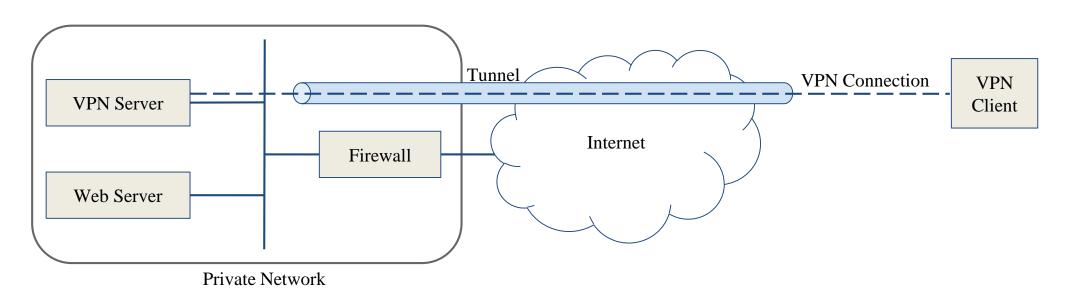
# VPN Virtual Private Network

#### Introduction

- Uses public telecommunication channels, such as the Internet or other network service, instead of leased lines channels.
- Described as Virtual because it is distant connection using private connections.
- Used to widely now because of today's globalization.
- Connects users or branches.
- Used to use dial-up or Leased communication, now using IP-VPN's

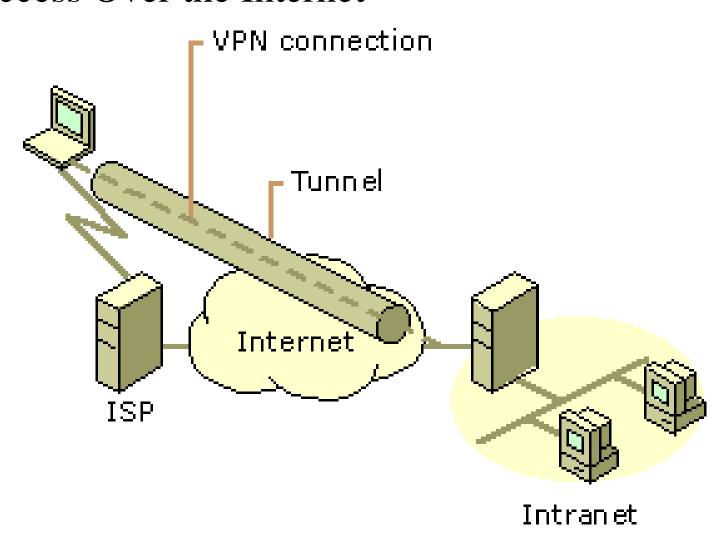
#### What is VPN

- Extension of a private network that encompasses links across shared or public networks like the Internet.
- Enable to send data between two computers across a shared or public internetwork in a manner that emulates the properties of a point-to-point private link.



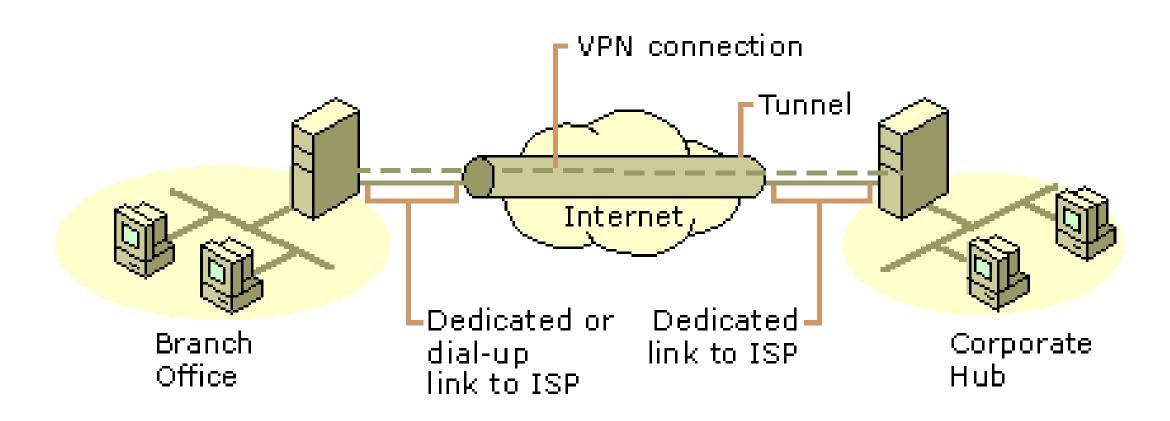
#### Common Uses of VPNs (1/3)

