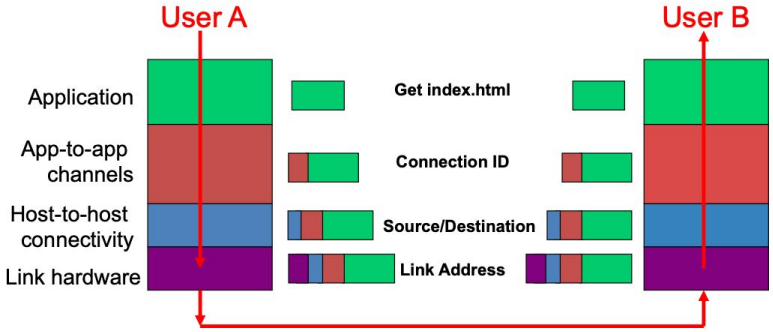
Request

Response

```
HTTP/1.1 200 OK
Date: Wed, 11 Aug 2021 09:28:28 GMT
Server: Apache/2.4.41
Last-Modified: Fri, 06 Aug 2021 04:46:59 GMT
Content-Length: 23
CRLF
Site under construction
```

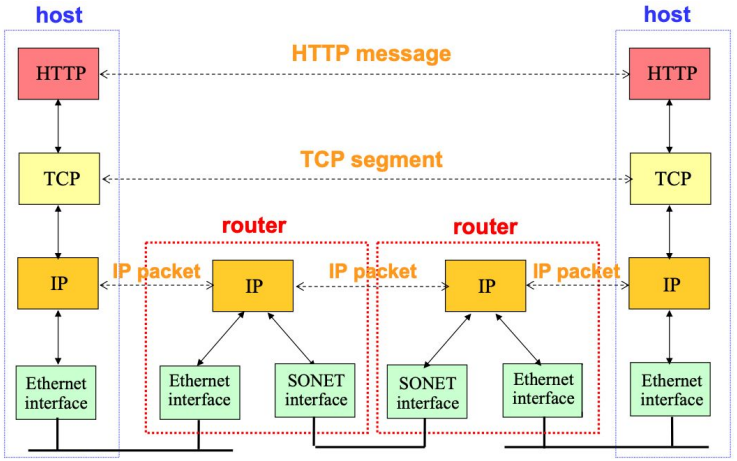

Key concepts in networking

- Layer encapsulation in HTTP



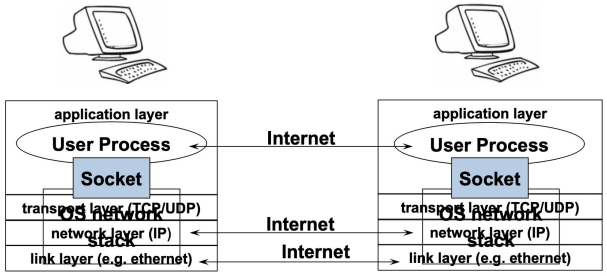
Key concepts in networking

- End hosts vs router



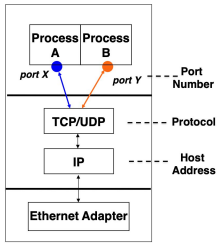
Key concepts in networking

- Socket and process communication
  - Interface that OS provides to its networking subsystem



Key concepts in networking

- Socket and process communication
  - Receiving host
    - Destination **address** that uniquely identifies host
      - IP address: 32-bit (“1.2.3.4”)
  - Receiving socket
    - Host may be running many different processes
      - Destination **port** that uniquely identifies socket
        - Port number: 16-bit (“80”)

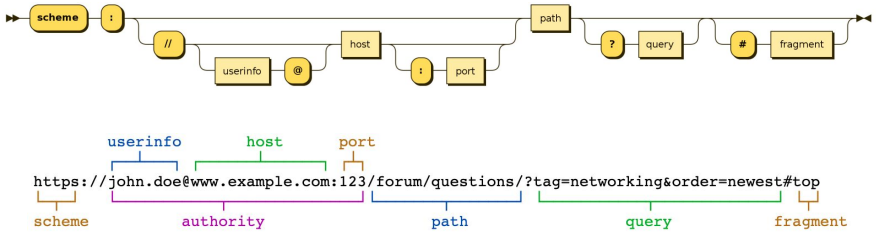


Key concepts in networking

- Central concepts
  - Naming
    - What to call computers, services, protocols, etc.
  - Layering
    - Abstraction is key to managing complexity
  - Protocols
    - Speaking same language
      - Syntax and semantics
  - Resource allocation
    - Dividing scare resources among competing parties
      - Memory, link bandwidth, wireless spectrum, paths

