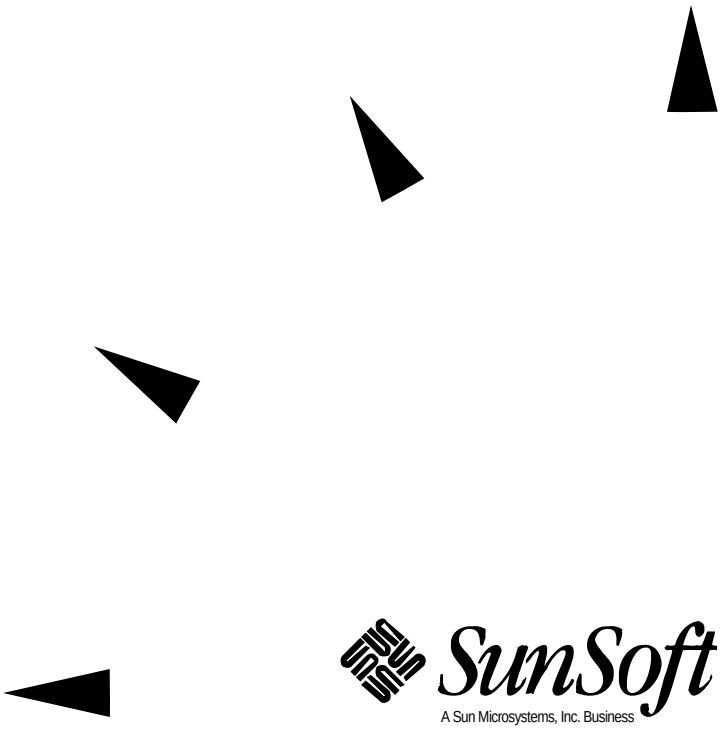
Federated Naming Service Guide



2550 Garcia Avenue
Mountain View, CA 94043
U.S.A.

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Preface

The Federated Naming Service (FNS) is new to the Solaris™ product family. FNS is a set of application programming interfaces and policies that allow applications to use a common set of names and policies over different name services.

FNS is not a replacement for NIS+, the network name service included in the Solaris software environment. Rather, FNS is implemented on top of NIS+ and allows you to use a set of common names with desktop applications. SunSoft Inc.'s implementation of FNS conforms to the X/Open™ federated naming (XFN) specification.

Who Should Use This Book

The primary audience of *Federated Naming Service Guide* is software developers who write distributed applications. Use of this guide assumes basic competence in programming, a working familiarity with the C programming language, and a working familiarity with the UNIX® operating system. Developers should read all four parts of this manual.

The secondary audiences are system and network administrators and application users. All should read Part 1 to get an overview of FNS. Administrators should also read Part 2 and, especially, Part 3 to set up and administer FNS. This manual does not cover NIS+ or the Domain Name System (DNS) except as they relate to FNS.

How This Book Is Organized

Part 1—Introduction

Chapter 1, "Introduction to the Federated Naming Service (FNS)," is a high-level overview of what FNS is and the problems it addresses.

Chapter 2, "The XFN Model," depicts the architectural model of federated naming from the application, API, and end-user's views.

Part 2—FNS Policies

Chapter 3, "Introduction to FNS Policies," introduces FNS enterprise and global policies.

Chapter 4, "Policies for the Enterprise Namespace," explains the policies for naming objects within an enterprise and how applications can use these policies.

Chapter 5, "Policies for the Global Namespace," describes naming objects in global namespaces.

Part 3—Administration

Chapter 6, "Administering FNS on NIS+," is a reference for system administrators who need to administer FNS in an NIS+ environment.

Chapter 7, "Federating NIS+ With Global Naming Systems,"describes the procedures for federating NIS+ with DNS and X.500.

Chapter 8, "Administering the File System Namespace," describes the setup and administration of the file system namespace.

Chapter 9, "Administering the Printer Namespace," describes the setup and administration of the printer namespace**.**

Part 4—Application Programming

Chapter 10, "Interfaces for Writing XFN Applications," defines the client programming interfaces.

Chapter 11, "XFN Composite Names," describes the XFN composite name string syntax and the resolution techniques for composite names.

Chapter 12, "XFN Programming Examples," presents self-contained executable programs for a namespace browser and a printer client and server.

Appendixes

Appendix A, "XFN Composite Names Syntax," gives supplemental information about composite name syntax.

Appendix B, "DNS Text Record Format for XFN References," gives supplemental information about FNS in a DNS environment.

Appendix C, "X.500 Attribute Syntax for XFN References," gives supplemental information about FNS in a X.500 environment**.**

Related Books

With the exception of the XFN specification, these books do not specifically cover FNS but they provide a good background on how name services work in client-server computing:

- *Distributed Computing—Implementation and Strategy* by Raman Khanna (Prentice Hall, 1993)
- *Distributed Systems* edited by Sape J. Mullender (ACM Press, 1990)
- *DNS and BIND* by P. Albitz and C. Liu (O'Reilly, 1992)
- *Managing the X.500 Client Toolkit* (SunSoft Inc., 1995)
- *X/Open Preliminary Specifications, Federated Naming: The XFN Specifications,* X/Open Document #P403, ISBN: 1-85912-045-8 (X/Open, July 1994)

You may also want to reference the following AnswerBook® on-line documentation:

- *Solaris 2.5 Reference Manual AnswerBook*
- *Solaris 2.5 Software Developer AnswerBook*
- *Solaris 2.5 System Administrator AnswerBook*

What Typographic Changes and Symbols Mean

The following table describes the typographic changes used in this book.

Table P-1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `machine_name% You have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`machine_name% su` `Password:`
AaBbCc123	Command-line placeholder: replace with a real name or value	To delete a file, type `rm` *filename*.
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in *User's Guide*. These are called *class* options. You *must* be root to do this.

Shell Prompts in Command Examples

The following table shows the default system prompt and superuser prompt for the C shell, Bourne shell, and Korn shell.

Table P-2 Shell Prompts

Shell	Prompt
C shell prompt	`machine_name%`
C shell superuser prompt	`machine_name#`
Bourne shell and Korn shell prompt	`$`
Bourne shell and Korn shell superuser prompt	#

Part 1 — Introduction

This part of the manual is an overview of FNS and its naming model.

Introduction to the Federated Naming Service (FNS)

1

This chapter is a high-level overview of the Federated Naming Service (FNS).

Name services are fundamental to any computing system. Among other features, a name service provides functionality that

- Associates names with objects (binds)
- Resolves names to objects
- Removes bindings
- Lists names
- Renames

Name services are often embedded in many different applications and services in a computing environment, as shown in Figure 1-1 on page 4. Working with different name services presents significant difficulties to the application developer. Most applications are designed to use a single name service and have very limited access to objects in a distributed computing environment. Moreover, different applications use different name services and expect names to be composed differently. They often use different names for what the user considers very similar objects. For example, you may be able to send mail to

your friend Joan using her name `joan@admin`, but be required to use another name, `jsmith@hal`, to access her calendar. FNS allows the user to name objects such as users in a uniform way.

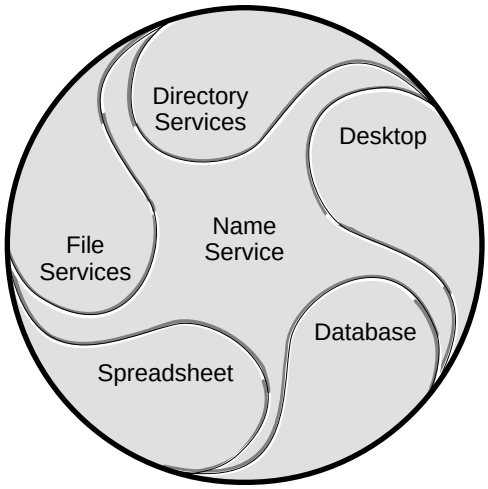

Figure 1-1 Naming Is an Integral Part of Existing Services

What Is FNS?

FNS provides a method for federating multiple name services under a single, simple uniform interface for the basic naming operations. The service supports resolution of composite names—names that span multiple name systems—through the naming interface. Each member of a federation has autonomy in its choice of naming conventions, administrative interfaces, and its particular set of operations other than name resolution.

In the Solaris environment, the FNS implementation consists of a set of enterprise-level name services with specific policies and conventions for naming organizations, users, hosts, sites, and services as well as support for global name services such as DNS and X.500.

What Is XFN?

XFN is X/Open Federated Naming. XFN is a standard actively supported by organizations such as SunSoft, Inc., IBM, Hewlett-Packard, DEC, Siemens, and OSF. FNS, the Solaris implementation, is compliant with the *X/Open Preliminary Specification for Federated Naming* (July 1994). Applications that use FNS are portable across platforms because the interface exported by FNS is XFN, a public, open interface endorsed by other vendors and X/Open. The X/Open Co. Ltd. is an international standards organization committed to defining computing standards that are endorsed and adhered to by the major computer vendors.

Note – In this manual it is important to distinguish between XFN and FNS. For example, the FNS policies include some extensions to XFN policies, and these are explicitly defined with notes. Objects belonging to the XFN programming interface are designated as XFN objects in order to avoid confusion with other programming interfaces.

Why FNS?

FNS is useful for the following reasons:

- A single uniform naming interface is provided to clients for accessing different name services. As a consequence, the addition of new name services does not require changes to applications or to existing member name services.
- Names can be composed in a uniform way, and the resulting composite names can have any number of components.
- Coherent naming is encouraged through the use of shared contexts and shared names.

The following subsections expand on these reasons.

Uniform Naming Interface

Within the Solaris environment, name services are integrated into other services such as the file system, the network information service, the mail system, and the calendar service. For example, the file system includes a

naming system for files and directories; NIS+ service combines a naming system with a specialized information service; a spreadsheet application names cells and macros. An application in the Solaris environment must often deal with this diversity of name service interfaces. In addition, the application may be exposed to a great variety of often incompatible naming systems external to the Solaris environment. Local- and wide-area networks connect a heterogeneous array of hardware and operating systems, increasing the variety of potential interfaces. Not only do these naming interfaces differ widely, but the essential naming operations are often obscure.

A standard interface that provides the basic naming functions greatly simplifies the naming aspect of applications for developers because now a single interface to name different types of objects can be used. Changes to the underlying name service and adding new name services can be applied without requiring changes to the applications.

Uniform Means of Composing Names

Historically, a small percentage of applications use composite names to access objects in the Solaris environment. The commands `mail` and `rcp` are examples of such applications. `rcp` uses composite names such as `sylvan:/usr/jsmith/memo`, which has two components: the host name `sylvan` and the file name (path) `/usr/jsmith/memo`. The `mail` program uses composite names such as `jsmith@hal`, which has two components: the user name `jsmith` and the host name `hal`. Each application defines its own composition rule for names, parses the composite names, and resolves composite names. Composition rules often differ from one application to another.

The user must remember which applications permit composite naming and which do not. For example, the composite name `sylvan:/tmp/foo` is accepted by the `rcp` command, but not by the `cp` command. The user must also remember the different composition rules used among different applications. Applications that support composite names on their own can use only a small and specific set of naming systems, and must be changed whenever a new type of naming system is added.

Incorporating a uniform policy for composite naming into the computing platform permits any application to support composite names in a uniform way.

Figure 1-2 shows an example of a federated naming system consisting of two component naming systems: a host naming system and a file naming system. When the name `jurassic /usr/games/bin/pirates.exe` is passed to the federated naming system, the host part of the name, `jurassic`, is resolved by the host naming system, while the file part of the name, `/usr/games/bin/pirates.exe`, is resolved by the file naming system. The important point to note is that the application passes *one* name to *one* interface.

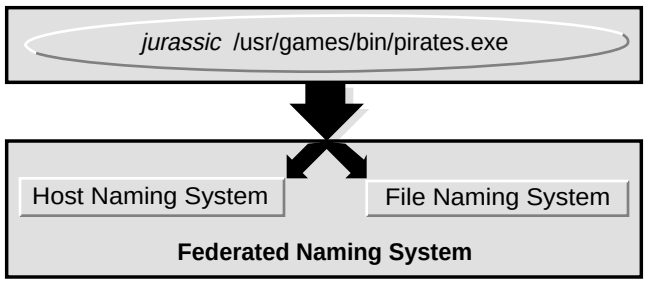

Figure 1-2 A Federated Naming System

Coherence in Naming

At present, users of the Solaris environment must use different, inconsistent names to refer to objects. To expand on an earlier example: you may use the name `jsmith@admin` to send mail to Joan, the name `jsmith@hal` to access her calendar, and the name `/home/jsmith/.cshrc` to reach a file in her home directory. This disparity makes it hard for users to formulate names and hard for applications to automatically generate names on behalf of users. FNS policies define a coherent way for naming these objects.

The following principles were used to arrive at FNS policies:

- *When it is natural to name other objects relative to a certain object, that object should provide a naming context.* For example, because it is natural to want to name various things relative to a user, a user object should be a naming context.

- *It should be possible to compose names using common components.* This reduces the number of names that users need to remember and makes it easier for applications and users to construct names based on their knowledge of common constituents and how they can be logically composed.
- *Names should be intuitive and self-evident.* For example, the calendar name `jsmith@hal` names the host where the calendar service is being provided. To the user, there is no obvious connection between the user's calendar and a host. The host name is extraneous and difficult to discover and remember.
- *Never use two contexts when one context will do.* In the example above, we would like to name a mail address, a calendar, and a file's directory relative to the user `jsmith`. Sharing contexts and their names make naming more coherent and simplifies administration.

FNS in the Solaris Environment

In the Solaris environment, the FNS implementation currently consists of a set of enterprise-level name services implemented on top of NIS+, global-level naming systems using DNS and X.500, file naming, and support for printer naming. FNS will become increasingly more visible to the Solaris user as more applications and systems use FNS.

FNS and NIS+

NIS+ is the enterprise-wide information service in the Solaris environment. It is an information-retrieval system for well-known UNIX databases, such as the password tables, host tables, and mail aliases tables. It also supports Solaris-specific databases such as the automount maps and the credentials tables. It partitions an enterprise into organizational units that are arranged into a tree and assigned hierarchical domain names.

FNS federates NIS+ in order to support enterprise-level naming policies in the Solaris environment. To do this, FNS provides the XFN interface for performing naming operations on organization, site, user, and host objects. It implements these operations using the NIS+ programming interface for accessing NIS+ directories and tables. It stores bindings for enterprise-level objects in NIS+ and uses them in conjunction with the standard NIS+ tables for passwords and hosts.

FNS and DNS

The Internet Domain Name System (DNS) is a hierarchical collection of name servers that provide the Internet community with host and domain name resolution. FNS uses DNS to name entities globally. Names can be constructed for any enterprise that is accessible on the Internet; consequently, names can also be constructed for objects exported by these enterprises. For more information about FNS and DNS, see “Federating DNS” on page 62.

FNS and X.500

X.500 is a global directory service. Its components cooperate to manage information about objects in a worldwide scope. Such objects include countries, organizations, people, and machines. FNS federates X.500 in order to enable global access to enterprise name services. For more information about FNS and X.500, see “Federating X.500” on page 63.

FNS-based File Naming

FNS-based file naming integrates FNS naming into the Solaris file service. FNS-based file naming enables files to be named relative to users, hosts, sites, and organizations, using the FNS policies shared with other non-file applications. FNS-based file naming gives clients a common view of the global and enterprise-wide file namespaces. Solaris applications that access the file system will, without modification, have access to the file namespaces supported by FNS.

FNS-based Printer Naming

FNS-based printer naming provides the basic naming support for the unbundled SunSoft Print Client (SSPC). FNS-based printer naming enables printers to be named relative to users, hosts, sites, and organizations, using the FNS policies shared with other non-printing-related applications. FNS-based printer naming gives clients a common view of the global and enterprise-wide printer namespaces and allows centralized administration of the printer namespaces.

1

FNS and Applications

Applications that are aware of FNS can expect the namespace to be arranged according to the FNS policies, and applications that bind names in the FNS namespace are expected to follow these policies.

There are three ways for applications to use FNS:

- *Applications could be direct clients of the XFN interface and policies.* Application-level utilities such as the file system, the printing service, and the desktop tools (calendar manager, file manager) are examples of clients that use the XFN interface directly.
- *Applications can use FNS through existing interfaces.* A significant proportion of FNS use will be through existing application programming interfaces. For example, consider a UNIX application that obtains a file name that it later supplies to the UNIX `open()` function. With FNS support for resolution of file names, the application need not be aware that the strings it deals with are composite names rather than the traditional local path names. Many applications can thereby support the use of composite names without modification.
- *Systems can export the XFN interface.* Naming systems, such as DNS and X.500, and naming systems embedded in other services, like the file system and printing service, are examples of naming systems that export the XFN interface.

The XFN Model 2

This chapter describes the XFN naming model from several perspectives. Some aspects are graphically presented as a way of helping you visualize XFN concepts.

XFN Architectural Model

The primary services provided by a federated naming system are mapping a composite name to a reference and providing access to attributes associated with a named object. This section defines the elements of the XFN naming model.

References

A reference is the information on how to reach an object. It contains a list of addresses. An address identifies a communication endpoint. Multiple addresses identify multiple communication endpoints for a single conceptual object or service. For example, a list of addresses may be required because the object is distributed or because the object can be accessed through more than one communication mechanism.

Note – XFN cannot guarantee specific properties of addresses such as their stability, validity, or reachability. A client may be able to look up a name but not be able to use the returned reference because the client may not have support for any of the necessary communication mechanisms or may lack the necessary network connectivity to reach the address. Further, the address may be invalid from that origin or stale; these issues are the province of convention between the name's binder, the clients, and the service provider specified in the address.

Contexts

An XFN context is an object that exports the XFN base context programming interface. A context contains a list of atomic names bound to references, as shown in Figure 2-1. An atomic name may have zero or more attributes. Contexts are at the heart of the lookup and binding operations, described extensively in Chapter 10, “Interfaces for Writing XFN Applications.”

