IPS
Internet Draft
Document: draft-ietf-ips-iscsi-boot-04.txt
Category: Informational

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20 November 2001

Bootstrapping Clients using the iSCSI Protocol

Status of this Memo

Abstract

The Small Computer Systems Interface (SCSI) is a popular family of protocols for communicating with I/O devices, especially storage devices. iSCSI is a proposed transport protocol for SCSI that operates on top of TCP[12]. This memo describes a standard mechanism to enable clients to bootstrap themselves using the iSCSI protocol. The goal of this standard is to enable iSCSI boot clients to obtain the information to open an iSCSI session with the iSCSI boot server, assuming this information is not available.

1. Requirements

1. There must be no restriction of network topology between the iSCSI boot client and the boot server. Consequently, it is possible for an iSCSI boot client to boot from an iSCSI boot server behind gateways or firewalls as long as it is possible to establish an iSCSI session between the client and the server.

2. The following represents the minimum information required for an

iSCSI boot client to contact an iSCSI boot server: (a) the client's IP address (IPv6 or IPv4); (b) the server's iSCSI Service Delivery Port Name; and (c) mandatory iSCSI initiator capability.

The above assumes that the default LUN for the boot process is 0 and the default port for the iSCSI boot server is the well-known iSCSI port. However, both may be overridden at the time of configuration.

Additional information may be required at each stage of the boot process.

3. It is possible for the iSCSI boot client to have none of the above information or capability on starting.

4. The client should be able to complete boot without user intervention (for boots that occur during an unattended power-up). However, there should be a mechanism for the user to input values so as to bypass stages of the boot protocol.

5. Additional protocol software (for example, DHCP) may be necessary if the minimum information required for an iSCSI session is not provided.

2. Related Work

The Reverse Address Resolution Protocol (RARP)[7](through the extensions defined in the Dynamic RARP (DRARP))[4] explicitly addresses the problem of network address discovery, and includes an automatic IP address assignment mechanism. The Trivial File Transfer Protocol (TFTP)[9] provides for transport of a boot image from a boot server. BOOTP[5,8,10] is a transport mechanism for a collection of configuration information. BOOTP is also extensible, and official extensions have been defined for several configuration parameters. DHCPv4[3,6] and DHCPv6[13] are standards for hosts to be dynamically configured in an IP network. The Service Location Protocol (SLP) provides for location of higher level services[1,15].

3. Software stage

Some iSCSI boot clients may lack the resources to boot up with the mandatory iSCSI initiator capability. Such boot clients may choose to obtain iSCSI initiator software from a boot server. Currently, there are many established protocols that allow such a service to enable clients to load software images. For example, BOOTP and DHCP servers have the capability to provide software images on requests from boot clients. A particular implementation of this approach is the PXE protocol[17], which uses DHCP extensions and MTFTP to allow boot clients to load software images.

It is to be noted that this document does not recommend any of the above protocols, and the final decision of which boot protocol is to be used to load iSCSI initiator software is left to the discretion of the implementor.

4. DHCP stage

In order to use an iSCSI boot server, the following pieces of information are required.

- The IP address of the iSCSI boot client (IPv4 or IPv6)

- The IP transport endpoint for the iSCSI service delivery port for the iSCSI boot server. If the transport is TCP, for example, this has to resolve to an IP address and a TCP port number.

- The eight-byte LUN structure identifying the device within the iSCSI boot server.

At boot time, all or none of this information may be stored in the firmware of the iSCSI boot client. This section describes techniques for obtaining the required information.

An iSCSI boot client which does not know its IP address at power-on may acquire its IP address via DHCP. An iSCSI boot client which is capable of using both DHCPv6 and DHCPv4 should first attempt to use DHCPv6 to obtain its IP address, falling back on DHCPv4 in the event of failure.

Unless otherwise specified here, DHCP fields such as the client ID and gateway information are used identically with applications other than iSCSI.

A DHCP server (v4 or v6) may instruct an iSCSI client how to reach its boot device. This is done using a variable length DHCP option field known as the Root Path option. The details of the use of this option for the iSCSI boot process is detailed in [?]. The key fields from the option are "servername", "protocol", "port", "LUN" and "targetname".

