Internet Topology and Terminology

Rick Lamb
German Valdez
Bill Woodcock
Introductions
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**Bill Woodcock:** Research director at Packet Clearing House, ARIN board member, and past network architect at Zocalo, a global ISP based in California.
Introductions

What is the Internet?
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What is the Internet?

Internet: The network of networks. The proper-noun, capital-I Internet is the network of all networks which provide global end-to-end Internet Protocol connectivity between their nodes.

internet: Any set of interconnected networks. A lower-case-i internet doesn’t necessarily use Internet Protocols, nor need it be interconnected with the Internet. No longer in widespread use.
How the Internet Works

Rick Lamb
Bill Woodcock
Web Browsing: An Example

When we type a URL, or Uniform Resource Locator, into a browser window, how does the Internet provide us with a web page?
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Uniform Resource Locator: A URL consists of a “scheme” or protocol by which a resource can be contacted or retrieved, followed by an address or “network location.” In addition to web pages, URLs can encode addresses for email, voice and video communications, and other network resources.
Extracting the Domain Name from the URL

The URL contains a “domain name” which will is our computer’s clue where to find the web page we’re looking for.

http://www.isoc.org
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HTTP, or HyperText Transfer Protocol, is an IETF standard for transporting web pages and other objects across the Internet.

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The fully-qualified domain name “www.isoc.org” identifies the location on the Internet where this web page can be found.
Parsing the Domain Name

That domain name, in turn, consists of several parts.

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“org” is a “generic top level domain” or gTLD which is available for the use of noncommercial organizations anywhere in the world.

http://www.isoc.org
Parsing the Domain Name

That domain name, in turn, consists of several parts.

"isoc" in the "second level" of this domain name is identifying an organization which possesses its own named domain.
Parsing the Domain Name

That domain name, in turn, consists of several parts.

“www” in the “third level” of this domain name, as read right-to-left, is identifying a named service, in the case, a World Wide Web service.
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Top Level Domain: The most common types of TLDs are “Generic” and “Country Code.” gTLDs like .com, .net, and .org, are available globally, while ccTLDs like .ar (Argentina) and .za (South Africa) are administered nationally. New top level domains are formed through an ICANN administrative process.
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Internationalized Domain Names: But what if a name contains accented characters, or is written in a non-roman script? IDNs allow faithful representation of other languages in some second-level domains today, and will likely be possible in top-level domains in the future.
Resolving the Domain Name to an Internet Address

Just like the user of a 20th-century telephone needed to look up the name of the person they wanted to call in a telephone book to find a telephone number to dial to complete the call, our computer needs to resolve the domain name found in the URL to a numeric Internet Protocol address in order to address the packet which will contain the query for the web page.
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Resolve: Resolution is the process of converting a human-readable domain name to a machine-readable Internet Protocol address, or vice-versa.
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Internet Protocol Address: an IP version 4 address is a 32-bit binary number which a computer uses to identify a destination on the Internet. IPv4 addresses are usually written in “dotted quad” notation, like this: 206.131.241.137.

There are about 4.3 billion IPv4 addresses, and one is needed for each Internet-connected computer, so in 1996 the Internet Engineering Task Force defined IP version 6, which has \(2^{128}\)th addresses, or 100,000,000,000,000,000,000,000,000,000 times more than IPv4.
Resolving the Domain Name to an Internet Address

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Packet: The smallest unit of communication sent across the Internet, a packet is like an envelope: it has the IP addresses of the sender and recipient on the outside, and it contains a message encoded in binary ones and zeros. Very simple transactions may only require a single packet in each direction and complete in a few milliseconds, while complex ones may require millions and take hours or days.
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Query: A message which usually originates with a human requesting something like a web page. A query is usually a very small packet containing a simple “question” like “give me your web page,” which may result in a much larger reply, containing text, images, or video.
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Resolving the Domain Name to an Internet Address
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The Nearest Root Nameserver

