Network Access Server Requirements
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Network Access Server Requirements Next Generation (NASREQNG) NAS Model

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Abstract

This document describes the terminology and gives a model of typical Network Access Server (NAS). The purpose of this effort is to set the reference space for describing and evaluating NAS service protocols, such as RADIUS (RFC 2138, 2139)[1],[2] and follow-on efforts like AAA Working Group, and the Diameter protocol [3]. These are protocols for carrying user service information for authentication, authorization, accounting, and auditing, between a Network Access Server which desires

to authenticate its incoming calls and a shared authentication server.

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1. Introduction

A Network Access Server is the initial entry point to a network for the majority of users of network services. It is the first device in the network to provide services to an end user, and acts as a gateway for all further services. As such, its importance to users and service providers alike is paramount. However, the concept of a Network Access Server has grown up over the years without being formally defined or analyzed. [4]

1.1 Scope of this Document

There are several tradeoffs taken in this document. The purpose of this document is to describe a model for evaluating NAS service protocols. It will give examples of typical NAS hardware and software features, but these are not to be taken as hard limitations of the model, but merely illustrative of the points of discussion. An important goal of the model is to offer a framework that allows further development and expansion of capabilities in NAS implementation.

As with most IETF projects, the focus is on standardizing the protocol interaction between the components of the system. The documents produced will not address the following areas:

- AAA server back-end implementation is abstracted and not prescribed. The actual organization of the data in the server, its internal interfaces, and capabilities are left to the implementation.
- NAS front-end call technology is not assumed to be static. Alternate and new technology will be accommodated. The resultant protocol specifications must be flexible in design to allow for new technologies and services to be added with minimal impact on existing implementations.

1.2 Specific Terminology

The following terms are used in this document in this manner:
A "Call" - the initiation of a network service request to the NAS. This can mean the arrival of a telephone call via a dial-in or switched telephone network connection, or the creation of a tunnel to a tunnel server which becomes a virtual NAS.
A "Session" - is the NAS provided service to a specific authorized user entity.

2. Network Access System Equipment Assumptions

A typical hardware-based NAS is implemented in a constrained system. It is important that the NAS protocols don't assume unlimited resources

on the part of the platform. The following are typical constraints:

- A computer system of minimal to moderate performance
  (example processors: Intel 386 or 486, Motorola 68000)
- A moderate amount, but not large RAM (typically varies with supported
  # of ports 1MB to 8MB)
- Some small amount of non-volatile memory, and/or way to be configured
  out-of-band
- No assumption of a local file system or disk storage

A NAS system may consist of a system of interconnected specialized processor system units. Typically they may be circuit boards (or blades) that are arrayed in a card cage (or chassis) and referred to by their position (i.e. slot number). The bus interconnection methods are typically proprietary and will not be addressed here.

A NAS is sometimes referred to as a Remote Access Server (RAS) as it typically allows remote access to a network. However, a more general picture is that of an "Edge Server", where the NAS sits on the edge of an IP network of some type, and allows dynamic access to it.

Such systems typically have;
- At least one LAN or high performance network interface (e.g.
  Ethernet, ATM, FR)
- At least one, but typically many, serial interface ports, which could
  be;
  - serial RS232 ports direct wired or wired to a modem, or
  - have integral hardware or software modems (V.22bis,V.32, V.34, X2,
    Kflex, V.90, etc.)
  - have direct connections to telephone network digital WAN lines
    (ISDN, T1, T3, NFAS, or SS7)
  - an aggregation of xDSL connections or PPPoe sessions[5].

However, systems may perform some of the functions of a NAS, but not have these kinds of hardware characteristics. An example would be a industry personal computer server system, that has several modem line connections. These lines will be managed like a dedicated NAS, but the system itself is a general file server. Likewise, with the development of tunneling protocols (L2F[6], ATMP[7], L2TP[8]), tunnel server systems must behave like a "virtual" NAS, where the calls come from the network tunneled sessions and not hardware ports ([11][9][10]).