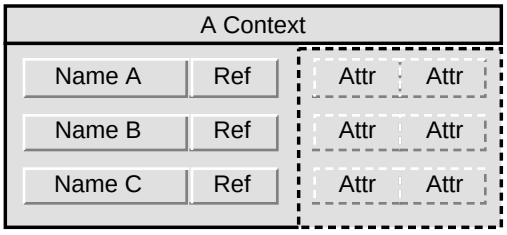

Figure 2-1 An XFN Context

Attributes

Each named object is associated with zero or more attributes. Thus, attributes are optional, as shown by the dotted lines in Figure 2-1 on page 12. Each attribute has a unique attribute identifier, an attribute syntax, and a set of zero or more distinct attribute values. XFN defines the base attribute interface for examining and modifying the values of attributes associated with existing named objects. These objects may be contexts or any other types of objects. Associated with a context are syntax attributes that describe how the context parses compound names.

Compound Names

A compound name is a sequence of one or more atomic names. An atomic name in one context object can be bound to a reference to another context object of the same type, called a subcontext. Objects in the subcontext are named using a compound name. Compound names are resolved by looking up each successive atomic name in each successive context.

A familiar analogy for UNIX users is the file naming model, where directories are analogous to contexts, and path names serve as compound names. Furthermore, contexts can be arranged in a "tree" structure, just as directories are, with the compound names forming a hierarchical namespace.

- **UNIX example**: `usr/local/bin`. UNIX atomic names are ordered from left to right and are delimited by slash (`/`) characters. The name `usr` is bound to a context in which `local` is bound. The name `local` is bound to a context in which `bin` is bound.
- **DNS example**: `sales.Wiz.COM`. DNS atomic names are ordered from right to left, and are delimited by dot (`.`) characters. The domain name `COM` is bound to a context in which `Wiz` is bound. `Wiz` is bound to a context in which `sales` is bound.
- **X.500 example**: `c=us/o=wiz/ou=sales`. An X.500 atomic name comprises an attribute type and an attribute value. Atomic names are known as *relative distinguished names* in X.500. In this string representation X.500 atomic names are ordered from left to right, and are delimited by slash (`/`) characters. An attribute type is separated from an attribute value by an equal sign (`=`) character. Abbreviations are defined for commonly used attribute types (for

example, “c” represents country name). The country name `US` is bound to a context in which `wiz` is bound. The organization name `wiz` is bound to a context in which the organizational unit name `sales` is bound.

Figure 2-2 shows an example of a hierarchical naming system with compound names.

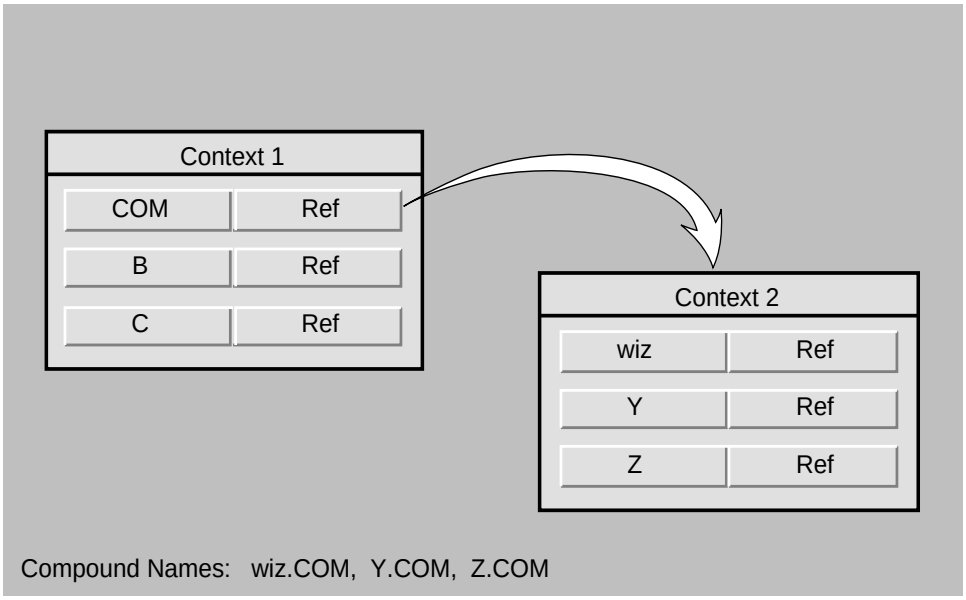

Figure 2-2 Hierarchical Naming System With Compound Names

Composite Names

A composite name is a name that spans multiple naming systems. It consists of an ordered list of zero or more components. Each component is a name from the namespace of a single naming system. Composite name resolution is the process of resolving a name that spans multiple naming systems. Chapter 11, “XFN Composite Names,” and Appendix A, “XFN Composite Names Syntax,” supply more detail about composite names.

Components are slash-separated (/) and ordered from left to right, according to XFN composite name syntax. For example, the composite name

```
sales.Wiz.COM/usr/local/bin
```

has two components, a DNS name (`sales.Wiz.COM`) and a UNIX path name (`usr/local/bin`).

Figure 2-3 on page 16 shows an example of a federated naming system with composite names. Note that the position of the name within a context has no inherent significance in this illustration.

XFN Links

An XFN link is a special form of a reference that is bound to an atomic name in a context. Instead of an address, a link contains a composite name. Many naming systems support a native notion of link that may be used within the naming system itself. XFN does not specify whether there is any relationship between such native links and XFN links.

“XFN Links” on page 165 describes links in detail.

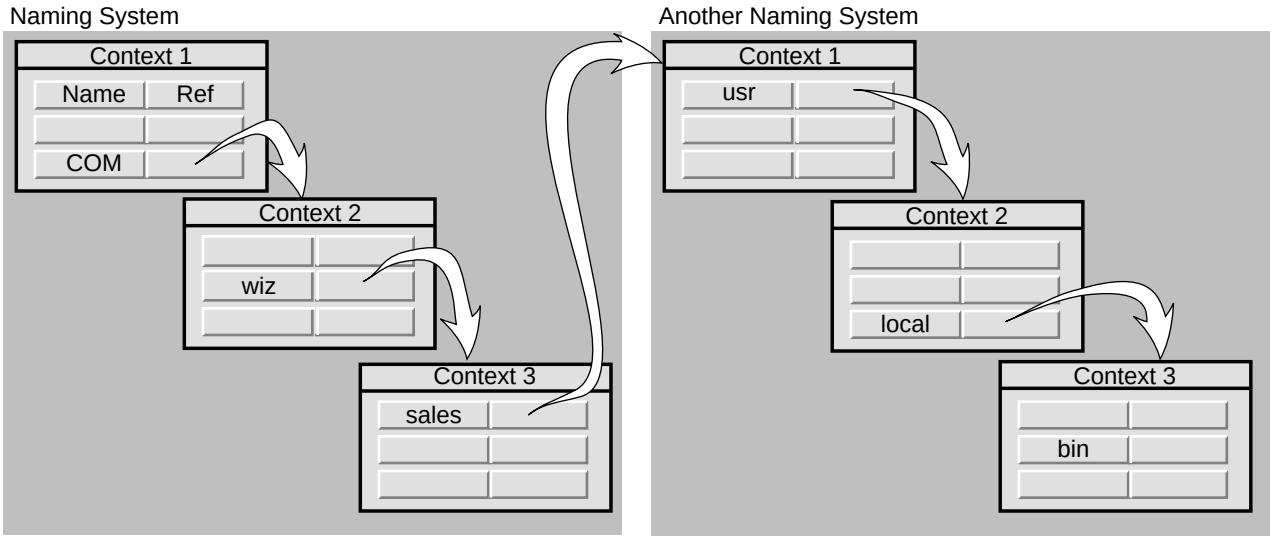

Figure 2-3 Federated Naming System With Composite Names

Initial Context

Every XFN name is interpreted relative to some context, and every XFN naming operation is performed on a context object. The *initial context* object provides a starting point for the resolution of composite names. The XFN interface provides a function that allows the client to obtain an initial context.

The policies described in Part 2 of this guide specify a set of names that the client can expect to find in this context and the semantics of their bindings. This provides the initial pathway to other XFN contexts.

User's View

Users experience federated naming through applications, as shown in Figure 2-4. The user can interact with XFN-aware applications in a simple, intuitive, and consistent manner. Typically, the user does not need to compose or know the full composite name of the objects because the application takes care of constructing the composite names.

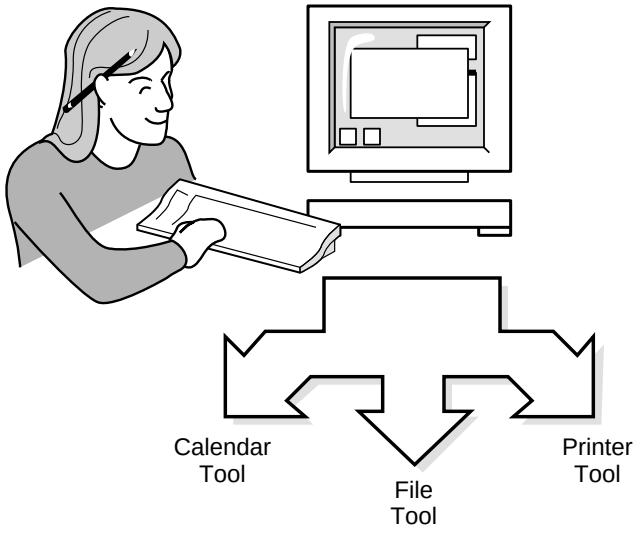

Figure 2-4 User View of XFN

For example, if the application is expecting you to type a user name, the application may include the `user/` string in front of names that you enter. Furthermore, if the application needs to name one of the user's services, such as the user's default fax machine, it can append the rest of the name, `/service/fax`, to the input supplied. Hence, a fax tool may take as input `jsmith` and compose the name `user/jsmith/service/fax` for the default fax of the user `jsmith`. Policies such as `user/` and `service/` are described in Part 2, "FNS Policies."

Similarly, to access a person's calendar, you just need to type the person's user name. The application takes the input, `jsmith`, and uses it to construct the composite name of the object, in this case, `user/jsmith/service/calendar`, as shown in Figure 2-5.

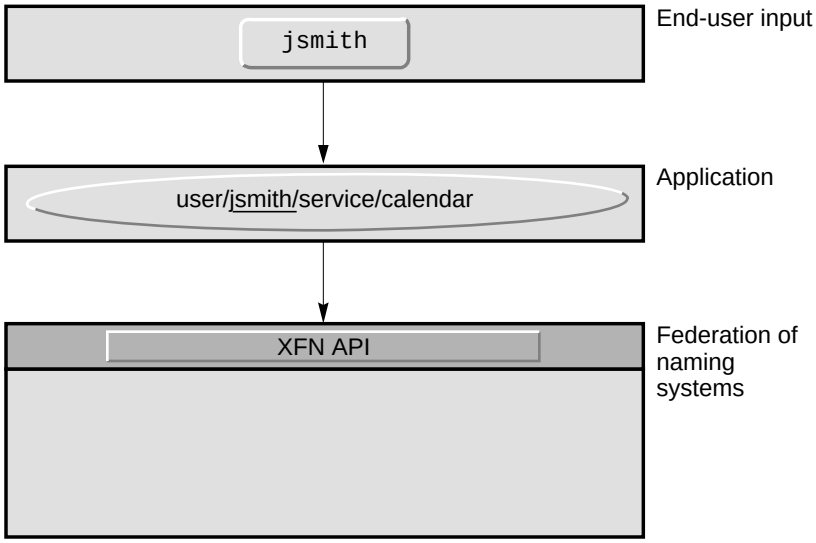

Figure 2-5 User Interaction With XFN

File System View

Users and applications also experience federated naming through the file system. The initial context is located under `/xfn` in the root directory. For example, user `jsmith`'s to_do file has the XFN name, `user/jsmith/fs/to_do`. To read this file, you could type:

```
% cat /xfn/user/jsmith/fs/to_do
```

Applications access the files under `/xfn` just as they do any other files. Applications do not need to be modified in any way, nor do they need to use the XFN API.

Application View

The way that client applications interact with XFN to access different naming systems is illustrated in a series of figures. Figure 2-6 shows an application that uses the XFN API and library.

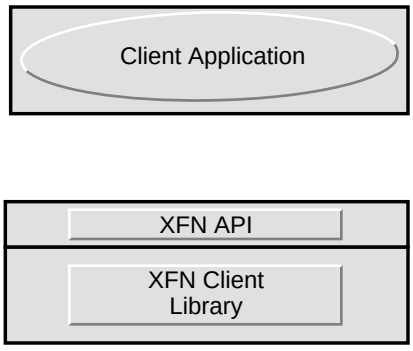

Figure 2-6 Client Application Interaction With XFN

Figure 2-7 shows the details beneath the API. A name service that is federated is accessed through the XFN client library and a *context shared object module*. This module translates the XFN calls into name service–specific calls.

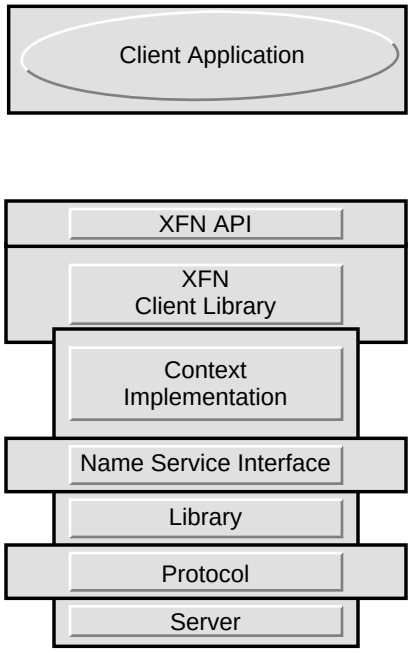

Figure 2-7 Details Beneath XFN API

X.500, DNS, and NIS+ are the name services that have been federated in the example shown in Figure 2-8.

As resolution of a composite name proceeds, it may cause these different modules to be linked in, depending on the types of contexts referenced in the name.

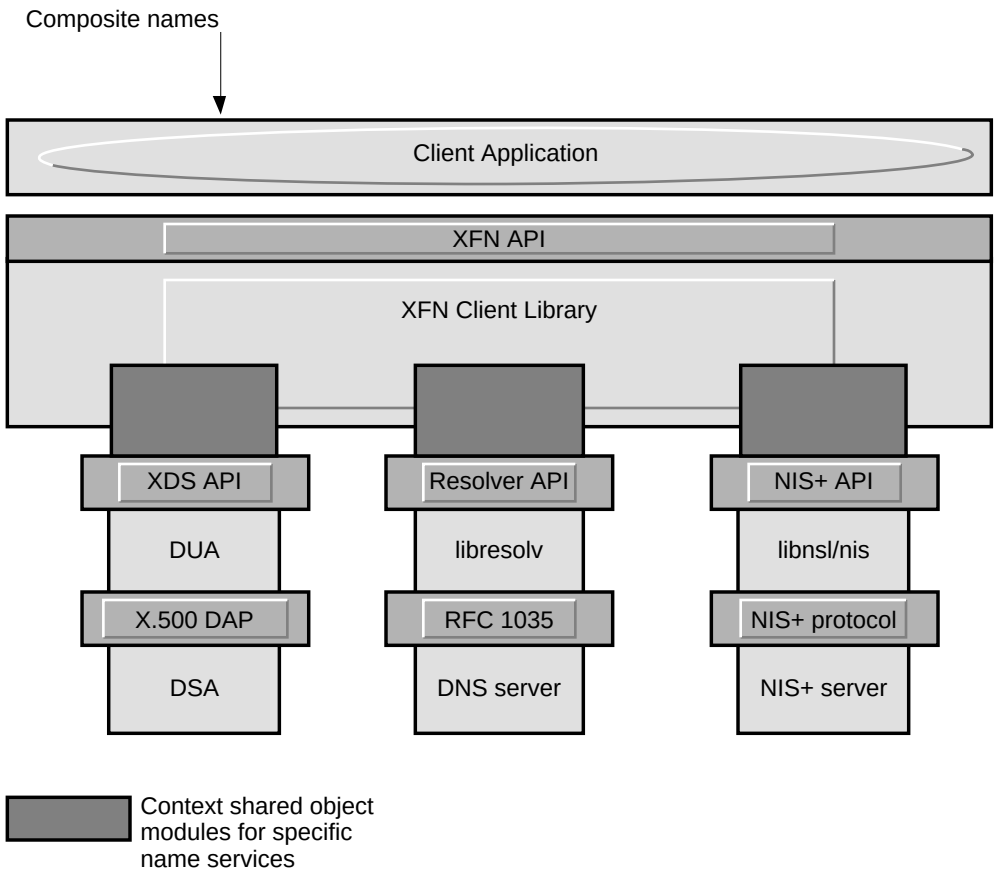

Figure 2-8 XFN Implementation Examples

2

API Usage Model

Many clients of the XFN interface are only interested in lookups. Their usage of the interface amounts to:

- Obtaining the initial context
- Looking up one or more names relative to the initial context

Once the client obtains a desired reference from the lookup operation, it constructs a client-side representation of the object from the reference. This need not be code within the application layer but may be code inside the service layer. For example, RPC services can provide clients with a means of constructing client-side handles from a composite name for the service or from a reference containing an RPC address for the service. After getting this handle, the client performs all further operations on the object or service by supplying the handle.

This is the basic model of how the XFN interface is expected to be used. The enterprise policies presented in Chapter 4 further encourage a bind/lookup model for how services and clients may rendezvous through the use of the name service.

Part 2 — FNS Policies

These three chapters examine the FNS naming policies that are integral to using FNS.