If the "servername" field is left blank, then no default value is assumed in its place. If the "protocol" field is left bank, the default value is assumed to be "6" for TCP. If the "port" field is not specified, the port defaults to the well-known iSCSI port. If the LUN field is blank, then LUN 0 is assumed.

If the "servername" field is provided by DHCP, then that field is

used in conjunction with other associated fields to contact the boot server in the Boot stage (Section 6).

However, if the "servername" field is not provided, then the "targetname" field is then used in the Discovery Service stage (Section 5).

5. Discovery Service stage:

This stage is required if the DHCP server (v4 or v6) is unaware of the Service Delivery Port Name of the iSCSI boot server. The implemention of the discovery service is to based on the SLP protocol[1,24].

The iSCSI boot client may have obtained the targetname of the iSCSI boot server in the DHCP stage (Section 4). In that case, the iSCSI boot client queries the Discovery Service using query string 1 as specified in the iSCSI SLP interaction document[24] to resolve the targetname to an IP address and port number. One this is obtained, the iSCSI boot client proceeds to the Boot Stage (Section 6).

It is possible that the port number obtained from the Discovery Service may conflict with the one obtained from the DHCP service. In such a case, the implementor has the option to try both port numbers in the Boot stage.

If the iSCSI boot client does not have any targetname information, the iSCSI boot client then may query the Discovery Service with query string 4 as specified in the iSCSI SLP interaction document[24]. In response to this query, the discovery service provides the boot client with a list of iSCSI boot servers the boot client is allowed to access.

If the list of iSCSI boot servers is empty, subsequent actions are left to the discretion of the implementor. Otherwise, the iSCSI boot client may contact any iSCSI boot server in the list. Moreover, the the order in which iSCSI boot servers are contacted is also left to the discretion of the implementor.

6. Boot Stage

Once the iSCSI boot client has obtained the minimum information to open an iSCSI session with the iSCSI boot server, the actual booting process can start.

The actual sequence of iSCSI commands needed to complete the boot process is left to the implementor. This was done because of varying

requirements from different vendors and equipments, making it difficult to specify a common subset of the iSCSI standard that would be acceptable to everybody.

However, the use of a discovery session is not recommended because at this stage (i) a boot server has probably been found and (ii) the response obtained from the discovery session does not qualify an iSCSI boot server from an iSCSI target.

The iSCSI session established for boot may be taken over the booted software in the iSCSI boot client.

7. Security

The security discussion is centered around each stage of the iSCSI boot process.

The software stage can be secured by using public key encryption and digitial signatures. This is the approach taken by the popular PXE boot framework.

With regards to the DHCP stage, securing the host configuration protocol is beyond the scope of this document. Authentication of DHCP messages is described in [16].

The security issues in the Discovery Service stage are addressed by public key ciphering as stated in the the SLP version 2 document[1].

For the Boot stage, the iSCSI standard supports various methods of authenticated login and encrypted and authenticated connections for security[12]. How to configure the security parameters of an iSCSI boot client is beyond the scope of this document.

The iSCSI boot service may be subjected to denial of service attacks. The use of IPSEC as mandated by the iSCSI standard[12] can be used to protect against such attacks. However, ARP is still vulnerable to such type of attacks.

Security in the Boot stage is also dependent on the verification of the boot image being loaded. One key difference between the iSCSI boot mechanism and BOOTP-based image loading is the fact that the identity of a boot image may not be known when the Boot stage starts. The identity of certain boot images and their locations are known only after examining the contents of a boot disk exposed by the iSCSI boot service. Furthermore, images themselves may recursively load other images based on both hardware configurations and user input.

Consequently, a practical way to verify loaded boot images is to make sure that each image loading software verify the image to be loaded using a mechanism of their choice.

Another point to be noted is that if a boot image inherits an iSCSI session from a previously loaded boot image, the boot image also inherts the security properties of the iSCSI session.

Acknowledgments

We wish to thank John Hufferd for taking the initiative to form the iSCSI boot team. We also wish to thank Doug Otis, Julian Satran, Bernard Aboba, David Robinson and Mark Bakke for helpful suggestions and pointers regarding the draft document.

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