3. NAS Services

The core of what a NAS provides, are dynamic network services. What distinguishes a NAS from a typical routing system, is that these services are provided on a per-user basis, based on an authentication and the service is accounted for. This accounting may lead to policies and controls to limit appropriate usage to levels based on the availability of network bandwidth, or service agreements between the

user and the provider.

Typical services include:

- dial-up or direct access serial line access; Ability to access the network using a the public telephone network.
- network access (SLIP, PPP, IPX, NETBEUI, ARAP); The NAS allows the caller to access the network directly.
- asynchronous terminal services (Telnet, Rlogin, LAT, others); The NAS implements the network protocol on behalf of the caller, and presents a terminal interface.
- dial-out connections; Ability to cause the NAS to initiate a connection over the public telephone network, typically based on the arrival of traffic to a specific network system.
- callback (NAS generates call to caller); Ability to cause the NAS to reverse or initiate a network connection based on the arrival of a dial-in call.
- tunneling (from access connection to remote server); The NAS transports the callers network packets over a network to a remote server using an encapsulation protocol. (L2TP[8] RADIUS support[11])

4. Authentication, Authorization and Accounting (AAA) Servers

Because of the need to authenticate and account, and for practical reasons of implementation, NAS systems have come to depend on external server systems to implement authentication databases and accounting recording.

By separating these functions from the NAS equipment, they can be implemented in general purpose computer systems, that may provide better suited long term storage media, and more sophisticated database software infrastructures. Not to mention that a centralized server can allow the coordinated administration of many NAS systems as appropriate (for example a single server may service an entire POP consisting of multiple NAS systems).

For ease of management, there is a strong desire to piggyback NAS authentication information with other authentication databases, so that authentication information can be managed for several services (such as OS shell login, or Web Server access) from the same provider, without creating separate passwords and accounts for the user.

Session activity information is stored and processed to produce accounting usage records. This is typically done with a long term (nightly, weekly or monthly) batch type process.

However, as network operations grow in sophistication, there are requirements to provide real-time monitoring of port and user status, so that the state information can be used to implement policy decisions, monitor user trends, and the ability to possibly terminate access for administrative reasons. Typically only the NAS knows the true dynamic state of a session.

5. Typical NAS Operation Sequence:

The following details a typical NAS operational sequence:

- Call arrival on port or network
  - Port:
    - auto-detect (or not) type of call
    - CLI/SLIP: prompt for username and password (if security set)
    - PPP: engage LCP, Authentication
    - Request authentication from AAA server
    - if okay, proceed to service
    - may challenge
    - may ask for password change/update
  - Network:
    - activate internal protocol server (telnet, ftp)
    - engage protocol's authentication technique
    - confirm authentication information with AAA server

- Call Management Services
  - Information from the telephone system or gateway controller arrives indicating that a call has been received
  - The AAA server is consulted using the information supplied by the telephone system (typically Called or Calling number information)
  - The server indicates whether to respond to the call by answering it, or by returning a busy to the caller.
  - The server may also need to allocate a port to receive a call, and route it accordingly.

- Dial-out
  - packet destination matches outbound route pre-configured
  - find profile information to setup call
  - Request information from AAA server for call details

- VPN/Tunneling (compulsory)
  - authentication server identifies user as remote
  - tunnel protocol is invoked to a remote server
  - authentication information may be forwarded to remote AAA server
  - if successful, the local link is given a remote identity

- Multi-link aggregation
  - after a new call is authenticated by the AAA server, if MP options are present, then other bundles with the same identifying information is searched for
  - bundle searches are performed across multiple systems
  - join calls that match authentication and originator identities as one network addressable data source with a single network IP address

- Hardwired (non-interactive) services

- permanent WAN connections (Frame Relay or PSVCs)
- permanent serial connections (printers)

5.1 Characteristics of Systems and Sessions:

Sessions must have a user identifier and authenticator to complete the authentication process. Accounting starts from time of call or service, though finer details are allowed. At the end of service, the call may be disconnected or allow re-authentication for additional services.