Introduction to FNS Policies 3

This chapter introduces FNS policies.

XFN defines policies for naming objects in the federated namespace. The goals of these policies are

- To allow easy and uniform composition of names
- To promote coherence in naming across applications and services
- To provide a simple, yet sufficiently rich, set of policies so that applications need not invent and implement ad hoc policies for specific environments
- To enhance an application's portability
- To promote cross-platform interoperability in heterogeneous computing environments

FNS policies contain all the XFN policies as well as extensions for the Solaris environment.

3

Policy Overview

Computing environments now offer worldwide scope and a large range of services. Users expect to have access to services at every level of the computing environment. Figure 3-1 on page 27 shows that FNS policies provide a common framework for the three levels of services: global, enterprise, and application.

What FNS Policies Specify

FNS provides applications with a set of policies on how name services are arranged and used at the enterprise level:

- Name services for enterprise objects: organizations, hosts, users, sites, and services. (these name services support contexts that allow other objects to be named relative to these objects)
- The relationships among the organization, host, user, site, and service name services, and the names used to refer to these name services
- The syntax of names in these name services
- How to federate the enterprise namespace so that it is accessible in the global namespace
- Names and bindings present in the initial context of every process

What FNS Policies Do Not Specify

The FNS policies do not specify the specific names used within name services. In addition, naming within the application is left to individual applications or groups of related applications.

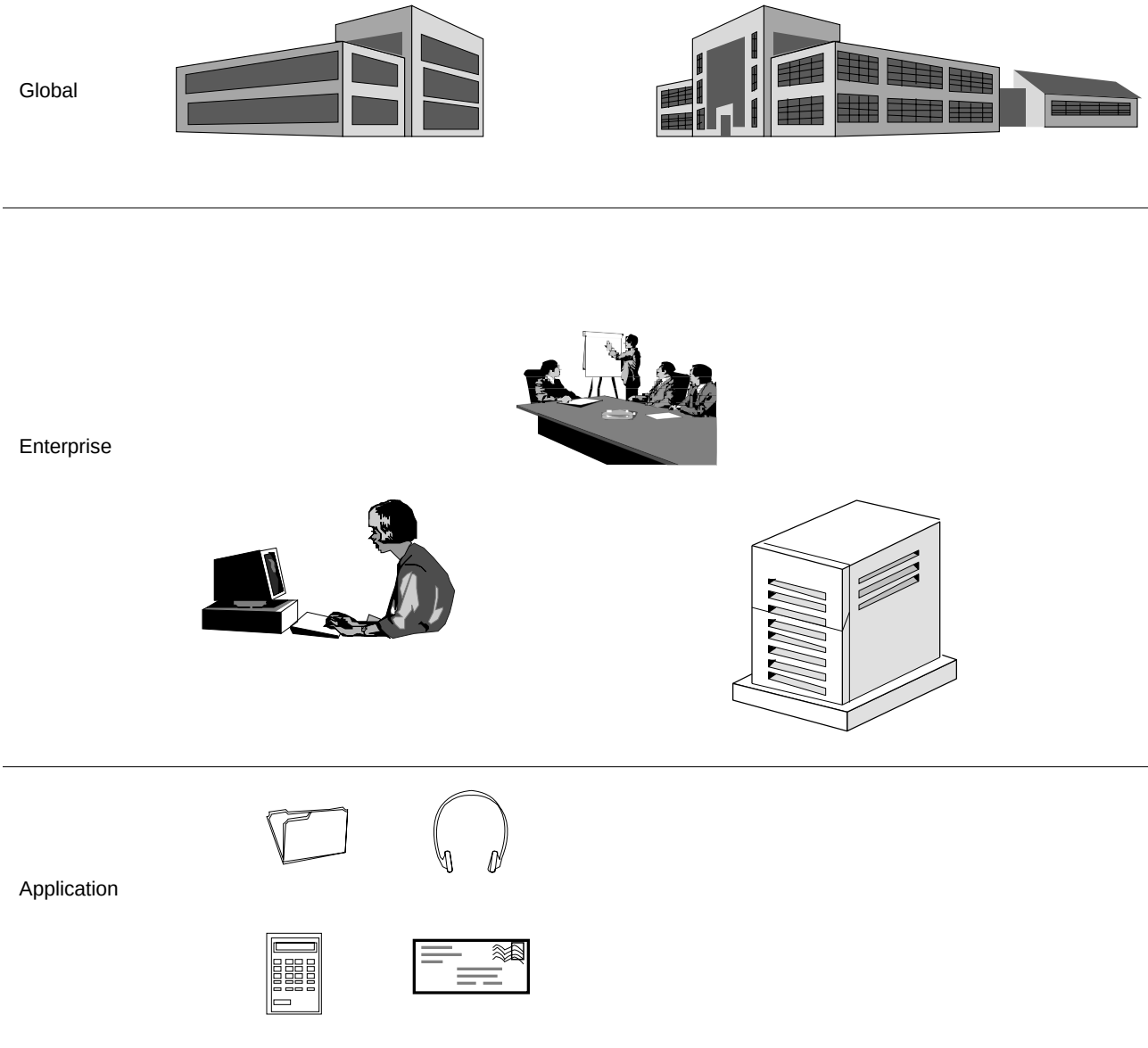

Figure 3-1 Different Levels of Name Services

3

What FNS Enterprise Policies Arrange

The FNS enterprise policies deal with the arrangement of objects within the enterprise namespace. This section introduces the types of objects named within an enterprise and how they are arranged, as shown in Figure 3-2. These entities are described in greater detail in Chapter 4, “Policies for the Enterprise Namespace.” The policies are summarized in Table 4-2 on page 43.

- **Organization** — Entities such as departments, centers, and divisions. Sites, hosts, users, and services can be named relative to an organization. The XFN term for organization is *organizational unit*.
- **Site** — Physical locations, such as buildings, machines in buildings, and conference rooms within buildings. Sites may have files and services associated with them.
- **Host** — Computers. Hosts may have files and services associated with them.
- **User** — Human users. Users may have files and services associated with them.
- **Service** — Services such as printers, faxes, mail, and electronic calendars.
- **File** — Files within a file system.

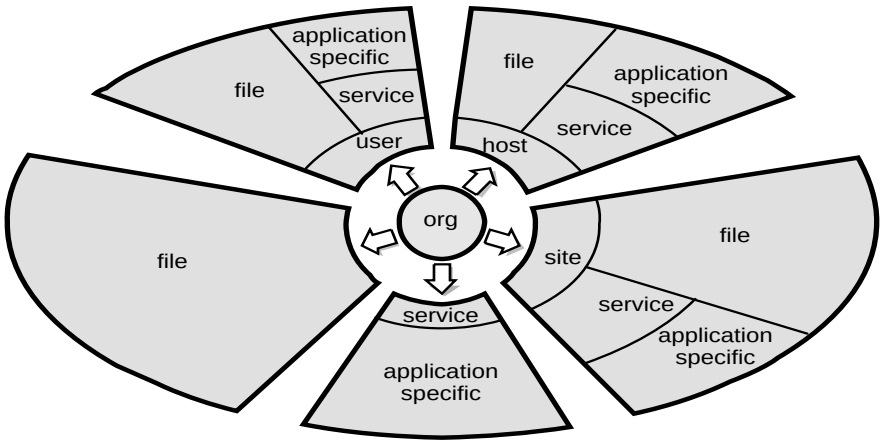

Figure 3-2 What FNS Policies Arrange

Examples of Composite Names

This section shows examples of names that follow FNS policies. The specific choices of organization names, site names, user names, host names, file names, and service names (such as "calendar" and "printer") are illustrative only; these names are not specified by FNS policy.

Composing Names Relative to Organizations

The naming systems to be found under an organization are: `user`, `host`, `service`, `fs`, and `site`.

`org/csl.parc/site/videoconference.northwing`
: names a conference room `videoconference` located in the north wing of the site associated with the organization `csl.parc`.

`org/csl.parc/user/mjones`
: names a user `mjones` in the organization `csl.parc`.

`org/csl.parc/host/inmail`
: names a machine `inmail` belonging to the organization `csl.parc`.

`org/csl.parc/fs/pub/blue-and-whites/CSL92-124`
: names a file `pub/blue-and-whites/CSL92-124` belonging to the organization `csl.parc`.

`org/csl.parc/service/calendar`
: names the `calendar` service for the organization `csl.parc`. This might manage the meeting schedules for the organization.

Composing Names Relative to Users

The naming systems associated with users are `service` and `fs`.

`user/jsmith/service/calendar`
: names the `calendar` service of the user `jsmith`.

`user/jsmith/fs/bin/games/riddles`
: names the file `bin/games/riddles` under the home directory of the user `jsmith`.

Composing Names Relative to Hosts

The naming systems associated with hosts are `service` and `fs`.

`host/mailhop/service/mailbox`
names the `mailbox` service associated with the machine `mailhop`.

`host/mailhop/fs/pub/saf/archives.91`
names the directory `pub/saf/archives.91` found under the root directory of the file system exported by the machine `mailhop`.

Composing Names Relative to Sites

The naming systems associated with sites are `service` and `fs`.

`site/B5.MountainView/service/printer/speedy`
names a printer `speedy` in the `B5.MountainView` site.

`site/B5.MountainView/fs/usr/dist`
names a file directory `usr/dist` available in the `B5.MountainView` site.

How FNS Policies Relate to NIS+

If you are not familiar with NIS+ and its terminology, refer to *NIS+ and DNS Setup and Configuration Guide.* You will find it helpful to be familiar with the structure of a typical NIS+ environment.

NIS+ Domains and FNS Organizational Units

FNS names organization, user, and host objects within the Solaris enterprise naming system, NIS+. An NIS+ domain is comprised of logical collections of users and machines and information about them, arranged to reflect some form of hierarchical organizational structure within an enterprise.

FNS is implemented on NIS+ by mapping NIS+ domains to FNS organizations. An organizational unit name corresponds to a NIS+ domain name and is identified using the fully qualified form of its NIS+ domain name, or its NIS+ domain name relative to the NIS+ root. The top of the FNS organizational namespace is mapped to the NIS+ root domain and is accessed using the name `org/` from the initial context.

In NIS+, users and hosts have a notion of a *home domain*. It is the primary NIS+ domain that maintains information associated with them. A user or host's home domain can be determined directly using its NIS+ *principal name*. An NIS+ principal name is composed of the atomic user (login) name or the atomic host name and the name of the NIS+ home domain. For example, user `jsmith` with home domain `wiz.com.` has an NIS+ principal name `jsmith.wiz.com.`

A user's NIS+ home domain corresponds to the user's FNS organizational unit. Similarly, a host's home domain corresponds to its FNS organizational unit.

Trailing Dot in Organization Names

The trailing dot in an organization name indicates that the name is a fully qualified NIS+ domain name. Without the trailing dot, the organization name is an NIS+ domain name to be resolved relative to the NIS+ root domain.

For example, if the NIS+ root domain is `wiz.com.`, with subdomains `eng.wiz.com.` and `sales.wiz.com.`, the following pairs of names refer to the same organization:

```
org/            org/wiz.com.
org/eng         org/eng.wiz.com.
org/sales       org/sales.wiz.com.
```

The name `org/eng.` (with trailing dot) would not be found, because there is no NIS+ domain with the `eng.` name.

NIS+ Users and FNS Users

Users in the NIS+ namespace are found in the `passwd.org_dir` table of a domain. Users in an FNS organization correspond to the users in the `passwd.org_dir` table of the corresponding NIS+ domain. FNS provides a context for each user in the `passwd` table.

NIS+ Hosts and FNS Hosts

Hosts in the NIS+ namespace are found in the `hosts.org_dir` table of a domain. Hosts in an FNS organization correspond to the hosts in the `hosts.org_dir` table of the corresponding NIS+ domain. FNS provides a context for each host in the `hosts` table.

Target Client Applications of FNS Policies

One goal of the FNS policies is to address coherence across the most commonly used tools, including the file system, the DeskSet™ tools, such as Calendar Manager, Print Tool, File Manager, and Mail Tool, and services that support these tools, such as RPC, email, and print subsystems.

Note – Some of these examples are not currently implemented in the Solaris environment. They are listed here as a way of illustrating how FNS may be used.

- **Calendars** — Instead of using names of the form *username@hostname* to access someone's calendar, you would simply supply a user's name, in most cases. You should also be able to use composite names to name calendars. For example, names of the following form would be accepted by calendar manager:

  `jsmith`
  `user/mjones`
  `site/clarke.b5.mtv` (calendar for Clarke conference room)

- **Printing** — Instead of naming a specific printer by its name, you should be able to name a printer relative to a user, site, or organization. For example:

  `jsmith` (`jsmith`'s default printer)
  `org/dct` (an organization's default printer)
  `site/clarke.b5.mtv` (printer in the Clarke conference room)

- **File access** — You should be able to use composite names to name file systems and files. The automounter should use FNS to make resolution of composite names possible. For example, you should be able to use a file name like `/xfn/user/mbrown/fs/.cshrc` to reference the `.cshrc` file for user `mbrown`.

- **RPC** — Instead of addressing services by their host name, program, and version numbers, you should be able to name the service using a composite name. For example, you should be able to name an RPC service relative to a user or an organization.
- **Mail** — Similarly, composite names can be used to name mail destinations. You should be able to use names such as the following:

  `jsmith`
  `user/jsmith`
  `org/dct` (an organization's mailing list)
  `site/clarke.b5.mtv` (mailbox of the conference room coordinator)
- **Other desktop applications** — You should be able to pass composite names to other desktop applications such as spreadsheets, document preparation tools, fax tools, and so on. Some of these applications would attach their own namespace to the service namespace, thus becoming part of the FNS federation.

Example Application: Calendar Service

This is a description of how one application, a calendar service, could be modified to use FNS policies. This example illustrates how FNS composite names might be presented to and accepted from users.

The DeskSet's calendar service is typical of client-server applications. Calendar servers runs on some set of machines and maintain the users' calendars. Calendar Manager (`cm`) runs on the desktop and contacts the appropriate server to obtain the calendars of interest.

The calendar service could benefit from FNS using a simple registry/lookup model as follows:

- **Binding** — Upon startup, the server registers the calendars that it manages by binding a reference containing its own ONC+ RPC address (*host*, *program*, *version*) to the composite name for each calendar it manages, such as `user/jsmith/service/calendar`.
- **Lookup** — When using `cm`, the user specifies another user's calendar simply by entering the user's name (for example, `jsmith`) or selecting it from a list of names previously entered. Given the user name `jsmith`, `cm` composes

the composite name `user/jsmith/service/calendar` and uses this to look up the RPC address that it needs to communicate with the server that manages that calendar.

In the previous example, we used the name "`calendar`" to denote a calendar binding. The developers of the calendar service should register the name "`calendar`" with the FNS administrator, much as RPC programs are registered with the RPC administrator. Refer to "Service Name and Reference Registration" on page 40.

Note – The name "`calendar`" used here is an example. FNS policy does not specify the names of specific services.

The calendar service could take further advantage of FNS policy by allowing calendars to be associated with sites, organizations, and hosts, while still naming them in a uniform way. For example, by allowing calendars to be associated with a conference room (a site), the service can be used to "multibrowse" the conference room's calendar as well as a set of user calendars to find an available time for a meeting in that room. Similarly, calendars can be associated with organizations for group meetings and hosts for keeping maintenance schedules.

`cm` could simplify what the user needs to specify by following some simple steps.

1. `cm` uses a tool for accepting composite names from the user and constructing the name of the object whose calendar is of interest. The object would be the name of a user, a site, a host, or an organization. For example, the user might enter the name `mjones` and the calendar manager would generate the composite name `user/mjones`. This tool could be shared amongst a group of DeskSet applications.
2. `cm` uses the XFN interface to compose this name with the suffix `/service/calendar` to obtain the name of the calendar.

3. This calendar name is then resolved relative to the process's initial context. Continuing with the example, this would result in the resolution of the name `user/mjones/service/calendar`. Similarly, if the user enters the name of a site, `clarke.B5.mtv`, `cm` would generate the name `site/clarke.B5.mtv/service/calendar` for resolution.

Other services such as printing and mail could take advantage of the FNS policies in a similar way.

3

Policies for the Enterprise Namespace

4

FNS policies specify the types and arrangement of namespaces within an enterprise and how such namespaces can be used by applications. This chapter describes these policies.

FNS policies described in this chapter include some extensions to XFN policy. These are explicitly defined with notes.

Namespaces in the Enterprise

This section introduces the types of namespaces within an enterprise:

- Organizational units
- Sites (an extension to the XFN policy)
- Hosts
- Users
- Services
- Files
- Printers (an extension to the XFN policy)

Some of these namespaces, such as users and hosts, can appear more than once in a federated namespace.

Organizational Unit Namespace

The organizational unit namespace provides a hierarchical namespace for naming subunits of an enterprise. Each organizational unit name is bound to an *organizational unit context* that represents the organizational unit.

In the Solaris environment, organizational units correspond to NIS+ domains and are named using dot-separated right-to-left compound names, where each atomic part names an organizational unit within a larger unit. For example, the name `dct.eng` names an organizational unit `dct` within a larger unit named `eng`.

Organizational unit names can be either fully qualified NIS+ domain names or relatively named NIS+ domain names. Fully qualified names have a terminal dot; relative names do not. If a terminal dot is present in the organization name, the name is treated as a fully qualified NIS+ domain name. If there is no terminal dot, the organization name is resolved relative to the top of the organizational hierarchy. For example, if the top organization corresponds to the NIS+ root domain `wiz.com.`(the trailing dot is significant) and if `dct.eng` is one of its suborganizations, the organization names `dct.eng` and `dct.eng.wiz.com.` (the trailing dot is significant) are equivalent.

Site Namespace

The site namespace provides a geographic namespace for naming objects that are naturally identified with their physical locations. These objects may be, for example, buildings on a campus, machines and printers in a building, conference rooms in a building and their schedules, and users in a particular quadrant of a building.