1. Remote Access Over the Internet



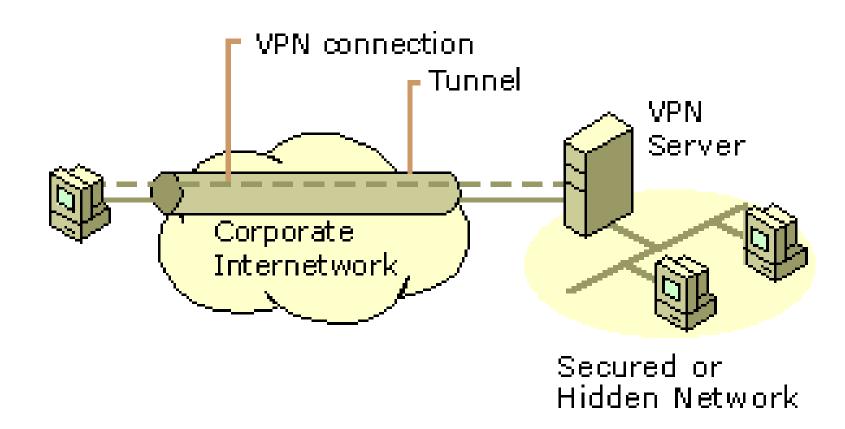
## Common Uses of VPNs (2/3)

2. Connecting Networks Over the Internet (Site to Site VPN)



#### Common Uses of VPNs (3/3)

3. Connecting Computers over an Intranet (similar to 1.)



# Why Use VPN?

#### Cheap

• Legacy private network uses remote connectivity through dial-up modems or through leased line connections, it's expensive.

#### Scalable

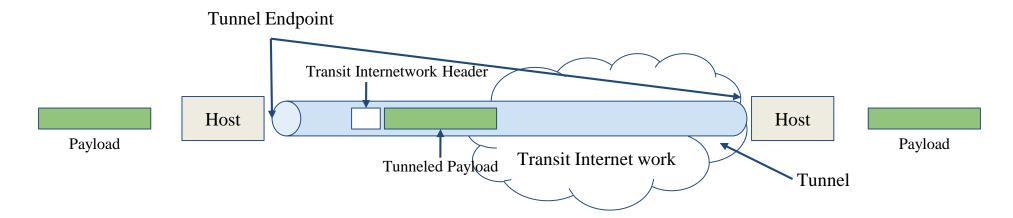
- Extending a leased line connection is complex.
- Easy to administer.

#### Security

o Provide encryption and file integrity.

# VPN Key Concept - Tunneling

- VPN consists of a set of point to point connections tunneled over the Internet.
- In order to achieve tunneling, the packets are encapsulated as the payload of packets.
  - Payloads, to and from addresses, port numbers and other standard protocol packet headers
  - As seen by the external routers carrying the connection



#### **Basic VPN Requirements**

- User Authentication
- Key Management
- Address Management
- Data Encryption

#### Basic VPN Requirements (1/2)

- User Authentication
  - Verify the VPN client's identity and restrict VPN access to authorized users only.
  - Provide audit and accounting records to show who accessed what information and when.
  - X.509, pre-shared key, etc.
- Key Management
  - Generate and refresh encryption keys for the client and the server.
  - Simple Key Management for IP: ISAKMP/Oakley, etc.

#### Basic VPN Requirements (2/2)

- Address Management
  - Assign a VPN client's address on the intranet and ensure that private addresses are kept private
- Data Encryption
  - No one outside the VPN can alter the VPN.
  - Data carried on the public network must be rendered unreadable to unauthorized clients on the network.

### **VPN Security**

- Authentication
  - Ensuring that the data originates at the source that it claims.
- Access Control
  - Restricting unauthorized users from gaining admission to the network.
- Confidentiality
  - Preventing anyone from reading or copying data as it travels across the Internet.
- Data Integrity
  - Ensuring that no one tampers with data as it travels across the Internet.

