HOW THE INTERNET WORKS AND THE IMPACT ON AMATEUR VoIP TECHNOLOGIES: QoS, PEERING, AND TRANSIT AGREEMENTS

By

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Echolink

Allstar

D-STAR

YAESU System Fusion
The radio

AMATEUR RADIO
DMR
DIGITAL MOBILE RADIO
WORLDWIDE NETWORKS

THE EARLY INTERNET

- In the beginning there was one Internet funded by DARPA (Defense Advance Research Projects Agency) known as the ***ARPANET***. This can be traced back a concept put forward by J.C.R. Lickliter of MIT in August 1962 called the

Galactic Network.

J.C.R Lickliter

- Vender neutral network.
- Under contract with DARPA, BBN (Bolt, Beranek and Newman) installed the first connection in September 1969 at UCLA. A month later SRI (Stanford Research Institute) was connected and the first computer-to-computer exchange took place over the ARPANET.

FEDERAL NETWORKING COUNCIL (FNC) DEFINITION OF THE INTERNET

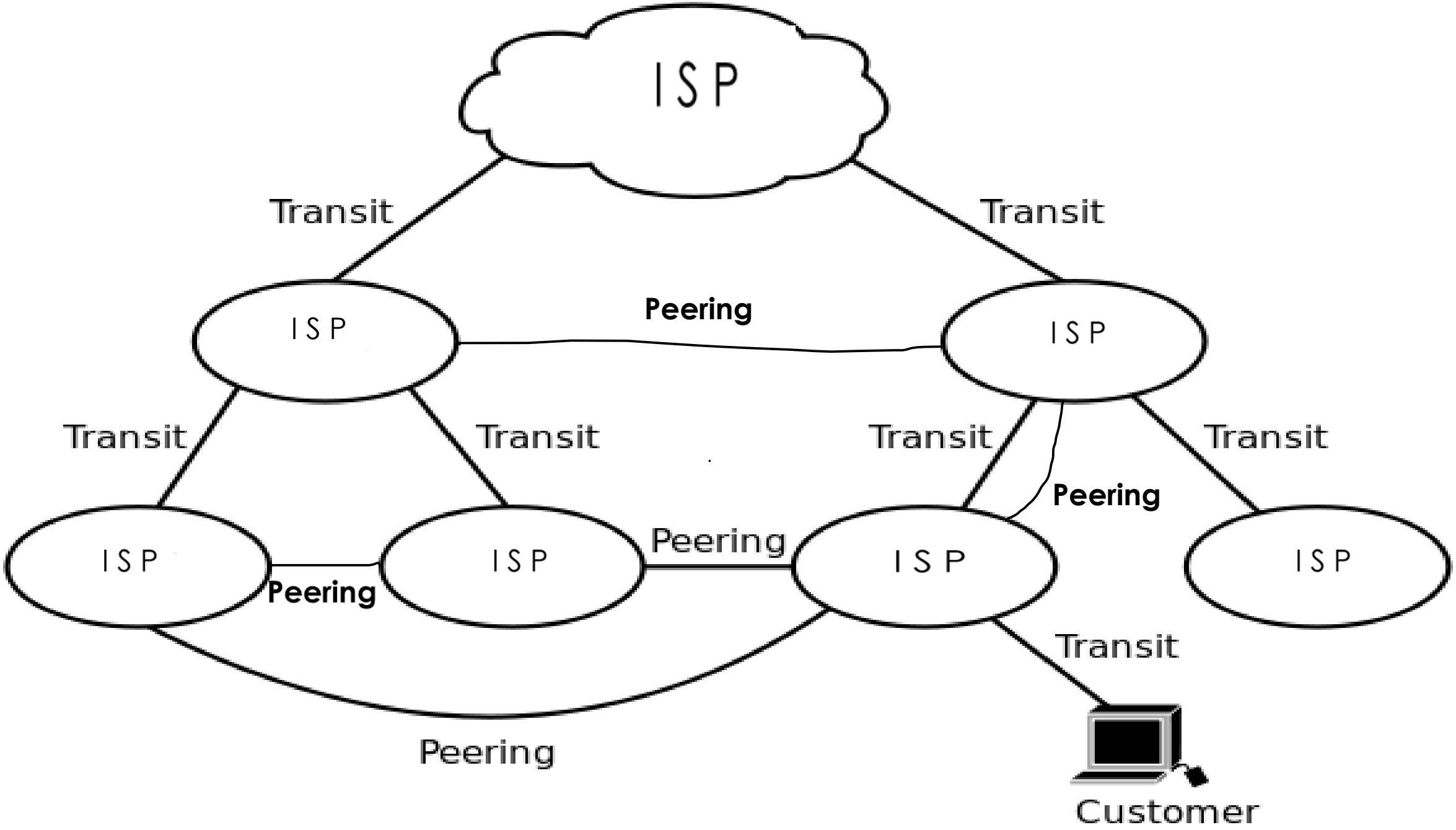
- The ***Internet*** refers to the global information system that —
  (i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;
  (ii) is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, and/or other IP-compatible protocols;
  (iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein.

THE INTERNET TODAY

- Today there are multiple ***Internets*** operated by different ISPs (Internet Service Providers) servicing regional, national, and global markets.
- These ***Internets*** are interconnected for the exchange of traffic between providers (ISPs)using both peering and transit agreements.

PEERING AND TRANSIT AGREEMENTS

- **Peering:** when two Internet providers have a mutual need to exchange traffic between end points on each other's network they enter into a Peering agreement for interconnect without additional cost beyond the physical interconnection.
- **Transit:** when an Internet provider agrees to transport traffic that is not terminating at one of their endpoints they require a Transit agreement which requires the payment of fees beyond the cost of the physical interconnection.