In the Solaris environment, sites are named using compound names, where each atomic part names a site within a larger site. The syntax of site names is dot-separated right-to-left, with components arranged from the most general to the most specific location description. For example, `clarke.b5.mtv` names the Clarke conference room in building 5 on the Mountain View campus of some enterprise.

User Namespace

The user namespace provides a namespace for naming human users in a computing environment.

Users are named in *username contexts*. The `username` context has a single-level namespace and contains bindings of user names to *user contexts*. A user context allows you to name objects relative to a user, such as files, services, or resources associated with the user.

In the Solaris environment, user names correspond to Solaris login user names.

Host Namespace

The host namespace provides a namespace for naming computers.

Hosts are named in *hostname* contexts. The `hostname` context has a flat namespace and contains bindings of host names to *host contexts*. A host context allows you to name objects relative to a host, such as files and printers found at that host.

In the Solaris environment, host names correspond to Solaris host names. Alias names for a single machine share the same context.

Service Namespace

The service namespace provides a namespace for services used by or associated with objects within an enterprise. Examples of such services are electronic calendars, faxes, mail, and printing.

In the Solaris environment, the service namespace is hierarchical. Service names are slash-separated (`/`) left-to-right compound names. An application that uses the service namespace can make use of this hierarchical property to reserve a subtree for that application. For example, the printer service reserves the subtree `printer` in the service namespace.

FNS does not specify how service names or reference types are chosen. These are determined by service providers that share the service namespace. For example, the calendar service uses the name `calendar` in the service context to name the calendar service and what is bound to the name `calendar` is determined by the calendar service.

Service Name and Reference Registration

SunSoft, Inc., maintains a registry of the names bound in the first level of the `service` namespace. To register a name, send an email request to `fns-register@sun.com`, or write to:

FNS Registration
Sun Microsystems, Inc.
2550 Garcia Avenue
Mountain View, CA 94043

Please include a brief description of the intended use of the name and a description of the format of the reference that can be bound to that name. See “References and Addresses” on page 153 for details on reference formats.

Printer Namespace

The printer namespace provides a namespace for naming printers. The printer namespace and context is described in more detail in Chapter 9, “Administering the Printer Namespace.”

File Namespace

A file naming system (or file system) provides a namespace for naming files. The file context and namespace is described in more detail in Chapter 8, “Administering the File System Namespace.”

Namespace Identifiers

The organizational unit namespace, site namespace (an extension to XFN policies), user namespace, host namespace, service namespace, and file namespace are referred to by the atomic names `_orgunit`, `_site`, `_host`, `_user`, `_service`, and `_fs`, respectively, in the federated enterprise namespace. These atomic names are called *namespace identifiers*.

Table 4-1 Namespace Identifiers in the Enterprise

Namespace Identifier	**Resolves to**
`orgunit` `_orgunit`	Context for naming organizational units
`site` `_site`	Context for naming sites
`host` `_host`	Context for naming hosts
`user` `_user`	Context for naming users
`fs` `_fs`	Context for naming files
`service` `_service`	Context for naming services
`printer`	Context for naming printers

In addition, FNS also supports the use of these names without the leading underscore ("_") character (`orgunit`, `site`, `host`, `user`, `service`, and `fs`, respectively) as namespace identifiers for these namespaces. These names without the underscore are extensions to the XFN policies. The `site` and `printer` contexts are extensions to the XFN policies.

Note – In XFN terminology, the names with the leading underscore are the *canonical* namespace identifiers. The names without the underscore are the Solaris *customized* namespace identifiers. Solaris customized namespace identifiers, with the addition of `printer`, may not necessarily be recognized in non-Solaris environments. The canonical namespace identifiers are always recognized and, hence, portable to other environments.

The XFN component separator (`/`) is used to delimit namespace identifiers. For example, composing the namespace identifier `orgunit` with the organizational unit name `accountspayable.finance` gives the composite name, `orgunit/accountspayable.finance`.

Composing the namespace identifier `user` with the user name `jsmith` gives the composite name, `user/jsmith`.

FNS reserves the use of all atomic names in Table 4-1 as namespace identifiers in contexts in which namespace identifiers can appear, as defined by the arrangement of naming systems in “Structure of the Enterprise Namespace.” FNS does not otherwise restrict the use of these atomic names in other contexts. For example, the atomic name `service` is used as a namespace identifier relative to a user name, as in `user/jsmith/service/calendar`, to mean the root of user `jsmith`'s service namespace. This does not preclude a system from using the name `service` as a user name, as in `user/service`, because FNS specifies that the context to which the name `user/` is bound is for user names and not for namespace identifiers. Thus, in this case, `service` is unambiguously interpreted as a user name.

Structure of the Enterprise Namespace

FNS defines the structure of the enterprise namespace. The goal of this structure is to allow easy and uniform composition of names. This structure has two main rules: (1) objects with narrower scopes are named relative to objects with wider scopes, and (2) namespace identifiers are used to denote the

transition from one namespace to the next. Table 4-2 is a summary of FNS policy for arranging the enterprise namespace. Figure 4-1 on page 44 shows an example of a namespace layout that follows FNS policy.

Table 4-2 Policies for the Federated Enterprise Namespace

Namespace Identifiers	Name Service Type	Subordinate Context	Parent Context	Namespace Organization	Syntax
`orgunit` `_orgunit`	Organizational unit	Site, user, host, file system, service	Enterprise root	Hierarchical	NIS+ domain name Dot-separated, right-to-left
`site` `_site`	Site	Service, file system	Enterprise root, organizational unit	Hierarchical	Dot-separated, right-to-left
`user` `_user`	User	Service, file system	Enterprise root, organizational unit,	Flat	Solaris login name
`host` `_host`	Host	Service, file system	Enterprise root, organizational unit,	Flat	Solaris host name
`service` `_service`	Service	Application-specific	Enterprise root, organizational unit, site, user, host	Hierarchical	/ separated, left-to-right
`fs` `_fs`	File system	None	Enterprise root, organizational unit, site, user, host	Hierarchical	/ separated, left-to-right
`printer`	Printer	None	Service	Hierarchical	/ separated, left-to-right

4

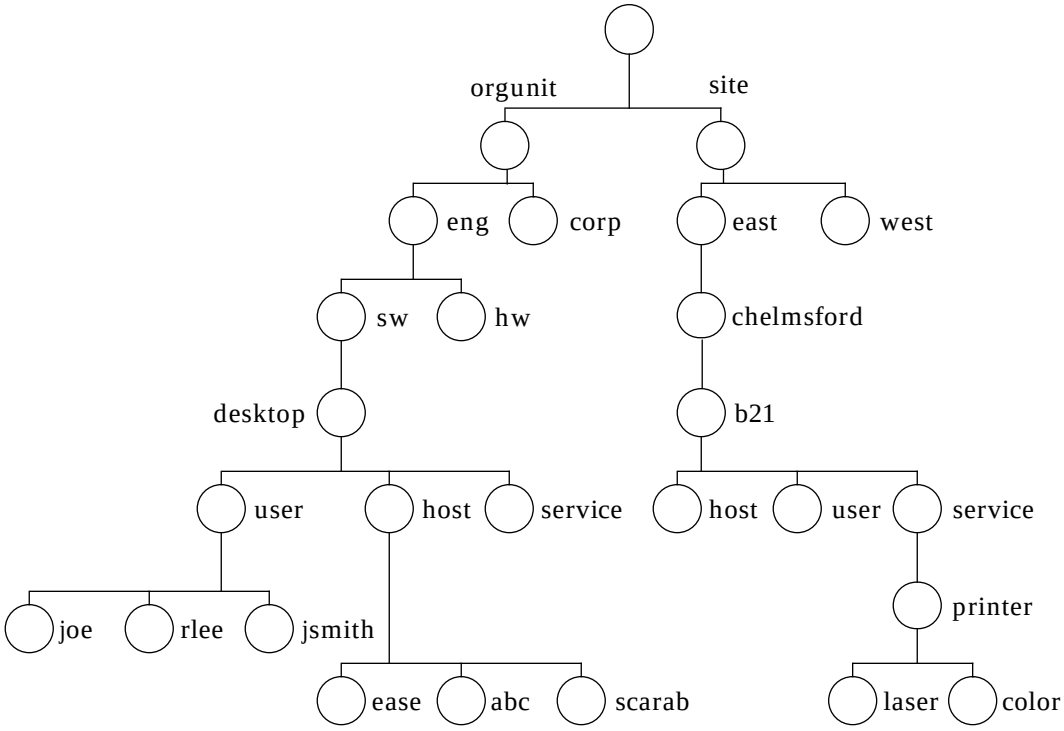

Figure 4-1 Example of an Enterprise Namespace

The namespace of an enterprise is structured around the hierarchical structure of organizational units of an enterprise. Names of sites, hosts, users, files, and services may be named relative to names of organizational units by composing the organizational unit name with the appropriate namespace identifier and object name.

In Figure 4-1, a user `jsmith` in the engineering organization of an enterprise is named using the name

```
orgunit/desktop.sw.eng/user/jsmith
```

Note the use of the namespace identifier `user` to denote the transition from the `orgunit` namespace to the `user` namespace. In a similar fashion (with the use of appropriate namespace identifiers), names of files and services may also be named relative to names of sites, users, or hosts. Names of sites may be named relative to organizational unit names.

The goal of easy and uniform composibility of names is met using this structure. For example, once you know the name for an organizational unit within an enterprise (for example, `orgunit/sw`), you can name a user relative to it by composing it with the `user` namespace identifier and the user's login name to yield a name such as

```
orgunit/sw/user/joe
```

To name a file in this user's file system, you can use a name like

```
orgunit/sw/user/joe/fs/notes
```

Double Slashes in Organization Name

`orgunit//` names the context of namespace identifiers associated with the root organizational unit, as in `orgunit//service/printer`. See "Significance of Double Slashes" on page 99 for more details on the significance of double slashes.

Enterprise Root

The root context of an enterprise, referred to as the *enterprise root*, is a context for naming objects found at the root of the enterprise namespace.

Parent Context

Enterprise roots are bound in the global namespace.

Subordinate Contexts

The following objects can be named relative to the enterprise root:

- Organizational units in that enterprise
- Sites in the top organizational unit of the enterprise (an extension to XFN policies)

- Users in the top organizational unit of the enterprise
- Hosts in the top organizational unit of the enterprise
- Services for the top organizational unit of the enterprise
- File service for the top organizational unit of the enterprise

These objects are named by composing with the namespace identifier of the target object's namespace and the name of the target object.

For example, if `.../wiz.com`[1] is the name of an enterprise, the root of the context for naming organizational units is

```
.../wiz.com/orgunit/
```

and an organizational unit in that enterprise would be named using a name like

```
.../wiz.com/orgunit/finance
```

Sites in that enterprise would be named using a name starting with

```
.../wiz.com/site/
```

Organizational Units

Parent Context

Organizational units may be named relative to the enterprise root.

Given an organization name, you can compose a name for its organizational unit context by using one of the namespace identifiers, `orgunit` or `_orgunit`. For example, if `.../wiz.com` is the name of an enterprise, the root of the context for naming organizational units is

```
.../wiz.com/orgunit/
```

and an organizational unit in that enterprise would be named using a name like

```
.../wiz.com/orgunit/finance
```

1. The atomic name "..." (three dots) appears in the initial context to mean the global context. See Chapter 5, "Policies for the Global Namespace" for a description of the global context.

Subordinate Contexts

The following objects can be named relative to an organizational unit name:

- Sites for that organizational unit (an extension to the XFN policies)
- Hosts in that organizational unit
- Users in that organizational unit
- Services for that organization unit
- File service for that organizational unit

These objects are named by composing the organizational unit's name with the namespace identifier of the target object's namespace and the name of the target object. For example, the name

```
orgunit/sales/service/calendar
```

names the calendar service of the `sales` organizational unit. Similar, the name

```
orgunit/sales/user/jpeters
```

names a user `jpeters` in the `sales` organizational unit.

To name an organizational unit's subunit, you use the organizational unit namespace's syntax to compose the subunit's name. For example, a subunit `accountspayable` of the organizational unit `finance` is named using the name

```
orgunit/accountspayable.finance
```

whereas user `jsmith` in the `finance` organizational unit is named using the name

```
orgunit/finance/user/jsmith
```

Sites

Sites are an extension to the XFN policies.

Parent Contexts

Sites may be named relative to

- The enterprise root
- An organizational unit

Sites named relative to the enterprise root are the same as sites named relative to the top organizational unit. Given an organization name, you can compose a name for its site context by using one of the namespace identifiers, `site` or `_site`. For example, if `.../wiz.com` is the name of an enterprise, the root of the context for naming sites is

```
.../wiz.com/site
```

which is equivalent to

```
.../wiz.com/orgunit//site
```

A site in that enterprise would be named using a name like

```
.../wiz.com/site/OceanSide
```

In another example, the name

```
orgunit/eng/site/
```

names the root of the site namespace for the organizational unit `orgunit/eng`, while the name

```
orgunit/eng/site/b5.mtv
```

names a location within that site; in this example, building 5 in Mountain View.

Subordinate Contexts

The following objects can be named relative to a site name:

- Services at the site, such as the site schedule or calendar, printers, and faxes
- The file service available at the site

These objects are named by composing the site name with the namespace identifier of the target object's namespace and the name of the target object.

For example, the name

```
site/Clark.b5.mtv/service/calendar
```

names the calendar service of the conference room `Clark.b5.mtv` and is obtained by composing the site name `site/Clark.b5.mtv` with the service name `service/calendar`. To name a subunit of a site, you use the site namespace syntax. For example, the name

```
site/b5.mtv
```

names building 5, on the Mountain View campus of some enterprise while the name

```
site/mtv/service/calendar
```

names the calendar service for the Mountain View site.

Users

Parent Contexts

Users can be named relative to

- An organizational unit
- The enterprise root

Users named relative to the enterprise root are the same as users named relative to the top organizational unit. Given an organization name, you can compose a name for its `username` context by using one of the namespace identifiers, `user` or `_user`. Thus, if `orgunit/dct.eng` names an organization, then

```
orgunit/dct.eng/user/
```

names the `username` context of `dct.eng`. The `username` context contains bindings of user names to user contexts.

Continuing with the above example, the name

```
orgunit/dct.eng/user/jsmith
```

names a user `jsmith` in the `dct.eng` organizational unit.

Subordinate Contexts

The following objects can be named relative to a user name:

- Services associated with the user
- The user's files

These objects are named by composing the user's name with the namespace identifier of the target object's namespace and the name of the target object. For example, the name

```
user/jjones/service/calendar
```

names the calendar for the user `jjones`.

Hosts

Parent Contexts

Hosts can be named relative to

- An organizational unit
- The enterprise root

Hosts named relative to the enterprise root are the same as hosts named relative to the top organizational unit. Given an organization name, you can compose a name for its `hostname` context by appending one of the namespace identifiers, `host` or `_host`. Thus if `orgunit/dct.eng` names an organization, then

```
org/dct.eng/host/
```

names the `hostname` context of `dct.eng`. The `hostname` context contains bindings of host names to `host` contexts. Continuing with the above example, the name

```
org/dct.eng/host/silver
```

names a machine `silver` in the `dct.eng` organizational unit.

Subordinate Contexts

The following objects can be named relative to a host name:

- Services associated with the host
- Files exported by the host

These objects are named by composing the host name with the namespace identifier of the target object's namespace and the name of the target object. For example, the name

```
host/silver/fs/release
```

names the file directory `release` being exported by the machine `silver`.

Typically, resources should not be named relative to hosts but relative to more intuitive entities such as organizations, users, or sites. Dependence on host names forces the user to remember information that is often obscure and sometimes not very stable. For example, a user's files may move from one host to another, because of hardware changes, file space usage, users who share the same file server, network reconfigurations, and so on. Yet if the files were named relative to the user, such changes would not affect how the files are named. There may be a few cases in which the use of host names is appropriate. For example, if a resource is available only on a particular machine and is tied to the existence of that machine, and there is no other logical way to name the resource relative to other entities, then it may make sense to name the resource relative to the host.

Services

Service names should be registered with SunSoft, Inc., as directed in "Service Name and Reference Registration" on page 40.

Parent Contexts

A service can be named relative to

- An organizational unit
- The enterprise root
- A user
- A host
- A site

Services named relative to the enterprise root are the same as services named relative to the top organizational unit.

The parent contexts allow services, such as Calendar Manager or printers, to be named relative to the parent object. A service context is named by using the namespace identifiers `service` or `_service`, relative to the organization, site, user, or host with which it is associated. For example, if `orgunit/accountspayable.finance` names an organizational unit, then

```
orgunit/accountspayable.finance/service/calendar
```

names the `calendar` service of the organizational unit `accountspayable.finance`.

Subordinate Contexts

FNS does not restrict the types of bindings in the service namespace. Applications may create contexts of a type other than service contexts and bind them in the service namespace.

FNS supports the creation of *generic* contexts in the service context. A generic context is similar to a service context except that a generic context has an application-determined reference type. All other properties of a generic context are the same as a service context.

For example, a company, World Intrinsic Designs Corp (WIDC), reserves the name `extcomm` in the service namespace to refer to a generic context for adding bindings related to its external communications line of products. The context bound to `extcomm` is a generic context, with reference type `WIDC_comm`. The only difference between this context and a service context is that this context has a different reference type.

Files

Parent Contexts

A file namespace can be named relative to

- The enterprise root
- An organizational unit
- A user
- A host
- A site

Files named relative to the enterprise root are the same as files named relative to the top organizational unit. A file context is named by using the namespace identifiers `fs` or `_fs`, relative to the organization, site, user, or host with which it is associated. For example, if `orgunit/accountspayable.finance` names an organizational unit, then

```
orgunit/accountspayable.finance/fs/
```

names the file service of the organizational unit `accountspayable.finance`. In another example, if `user/jsmith` names a user `jsmith`, the name

```
user/jsmith/fs/highlights95.mif
```

names her file `highlights95.mif`. The file service of the user defaults to her home directory, as specified in the NIS+ `passwd` table.