Our ISP’s Recursive Resolver DNS Server

Domain Name lookup to resolve www.isoc.org

Our Computer
Resolving the Domain Name to an Internet Address

Our Computer

Our ISP’s Recursive Resolver DNS Server

The Nearest Root Nameserver

DNS lookup www.isoc.org

Reply with IP address of .org nameserver

The Public Interest Registry’s .org Nameserver
Resolving the Domain Name to an Internet Address

Our Computer

Our ISP’s Recursive Resolver DNS Server

DNS lookup www.isoc.org

The Internet Society’s isoc.org Nameserver

The Public Interest Registry’s .org Nameserver

The Nearest Root Nameserver

Reply with IP address of isoc.org nameserver
Resolving the Domain Name to an Internet Address

Our Computer

The Nearest Root Nameserver

The Public Interest Registry’s .org Nameserver

The Internet Society’s isoc.org Nameserver

Our ISP’s Recursive Resolver DNS Server

DNS lookup www.isoc.org

Reply with IP address of www.isoc.org web server

The Internet Society’s www.isoc.org Web Server
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The Nearest Root Nameserver

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Our ISP’s Recursive Resolver DNS Server

Reply with IP address of www.isoc.org web server

Our Computer

The Internet Society’s www.isoc.org Web Server
Resolving the Domain Name to an Internet Address

The Nearest Root Nameserver

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The Public Interest Registry’s .org Nameserver

The Internet Society’s isoc.org Nameserver

Our Computer

The Internet Society’s www.isoc.org Web Server
Now We’re Ready to Request the Web Page...

Our Computer

The Nearest Root Nameserver

The Public Interest Registry’s .org Nameserver

Our ISP’s Recursive Resolver DNS Server

The Internet Society’s isoc.org Nameserver

The Internet Society’s www.isoc.org Web Server
Now We’re Ready to Request the Web Page...

...but how do the packets get back and forth?
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…but how do the packets get back and forth?

Routing: The decision-making process by which data packets are forwarded through a branching network. At each fork, each packet is routed in a direction which will take it nearer to its destination.
Now We’re Ready to Request the Web Page…

…but how do the packets get back and forth?
The Topology of the Internet

User ("Eyeballs")

Red ISP

Internet Exchange Point West

Internet Exchange Point East

Green ISP

Server ("Content")

Transit

Peering
The Topology of the Internet

Transit: A transaction in which one party purchases the right to send data to any location on the Internet via the other party’s network. Transit is how traffic is moved between ISPs and their customers, who may be users, or may be smaller ISPs.
The Topology of the Internet

**Peering**: An interconnection between two parties such that each can exchange traffic with the customers of the other at no cost. Internet bandwidth is produced by peering between ISPs, and it is transported to users via transit.
The Topology of the Internet

User ("Eyeballs")

Red ISP

Internet Exchange Point West

Green ISP

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Server ("Content")
The Topology of the Internet

User ("Eyeballs")

Red ISP

Internet Exchange Point West

Green ISP

Internet Exchange Point East

Server ("Content")
Hot Potato Routing

User ("Eyeballs")

Red ISP

Internet Exchange Point West

Transit

Green ISP

Internet Exchange Point East

Server ("Content")
Hot Potato Routing

User (“Eyeballs”) -> Red ISP -> Internet Exchange Point West -> Green ISP

Green ISP -> Internet Exchange Point East

Server (“Content”)
Hot Potato Routing

User ("Eyeballs")

Internet Exchange Point West

Red ISP

Green ISP

Internet Exchange Point East

Server ("Content")
Hot Potato Routing

Red ISP

Internet Exchange Point West

Transit

Green ISP

Internet Exchange Point East

Server

("Content")

User

("Eyeballs")
Hot Potato Routing

User ("Eyeballs")