Some systems allow decisions on call handling to be made based on telephone system information provided before the call is answered (e.g. caller id or destination number). In such systems, calls may be busied-out or non-answered if system resources are not ready or available.

Authorization to run services are supplied and applied after authentication. A NAS may abort call if session authorization information disagrees with call characteristics. Some system resources may be controlled by server driven policies

Accounting messages are sent to the accounting server when service begins, and ends, and possibly periodically during service delivery. Accounting is not necessarily a real-time service, the NAS may be queue and batch send event records.

5.2 Separation of NAS and AAA server functions

As a distributed system, there is a separation of roles between the NAS and the Server:

- Server provides authentication services; checks passwords (static or dynamic)
- Server databases may be organized in any way (only protocol specified)
- Server may use external systems to authenticate (including OS user databases, token cards, one-time-lists, proxy or other means)
- Server provides authorization information to NAS
- The process of providing a service may lead to requests for additional information
- Service authorization may require real-time enforcement (services may be based on Time of Day, or variable cost debits)
- Session accounting information is tallied by the NAS and reported to server

5.3 Network Management and Administrative features

The NAS system is presumed to have a method of configuration that allows it to know it's identity and network parameters at boot time.

Likewise, this configuration information is typically managed using the standard management protocols (e.g. SNMP). This would include the configuration of the parameters necessary to contact the AAA server

itself. The purpose of the AAA server is not to provide network management for the NAS, but to authorize and characterize the individual services for the users. Therefore any feature that can be user specific is open to supply from the AAA server.

The system may have other operational services that are used to run and control the NAS. Some users that have _Administrative_ privileges may have access to system configuration tools, or services that affect the operation and configuration of the system (e.g. loading boot images, internal file system access, etc..) Access to these facilities may also be authenticated by the AAA server (provided it is configured and reachable!) and levels of access authorization may be provided.

6. Authentication Methods

A NAS system typically supports a number of authentication systems. For async terminal users, these may be a simple as a prompt and input. For network datalink users, such as PPP, several different authentication methods will be supported (PAP, CHAP[12], MS-CHAP[13]). Some of these may actually be protocols in and of themselves (EAP[14][15], and Kerberos).

Additionally, the content of the authentication exchanges may not be straightforward. Hard token cards, such as the Safeword and SecurId, systems may generate one-time passphrases that must be validated against a proprietary server. In the case of multi-link support, it may be necessary to remember a session token or certificate for the later authentication of additional links.

In the cases of VPN and compulsory tunneling services, typically a Network Access Identifier (RFC 2486[16]) is presented by the user. This NAI is parsed into a destination network identifier either by the NAS or by the AAA server. The authentication information will typically not be validated locally, but by a AAA service at the remote end of the tunnel service.

7. Session Authorization Information

Once a user has been authenticated, there are a number of individual bits of information that the network management may wish to configure and authorize for the given user or class of users.

Typical examples include:

For async terminal users:
- banners
- custom prompts
- menus

- CLI macros - which could be used for: shortcuts, compound commands, restrictive scripts

For network users:
- addresses, and routes
- callback instructions
- packet and activity filters
- network server addresses
- host server addresses

Some services may require dynamic allocation of resources. Information about the resources required may not be known during the authentication phase, it may come up later. (e.g. IP Addresses for multi-link bundles) It's also possible that the authorization will change over the time of the session. To provide these there has to be a division of responsibility between the NAS and the AAA server, or a cooperation using a stateful service.

Such services include:

- IP Address management
- Concurrent login limitations
- Tunnel usage limitations
- Real-time account expirations
- Call management policies

In the process of resolving resource information, it may be required that a certain level of service be supplied, and if not available, the request refused, or corrective action taken.