Key concepts in networking

- Uniform Resource Identifier (URI)
  - Unique sequence of characters
    - Identifies a logical or physical resource used by web
      - Real-world objects (e.g., people, places)
      - Information resources (e.g., webpages, books)
  - Syntax
    - `URI = scheme:[//authority]path[?query][#fragment]`
      - `authority = [userinfo@]host[:port]`

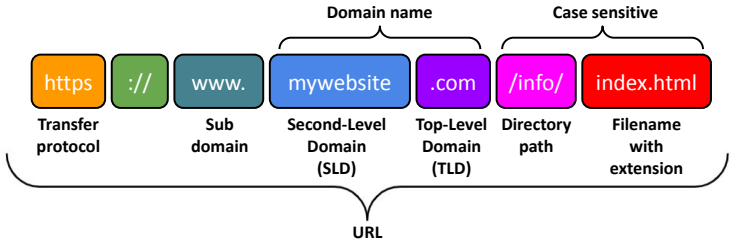


Key concepts in networking

- Uniform Resource Name (URN)
  - Type of URI
  - Provide only a unique name
    - Without means of locating/retrieving resource/information
  - URN identifies an item, e.g., ISBN of a book

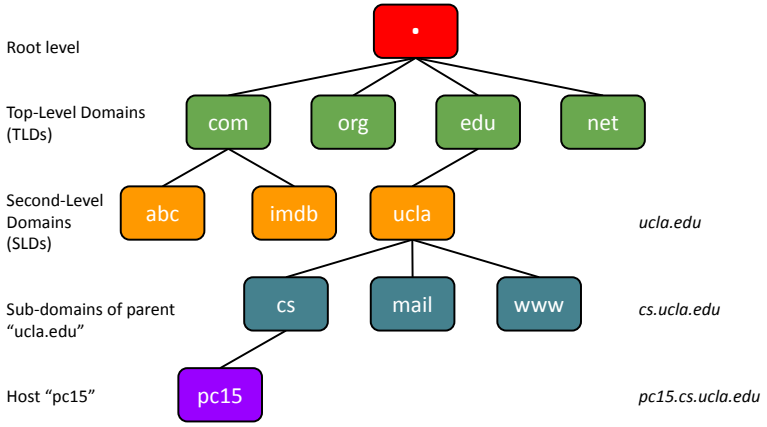
Key concepts in networking

- Uniform Resource Locator (URL)
  - Type of URI
  - Provide means of locating/retrieving resources/information
  - URL provides a method for finding resources/information, e.g., web



Key concepts in networking

- Domain Name System (DNS)
  - Serves as phone book for Internet
    - Translate human-friendly computer hostnames into IP addresses

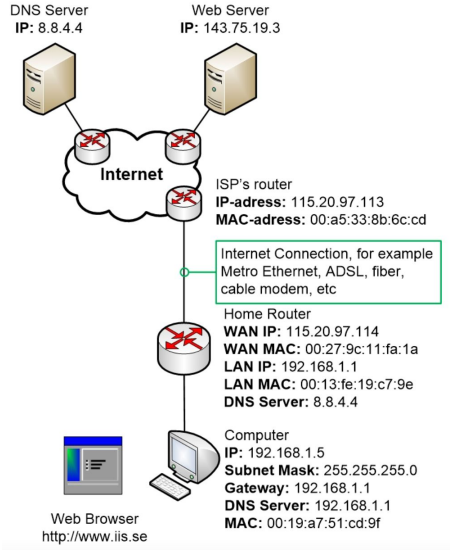


Key concepts in networking

- Dynamic Host Configuration Protocol (DHCP)
  - A server service that dynamically assigns, or leases, IP addresses and related IP information to network clients
  - Each client gets
    - Unique IP address
    - Subnet mask
    - Default gateways
    - Domain Name System (DNS) server addresses

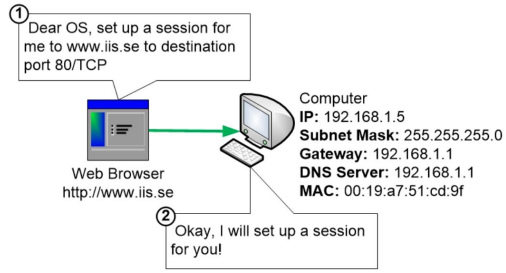
How does Internet work?

0. Sample setup



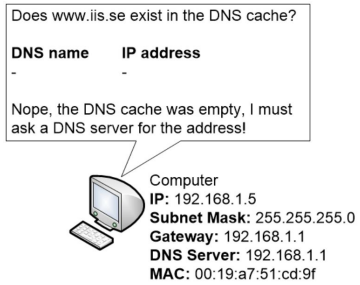
How does Internet work?