Subordinate Contexts

There can be no other type of context subordinate to a file system.

Printers

The printer context is an extension of XFN policies.

Parent Contexts

A printer namespace can be named in the service context.

A printer context is named by using the namespace identifier, `printer`, in the service context relative to

- An organizational unit
- A user
- A host
- A site

For example, if `orgunit/accountspayable.finance` names an organizational unit, then

```
orgunit/accountspayable.finance/service/printer
```

names the printer service of the organizational unit `accountspayable.finance`.

Subordinate Contexts

There can be no other type of context subordinate to a printer.

Initial Context Bindings for Naming Within the Enterprise

The XFN API provides a function, `fn_ctx_handle_from_initial()`, that allows the client to obtain an initial context object as a starting point for name resolution. The initial context contains bindings that allow the client application to (eventually) name any object in the enterprise namespace.Figure 4-2 on page 54 shows the same naming system as the one shown in Figure 4-1 on page 44, except that the initial context bindings are shaded and shown in italics.

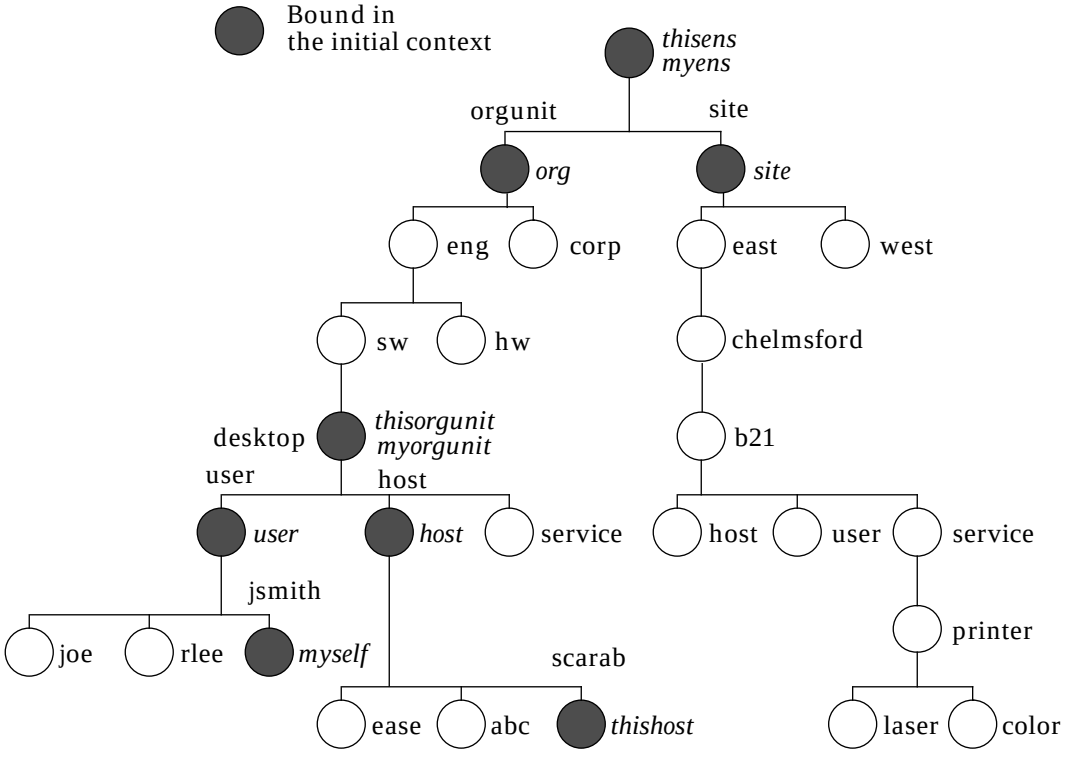

Figure 4-2 Example of Enterprise Bindings in the Initial Context

The initial context has a flat namespace for namespace identifiers. The bindings of these namespace identifiers are summarized in Table 4-3 on page 55 and are described in more detail in subsequent sections. There are three categories of bindings:

- User-related bindings
- Host-related bindings
- “Shorthand” bindings

In Table 4-3, the user to which the bindings are related is denoted by U, and the host to which the bindings are related is denoted by H. Not all of these names need to appear in all initial contexts. For example, when a program is invoked by the superuser, none of the user-related bindings appears in the initial context. These bindings are described in more detail in the following sections.

Table 4-3 Initial Context Bindings for Naming Within the Enterprise

Namespace Identifier	Binding

`myself`
`_myself`
`thisuser`
	U’s user context

`myens` `_myens`	The enterprise root of U
`myorgunit` `_myorgunit`	U’s distinguished organizational unit context; in the Solaris environment, the distinguished organizational unit is U’s NIS+ home domain
`thishost` `_thishost`	H’s host context
`thisens` `_thisens`	The enterprise root of H
`thisorgunit` `_thisorgunit`	H’s distinguished organizational unit context; in the Solaris environment, the distinguished organizational unit is H’s NIS+ home domain
`user` `_user`	The context in which users in the same organizational unit as H are named
`host` `_host`	The context in which hosts in the same organizational unit as H are named

`org`
`orgunit`
`_orgunit`
	The root context of the organizational unit namespace in H’s enterprise; in the Solaris environment, this corresponds to the NIS+ root domain

Table 4-3 Initial Context Bindings for Naming Within the Enterprise *(Continued)*

Namespace Identifier	Binding
`site` `_site`	The root context of the site namespace at the top organizational unit if the site namespace has been configured

In XFN terminology, the names with the leading underscore prefix are the canonical namespace identifiers. The names without the leading underscore, with the additions of `org` and `thisuser`, are Solaris customizations. Solaris customized namespace identifiers are not guaranteed to be recognized in other, non-Solaris environments. The canonical namespace identifiers are always recognized and, hence, portable to other environments.

Note – The current implementations of FNS does not support the addition or modification of names and bindings in the initial context.

User-related Bindings

FNS assumes that there is a user associated with a process when `fn_ctx_handle_from_initial()` is invoked. This association is based on the effective user ID (*euid*) of the process. Although the association of user to process may change during the life of the process, the original context handle does not change.

In the following sections the user is denoted by "U." FNS defines the following bindings in the initial context that are related to U.

`myself`

The namespace identifier `myself` (or either synonym `_myself` or `thisuser`) in the initial context resolves to the user context of U. For example, if U is `jsmith`, the name `myself` resolves in the initial context to `jsmith`'s user context, and the name

```
myself/fs/.cshrc
```

names the file `.cshrc` of `jsmith`.

myorgunit

FNS assumes that each user is affiliated with an organizational unit of an enterprise. A user may be affiliated with multiple organizational units, but there must be one that is distinguished, perhaps by its position in the organizational namespace or by the user's role in the organization. In NIS+ terminology, this organizational unit corresponds to the user's home domain.

The namespace identifier `myorgunit` (or synonym `_myorgunit`) resolves in the initial context to the context of U's distinguished organizational unit. For example, if U is the user `jsmith`, and `jsmith`'s home domain is `accountspayable.finance`, then `myorgunit` resolves in the initial context to the organizational unit context for `accounts_payable.finance`, and the name

```
myorgunit/service/calendar
```

resolves to the calendar service of `accounts_payable.finance`.

myens

FNS assumes that there is an association of a user to an enterprise. This corresponds to the NIS+ hierarchy that holds `myorgunit`.

The namespace identifier `myens` (and synonym `_myens`) resolves in the initial context to the enterprise root of the enterprise to which U belongs. For example, assume that U is `jsmith` and `jsmith`'s NIS+ home domain is `accountspayable.finance`, which in turn is in the NIS+ hierarchy with root domain name `wiz.com`. The name

```
myens/orgunit/
```

resolves to the top organizational unit of `wiz.com`.

Note – Writers of set-user-ID programs need to be careful when using user-related composite names, such as `myorgunit` or `myself/service`, because these bindings depend on the effective user ID of a process. In cases where programs have a set-user-ID of `root` in order to access system resources on behalf of the caller, it will generally be desirable to call `seteuid(getuid())` before calling `fn_ctx_handle_from_initial()`.

Host-related Bindings

A process is running on a particular host when `fn_ctx_handle_from_initial()` is invoked. In the following discussion this host is denoted by "H." FNS defines the following bindings in the initial context that are related to H.

`thishost`

The namespace identifier `thishost` (or its synonym `_thishost`) is bound to the host context of H. For example, if the process is running on the machine `gofer`, `thishost` would be bound to the host context of `gofer`, and the name

```
thishost/service/calendar
```

would refer to the calendar service of `gofer`.

`thisorgunit`

FNS assumes that there is an association of a host to an organizational unit. A host may be associated with multiple organizational units, but there must be one that is distinguished. In NIS+ terminology, this organizational unit corresponds to the host's home domain.

The namespace identifier `thisorgunit` (or its synonym `_thisorgunit`) resolves to H's distinguished organizational unit. For example, if H is the machine `gofer`, and `gofer`'s NIS+ home domain is `desktop.engineering`, `thisorgunit` resolves to the organizational unit context for `desktop.engineering` and the name

```
thisorgunit/service/fax
```

refers to the fax service of the organizational unit `desktop.engineering.`

`thisens`

FNS assumes that there is an association of a host to an enterprise. This corresponds to the NIS+ hierarchy that holds `thisorgunit`.

The namespace identifier `thisens` (or its synonym `_thisens`) resolves to the enterprise root of H. For example, assume that H is the machine `gofer` and `gofer`'s NIS+ home domain is `desktop.engineering`, which in turn is in the NIS+ hierarchy with root domain name `wiz.com`. The name

```
thisens/site/
```

resolves to the root of the site namespace of `wiz.com.`

"Shorthand" Bindings

FNS defines the following "shorthand" bindings in the initial context to enable the use of shorter names to refer to objects in certain commonly referenced namespaces.

`user`

The namespace identifier `user` (or its synonym `_user`) is bound in the initial context to the username context in H's organizational unit. This allows other users in the same organizational unit as H to be named from this context.

From the initial context, the names `user` and `thisorgunit/user` resolve to the same context. For example, if H is the machine `gofer` and `gofer` is in the `desktop.engineering` organizational unit, the name `user/mjones` names the user `mjones` in `desktop.engineering`.

`host`

The namespace identifier `host` (or its synonym `_host`) is bound in the initial context to the hostname context in H's organizational unit. This allows other hosts in the same organizational unit as H to be named from this context.

From the initial context, the names `host` and `thisorgunit/host` resolve to the same context. For example, if H is the machine `gofer` and `gofer` is in the `desktop.engineering` organizational unit, the name `host/bigbig` names the machine `bigbig` in the organizational unit `desktop.engineering`.

`org`

The namespace identifier `org` (or its synonyms `orgunit, _orgunit`) is bound in the initial context to the root context of the organization naming system of the enterprise to which H belongs.

From the initial context, the names `org` and `thisens/orgunit` resolve to the same context. For example, if H is the machine `gofer` and `gofer` is in the enterprise `wiz.com.`, the name

```
org/accountspayable.finance
```

names the organizational unit `accountspayable.finance` in `wiz.com.`

`site`

The namespace identifier `site` (or its synonym `_site`) is bound in the initial context to the root of the site naming system of the top organizational unit of the enterprise to which H belongs.

From the initial context, the names `site` and `thisens/site` resolve to the same context. For example, if H is the machine `gofer` and `gofer` is in the enterprise `wiz.com`., the name

```
site/clarke.b5.mtv
```

names a conference room, `clarke` in building 5 on the Mountain View campus of `wiz.com.`

Policies for the Global Namespace 5

This chapter describes the policies for naming objects that use global naming systems.

The Global Namespace

Table 5-1 Policies for the Federated Global Namespace

Namespace Identifier	Name Service Type	Subcontexts	Parent Context	Namespace Organization	Syntax
. . .	Global	Enterprise root	None	Hierarchical	DNS or X.500

Global name services have worldwide scope. An enterprise “hooks up” to the federated global namespace by binding the root of the enterprise in the global namespace. This enables applications and users outside the enterprise to name objects within that enterprise. For example, a user within an enterprise can give out the global name of a file to a colleague in another enterprise to use.

DNS and X.500 contexts provide global-level name service for naming enterprises. FNS provides support for both DNS and X.500 contexts.

5

Initial Context Bindings for Global Naming

Table 5-2 Initial Context Bindings for Global Naming

Atomic Name	Binding
`...`	Global context for resolving DNS or X.500 names
`/...`	Synonym for three dots

The atomic name "`...`" (three dots) appears in the initial context of every FNS client. The atomic name "`...`" is bound to a context from which global names can be resolved.

Global names can be either fully qualified Internet domain names or X.500 distinguished names.

- Internet domain names appear in the syntax specified by Internet RFC 1035.
- X.500 names appear in the syntax determined by the X/Open DCE Directory.

For example, `.../wiz.com` specifies a name to be resolved by DNS, whereas `.../c=us/o=wiz` specifies a name to be resolved by X.500.

The names "`...`" and "`/...`" are equivalent when resolved in the initial context. For example, the names `/.../c=us/o=wiz` and `.../c=us/o=wiz` resolve in the initial context to the same object.

Federating DNS

When a DNS name is encountered in the global namespace, it is resolved using the DNS name-resolution mechanism, the resolver library. The name typically resolves to an Internet host address or DNS domain records. Any fully qualified DNS names may be used in the global context. When the global context detects a DNS name, the name is passed to the DNS resolver for resolution. The result is converted into an XFN reference structure and returned to the caller.

The contents of DNS domains may be listed. However, the listing operations may be limited by practical considerations such as connectivity and security on the Internet. For example, listing the global root of the DNS domain is generally not supported by the root DNS servers. Most entities below the root, however, do support the list operation.

DNS hosts and domains are distinguished by the presence or absence of name service (NS) resource records associated with DNS resource names. If an NS record exists for a resource name, then that name is considered to be the name of the domain, and the returned reference is of type `inet_domain`. Otherwise, the returned reference is of type `inet_host`.

DNS may be used to federate other naming systems by functioning as a nonterminal naming system. For example, an enterprise naming system may be bound to `wiz.com` in DNS such that the FNS name `.../wiz.com/` refers to the root of that enterprise's FNS namespace. The enterprise naming system is bound to a DNS domain by adding the appropriate text (TXT) records to the DNS map for that domain. When the FNS name for that domain includes a trailing slash (`/`), the TXT resource records are used to construct a reference to the enterprise naming system. Procedural information for federating an NIS+ domain under FNS is provided in "Federating NIS+ Under DNS" on page 112.

For general information about DNS, see `in.named(1M)` or the DNS chapters in *NIS+ and DNS Setup and Configuration Guide*.

Federating X.500

X.500 is a global directory service. It stores information and provides the capability to look up information by name as well as to browse and search for information. The information is held in a directory information base (DIB). Entries in the DIB are arranged in a tree structure. Each entry is a named object and comprises a defined set of attributes. Each attribute has a defined attribute type and one or more values.

An entry is unambiguously identified by a *distinguished name* that is the concatenation of selected attributes from each entry in the tree along a path leading from the root down to the named entry. For example, using the DIB shown in Figure 5-1 on page 64,

```
c=us/o=wiz
```

is a distinguished name of the `wiz` organization in the U.S. Users of the X.500 directory may interrogate and modify the entries and attributes in the DIB.

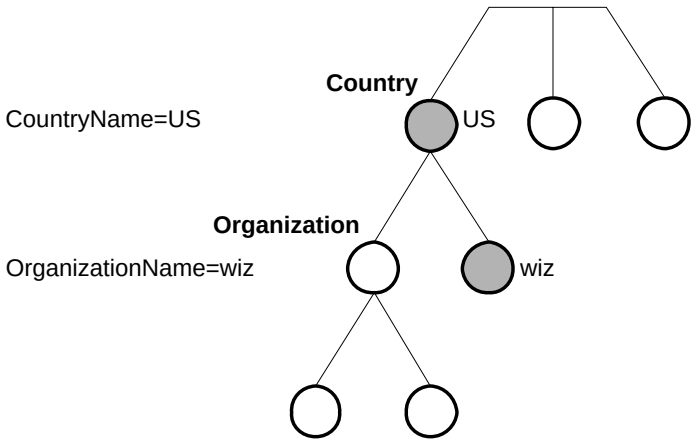

Figure 5-1 Example of an X.500 Directory Information Base

FNS federates X.500 by supplying the necessary support to permit namespaces to appear to be seamlessly attached below the global X.500 namespace.

For example, FNS facilitates “hooking” the enterprise naming system for the `wiz` organization below X.500. Starting from the initial context, an FNS name to identify the `sales` organizational unit of the `wiz` organization might be

```
.../c=us/o=wiz/orgunit/sales
```

The name within the enterprise is simply concatenated onto the global X.500 name. (Note that FNS names use the name `"..."` in the initial context to indicate that a global name follows.)

Name resolution of FNS names takes place as follows. When an X.500 name is encountered in the global namespace, it is resolved using the X.500 name-resolution mechanism. One of three outcomes is possible:

- The full name resolves to an X.500 entry. This indicates that the entry is held in X.500. The requested FNS operation is then performed on that entry.
- A prefix of the full name resolves to an X.500 entry. This indicates that the remainder of the name belongs to a subordinate naming system.

The next naming system pointer (NNSP) to the subordinate naming system is examined to return the XFN reference. Name resolution then continues in the subordinate naming system. NNSP is discussed in “Composite Name Resolution” on page 163.

- An error is reported.

X.500 entries may be examined and modified using FNS operations (subject to access controls). However, it is not currently possible to list the subordinate entries under the root of the X.500 namespace by using FNS.