#### Common Implementations

- Based on PPP
  - Point-to-Point Tunneling Protocol (PPTP) (PPP + encryption + GRE)
  - Layer Two Tunneling Protocol (L2TP) (PPTP + L2F)
- Based on TCP/IP
  - L2TP/IPsec
  - IPsec Tunnel mode [RFC 4301]
  - BGP/MPLS IP VPN [RFC 4364]
- SSL/TLS
  - Secure Socket Tunneling Protocol (<u>SSTP</u>) (PPTP + SSL)
  - SSL VPN
  - OpenVPN

#### PPP - Point-to-Point Protocol

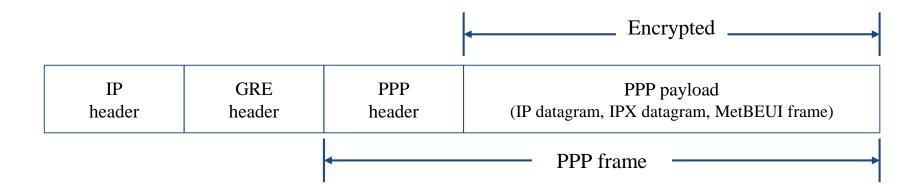
- PPP [RFC 1661] provides a standard method for transporting multi-protocol datagrams over point-to-point (direct) links.
  - Data link layer (layer 2) protocol
- Three components
  - Encapsulation (for transporting purpose)
  - Link Control Protocol (for data-link connectability)
  - Network Control Protocols (NCP) family (L3 management support)
- Extra Options
  - o Authentication: <u>PAP</u>, <u>CHAP</u>, <u>EAP</u>, <u>MS-CHAP</u>, <u>MS-CHAPv2</u>, etc.
  - Link Quality and error detection
  - Compression
  - Encryption: <u>MPPC</u> + <u>MPPE</u>, etc.
  - Multilink (MP, The PPP Multilink Protocol)

# **Tunneling Protocol**

- Allows a network user to access or provide a network service that the underlying network does not support or provide directly. (Wikipedia)
- GRE (Generic Routing Encapsulation): Establish a virtual point-topoint connection between two networks.
  - IP as a delivery protocol
  - Virtual Tunnel: (Tunnel) IP header + GRE packet header
  - Encapsulation, not encryption
- PPTP / L2TP
- IPsec
- OpenVPN (with SSL/TLS)
- etc.

# PPTP - Point-to-Point Tunneling Protocol

- PPTP [RFC 2637] uses an enhanced GRE mechanism to provide a <u>flow- and congestion-controlled</u> (TCP) encapsulated datagram service for carrying PPP packets.
- PPTP creates a GRE tunnel through which the PPTP GRE packets are sent.

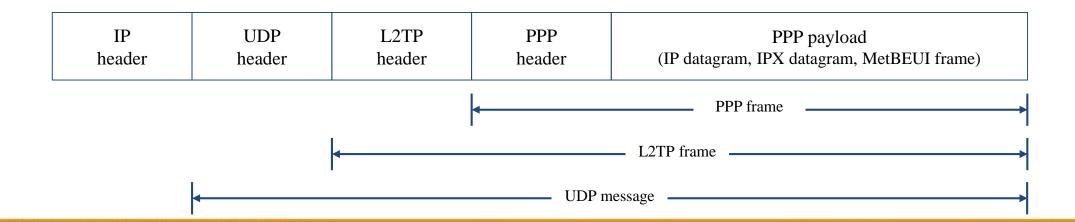


# Security of PPTP

- PPTP has been the subject of many security analyses and
- serious security vulnerabilities have been found
  - MS-CHAP is fundamentally insecure.
  - MS-CHAPv2 is vulnerable to dictionary attack on the captured challenge response packets.
- The PPP payload can be encrypted by using Microsoft Point to Point Encryption (MPPE) when using MS-CHAPv1/v2
- <u>EAP-TLS</u> (<u>Extensible Authentication Protocol</u> TLS) is the superior authentication choice for PPTP.