1. Computer wants to send traffic



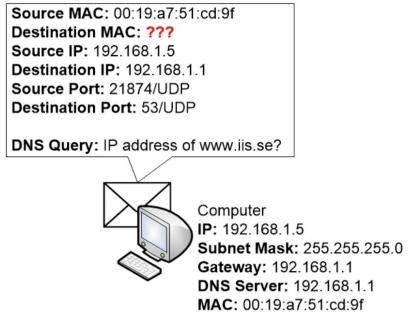
How does Internet work?

2. DNS
   a. DNS cache



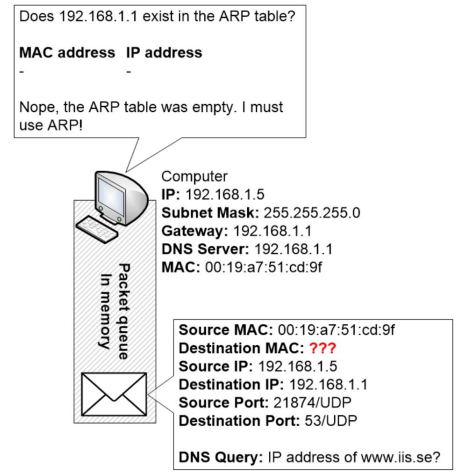
How does Internet work?

2. DNS
   b. Putting a DNS query together



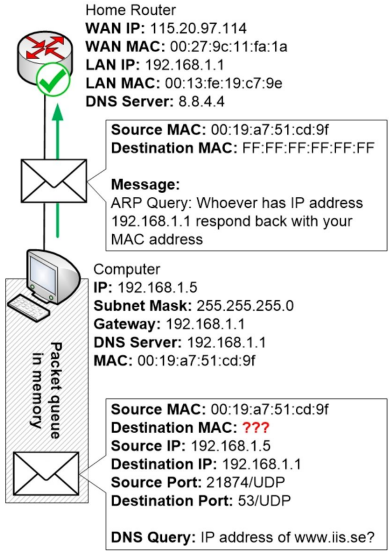
How does Internet work?

2. DNS
   c. Check ARP table for a valid MAC address



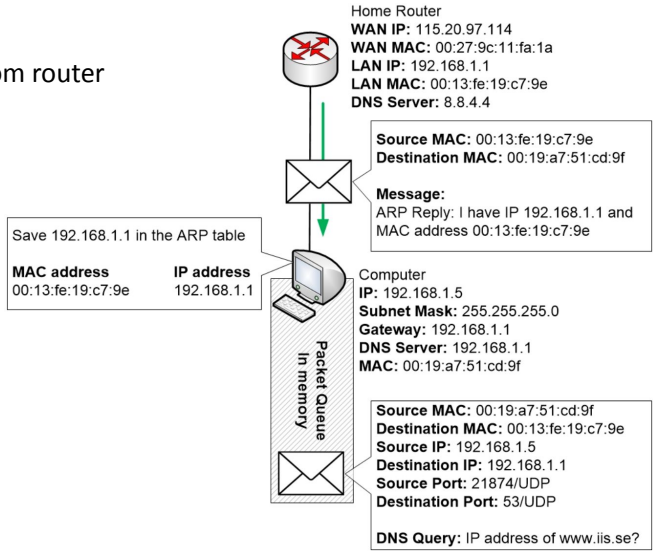
How does Internet work?

2. DNS
   d. ARP request to network



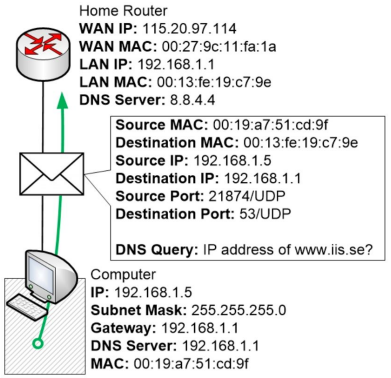
How does Internet work?

2. DNS
   e. ARP reply from router



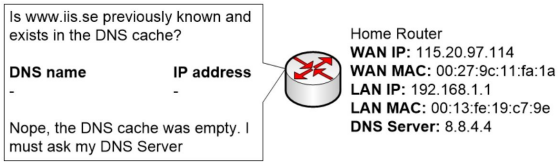
How does Internet work?