ISP
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Customer

TCP/IP PROTOCOLS

- TCP/IP is a suite of protocols. The main transport protocols are TCP and UDP.
- IP (Internet Protocol): Logical addressing scheme for devices. IPv4 utilizes a 32-bit binary number, IPv6 uses a 128-bit binary number. The Internet is transitioning to IPv6. IP is a routed protocol.
- TCP (Transmission Control Protocol): utilizes acknowledgements to confirm delivery of the traffic, and windowing control. Non-delivery will result in retransmission.
- UDP (User Datagram Protocol): is a best effort with no confirmation of delivery of traffic.

IP PROTOCOL AND ROUTING

- The IP networks uses the destination address to determine where to route the traffic next typically using Routers (Layer 3 devices).
- Routers exchange their view of the network using routing protocols (such as EIGRP, OSPF, ISIS, and BGP) to build a routing table to make forwarding decisions.
- An Autonomous System (AS) is a group of one or more IP prefixes run by one or more network operators which has a SINGLE and CLEARLY DEFINED routing policy. [RFC 1930]
- On the Internet, routes are exchanged between autonomous systems using BGP (Border Gate Protocol) which is an exterior gateway protocol.
- The best route through the Internet is the one that passes through the least number of autonomous systems.

QoS (QUALITY OF SERVICE)

- In computer networking QoS refers to traffic prioritization and resource reservation control mechanisms rather than the achieved service quality. QoS is the ability to provide different priority to different applications, users, or data flows or to guarantee a certain level of performance to a data flow.

- On the Internet, there is no QoS between ISP networks. Providers may drop different types of traffic (typically UDP) when there is network congestion.

VoIP: VOICE OVER INTERNET PROTOCOL

- VoIP utilizes the conversion (vocoding) of analog voice into a digital data stream typically including compression; transporting the data stream over an IP network using the UDP protocol.
- In the amateur radio community, we use a variety of protocols for transporting the digital data stream over radio, including DMR, D-Star, P25, NXDN, and Fusion.
  - The amateur network access points (Repeaters and Hot Spots) then convert the traffic for transport over the Internet.
  - Some amateur applications such as Echolink do not require a radio link to access their network. They allow the vocoding of analog audio into a digital data stream from a microphone or audio source directly connected to a computer.

VoIP NETWORK ISSUES

- VoIP quality degrades for a number of reasons including:
  - Vocoder compression
  - Jitter
  - Delay
  - Buffer runout
  - Dropped packets
- In amateur radio applications the RF link is an additional point of errors.
- Since VoIP uses UDP for transport there is a big issue of dropped packets by the ISPs.

WHY DO ISPs DROP PACKETS?

- Limited bandwidth available on infrastructure ports. Bandwidth cost money!
- Traffic can be divided based upon packet size, protocols including TCP, UDP; source and/or destination address.
- HTTP/HTTPS traffic and email use TCP for transport, if a TCP packet is dropped, it will cause the sending node to resend the packet which results in increased traffic.
- VoIP and streaming multimedia use UDP for transport. If a UDP packet is dropped, it is not retransmitted by the sending node and the receiving node application is typically designed to handle a minimum loss of packets.

- Bandwidth costs more as you connect closer to the core backbones.
  - An ISP may sell 1-Gigabit connections to a thousand end users, they would need 1-Terabit bandwidth to be able to supply full bandwidth to each of their customers. More likely they only have a few gigabits or less bandwidth to other ISPs. This is because it is assumed the individual customers will only need bursts of bandwidth and not continuous peak utilization of the connection. Users share the available bandwidth.
- ISPs that do not operate their own backbones nor have peering agreements with the destination ISP must purchase transit bandwidth from other ISPs to carry the traffic as a 3rd party.
- Backbone providers have peering and transit agreements with other backbone providers to service their customer needs.
- The increase use of streaming media has been putting peak loads on ISP networks, resulting in increased UDP packets being dropped.

THE INTERNET IS A PYRAMID SCHEME!

HOTSPOTS

- A HotSpot like a repeater is a bridge between the RF interface and the Internet interface.
- Most HotSpots use WiFi for their Internet connection, this increases BER (Bit error rate) which can result in corrupt packets. Some use WiFi to interface to cellphones for their Internet connection which increases the probability of errors.
- Using a DMR radio close to another RF device (WiFi, cellular, etc.) can result in front end overload and can also cause issues with microprocessors if not properly shielded especially in near field situations.
  - Do not operate your DMR radio in the near field of other RF devices (WiFi, cellular, etc.)
- If you are using a HotSpot with a non-metal case consider upgrading to a metal case.

HOTSPOTS

- Every time a UDP packet passes through a router (Layer 3) or bridge (Layer 2) there is a chance the UDP packet will be dropped or delayed because of congestion on the device or network bandwidth.
- Servers (Brandmeister, c-Bridge, IPSC2, etc.) add additional latency and can also drop UDP packets because of congestion.
- Connections between servers, repeaters and Hotspots are unidirectional; traffic in one direction can block traffic in the other direction not only for a single user but also many users.
  - This is why PTT Talk Groups can cause problems especially for Nets; if possible configure a TG used for a Net as NOT PTT for the duration of the Net.
- If you are connecting to BM for the TG3113 GA Net, consider using the BM3102 server as it is the one that feeds a number of other networks (DMRX, K4USD, etc.)

Questions??

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