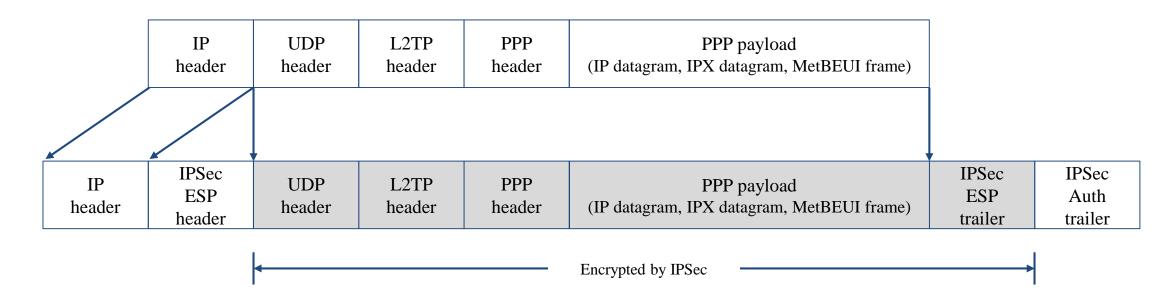
# L2TP - Layer Two Tunneling Protocol

- L2TP [RFC 2661]: PPTP + L2F (Layer Two Forwarding)
- High level protocols (e.g., PPP) establish L2TP session ("call") within the L2TP tunnel, and traffic for each session is isolated.
- A tunnel can contains multiple connections at once.
- L2TP over IP internetworks uses UDP and a series of L2TP messages for tunnel maintenance.
- <u>L2TPv3</u> provides additional security features, improved encapsulation, and the ability to carry data links other than simply PPP over an IP network. (Wikipedia)



### L2TP/IPsec

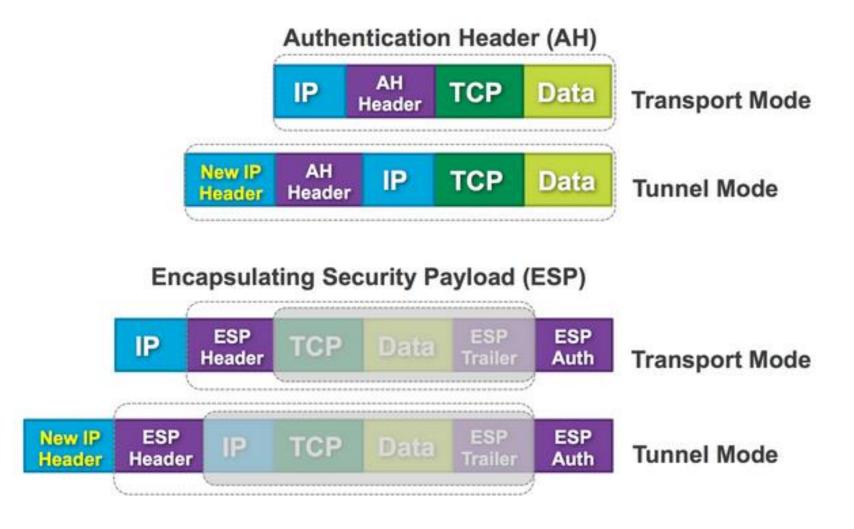
- L2TP does not provide confidentiality or strong authentication.
- Usually use **IPsec ESP** (Encapsulating Security Payload) to encrypt the L2TP packet.
  - Data encryption begins before the PPP connection process by negotiating an IPSec security association.
  - Require computer-level authentication using computer certificates.



#### **IPsec**

- IPsec [RFC 4301] is a secure network protocol suite provides authentication and encryption ability over IPv4 network.
- Two modes in IPsec
  - **Transport mode**: Insert IPsec header (AH/ESP) between IP and TCP header, then modify original IP header.
  - Tunnel mode: Encapsulate original packet, and prepend new IP and IPsec header.
- Two functions that ensure confidentiality:
  - Authentication Header (AH)
    - Provide source authentication and integrity without encryption.
  - Encapsulating Security Payload (ESP)
    - Provide both data authentication, data integrity and data encryption.
- Security Associations (SA) provides the parameters necessary for AH and/or ESP operations.
  - IKE (Internet Key Exchange): Provide authentication and key exchange. e.g., ISAKMP,
     OAKLEY

#### **IPsec Modes**



#### SSL VPN

- A form of VPN that can be used with a standard Web browser.
  - Also can be used to tunnel traffic via SSL or TLS protocol
- The traffic is encrypted with the SSL protocol or Transport Layer Security (TLS) protocol.
- Proprietary software
  - Cisco AnyConnect
  - Juniper Networks Pulse Secure
  - Fortigate
- Open Source
  - o OpenVPN

# Appendix

- I Am Anonymous When I Use a VPN 10 Myths Debunked
- Virtual Private Networking: An Overview
- <u>BeyondCorp</u> by Google: Protected connection from untrusted networks without the use of a VPN.
  - See also: Role-Based Access Control (RBAC)
- Protocol reference
  - o <u>VPN</u>
  - o <u>PPP</u> / <u>GRE</u> / <u>PPTP</u> / <u>L2TP</u>
  - o IPsec / IKE
  - IP protocol numbers