2. DNS
   f. Send off DNS query



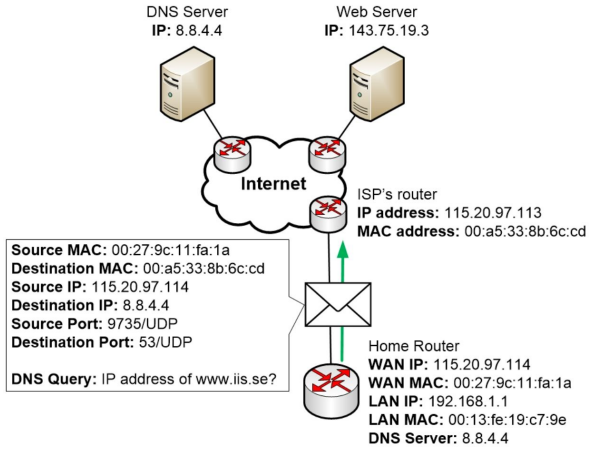
How does Internet work?

2. DNS
   g. Home router checks its DNS cache



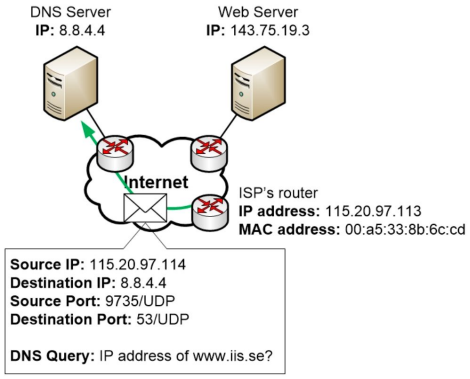
How does Internet work?

2. DNS
   h. Home router prepares and sends away its DNS query



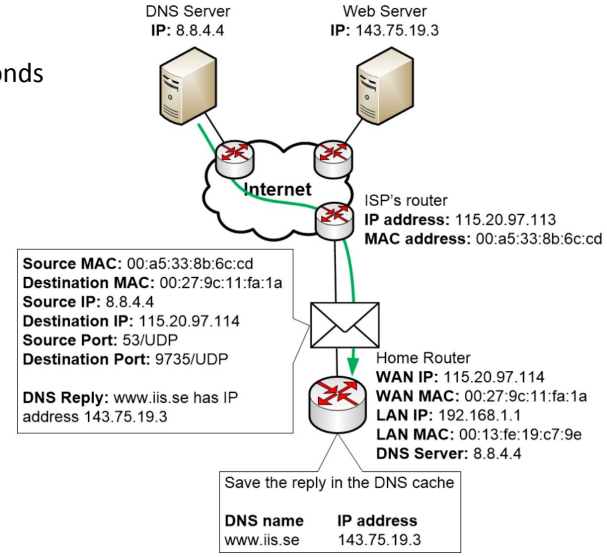
How does Internet work?

2. DNS
   i. DNS query is routed over Internet



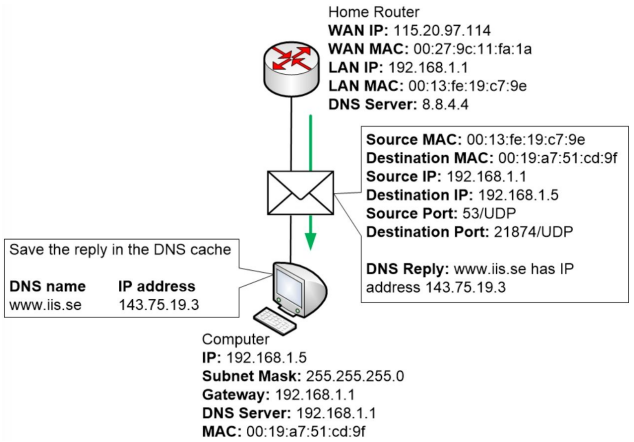
How does Internet work?

2. DNS
   j. DNS server responds



How does Internet work?

2. DNS
   k. Home router can send a DNS reply to computer

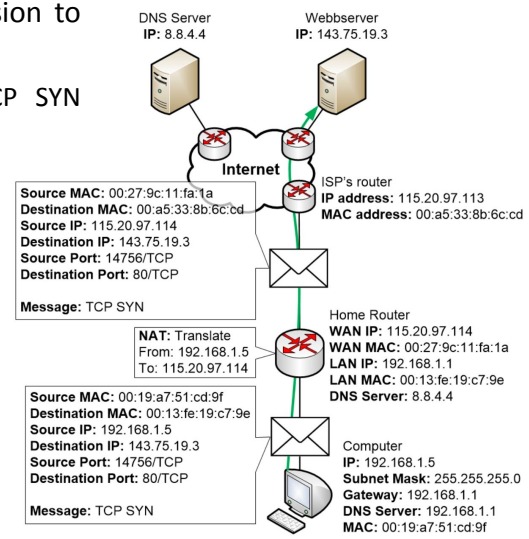


How does Internet work?

