1. Introduction

The Dynamic Host Configuration Protocol (DHCP) [1] defines a standard client-server mechanism for configuring hosts on a TCP/IP network dynamically. A host running TCP/IP needs to be assigned an IP address and other parameters such as gateway and DNS server addresses [2] before it can function properly on the network. Such assignment can be done either manually or automatically using DHCP. DHCP eliminates the need to configure hosts one by one. A DHCP server becomes the central administration point of IP configurations for all clients it services. DHCP eases the task of managing IP
addresses and other parameters. DHCP also makes it possible to transparently apply changes to host IP configurations.

Increasingly, TCP/IP is becoming the network protocol of choice for organizations as they strive towards building single protocol data networks. In a TCP/IP network, IP addresses and other IP parameters need to be managed globally across an organization’s network and assigned individually to all hosts. Many organizations are using DHCP to automate their IP management. Typically these organizations deploy more than one DHCP server for load balancing and fault tolerance. Without a central store for DHCP configuration, DHCP servers have to hold their own configuration separately. Each server contains a subset of a TCP/IP network’s IP addresses and related IP parameters. Maintaining configurations of multiple servers or making changes to them is often a multi-step process. Centralizing DHCP configurations can improve the management of multiple DHCP servers.

An LDAP-based directory is a central database with standard query and retrieval methods. It is accessible throughout an organization’s network. DHCP can use an LDAP-based directory to centralize its configurations. By integrating with an LDAP-based directory, DHCP as an organization-wide network service can be managed from a single point of administration. All DHCP servers can use the same directory structures for their configurations. Furthermore, administrative boundaries of DHCP service can be aligned closely with existing organizational structure in the directory.

Network services in an LDAP-based directory are represented by LDAP schemata. The proposed LDAP schema for DHCP is intended for creating a common representation of DHCP service in an LDAP-based directory. A standard DHCP schema offers many advantages including, but not limited to, interoperable DHCP solutions from multiple vendors. The DHCP schema consists of a number of object classes, each of which can be thought of as a logical partition of DHCP service. These object classes are described in the rest of this document, as follows. Section 2 gives an overview of the DHCP object classes and their relationships. Section 3 provides detailed definitions of the object classes. Section 4 discusses remaining work that needs to be done to complete administrative aspects of the schema.

1.1. Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

- "MUST"

This word or the adjective "REQUIRED" means that the item is an absolute requirement of this specification.
2. Schema Overview

This section gives an overview of DHCP object classes and their relationships to each other and to other related objects in an LDAP-based directory. DHCP object classes in this document are designed to conform to the Directory-Enabled Networks (DEN) specification [3]. They are defined in the context of DEN information model and base schema.
2.1. Object Relationships

The following diagram shows where the DHCPService object is stored in the directory hierarchy and how it relates to other DHCP objects.

Container/Organization/OrganizationalUnit
  |  +++-DHCPService
  |      |  +++-DHCPSubnet
  |      |      |  +++-DHCPRange
  |      |      |     |  +++-DHCPReservation

The following diagram shows where the DHCPServer object is stored in the directory hierarchy and how it relates to other DHCP objects.

Organization
  |  +++-OrganizationalUnit
  |      |  +++-GroupOfDevices
  |      |      |  +++-DHCPServer
  |      |      |      |  +++-DHCPSubnet
  |      |      |      |      |  +++-DHCPRange
  |      |      |      |      |     |  +++-DHCPReservation
  |      |      |      |      |     |     |  +++-DHCPLease (Optional)

2.2. Object Class Hierarchy

The diagram below shows how the DHCP object classes are derived based on the DEN base schemata. DHCPService is the only class that is derived from a specific DEN class -- the Service class. DHCPServer is a superclass of DHCPService. All other DHCP classes are derived from the Top class directly.
3. Schema Details

This section provides schema definitions for DHCP object classes.

3.1. Service Object Class

The Service object class is a CIM class extended by DEN. This abstract class serves as the base object class for DHCP service.