8. IP Network Interaction

As the NAS participates in the IP network, it interacts with the routing mechanisms of the network itself. These interactions may also be controlled on a per-user/session basis.

For example, some input streams may be directed to specific hosts other than the default gateway for the destination subnet. In order to control services within the network provider's infrastructure, some types of packets may be discarded (filtered) before entering the network. These filters could be applied based on examination of destination address and port number. Anti-spoofing packet controls may be applied to disallow traffic sourced from addresses other than what was assigned to the port.

A NAS may also be an edge router system, and apply Quality of Service (QoS) policies to the packets. This makes it a QOS Policy Enforcement Point. [19][17] It may learn QOS and other network policies for the user via the AAA service.

9. A NAS Model

So far we have looked at examples of things that NASes do. The following attempts to define a NAS model that captures the fundamentals

of NAS structure to better categorize how it interacts with other network components.

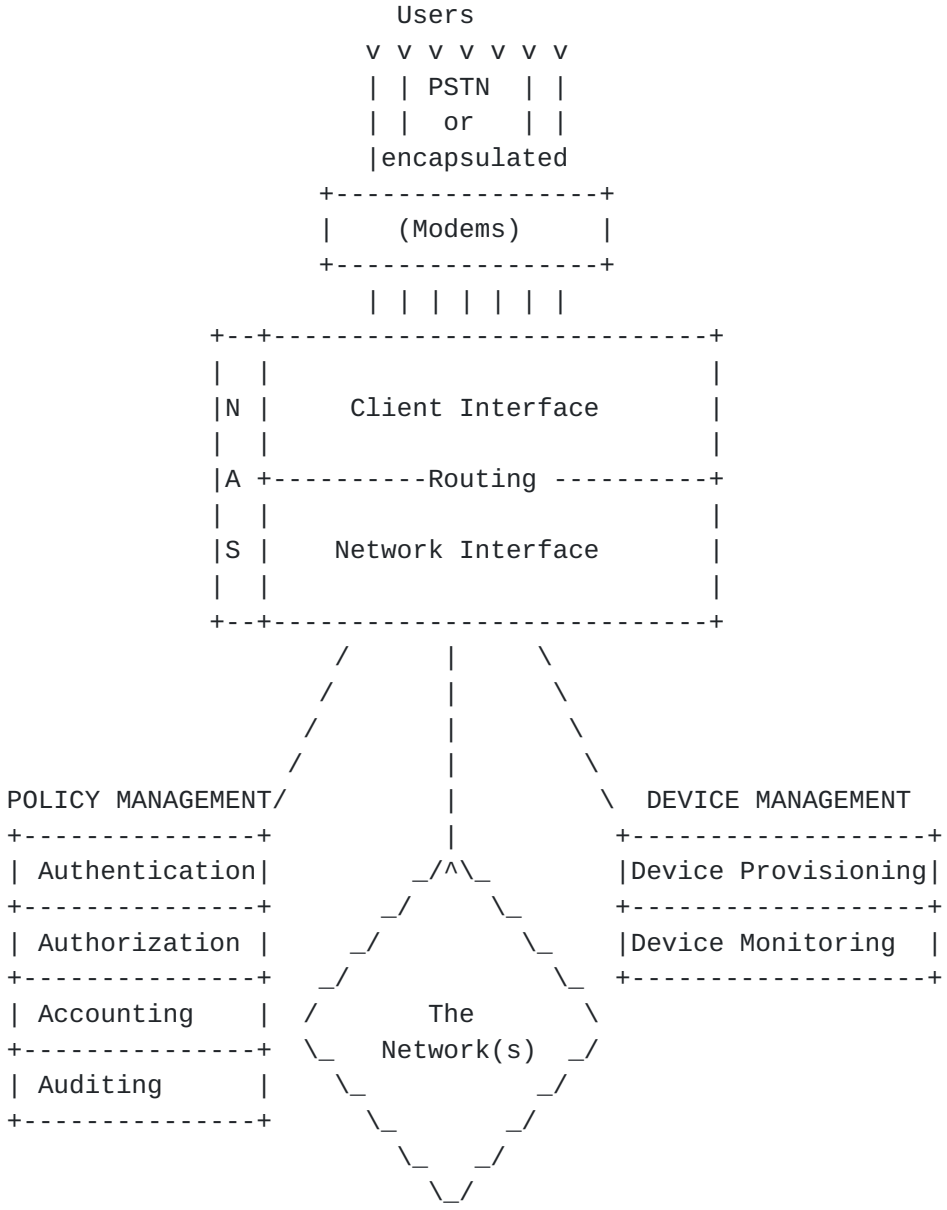
A Network Access Server is a device which sits on the edge of a network, and provides access to services on that network in a controlled fashion, based on the identity of the user of the network services in question and on the policy of the provider of these services. For the purposes of this document, a Network Access Server is defined primarily as a device which accepts multiple point-to-point [18] links on one set of interfaces, providing access to a routed network or networks on another set of interfaces.