3. Computer sets up a session to www.iis.se
   - Initialize TCP 3-way Handshake

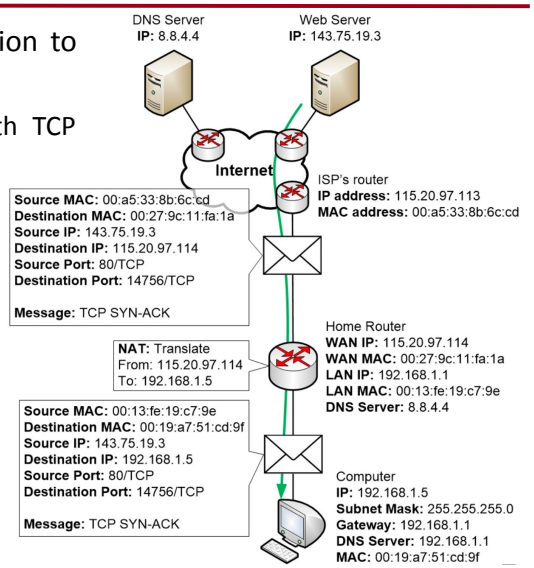
How does Internet work?

3. Computer sets up a session to www.iis.se
   a. Computer sends a TCP SYN message



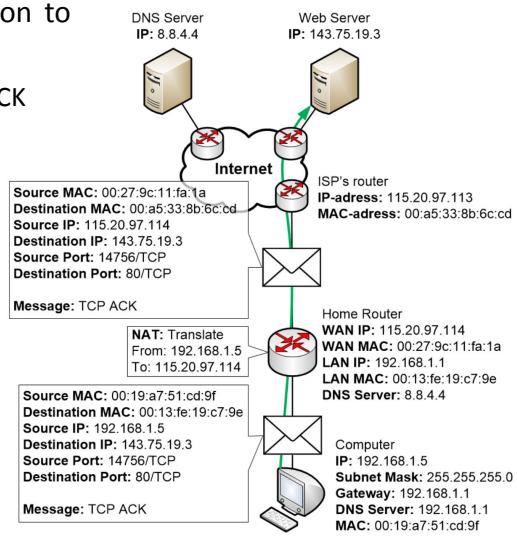
How does Internet work?

3. Computer sets up a session to www.iis.se
   b. Web server replies with TCP SYN-ACK



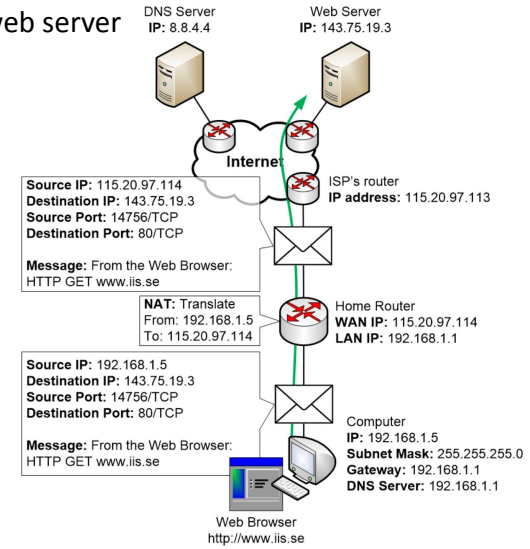
How does Internet work?

3. Computer sets up a session to www.iis.se
   c. Computer sends a TCP ACK



How does Internet work?

4. Web browser talks with web server



Summary and conclusions

- Growth/innovation vs create/exacerbate tensions
  - Does Internet design prevent misuse?
    - Which of following is true
      - (A) When connecting to network, individual endpoints can only use addresses given to them
      - (B) Individual endpoints can “spoof” any IP address

Summary and conclusions

- Growth/innovation vs create/exacerbate tensions
  - Central authority IANA assigns unique IP address blocks to networks
    - Which of following is true
      - (A) Networks can only announce assigned addresses
      - (B) Networks can spoof any address

Summary and conclusions

- Growth/innovation vs create/exacerbate tensions
  - Does Internet provide reliable packet delivery?
    - Which of following is true
      - (A) Yes, it's necessary for protocols like HTTP that require in-order streams
      - (B) No, packets can be arbitrarily dropped or reordered

Thank you!