Red ISP

Internet Exchange Point West

Green ISP

Internet Exchange Point East

Server ("Content")
Hot Potato Routing

- Red ISP
  - Internet Exchange Point West
  - User ("Eyeballs")
- Green ISP
  - Internet Exchange Point East
  - Server ("Content")

Transit flows between Red ISP and Green ISP.
Hot Potato Routing

Red ISP

Internet Exchange Point West

Green ISP

Internet Exchange Point East

Server ("Content")

User ("Eyeballs")

Transit

Transit
“Bill and Keep”
Symmetry

Red ISP

Internet Exchange Point West

Green ISP

Internet Exchange Point East

Server ("Content")

Transit

User ("Eyeballs")
Symmetry

Internet Exchange Point West

Red ISP

Green ISP

Internet Exchange Point East

Server ("Content")

User ("Eyeballs")

Transit
The Internet Governance Organizations

German Valdez
Protocol Definition

**IETF**: the Internet Engineering Task Force meets in person three times each year, and operates continuously online, to collectively define the open protocols by which Internet users are able to transparently communicate with each other.

**IESG**: the Internet Engineering Steering Group consists of the Area Directors of the IETF, who are together responsible for the IETF’s day-to-day functioning and productivity.

**IAB**: the Internet Architecture Board is a body of experts across the spectrum of Internet technical knowledge, who provide guidance and oversight of the IETF work-product.
Operational Standards

NOGs: the Network Operations Groups each meet one to three times a year locally or regionally to share technical knowledge and coordinate operational activities.

- **NANOG**: the North American Network Operations Group
- **SANOG**: the South Asian Network Operations Group
- **MENOG**: the Middle East Network Operations Group
- **NZNOG**: the New Zealand Network Operators Group... etc.

**Exchange Point Operations:**
- Regional meetings: **NAPLA, Euro-IX, APIX**
- Annual membership meetings of each IXP

**IEPG**: the Internet Engineering Planning Group meets three times a year, as a global forum for sharing operational knowledge.
User Advocacy

**ISOC:** the Internet Society consists of local chapters throughout the world, formed through a bottom-up process to represent end-users in the policy-making and regulatory processes.

**ONI:** the OpenNet Initiative is an independent monitor of censorship and transparency in the Internet, protecting end-to-end connectivity.
Uniquely-Assigned Identifiers

**IANA**: the Internet Assigned Numbers Authority is the root of the delegation hierarchy which maintains uniqueness in domain names, IP addresses, autonomous system numbers, and protocol identifiers. The IANA’s operations are defined by the **IAB** via **IETF RFC** standards documents. The IANA delegates specific functions to resource-specific **registries**.

**ICANN**: the Internet Corporation for Assigned Names and Numbers is the community-driven organization that hosts the IANA function.
IP Addresses and ASNs

RIRs: the five Regional Internet Registries are the fora in which Internet users and service providers set addressing policy and share constrained number resources.

- **LACNIC**: the Latin American and Caribbean Network Information Center
- **AfriNIC**: the African Network Information Center
- **RIPE NCC**: Réseaux IP Européens Network Coordination Centre
- **ARIN**: the American Registry for Internet Numbers
- **APNIC**: the Asia-Pacific Network Information Center

NRO: the Number Resource Organization is the coordination body which allows the five Regional Internet Registries to act as a global collective.

- **ASO AC**: the Address Supporting Organization Advisory Council represents the NRO to ICANN, and selects one ICANN board member.
Operational Support

**NSRC**: the Network Startup Resource Center provides training materials to people who are connecting their communities to the Internet.

**PCH**: Packet Clearing House provides operational support and services for the critical infrastructure at the core of the Internet; IXPds and the Domain Name System.

**FIRST**: the Forum of Incident Response and Security Teams coordinates Internet emergency responders around the world.
Discussion
Thank You.

Rick Lamb    richard.lamb@icann.org
German Valdez  german@apnic.net
Bill Woodcock  woody@pch.net