Note that there are many things that a Network Access Server is not. A NAS is not simply a router, although it will typically include routing functionality in it's interface to the network. A NAS is not necessarily a dial access server, although dial access is one common means of network access, and brings its own particular set of requirements to NAS's.

A NAS is the first device in the IP network to provide services to an end user, and acts as a gateway for all further services. It is the point at which users are authenticated, access policy is enforced, network services are authorized, network usage is audited, and resource consumption is tracked. That is, a NAS often acts as the policy enforcement point for network AAAA (authentication, authorization, accounting, and auditing) services. A NAS is typically the first place in a network where security measures and policy may be implemented.

9.1 A Reference Model of a NAS

For reference in the following discussion, a diagram of a NAS, its dependencies, and its interfaces is given below. This diagram is intended as an abstraction of a NAS as a reference model, and is not intended to represent any particular NAS implementation.



9.2 Terminology

Following is a description of the modules and interfaces in the reference model for a NAS given above:

Client Interfaces - A NAS has one or more client interfaces, which provide the interface to the end users who are requesting network access. Users may connect to these client interfaces via modems over a PSTN, or via tunnels over a data network. Two broad classes of NAS's may be defined, based on the nature of the incoming client interfaces, as follows. Note that a single NAS device may serve in both classes:

Dial Access Servers - A Dial Access Server is a NAS whose client interfaces consist of modems, either local or remote, which are attached to a PSTN.

Tunnel Servers - A Tunnel Server is a NAS whose client interfaces consists of tunneling endpoints in a protocol such as L2TP

Network Interfaces - A NAS has one or more network interfaces, which connect to the networks to which access is being granted.

Routing -If the network to which access is being granted is a routed network, then a NAS will typically include routing functionality.

Policy Management Interface - A NAS provides an interface which allows access to network services to be managed on a per-user basis. This interface may be a configuration file, a graphical user interface, an API, or a protocol such as RADIUS, Diameter, or COPS [19]. This interface provides a mechanism for granular resource management and policy enforcement.

Authentication - Authentication refers to the confirmation that a user who is requesting services is a valid user of the network services requested. Authentication is accomplished via the presentation of an identity and credentials. Examples of types of credentials are passwords, one-time tokens, digital certificates, and phone numbers (calling/called).

Authorization - Authorization refers to the granting of specific types of service (including "no service") to a user, based on their authentication, what services they are requesting, and the current system state. Authorization may be based on restrictions, for example time-of-day restrictions, or physical location restrictions, or restrictions against multiple logins by the same user. Authorization determines the nature of the service which is granted to a user. Examples of types of service include, but are not limited to: IP address filtering, address assignment, route assignment, QoS/differential services, bandwidth control/traffic

management, compulsory tunneling to a specific endpoint, and encryption.