5

Part 3 — Administration

These chapters describe the administration tasks for setting up and maintaining FNS in different namespaces.

Administering FNS on NIS+ 6

This chapter describes the setup and administration of the FNS implementation on top of the NIS+ environment. Use the following procedures for a standard setup (in which contexts are created automatically for you). If you wish to set up contexts individually, then specific procedures in “Creating FNS Contexts Individually” on page 73 will apply.

The following sections contain information to aid you in administering the FNS namespace after it has been set up.

6

Setting Up FNS

Setting up FNS involves preparing the NIS+ environment that FNS will use and then creating FNS contexts for organizations, users, hosts, services, and sites. Depending on the size of the organization, you should allow several hours for the FNS setup to be completed, not including the required hardware and software preparation or any NIS+ preparation.

Estimating Resource Requirements

Before proceeding with any installation procedure, you must first ensure that the machines on which NIS+ servers for supporting FNS will run have sufficient memory and disk storage.

For example, to support an FNS environment with 1200 users and hosts, you will need

- A minimum of 20 Mbytes of disk space beyond the space needed for NIS+
- An additional 40 Mbytes of swap space

Setting Up NIS+ Service for FNS

It is recommended, though not required, that NIS+ objects used by FNS and standard NIS+ domain information be supported on separate sets of servers. This avoids placing additional loads on the standard NIS+ service. It also allows you to keep the administration of FNS's use of NIS+ and the standard NIS+ service separate.

All NIS+ objects used by FNS are kept under the `ctx_dir` directory of an NIS+ domain, at the same level as the domain's `org_dir` directory. The NIS+ domain must be already set up before setting up FNS. That is, NIS+ domain tables, such as hosts and passwd, must already exist and be populated.

Before setting up the FNS namespace, do the following:

1. **Set the `NIS_GROUP` environment variable to the name of the group that will be administering the FNS objects.**
   In fact, the `fncreate` command will not let you complete the FNS setup without setting the variable first. In this example, `NIS_GROUP` is set to `fns_admins.wiz.com`. When `fncreate` creates user and host contexts, they will be owned by those hosts and users, and not by the administrator

who executed the command. Setting NIS_GROUP allows the administrators who are members of the group to subsequently modify these contexts even thought they do not own the objects.

```
# set NIS_GROUP=fns_admins.wiz.com;export NIS_GROUP
```

2. **To set up separate servers, create the** ctx_dir **directory for the NIS+ domain. Assign a master server to service it with the NIS+ command** nismkdir**.**
   The example shows how nismkdir creates the ctx_dir directory and assigns the machine fns_mserver as the master server for that directory. Include the trailing dot as shown.

```
# nismkdir -m fns_mserver ctx_dir.wiz.com.
```

3. **Use the** nisls **command to verify that the** ctx_dir **directory has been created.**

```
# nisls wiz.com.
ctx_dir
groups_dir
org_dir
```

Setting Up the FNS Namespace

The FNS namespace is created by the fncreate command. This command creates the contexts for the specified organization and all its subcontexts, including contexts for users and hosts in the NIS+ domain corresponding to the organization.

1. **For a standard setup, use the syntax of `fncreate` as shown.**
   This creates the organization context for the root NIS+ domain, `wiz.com.`, contexts for all users found in the `passwd.org_dir` table, and contexts for all hosts found in the `hosts.org_dir` table in the `wiz.com` NIS+ domain.

```
# fncreate -t org org/wiz.com./
```

   After setting up the FNS namespace, you should checkpoint the `ctx_dir` directory before performing other FNS operations.

2. **Use `nisping` to checkpoint the `ctx_dir` directory:**

```
# /usr/lib/nis/nisping -C ctx_dir.wiz.com.
```

For an organization with a few thousand users and hosts, the initial `fncreate` for an organization will typically take several hours; the subsequent checkpoint will also typically take several hours.

Replicating FNS Service

Additional replicas should be added to serve the `ctx_dir` directory after the FNS namespace has been set up on the master server. Replicas enhance availability and read performance of the servers.

1. **Use the `nismkdir -s` command to add a replica `fns_rserver` for the `ctx_dir` directory and send the contents of the directory to the replica.**

```
# nismkdir -s fns_rserver ctx_dir.wiz.com.
```

2. **Checkpoint the `ctx_dir` directory periodically with the `nisping` command.**
   The recommended period is every few days. The period you choose depends on how frequently changes are made to the FNS namespace.

```
# /usr/lib/nis/nisping -C ctx_dir.wiz.com.
```

At this point, you are done with the initial FNS setup.

Creating FNS Contexts Individually

FNS contexts are created using the `fncreate(1M)` command. This section describes the `fncreate` command and its other options. Use this section to create FNS contexts individually rather than for the entire organization as described in “Setting Up the FNS Namespace” on page 71.

The `fncreate` command has the following syntax,

```
fncreate -t context_type [-f input_file] [-o][-r reference_type][-s][-v] [-D] composite_name
```

where *context_type* specifies one of the following: `org`, `hostname`, `username`, `host`, `user`, `service`, `site`, `nsid`, `generic`, or `fs`.

`fncreate` creates a context of the specified type and binds it to the given composite name. It also creates subcontexts for the context.

Table 6-1 `fncreate` Command Options

Option	Description
`-t`	Specifies the type of context to create.
`-f`	Creates a context for every host or user listed in *input_file*. This option can only be used with the `-t username` or `-t hostname` option and is useful for creating contexts for a subset of users and hosts found in the corresponding NIS+ passwd and hosts tables, respectively.
`-o`	Creates only the context specified[1]. Without the `-o` option, subcontexts are created according to the FNS policies.
`-r`	Specifies the *reference_type* of the generic context being created. It can only be used with the `-t generic` option.
`-s`	Creates new contexts for composite names already in use. Otherwise, no new contexts are created for names already bound.
`-D`	Displays information about the NIS+ object associated with a context each time a context is created. This option is useful for debugging.
`-v`	Displays information about the creation as each context is created.

1. The `org` context is the exception where the contexts for hostname, username, and service are created but not populated.

When creating contexts bound to namespace identifiers, the name without the underscore (for example, `user`) is used to create the context and the name with the underscore (for example, `_user`) is then bound to the reference of the newly created context. The is done regardless of whether the name with or without the underscore is specified in the command line.

For example, the command

```
# fncreate -t username org/sales/_user
```

creates a context for `org/sales/user` and adds a binding for `org/sales/_user` to the context of `org/sales/user`.

Organization Context

Use the `org` type to create an organization context. The composite name must be that of an existing NIS+ domain. An NIS+ domain is an NIS+ directory with an `org_dir` subdirectory. Associated host and passwd tables for the domain must also exist.

Assume the root NIS+ domain is `wiz.com`. In the example

```
# fncreate -t org org/sales/
```

there must be an NIS+ domain named `sales`. When the new context is created, a `ctx_dir` directory, if it does not already exist, is created under the directory of the domain, `sales.wiz.com`. The previous example created an organization context for the composite name `org/sales/` and, in addition, created `hostname`, `username`, and `service` subcontexts for it, which in turn, created `host` and `user` contexts, and `service` subcontexts for hosts and users.

Effectively, the following commands are run:

```
fncreate -t hostname org/sales/host/
fncreate -t username org/sales/user/
fncreate -t service org/sales/service/
```

When `fncreate -o -t org` is used, only the `org` context is created. The `hostname`, `username`, and `service` contexts are also created but not populated with `host` and `user` contexts.

The `org` context is owned by the administrator who executed the `fncreate` command, as are the `hostname`, `username`, and `service` subcontexts. The `host` and `user` contexts, however, and their subcontexts are owned by the hosts or users for which the contexts were created. In order for the administrator to subsequently manipulate host and user contexts, the `NIS_GROUP` environment variable must have been set accordingly at the time `fncreate` is executed. See “Setting Up NIS+ Service for FNS” on page 70 for instructions.

All Hosts Context

The `hostname` type creates a hostname context in which host contexts can be created and bound. Host contexts and their subcontexts are created for each host name found in the NIS+ `hosts.org_dir` table unless the `-o` option is used. When the `-o` option is used, only the `hostname` context is created.

For example, running the command

```
# fncreate -t hostname org/sales/host/
```

creates the `hostname` context and effectively runs the command

```
# fncreate -t hostname org/sales/host/hname/
```

for each host name, *hname*, found in the `hosts.org_dir` table. It also adds a binding for `org/sales/_host/` that is bound to the reference of `org/sales/host/`.

The `hostname` context is owned by the administrator who executed the `fncreate` command. A host context and its subcontexts are owned by the host for which the contexts were created. That is, each host owns its own host context and subcontexts.

The `-f` option can be used to create contexts for a subset of the hosts found in the NIS+ table `hosts.org_dir`. It creates contexts for those hosts listed in the given input file.

Single Host Context

The `host` type creates the context and subcontexts for a host. The command automatically creates a `service` context for the host and a binding for `fs` unless the `-o` option is used. When the `-o` option is used, only the `host` context is created.

For example, the command

```
# fncreate -t host org/sales/host/capsule/
```

creates a context for the host named `capsule` and effectively runs the commands

```
fncreate -t service org/sales/host/capsule/service/
fncreate -t fs org/sales/host/capsule/fs/
```

The `host` context and its subcontexts are owned by the host. In the above example, the host `capsule`, with NIS+ principal name `capsule.sales.wiz.com`, owns the contexts `org/sales/host/capsule/`, `org/sales/host/capsule/service/`, and `org/sales/host/capsule/fs`.

The `hostname` context (`org/sales/host` in the above example) to which the host belongs must already exist. The host name supplied should already exist in the NIS+ `hosts.org_dir` table.

Host Aliases

Alias host names may exist in an NIS+ `hosts.org_dir` table. These appear in the table as a set of hosts with the same canonical name but different alias names.

In FNS, a single host with multiple alias names has a single host context. Alias names for that host in the `hostname` context are bound to the reference of that host context.

All–Users Context

The `username` type creates a username context in which user contexts can be created and bound. User contexts and their subcontexts are created for each user name found in the NIS+ `passwd.org_dir` table unless the `-o` option is used. When the `-o` option is used, only the `username` context is created.

For example, running the command

```
# fncreate -t username org/sales/user/
```

creates the `username` context and effectively runs the command

```
fncreate -t user org/sales/user/uname/
```

for each user, *uname*, that appears in the `passwd.org_dir` table. It also adds a binding for `org/sales/_user/` that is bound to the reference of `org/sales/user/`.

The `username` context is owned by the administrator who executed the `fncreate` command. A user context and its subcontexts are owned by the user for which the contexts were created. Each user owns his or her own `user` context and subcontexts.

The `-f` option can be used to create contexts for a subset of the users found in the NIS+ table `passwd.org_dir`. It creates contexts for those users listed in the given input file.

Single User Context

The `user` type creates the `user` context and subcontexts for a user. A service subcontext and a binding for `fs` are created under the `user` context unless the `-o` option is used. When the `-o` option is used, only the `user` context is created.

For example, the command

```
# fncreate -t user org/sales/user/jjones/
```

creates the `user` context for the user named `jjones` and effectively runs the commands

```
fncreate -t service org/sales/user/jjones/service/
fncreate -t fs org/sales/user/jjones/fs/
```

The `user` context and its subcontexts are owned by the user for whom the contexts were created. In the above example, the contexts created are owned by the user `jjones` with NIS+ principal name `jjones.sales.wiz.com`.

The username context (org/sales/user in the above example) to which the user belongs must already exist. The user name supplied should already exist in the NIS+ passwd.org_dir table.

Service Context

The service type creates the service context in which service names can be bound. There is no restriction on what type of references may be bound in a service context. The policies depend on the applications that use the service context. For example, a group of desktop applications may bind references for a calendar, a telephone directory, a fax service, and a printer in a service context.

For example, the command

```
# fncreate -t service org/sales/service/
```

creates a service context for the organization sales. Because the terminal atomic name is a namespace identifier, fncreate also adds a binding for org/sales/_service/ that is bound to the reference of org/sales/service/. After executing this command, names such as org/sales/service/calendar and org/sales/service/fax can then be bound in this service context.

The service context supports a hierarchical namespace, with slash-separated left-to-right names. The service namespace can be partitioned for different services. Continuing with the desktop applications example, a group of plotters may be named under the service context after the creation of the plotter context.

```
# fncreate -t service org/sales/service/plotter
```

Names such as org/sales/service/plotter/speedy and org/sales/service/plotter/production could then be bound under the service context.

Note – Because the terminal atomic name is not a namespace identifier, no additional binding is added (as was the case with service and _service).

The `service` context created is owned by the administrator who ran the `fncreate` command.

Printer Context

The `printer` context is created under the `service` context of the respective composite name. Refer to Chapter 9, "Administering the Printer Namespace," for more information.

Generic Context

The `generic` type creates a context for binding names used by applications.

A generic context is similar to a service context except it can have a different reference type. The `-r` option is used to specify the reference type for the generic context being created. If it is omitted, the reference type is inherited from its parent generic context or, if the parent context is not a generic context, the reference type used is a default generic reference type.

Like a service context, there is no restriction on what type of references may be bound in a generic context. The policies depend on the applications that use the generic context.

For example, the command

```
# fncreate -t generic -r WIDC_comm org/sales/service/extcomm
```

creates a generic context with the `WIDC_comm` reference type under the `service` context of the organization `sales`. Names such as `org/sales/service/extcomm/modem` can then be bound in this generic context.

The `generic` context supports a hierarchical namespace, with slash-separated left-to-right names, which allows an application to partition its namespace for different services. Continuing with the example above, a `generic` subcontext for `modem` can be created running the command

```
# fncreate -t generic org/sales/service/extcomm/modem
```

Names such as `org/sales/service/extcomm/modem/secure` and `org/sales/service/extcomm/modem/public` could then be bound under the `modem` context.

The generic context created is owned by the administrator who ran the `fncreate` command.

Site Context

The `site` type creates contexts in which site names can be bound.

For example, the command

```
# fncreate -t site org/sales/site/
```

creates a site context. Because the terminal atomic name is a namespace identifier, `fncreate` also adds a binding for `org/sales/_site/` that is bound to the reference of `org/sales/site/`.

The `site` context supports a hierarchial namespace, with dot-separated right-to-left names, which allows sites to be partitioned by their geographical coverage relationships.

For example, the commands

```
# fncreate -t site org/sales/site/east
# fncreate -t site org/sales/site/maynard.east
```

create a site context `east` and a site subcontext `maynard.east` for it.

Note – Because these terminal atomic names are not namespace identifiers, no additional binding are added (as was the case with `site` and `_site`).

The `site` context created is owned by the administrator who ran the `fncreate` command.

File Context

The `fs` type creates a file system context (or file context) for a user or a host. For example, the command

```
# fncreate -t fs org/sales/user/jjones/fs/
```

creates the `fs` context for user `jjones`. Because the terminal atomic name is a namespace identifier, `fncreate` also adds a binding for `org/sales/user/jjones/_fs/` that is bound to the reference of `org/sales/user/jjones/fs/`.

The `fs` context of a user is the user's home directory as it is stored in the NIS+ `passwd.org_dir` table. The `fs` context of a host is the set of NFS file systems that the host exports (see *NFS Administration Guide*).

Use the `fncreate_fs` command to create file contexts for organizations and sites or to create file contexts other than the defaults for users and hosts. See Chapter 8, "Administering the File System Namespace," for details.

The `fs` context created is owned by the administrator who ran the `fncreate` command.

Namespace Identifier Context

The `nsid` (namespace identifier) type creates a context in which namespace identifiers can be bound.

For example, the command

```
# fncreate -t nsid org/sales/site/maynard.east/
```

creates the `nsid` context for the site `maynard.east` and permits the creation of subcontexts such as `service/`. Continuing with this example, you could then execute the command

```
# fncreate -t service org/sales/site/maynard.east/service/
```

to create the `service` context for `maynard.east`.

The `nsid` context created is owned by the administrator who ran the `fncreate` command.

Managing and Examining FNS Contexts

A number of tools are provided for examining and managing FNS contexts. The commands and their syntax are shown as follows. For additional information, see the man page for the tool. Note that `fnbind` has two usages.

```
fnlookup [-v][-L] composite_name

fnlist [-l][-v] [composite_name]

fnbind [-s][-v][-L] name new_name

fnbind -r [-s] [-v] new_name [-O | -U] ref_type {[-O | -U] | address_type [-c|-x] address_contents}+

fnunbind composite_name

fnrename [-sv] context_name old_atomic_name new_atomic_name

fndestroy composite_name
```

Displaying the Binding

`fnlookup` displays the binding of the given composite name.

Table 6-2 `fnlookup` Command Options

Option	Description
`-v`	Displays the binding in more detail
`-L`	Displays the reference to which the XFN link is bound

For example, the command

```
# fnlookup user/jjones/
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 context type: user
```

shows the binding of the user `jjones`.

```
# fnlookup -v user/jjones/
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 length: 52
 context type: user
 representation: normal
 version: 0
 internal name: fns_user_jjones.ctx_dir.sales.wiz.com.
```

Suppose `user/James.Jones` is linked to `user/jjones`. The first command in the following example shows what `user/James.Jones` is bound to (an XFN link). The second command follows the XFN link, `user/jjones`, and shows what `user/jjones` is bound to (the `user` context).

```
# fnlookup user/James.Jones
Reference type: fn_link_ref
Address type: fn_link_addr
 Link name: user/jjones

# fnlookup -L user/James.Jones
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 context type: user
```

Listing the Context

`fnlist` lists the contents of the context identified by the given name.

Table 6-3 `fnlist` Command Options

Option	Description
`-v`	Displays the binding in more detail
`-l`	Displays the bindings of the names bound in the named context

For example, the command

```
# fnlist user/
Listing 'user/':
jjones
mladd
jsmith
James.Jones
```

shows the bindings under the `user` context.