NAME               ‘Service’
DESCRIPTION        ‘The Service class is a LogicalElement that contains the information necessary to represent and manage the functionality provided by a Device and/or SoftwareFeature. A Service is a general-purpose object to configure and manage the implementation of functionality. It is not the functionality itself. This is a CIM class extended by DEN.’
TYPE               Abstract
DERIVED FROM       LogicalElement
POSSIBLE SUPERIORS ( Container $ Organization $ OrganizationalUnit $ Group $ GroupOfDevices )
MUST CONTAIN       ( ServiceCreationClassName $ ServiceName $ ServiceURL $ Started $ StartMode )
MAY CONTAIN

The attributes of the Service class are defined as follows.
### NAME

'ServiceCreationClassName'

**DESCRIPTION**  
Provides scoping and keying for the Service class hierarchy

**SYNTAX**  
'DirectoryString' SINGLE-VALUE

### NAME

'ServiceName'

**DESCRIPTION**  
A user-friendly name of this service class

**SYNTAX**  
'DirectoryString' SINGLE-VALUE

### NAME

'ServiceURL'

**DESCRIPTION**  
A URL that provides the protocol, network location, and other service-specific information required in order to access the service

**SYNTAX**  
'DN' SINGLE-VALUE

### NAME

'Started'

**DESCRIPTION**  
TRUE indicates that the Service has been started

**SYNTAX**  
'Boolean' SINGLE-VALUE

### NAME

'StartMode'

**DESCRIPTION**  
This is a string value indicating whether the Service is automatically started by a System, Operating Systems, etc. or only started upon request

**SYNTAX**  
'DirectoryString' SINGLE-VALUE

### 3.2. DHCPService Object Class

This object class is one of the two container classes for DHCP (the other being the DHCPServer class). The DHCPService object represents DHCP service configuration for an entire enterprise or a specific branch of an organization. As such, DHCPService is a child of either the Container object or an Organization/OrganizationalUnit object. The Container object is an enterprise-wide entity. It contains information that is global to the enterprise. A DHCPService object parented under the Container object holds configurations that are common to all DHCP servers in the enterprise. On the other hand, Organization and OrganizationalUnit objects define logical divisions of an enterprise. A DHCPService object parented under an Organization/OrganizationalUnit object has more limited scope. It holds configurations for only those DHCP servers that belong to the branch it represents. In either case, each parent has at most one DHCPService object.

The DHCPService object is derived from the abstract Service class. It inherits all attributes of the Service class. In addition, it may contain the DN’s of the subnets that it manages. The IP addresses and masks associated with these subnets are included for convenience. The DHCPService object also contains any class or option that is defined for it.
NAME               'DHCPService'
DESCRIPTION        'This class represents the dynamic host configuration protocol service.'
TYPE               Structural
DERIVED FROM       Service
POSSIBLE SUPERIORS ( Container $ Organization $ OrganizationalUnit )
MUST CONTAIN        ( DHCPSubnetList $ DHCPClassList $ DHCPOptionDefinitions $ DHCPOptionList )
MAY CONTAIN         ( DHCPSubnetList $ DHCPClassList $ DHCPOptionDefinitions $ DHCPOptionList )

The attributes of the DHCPService class are defined as follows.

NAME               'DHCPSubnetList'
DESCRIPTION        'Provides the DN’s of the DHCPSubnet objects, as well as their subnet IP addresses and masks.'
SYNTAX             'DirectoryString' MULTI-VALUE

NAME               'DHCPClassList'
DESCRIPTION        'Provides encoding of user or vendor class names. Each class contains (ClassName, ClassID, ClassType, Description).'</n
SYNTAX             'OctetString' MULTI-VALUE

NAME               'DHCPOptionDefinitions'
DESCRIPTION        'Provides encoding of option definitions, both standard and vendor-specific, and any default values for those options. Each option definition contains (OptionName, OptionID, OptionDataType, MultiValued, VendorClassID, DefaultValue, Description).'</n
SYNTAX             'OctetString' MULTI-VALUE

NAME               'DHCPOptionList'
DESCRIPTION        'Provides encoding of options, both standard and vendor-specific, to be sent to clients. Each option contains (OptionID, OptionValue, VendorClassID, UserClassID).'</n
SYNTAX             'OctetString' MULTI-VALUE

3.3. DHCPSubnet Object Class

The DHCPSubnet object represents an IP subnet that is managed by DHCP. A subnet is defined by an IP address and mask. If the superscope name is not NULL, the subnet is also considered as part of that superscope group. A subnet is further divided into ranges, which part subsets of addresses within the subnet. Each range is managed by one or more DHCP servers for address assignments.