Accounting - Accounting refers to the tracking of the consumption of NAS resources by users. This information may be used for management, planning, billing, or other purposes. Real-time accounting refers to accounting information that is delivered concurrently with the consumption of the resources. Batch accounting refers to accounting information that is saved until it is delivered at a later time. Typical information that is gathered in accounting is the identity of the user, the nature of the service delivered, when the service began, and when it ended.

Auditing - Auditing refers to the tracking of activity by users. As opposed to accounting, where the purpose is to track consumption of resources, the purpose of auditing is to determine the nature of a user's network activity. Examples of auditing information include the identity of the user, the nature of the services used, what hosts were accessed when, what protocols were used, etc.

AAAA Server - An AAAA Server is a server or servers that provide authentication, authorization, accounting, and auditing services. These may be co-located with the NAS, or more typically, are located on a separate server and communicate with the NAS's User Management Interface via an AAAA protocol. The four AAAA functions may be located on a single server, or may be broken up among multiple servers.

Device Management Interface - A NAS is a network device which is owned, operated, and managed by some entity. This interface provides a means for this entity to operate and manage the NAS. This interface may be a configuration file, a graphical user interface, an API, or a protocol such as SNMP [20].

Device Monitoring - Device monitoring refers to the tracking of status, activity, and usage of the NAS as a network device.

Device Provisioning - Device provisioning refers to the configurations, settings, and control of the NAS as a network device.

9.3 Analysis

Following is an analysis of the functions of a NAS using the reference model above:

9.3.1 Authentication and Security

NAS's serve as the first point of authentication for network users, providing security to user sessions. This security is typically performed by checking credentials such as a PPP PAP user name/password pair or a PPP CHAP user name and challenge/response, but may be extended to authentication via telephone number information, digital

certificates, or biometrics. NAS's also may authenticate themselves to users. Since a NAS may be shared among multiple administrative

entities, authentication may actually be performed via a back-end proxy, referral, or brokering process.

In addition to user security, NAS's may themselves be operated as secure devices. This may include secure methods of management and monitoring, use of IP Security [21] and even participation in a Public Key Infrastructure.

9.3.2 Authorization and Policy

NAS's are the first point of authorization for usage of network resources, and NAS's serve as policy enforcement points for the services that they deliver to users. NAS's may provision these services to users in a statically or dynamically configured fashion. Resource management can be performed at a NAS by granting specific types of service based on the current network state. In the case of shared operation, NAS policy may be determined based on the policy of multiple end systems.

9.3.3 Accounting and Auditing

Since NAS services are consumable resources, usage information must often be collected for the purposes of soft policy management, reporting, planning, and accounting. A dynamic, real-time view of NAS usage is often required for network auditing purposes. Since a NAS may be shared among multiple administrative entities, usage information must often be delivered to multiple endpoints. Accounting is performed using such protocols as RADIUS[2].

9.3.4 Resource Management

NAS's deliver resources to users, often in a dynamic fashion. Examples of the types of resources doled out by NAS's are IP addresses, network names and name server identities, tunnels, and PSTN resources such as phone lines and numbers. Note that NAS's may be operated in a outsourcing model, where multiple entities are competing for the same resources.

9.3.5 Virtual Private Networks (VPN's)

NAS's often participate in VPN's, and may serve as the means by which VPN's are implemented. Examples of the use of NAS's in VPN's are: Dial Access Servers that build compulsory tunnels, Dial Access Servers that provide services to voluntary tunnelers, and Tunnel Servers that provide tunnel termination services. NAS's may simultaneously provide VPN and public network services to different users, based on policy and

user identity.

9.3.6 Service Quality

A NAS may delivery different qualities, types, or levels of service to different users based on policy and identity. NAS's may perform bandwidth management, allow differential speeds or methods of access, or even participate in provisioned or signaled Quality of Service (QoS) networks.