If no name is given, the command lists the contents of the initial context.

```
# fnlist
Listing '':
_myorgunit
...
_myself
thishost
myself
_orgunit
_host
_thisens
myens
thisens
org
orgunit
thisuser
_thishost
myorgunit
_user
thisorgunit
host
_thisorgunit
_myens
user
```

When the `-l` option is given, the bindings of the names bound in the named context are displayed.

```
# fnlist -l user/
Listing bindings 'user/':
name: mladd
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 context type: user
name: jsmith
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 context type: user
name: James.Jones
Reference type: fn_link_ref
Address type: fn_link_addr
 Link name: user/jjones
name: jjones
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 context type: user
```

When the `-v` option is given in conjunction with the `-l` option, the bindings are displayed in detail.

```
# fnlist -lv user/
Listing bindings 'user/':
name: mladd
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 length: 52
 context type: user
 representation: normal
 version: 0
 internal name: fns_user_mladd.ctx_dir.sales.wiz.com.
name: jsmith
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 length: 52
 context type: user
 representation: normal
 version: 0
 internal name: fns_user_jsmith.ctx_dir.sales.wiz.com.
name: James.Jones
Reference type: fn_link_ref
Address type: fn_link_addr
 length: 11
 data: 0x75 0x73 0x65 0x72 0x2f 0x6a 0x6a 0x6f 0x6e 0x65
user/jjones
name: jjones
Reference type: onc_fn_user
Address type: onc_fn_nisplus
 length: 52
 context type: user
 representation: normal
 version: 0
 internal name: fns_user_jjones.ctx_dir.sales.wiz.com.
```

Binding a Composite Name to a Reference

`fnbind` allows you to bind a composite name to a reference. There are two uses of this command. The first usage allows the user to bind the reference of an existing name to a new name. The second usage allows the user to bind a reference constructed using arguments in the command line to a name.

Table 6-4 `fnbind` Command Options

Option	Description
`-s`	Supersedes any existing binding of the original composite name
`-v`	Prints out the reference used for the binding
`-L`	Creates an XFN link using *name* and binding it to *new_name*
`-c`	Stores address contents without XDR encoding
`-x`	Interprets address contents as a hexadecimal input string and store it as is
`-r`	Creates a reference with a specified type and bind the reference to a name specified on the command line
`-O`	Interprets and stores type string as ASN.1 dot-separated integer list
`-U`	Interprets and stores type string as a DCE UUID

The first usage of `fnbind` is

```
fnbind [-s][-v][-L] name new_name
```

For example, the command

```
# fnbind myorgunit/service/printer user/mladd/service/printer
```

binds the name `user/mladd/service/printer` to the reference of `myorgunit/service/printer`.

If the given *new_name* is already bound, `fnbind -s` must be used or the operation will fail. In the above example, if `user/mladd/service/printer` is already bound, the `-s` option must be used to overwrite the existing binding with that of `myorgunit/service/printer`.

```
# fnbind -s myorgunit/service/printer user/mladd/service/printer
```

The `-v` option prints out the reference used for the binding.

```
# fnbind -v myorgunit/service/printer user/mladd/service/printer
Reference type: onc_printers
Address type: onc_fn_printer_nisplus
```

The following command constructs an XFN link out of `user/jjones` and binds it to the name `user/James.Jones`

```
# fnbind -L user/jjones user/James.Jones
```

Similarly, the following creates a link from `user/mladd/service/printer` to `myorgunit/service/printer`.

```
# fnbind -sL myorgunit/service/printer user/mlad/service/printer
```

The second usage of `fnbind` constructs a reference using arguments in the command line and binds it to the given name.

```
fnbind -r [-s] [-v] new_name [-O | -U] ref_type {[-O | -U] | address_type [-c|-x] address_contents}+
```

For example

```
# fnbind -r thisorgunit/service/calendar onc_calendar onc_cal_str staff@exodus
```

binds the name `thisorgunit/service/calendar` to the reference with type `onc_calendar` and address type `onc_cal_str` and address contents of `staff@exodus`.

By default, the address contents supplied in the command line is XDR-encoded before being stored in the reference. If the `-c` option is given, the address contents are stored in the clear, not as an XDR-encoded string. If the `-x` option is given, the address contents supplied in the command line are interpreted as a hexadecimal string and stored (and not XDR-encoded).

By default, the reference and address types of the reference to be constructed uses the `FN_ID_STRING` identifier format. If the `-O` option is given, the identifier format is `FN_ID_ISO_OID_STRING`, an ASN.1[1] dot-separated integer list string. If the `-U` option is given, the identifier format is `FN_ID_DCE_UUID`, a DCE UUID[2] in string form. For example, the following command binds to the name `thisorgunit/service/nx` a reference with OIDs as reference and address types and a hexadecimal string as the address contents.

```
# fnbind -r thisorgunit/service/nx -O 1.2.99.6.2.1 -O 1.2.99.6.2.3 -x ef12eab67290
```

Removing a Composite Name

`fnunbind` removes the given composite name from the namespace. Note that this does not remove the object associated with the name; it only unbinds the name from the object. For example, the command

```
# fnunbind user/jjones/service/printer/color
```

removes the binding associated with the name `user/jjones/service/printer/color`.

Renaming an Existing Binding

`fnrename` renames an existing binding. The following example renames the binding of `clndr` to `calendar`, in the context named by `user/jjones/service/`.

```
# fnrename user/jjones/service/ clndr calendar
```

The `-s` option is used to overwrite any binding to *new_atomic_name*.

1. See ISO 8824: 1990, Information Technology — Open Systems Interconnection — Specification of Abstract Syntax Notation One (ASN.1)
2. See X / Open Preliminary Specification, October 1993, X / Open DCE: Remote Procedure Call (ISBN: 1-872630-95-2)

Destroying the Named Context

`fndestroy` removes the given composite name from the namespace and destroys the context named by the composite name.

For example, the command

```
# fndestroy user/jjones/
```

unbinds the name `user/jones/` from the namespace and destroys the context named by `user/jjones/`.

If the composite name identifies a context to be removed, the command fails if the context contains subcontexts.

Managing and Examining FNS Attributes

The `fnattr` command lets you update and examine attributes associated with FNS named objects. The four main options are for adding, deleting, listing, and modifying an attribute. In each of these cases, the identifier format is `FN_ID_STRING`, unless the option `-O` or `-U` is used.

Adding an Attribute

The `-a` option is for adding an attribute or adding a value to an attribute. You need to specify the composite name the attribute is associated with, the attribute identifier, and the values to add.

```
fnattr -a [-s] composite_name [-O | -U] identifier value1 [value2+]
```

The following example adds the attribute identifier `model` and the value `hplaser` to `thisorgunit/service/printer`.

```
# fnattr -a thisorgunit/service/printer model hplaser
```

The `-s` option means “add in supersede” mode. If an attribute with the specified identifier already exists, `-s` removes all of its values and replaces them with the values added. If this option is omitted, the resulting values for the specified attribute includes the existing values and the new values added.

```
# fnattr -as thisorgunit/service/printer model hplaser
```

The example above will first remove any existing values associated with `model` and add `hplaser` as the value.

Deleting an Attribute

To delete an attribute associated with an FNS named object, use the `-d` option. You can control what to delete:

- If an identifier is not specified, all the attributes associated with the named object are removed.
- If an identifier is specified, but without values, the entire attribute identified by *identifier* is removed.
- If individual values are specified, then only those values are removed from the attribute. Removal of the last value of an attribute is the same as removing the attribute itself.

```
fnattr -d composite_name [[-O | -U] identifier value1 [value2+]]]
```

The following command deletes all the attributes associated with `thisorgunit/service/printer`.

```
# fnattr -d thisorgunit/service/printer
```

Listing an Attribute

The `-l` option is for listing attributes and their values. The command syntax is

```
fnattr -l composite_name [[-O | -U] identifier]
```

The following example lists the values of the `model` attribute of `thisorgunit/service/printer`.

```
# fnattr -l thisorgunit/service/printer model
laser
postscript
```

If an identifier is not specified, all the attributes associated with the named object are displayed.

Modifying an Attribute

The `-m` option lets you modify an attribute value. The command syntax is

```
fnattr -m composite_name [-O | -U] identifier old_value new_value
```

For example,

```
# fnattr -m thisorgunit/service/printer model postscript laser
```

replaces the value `postscript` with `laser`. Other attributes and values associated with `thisorgunit/service/printer` are not affected.

Other Options

The `-O` option assumes the format of the attribute identifier is an ASN.1 dot-separated integer string list (`FN_ID_ISO_OID_STRING`).

The `-U` option assumes the format of the attribute identifier is a DCE UUID string form (`FN_ID_DCE_UUID`).

Maintaining Consistency Between NIS+ and FNS

A key task of the system administrator is to maintain consistency between FNS and NIS+ by ensuring that the contents of FNS contexts and NIS+ tables correspond. This correspondence is initially accomplished by the `fncreate` command, which ensures that FNS contexts are correctly created and

populated and are consistent with NIS+ domain and table information. After the FNS contexts have been set up, the correspondence needs to be maintained as new users and hosts are added to and removed from the system.

The Solstice™ AdminTools™ product that adds user and host information to NIS+ also updates FNS. When updates to FNS or NIS+ are made independent of the Solstice AdminTools product, the resulting inconsistencies can be resolved by the use of the FNS tool, `fncheck`. `fncheck` checks for inconsistencies between user and host names in FNS, and user and host names in NIS+.

Checking Naming Inconsistencies

The `fncheck` command checks for naming inconsistences between the `hostname` and `username` contexts, and the NIS+ standard system tables `hosts.org_dir` and `passwd.org_dir`, respectively. `fncheck` lists host and user names that are in the FNS namespace but not in the NIS+ standard system tables. It also lists host or user names that are in the NIS+ standard system tables but not in the FNS namespace.

The command syntax is

```
fncheck[-r][-s][-u][-t hostname|username][domain_name]
```

Table 6-5 `fncheck` Command Options

Option	Description
`-t`	Specifies the type of context to check
`-s`	Lists host or user names from the NIS+ standard system tables that are not in the FNS namespace
`-r`	Lists host or user names from the FNS namespace that do not have entries in the corresponding NIS+ standard system tables
`-u`	Updates the FNS namespace based on information in the relevant NIS+ standard system tables

The `-t` option is used to specify the contexts to check. For the `-t hostname` option, the hostname context associated with the organization is checked against the NIS+ `hosts.org_dir` table of the same organization. For the `-t username` option, the username context associated with the organization is

checked against the NIS+ `passwd.org_dir` table in the same organization. When the `-t` option is omitted, both the `hostname` and `username` contexts are checked.

When the `-r` option is used in conjunction with the `-u` option, items that appear only in the FNS context are removed from the FNS context. When the `-s` option is used in conjunction with the `-u` option, items that appear only in the NIS+ standard system tables are added to the FNS context. If neither `-r` or `-s` are specified, items are added and removed from the FNS context to make it consistent with the corresponding NIS+ table.

Advanced FNS and NIS+ Issues

This section provides detailed information on the relationship between NIS+ objects and FNS objects. This information is useful when you must change the access control of FNS objects.

Mapping FNS Contexts to NIS+ Objects

FNS contexts are stored as NIS+ objects. All contexts associated with an organization are stored under the `ctx_dir` directory of the associated NIS+ domain, which resides at the same level as the `org_dir` directory of the same domain.

Use the `-v` option for the `fnlookup` or `fnlist` command to see the detailed description of references. The internal name field displays the name of the corresponding NIS+ object.

Browsing FNS Structures Using NIS+ Commands

The NIS+ command, `nisls`, can be used to list the NIS+ objects used by FNS. For example, the following commands list the contents of the NIS+ domain directory and its `ctx_dir` subdirectory.

```
# nisls wiz.com.
wiz.com.:
eng
sales
org_dir
ctx_dir
```

```
# nisls ctx_dir.wiz.com.
ctx_dir_Wiz.COM.:
fns
fns_user
fns_host
fns_host_alto
fns_host_mladd
fns_host_elvira
fns_user_jjones
fns_user_jsmith
fns_user_aw
```

Use the `niscat` command to list the contents of the `fns_hosts` table.

```
# niscat fns_host.ctx_dir
alto *BINARY* *BINARY*
mladd *BINARY* *BINARY*
elvira *BINARY* *BINARY*
```

Checking Access Control

Use `niscat -o` to see the access control of a context.

```
# niscat -o fns_host.ctx_dir
Object Name:fns_host
Owner: alto.wiz.com.
Group: admin.wiz.com.
Domain: ctx_dir.wiz.com.
Access Rights:r-c-rmcdrmcdr-c-
Time to Live:53:0:56
Object Type:TABLE
Table Type:H
Number of Columns:3
Character Separator:
Search Path:
Columns:
[0] Name:  atomicname
    Attributes:(SEARCHABLE, TEXTUAL DATA,CASE INSENSITIVE)
    Access Rights:r-c-rmcdrmcdr-c-
[1] Name:  reference
    Attributes:(BINARY DATA)
    Access Rights:r-c-rmcdrmcdr-c-
[2] Name:  flags
    Attributes:(BINARY DATA)
    Access Rights:r-c-rmcdrmcdr-c-
```

To see the access control of a particular binding, use the name of the binding entry in the parent context's binding table (that is, the name displayed in the internal name field in the output of `fnlookup -v` and `fnlist -v`):

```
# niscat -o "[atomicname=alto],fns_host.ctx_dir"
Object Name:fns_host
Owner:  alto.wiz.com.
Group: admin.wiz.com.
Domain: ctx_dir.wiz.com.
Access Rights:r-c-rmcdrmcdr-c-
Time to Live:12:0:0
Object Type:ENTRY
     Entry data of type H
     [1] - [5 bytes] 'alto'
     [2] - [104 bytes] '0x00 ...'
     [3] - [1 bytes] 0x01
```

To change the access control or ownership of a particular context, use the commands

- `nischown`
- `nischmod`
- `nischgrp`

and give as an argument either the binding entry or the bindings table, depending on the object the operation is to affect.

Significance of Double Slashes

In the name, `org//`, the double slashes identifies the context of namespace identifiers associated with the root organizational name, as in `org//service/printer`.

In contrast, `org/` points to the root of an organizational context. Each organizational context has suborganizations as well as a pointer to the context that contains namespace identifiers such as `service`, `user`, and `host`. `org/` names the root organizational context in which you can name suborganizations, as in `org/sales.finance`.

6

Significance of Trailing Slash

The trailing / names objects in the next naming system. You need it whenever you are going from one naming system to another. For example, the name, `org/sales.finance` names the context for naming suborganizations of the `sales.finance` organization, as in `org/audit.sales.finance.`

On the other hand, `org/sales.finance/` names the context for naming namespace identifiers of the `sales.finance` organization, as in `org/sales.finance/service/printer`.

Error Messages

When an error occurs, FNS commands print out the remaining part of the name on which the operation failed. The part of the name that has not been printed has been processed successfully.

For example, a user attempted to create a context for `org//service/trading/bb`. The name `org//service/` was resolved successfully, but `trading` was not found in the context named by `org//service/`. Thus, `trading/bb` is displayed as the part of the name that remains when the operation failed:

```
Error in creating 'org//service/trading/bb': Name Not Found:
'trading/bb'
```

In another example, a user attempted to destroy the context `org//service/dictionary/english`, but could not carry out the operation because the context named was not empty. The pair of single quotes (`''`) indicates that FNS was able to resolve the complete name given, but could not complete the operation as requested:

```
Error in destroying 'org//service/dictionary/english': Context
Not Empty: ''
```

FNS Message Descriptions

The FNS messages and their descriptions are as follows. These messages are encoded in the `FN_status_t` object as status codes. See either Table 10-3 on page 151 or the `FN_status_t(3)` man page for the corresponding status codes.

`attribute no permission`

The caller did not have permission to perform the attempted attribute operation.

`attribute value required`

The operation attempted to create an attribute without a value, and the specific naming system does not allow this.

`authentication failure`

The operation could not be completed because the principal making the request cannot be authenticated with the name service involved. If the service is NIS+, check that you are identified as the correct principal (run the command `nisdefaults`) and that your machine has specified the correct source for public keys. Check that the `/etc/nsswitch.conf` file has the entry, `publickey`: `nisplus`.

`bad reference`

FNS could not interpret the contents of the reference. This may result if the contents of the reference has been corrupted or when the reference identifies itself as an FNS reference, but FNS doesn't know how to decode it.

`communication failure`

FNS could not communicate with the name service to complete the operation.

`configuration error`

An error resulted because of configuration problems. Examples: (1) the bindings table are removed out-of-band (outside of FNS), (2) and a host is in the NIS+ hosts table but does not have a corresponding FNS host context.

`context not empty`

An attempt has been made to remove a context that still contains bindings.

`continue operation using status values`

The operation should be continued using the remaining name and the resolved reference returned in the status.

`error`

An error that cannot be classified as one of the other errors listed above occurred while processing the request. Check the status of the name services involved in the operation and see whether any of them are experiencing extraordinary problems.

`illegal name`

The name supplied is not a legal name.

`incompatible code sets`

The operation involved character strings from incompatible code sets, or the supplied code set is not supported by the implementation.

`insufficient resources`

The name service used by FNS does not have sufficient resources to complete the request. Check memory and disk availability on the name servers involved.

`invalid attribute identifier`

The attribute identifier is in a format not acceptable to the naming system, or its contents are not valid for the format specified for the identifier.

`invalid attribute value`

The value supplied is not in the correct form for the given attribute.

`invalid enumeration handle`

The enumeration handle supplied is invalid. The handle could have been from another enumeration, an update operation may have occurred during the enumeration, or there may have been some other reason.

`invalid syntax attributes`

The syntax attributes supplied are invalid or insufficient to fully specify the syntax.

`link error`

An error occurred while resolving an XFN link with the supplied name.