A DHCPSubnet object may contain a list of options for all clients on the subnet. It may also have settings that specify if and how dynamic DNS updates are done for clients.
The attributes of the DHCPSubnet class are defined as follows.

- **NAME** 'SubnetIPAddress'
  - **DESCRIPTION** 'Defines the subnet IP address.'
  - **SYNTAX** 'DirectoryString' SINGLE-VALUE

- **NAME** 'SubnetMask'
  - **DESCRIPTION** 'Defines the subnet mask.'
  - **SYNTAX** 'DirectoryString' SINGLE-VALUE

- **NAME** 'DDNSUpdateOptions'
  - **DESCRIPTION** 'Specifies options for dynamic DNS update.
  1 = Update according to client request,
  2 = Always update forward and reverse lookups,
  4 = Discard forward lookups when leases expire,
  8 = Do updates for non-dynamic DNS clients.'
  - **SYNTAX** 'Integer' SINGLE-VALUE

- **NAME** 'SuperscopeName'
  - **DESCRIPTION** 'Specifies name of the superscope, if any, to which the scope belongs.'
  - **SYNTAX** 'DirectoryString' SINGLE-VALUE

- **NAME** 'DHCPRangeList'
  - **DESCRIPTION** 'Specifies the DN’s of the DHCPRange objects for the subnet and their start and end IP addresses.'
  - **SYNTAX** 'DirectoryString' MULTI-VALUE

### 3.4. DHCPRange Object Class

The DHCPRange object represents a subset of IP addresses within a subnet that are to be assigned. The addresses are specified by a range subtracting any exclusion. Each DHCPRange is assigned to one or more DHCP servers.

The DHCPRange object may contain a list of options for all clients whose addresses come from the range. These are options that are not defined by a parent DHCP object or that overwrite ones defined by a parent object.
NAME               'DHCPRange'
DESCRIPTION        'This class represents a DHCP range, which
specifies an IP address range within a subnet
and associated IP configuration.'
TYPE               Structural
DERIVED FROM       Top
POSSIBLE SUPERIORS ( DHCPSubnet )
MUST CONTAIN       ( StartIPAddress $ EndIPAddress $ ScopeType )
MAY CONTAIN        ( Exclusions $ DHCPServerList $ DHCPOptionList $ Description )

The attributes of the DHCPRange class are defined as follows.

NAME        'StartIPAddress'
DESCRIPTION 'Defines the first IP address in the IP address range.'
SYNTAX      'DirectoryString' SINGLE-VALUE

NAME        'EndIPAddress'
DESCRIPTION 'Defines the last IP address in the IP address range.
If the scope has only one address, then EndIPAddress =
StartIPAddress.'
SYNTAX      'DirectoryString' SINGLE-VALUE

NAME        'ScopeType'
DESCRIPTION 'Specifies the scope type as being one of the following
1  = DHCP,
2  = Dynamic BOOTP,
3  = DHCP and Dynamic BOOTP.'
SYNTAX      'Integer' SINGLE-VALUE

NAME        'Exclusions'
DESCRIPTION 'Defines the list of addresses in the scope’s IP address
range that are excluded from assignment. Each entry in
the list is a (StartIPAddress, EndIPAddress) pair.'
SYNTAX      'DirectoryString' MULTI-VALUE

NAME        'DHCPServerList'
DESCRIPTION 'Specifies the DN’s of the DHCPServer objects and their
fully-qualified DNS names.'
SYNTAX      'DirectoryString' MULTI-VALUE

3.5. DHCPReservation Object Class

The DHCPReservation object represents a client with a reserved IP
address. The client can be a DHCP client, a BOOTP client, or both.
It is identified by a unique ID, which is typically the MAC address
of its network interface.

The DHCPReservation object may contain a list of options for the
client with reservation. These are options that are not defined by a
parent DHCP object or that overwrite ones defined by a parent
object.
NAME              'DHCPReservation'
DESCRIPTION       'This class defined a DHCP reservation, which is a
fixed IP address assigned to a particular DHCP
client.'
TYPE               Structural
DERIVED FROM       Top
POSSIBLE SUPERIORS ( DHCPSubnet )
MUST CONTAIN       ( IPAddress $ UniqueID $ ClientName )
MAY CONTAIN        ( ClientType $ DHCPOptionList $ Description )

The attributes of the DHCPReservation class are defined as follows.