9.3.7 Roaming

NAS's are often operated in a shared or outsourced manner, or a NAS operator may enter into agreements with other service providers to grant access to users from these providers (roaming operations). NAS's often are operated as part of a global network. All these imply that a NAS often provides services to users from multiple administrative domains simultaneously. The features of NAS's may therefore be driven by requirements of roaming [22].

10. Security Considerations

This document describes a model not a particular solution.

As mentioned in section 9.3.1 and elsewhere, NAS'es are concerned about the security of several aspects of their operation, including:

- Providing sufficiently robust authentication techniques as required by network policies,
- NAS authentication of configured authentication server(s),
- Server ability to authenticate configured clients,
- Hiding of the authentication information from network snooping to protect from attacks and provide user privacy,
- Protecting the integrity of message exchanges from attacks such as; replay, or man-in-the middle,
- Inability of other hosts to interfere with services authorized to NAS, or gain unauthorized services,
- Inability of other hosts to probe or guess at authentication information.
- Protection of NAS system configuration and administration from unauthorized users
- Protection of the network from illegal packets sourced by accessing connections

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This document is a synthesis of my earlier draft and Mark Beadles NAS Reference Model draft (draft-beadles-nas-01.txt).

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13. Full Copyright Statement

14. Appendix - Acronyms and Glossary:

AAA - Authentication, Authorization, Accounting, The three primary services required by a NAS server or protocol.
NAS - Network Access Server, a system that provides access to a network. In some cases also know as a RAS, Remote Access Server.
CLI - Command Line Interface, an interface to a command line service for use with an common asynchronous terminal facility.
SLIP - Serial Line Internet Protocol, an IP-only serial datalink, predecessor to PPP
PPP - Point-to-Point Protocol; a serial datalink level protocol that supports IP as well as other network protocols. PPP has three major states of operation: LCP - Link layer Control Protocol, Authentication, of which there are several types (PAP, CHAP, EAP), and NCP - Network layer Control Protocol, which negotiates the network layer parameters for each of the protocols in use.
IPX - Novell's NetWare transport protocol
NETBEUI - A Microsoft/IBM LAN protocol used by Microsoft file services and the NETBIOS applications programming interface.
ARAP - AppleTalk Remote Access Protocol

LAT - Local Area Transport; a Digital Equipment Corp. LAN protocol for terminal services

PPPoe - PPP over Ethernet; a protocol that forwards PPP frames on an LAN infrastructure. Often used to aggregate PPP streams at a common server bank.
VPN - Virtual Private Network; a term for networks that appear to be private to the user by the use of tunneling techniques.
FR - Frame Relay, a synchronous WAN protocol and telephone network intraconnect service.
PSVC - Permanent Switched Virtual Circuit - a service which delivers an virtual permanent circuit by a switched network.
PSTN - Public Switched Telephone Network
ISDN - Integrated Services Digital Network, a telephone network facility for transmitting digital and analog information over a digital network connection. A NAS may have the ability to receive the information from the telephone network in digital form.
ISP - Internet Service Provider; a provider of Internet access (also Network Service Provider, NSP)
BRI - Basic Rate Interface; a digital telephone interface
PRI - Primary Rate Interface; a digital telephone interface of 64K bits per second.
T1 - A digital telephone interface which provides 24-36 channels of PRI data and one control channel (2.048 Mbps).
T3 - A digital telephone interface which provides 28 T1 services. Signalling control for the entire connection is provided on a dedicated in-band channel.
NFAS - Non-Facility Associated Signaling, a telephone network protocol/service for providing call information on a separate wire connection from the call itself. Used with multiple T1 or T3 connections.
SS7 - A telephone network protocol for communicating call supervision information on a separate data network from the voice network.
POP - Point Of Presence; a geographic location of equipment and interconnection to the network. An ISP typically manages all equipment in a single POP in a similar manner.
VSA - Vendor Specific Attributes; RADIUS attributes defined by vendors using the provision of attribute 26.