NAME        'IPAddress'
DESCRIPTION 'Defines the IP address of an active lease.'
SYNTAX      'DirectoryString' SINGLE-VALUE

NAME        'UniqueID'
DESCRIPTION 'Identifies the client using either the MAC address of
one of its network interfaces, or a unique byte
string.'
SYNTAX      'OctetString' SINGLE-VALUE

NAME        'ClientName'
DESCRIPTION 'Specifies the name of the client for the reservation.'
SYNTAX      'DirectoryString' SINGLE-VALUE

NAME        'ClientType'
DESCRIPTION 'Specifies the lease type as one of the following
1  = DHCP,
2  = BOOTP,
3  = DHCP/BOOTP.'
SYNTAX      'Integer' SINGLE-VALUE

3.6. DHCPServer Object Class

The DHCPServer object represents a server that implements DHCP
service. It is therefore derived from the DHCPService object and
inherits all its attributes. In addition, the DHCPServer object
specifies the vendor who makes the server and the revision it is in.
Lastly, it contains a flag that indicates whether the DHCP server
has been authorized to service any client request. The flag is added
to prevent rogue DHCP servers on a network.

NAME               'DHCPServer'
DESCRIPTION        'This class describes the configuration a DHCP
server.'
TYPE               Structural
DERIVED FROM       DHCPService
POSSIBLE SUPERIORS ( GroupOfDevices )
MUST CONTAIN       ( VendorID $ VersionNumber $ Authorized )
MAY CONTAIN
The attributes of the DHCPServer class are defined as follows.

NAME 'VendorID'
DESCRIPTION 'Indicates the DHCP server vendor, using IANA assigned enterprise code (see http://www.isi.edu/in-notes/iana/assignments/enterprise-numbers).'
SYNTAX 'Integer' SINGLE-VALUE

NAME 'VersionNumber'
DESCRIPTION 'Specifies the major and minor version numbers of the DHCP server.'
SYNTAX 'DirectoryString' SINGLE-VALUE

NAME 'Authorized'
DESCRIPTION 'TRUE indicates that the Server has been authorized to respond to DHCP client requests; FALSE indicates that the Server is a rogue server.'
SYNTAX 'Boolean' SINGLE-VALUE

3.7. DHCPLease Object Class

The DHCPLease object represents an IP address that is currently assigned to a DHCP client. It is a DHCP/BOOTP assigned dynamic address, a reservation, or an address allocated for a RAS server. DHCP leases are stored under the DHCPServer object which has handed out the leases. A DHCP server can contain a large number of leases. Writing all those leases to the directory could have a significant performance impact on the directory and the server as well, especially when there is a large burst of lease assignments. For this reason, the support for DHCPLease is optional.

NAME 'DHCPLease'
DESCRIPTION 'This class specifies individual lease information.'
TYPE Structural
DERIVED FROM Top
POSSIBLE SUPERIORS ( DHCPSubnet )
MUST CONTAIN ( IPAddress $ LeaseType )
MAY CONTAIN ( UniqueID $ ClientName $ LeaseExpiration $ LeaseState $ Description )

The attributes of the DHCPLease class are defined as follows.

NAME 'LeaseType'
DESCRIPTION 'Specifies the lease type as one of the following
1  = DHCP assigned,
2  = BOOTP assigned,
3  = Reservation,
4  = Allocation for RAS.'
SYNTAX 'Integer' SINGLE-VALUE
4. Future Work
This document defines a schema for storing and retrieving DHCP configuration information in an LDAP-based directory. It does not address the issues of how this information is managed. Specifically, it does not provide the schema for access control to DHCP service. This will be defined in the future.

5. Acknowledgements
The authors would like to thank Munil Shah and Peter Ford for reviewing this draft.

6. References

7. Author’s Address
Ye Gu
Microsoft Corporation
One Microsoft Way
Redmond, WA 98052

Phone: 425 936 8601
EMail: yegu@microsoft.com

Ramesh Vyaghrapuri
Microsoft Corporation