`link loop limit reached`

A nonterminating loop was detected due to XFN links encountered during composite name resolution, or the implementation-defined limit was exceeded on the number of XFN links allowed for a single operation.

`malformed link`

A malformed link reference was found during an `fn_ctx_lookup_link()` operation. The name supplied resolved to a reference that was not a link.

`name in use`

The name supplied is already bound in the context.

`name not found`

The name supplied was not found.

`no permission`

The operation failed because of access control problems.

`no such attribute`

The object did not have an attribute with the given identifier.

`no supported address`

No shared library could be found under the `/usr/lib/fn` directory for any of the address types found in the reference bound to the FNS name. Shared libraries for an address type are named according to this convention: `fn_ctx_`*address_type*`.so`.

For example, a reference with address type `onc_fn_nisplus` would have a shared library in the path name: `/usr/lib/fn/fn_ctx_onc_fn_nisplus.so`.

`not a context`

The reference does not correspond to a valid context.

`operation not supported`

The operation is not supported by the context. For example, trying to destroy an organization is not supported.

`partial result returned`

The operation returned a partial result.

`success`

Operation succeeded.

`syntax not supported`

The syntax type is not supported.

`too many attribute values`

The operation attempted to associate more values with an attribute than the naming system supports.

`unavailable`

The name service upon which the operation depends is unavailable.

Troubleshooting

This section presents problem scenarios with a description of probable causes, diagnoses, and solutions.

Cannot Obtain Initial Context

Symptom

I get the message “Cannot obtain initial context.”

Possible Cause

This is caused by an installation problem.

Diagnosis

Check that FNS has been installed properly by looking for the file, `/usr/lib/fn/fn_ctx_initial.so`.

Solution

Install the `fn_ctx_initial.so` library.

Nothing in Initial Context

Symptom

I run `fnlist` to look at what is in the initial context but see nothing.

Possible Cause

This is caused by an NIS+ configuration problem. The organization associated with the user and machine running the `fn*` commands do not have an associated `ctx_dir` directory.

Diagnosis

Use the `nisls` command to see whether there is a `ctx_dir` directory.

Solution

If there is no `ctx_dir` directory, run `fncreate -t org/`*nis+_domain_name*`/` to create the `ctx_dir` directory.

"No Permission" Messages

Symptom

I get "no permission" messages.

Possible Cause

"No permission" messages mean that you do not have access to perform the command.

Diagnosis

Check permission using the appropriate NIS+ commands, described in "Advanced FNS and NIS+ Issues" on page 96. Use the `nisdefaults` command to determine your NIS+ principal name.

Another area to check is whether you are using the right name. For example, `org//` names the context of the root organization. Make sure you have permission to manipulate the root organization. Or maybe you meant to specify `myorgunit/`, instead.

Solution

If you do have permission, then the appropriate credentials probably have not been acquired.

This could be caused by the following:

- A `keylogin` has not been performed (defaults to NIS+ principal nobody).
- A `keylogin` was made to a source other than NIS+.
  - Check that the `/etc/nsswitch.conf` file has a `publickey: nisplus` entry.
  - This might manifest itself as an authentication error.

`fnlist` *Does Not List Suborganizations*

Symptom

I run `fnlist` with an organization name, expecting to see suborganizations, but instead see nothing.

Possible Cause

This is caused by an NIS+ configuration problem. Suborganizations must be NIS+ domains. By definition, an NIS+ domain must have a subdirectory named `org_dir`.

Diagnosis

Use the `nisls` command to see what subdirectories exist. Run `nisls` on each subdirectory to verify which subdirectories have an `org_dir`. The subdirectories with an `org_dir` are suborganizations.

Solution

Not applicable.

Cannot Create Host- or User-related Contexts

Symptom

When I run `fncreate -t` for the `user`, `username`, `host`, or `hostname` contexts, nothing happens.

Possible Cause

You have not set the `NIS_GROUP` environment variable. When you create a user or host context it is owned by the host or user, and not by the administrator who set up the namespace. Therefore, `fncreate` requires that the `NIS_GROUP` variable be set to enable the administrators who are part of that group to subsequently manipulate the contexts.

Diagnosis

Check the `NIS_GROUP` environment variable.

Solution

The `NIS_GROUP` environment variable should be set to the group name of the administrators who will administer the contexts.

Cannot Remove a Context I Created

Symptom

When I run `fndestroy` on the `host` or `user` context the context is not removed.

Possible Cause

You do not own the `host` or `user` context. When you create a user or host context it is owned by the host or user, and not by the administrator who set up the namespace.

Diagnosis

Check the `NIS_GROUP` environment variable.

Solution

The `NIS_GROUP` environment variable needs to be set to the group name of the administrator who will administer the contexts.

"Name in Use" With `fnunbind`

Symptom

I get "name in use" when trying to remove bindings. It works for certain names but not for others.

Possible Cause

You cannot unbind the name of a context. This restriction is in place to avoid leaving behind contexts that have no name ("orphaned contexts").

Diagnosis

Run the `fnlist` command on the name to verify that it is a context.

Solution

If the name is a context, use the `fndestroy` command to destroy the context.

"Name in Use" With `fnbind`/`fncreate -s`

Symptom

I use the `-s` option with `fnbind` and `fncreate`, but for certain names I get "name in use."

Possible Cause

`fnbind -s` and `fncreate -s` overwrite the existing binding if it already exists; but if the old binding is one that must be kept to avoid orphaned contexts, the operation fails with a "name in use" error because the binding could not be removed. This is done to avoid orphaned contexts.

Diagnosis

Run the `fnlist` command on the name to verify that it is a context.

Solution

Run the `fndestroy` command to remove the context *before* running `fnbind` or `fncreate` on the same name.

`fndestroy`/`fnunbind` *Does Not Return "Operation Failed"*

Symptom

When I do an `fndestroy` or `fnunbind` on certain names that I know do *not* exist, I receive no indication that the operation failed.

Possible Cause

The operation did not fail. The semantics of `fndestroy` and `fnunbind` are that if the terminal name is not bound, the operation returns success.

Diagnosis

Run the `fnlookup` command on the name. You should receive the message, "name not found."

Solution

Not applicable.

6

Federating NIS+ With Global Naming Systems

7

FNS supports federation of enterprise naming systems implemented using NIS+ into the global naming systems, DNS and X.500. This chapter describes the procedures for federating NIS+ with DNS and X.500. In general, the procedures involve

- Determining the NIS+ root reference for your NIS+ hierarchy
- Adding this information in the format required by the global naming system

Obtaining the NIS+ Root Reference

To federate NIS+ under DNS or X.500, information must be added to these respective naming systems to enable access to an NIS+ hierarchy from outside of the NIS+ hierarchy. This information comes from the NIS+ *root reference*, which consists of network address information describing how to reach the top of a particular NIS+ hierarchy.

The NIS+ root reference consists of a single address. The address has an address type of `onc_fn_nisplus_root` and contains a single, XDR-encoded string. The three items in the network address are separated by white spaces:

```
nis+_root_domain nis+_server [server_IP_address]
```

Table 7-1 is a description of the NIS+ root reference.

Table 7-1 NIS+ Root Reference

Address Element	Description
`nis+_root_domain`	The fully qualified name of the NIS+ root domain (trailing dot required)
`nis+_server`	The host name of one of the servers serving *nis+_root_domain*
`server_IP_address`	The IP address of *nis+_server*. This is optional if the address of *nis+_server* is expected to be known. This means it should be available through one of the name services listed in the `/etc/nsswitch.conf` file. Refer to the `nsswitch.conf(4)`man page for information.

In the following example,

```
wiz.com. wiz-nis-master.wiz.com
```

the address indicates that name of the NIS+ root domain is `wiz.com.` (trailing dot is significant), and that it can be reached using the host `wiz-nis-master.wiz.com`. The IP address of the server is not given because it is expected to be available through other means.

In another example,

```
woz.com. wozwoz 133.33.33.33
```

indicates that the name of the NIS+ root domain is `woz.com`. (trailing dot is significant) and that it can be reached using the host `wozwoz`, with the IP address `133.33.33.33`.

Federating NIS+ Under DNS

This section describes the steps required to add TXT (text) records for a subordinate enterprise naming system implemented with NIS+. To federate a subordinate naming system in DNS, you need to add reference information into DNS describing how to reach the subordinate naming system.

1. **Obtain the NIS+ root reference for your NIS+ hierarchy, see "Obtaining the NIS+ Root Reference" on page 111.**
2. **Edit the DNS table (`/etc/named.local` is the default file name) and add a TXT record with the following format.**

```
TXT "XFNNISPLUS nis+_root_domain nis+_server [server_IP_address]"
```

For more information about DNS tables, see *NIS+ and DNS Setup and Configuration Guide*.

The following are examples of two records that convey the same information.

```
TXT     "XFNNISPLUS wiz.com. nis-master.wiz.com"
TXT     XFNNISPLUS\ wiz.com.\ nis-master.wiz.com
```

The TXT record must be associated with a DNS domain that includes an NS (name server) record entry. The following is an example of a DNS table with reference information for NIS+ bound in it.

```
$ORIGIN Wiz.com
@       IN SOA foo bar.eng.Wiz.com
           (
              100    ;; Serial
              3600   ;; Refresh
              3600   ;; Retry
              3600   ;; Expire
              3600   ;; Minimum
           )
        NS    nshost
        TXT   "XFNNISPLUS wiz.com. wiz-nis-master 133.33.33.33"

nshost IN  A 133.33.33.34
```

3. **After adding the TXT record into the DNS table, either restart the DNS server or send it a signal to reread the table.**

```
# kill -HUP pid-of-in.named
```

For further information on how DNS TXT records are used for XFN references, see Appendix B.

Federating NIS+ Under X.500

In order to federate a subordinate naming system in X.500, reference information must be added into X.500 describing how to reach that subordinate naming system. This section describes the steps for adding XFN reference information to the X.500 entry that will be the parent of the subordinate naming system.

Note – An X.500 client is required in order to access X.500 using FNS. The X.500 client must export the XDS/XOM APIs from the `/opt/SUNWxds/lib/libxomxds.so` shared object. Consult "*Getting started with the SunLink X.500 Client Toolkit*" for details on SunSoft's X.500 product.

1. **Obtain the NIS+ root reference for your NIS+ hierarchy.**
See "Obtaining the NIS+ Root Reference" on page 111.

2. **Create an X.500 entry that supports XFN reference attributes.**
For example, the following command creates a new X.500 entry called `c=us/o=wiz` with the object classes `top`, `organization`, and `XFN-supplement` (1.2.840.113536.25). The `XFN-supplement` object class allows the `c=us/o=wiz` entry to store reference information for a subordinate naming system.

```
# fnattr -a .../c=us/o=wiz object-class top organization XFN-supplement
```

If the X.500 entry already existed and was not defined with the `XFN-supplement` object class, it must be removed and re-created with the additional object class. Otherwise, it will not be able to hold reference information about the subordinate naming system.

3. **Add the reference information about the subordinate NIS+ system to the entry.**
   After creating the X.500 entry, you can then add information about the subordinate NIS+ system by binding the appropriate NIS+ root reference to the named entry:

```
# fnbind -r .../c=us/o=wiz/ onc_fn_enterprise onc_fn_nisplus_root "wiz.com. bigbig"
```

   This example binds the reference for the NIS+ hierarchy with the root domain name `wiz.com`, served by the machine `bigbig`, to the next naming system pointer (NNSP) of the X.500 entry `c=us/o=wiz`, thus linking the X.500 namespace with the `wiz.com`. NIS+ namespace hierarchy.

   The address format used is that of the NIS+ root reference described earlier. Note the use of the trailing slash in the name argument to `fnbind`, `.../c=us/o=wiz/`, to signify that the reference is being bound to the NNSP of the entry, rather than to the entry itself.

For further information on X.500 entries and XFN references, see Appendix C, “X.500 Attribute Syntax for XFN References.”

7

Administering the File System Namespace 8

This chapter describes the file system namespace and the procedures for creating file contexts.

The FNS File System Namespace

Files may be named relative to users, hosts, organizations, and sites in FNS by appending the `fs` namespace identifier to the name of the object, and following this with the name of the file. For example, an engineering organization's tools directory might be named `org/engineering/fs/tools`.

The initial context is located under `/xfn` in the file system's root directory. Thus a user might access the `tools` directory by typing

```
% cd /xfn/org/engineering/fs/tools
```

Existing applications can access this directory just as they would any other directory. Applications do not need to be modified in any way or use the XFN API.

NFS File Servers

NFS is Sun's distributed file system. The files associated with an object will generally reside on one or more remote NFS file servers. In the simplest case, the namespace identifier `fs` corresponds to the root of an exported NFS file system, as shown in Figure 8-1.

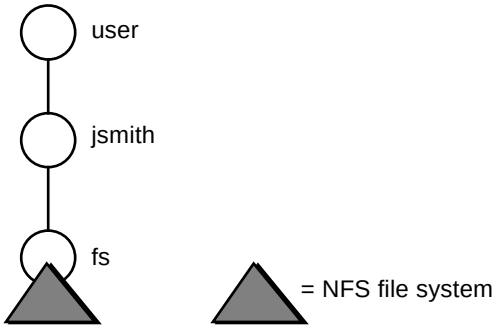

Figure 8-1 NFS File System—Simple Case

In contrast, an object's file system may be composed of multiple—and possibly overlapping—remote mounts, woven together into a "virtual" directory structure managed by FNS.

Figure 8-2 illustrates how this capability might be used to piece together an organization's file system from three separate file servers. The `project` directory, along with its `lib` subdirectory, resides on one file server, while the `src` subdirectory resides on another. Users and applications need not be aware of the use of multiple servers; they see a single, seamless namespace.

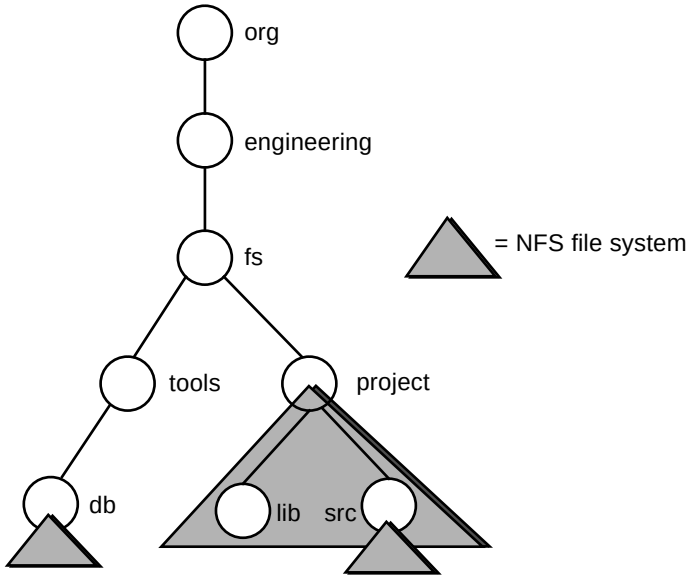

Figure 8-2 NFS File System—Multiple Servers

The Automounter

For efficiency, the automounter (see *NFS Administration Guide*) is used to mount FNS directories on demand. The default `/etc/auto_master` configuration file contains the line:

```
/xfn     -xfn
```

which tells the automounter that the FNS namespace is “mounted” under `/xfn`, as specified by XFN.

Since the automounter is used to mount directories named through FNS, the subdirectories of an FNS directory cannot be listed until they have been mounted. For example, suppose the file system of the sales organization is composed of multiple NFS file systems. The following `ls` command shows only two file systems that have been visited recently and are currently mounted:

```
% ls /xfn/org/sales/fs
  customers    products
```

To see the entire listing, use the `fnlist(1)` command.:

```
% fnlist org/sales/fs
  Listing 'org/sales/fs':
  products
  goals
  customers
  incentives
```

Creating File Contexts

The `fncreate_fs(1M)` command creates file contexts for organizations and sites. It may also be used to override the default file contexts for users and hosts that are created by the `fncreate(1M)`command. See "File Context" on page 82.

There are two methods of using the `fncreate_fs` command. The context bindings may be provided by an input file (See "Creating the Input File" on page 121) or on the command line (See "Using Command-line Input" on page 123).

The two methods of `fncreate_fs` have the following syntax:

```
fncreate_fs [-v] [-r] -f input_file composite_name
fncreate_fs [-v] [-r] composite_name [mount_options][mount_location...]
```

The `fncreate_fs` options `-v` and `-r` are described in Table 8-1.

Table 8-1 `fncreate_fs` Command Options

Option	Description
-v	Sets verbose output, displaying information about the contexts being created and modified.
-r	Replaces the bindings in the context named by *composite_name*—and all of its subcontexts—with *only* those specified in the input. This is equivalent to destroying the context (and, recursively, its subcontexts), and then running `fncreate_fs` without this option. The `-r` option should be used with care.

The `fncreate_fs` command manipulates FNS contexts and bindings of the `onc_fn_fs` reference type. It uses an address of type `onc_fn_fs_mount` to represent each remote mount point. The data associated with an address of this type are the corresponding mount options and locations in a single, XDR-encoded string.

Creating the Input File

The input file supplies the names and values to be bound in the context of *composite_name*. Its format is based upon and similar, but not identical, to the format of indirect automount maps (see *NFS Administration Guide*). The input file contains an entry with the form:

```
name [mount_options] [mount_location...]
```

For each entry a reference to the mount locations and the corresponding mount options is bound to the name *composite_name*/*name*.

The *name* field may be a simple atomic name or a slash-separated hierarchical name. It may also be "`.`" (dot), in which case the reference is bound directly to *composite_name*.

The *mount_location* field specifies the host or hosts that serve the files for *composite_name/name*. In a simple NFS mount, *mount_location* takes the form:

```
host:path
```

where *host* is the name of the server from which to mount the file system and *path* is the path name of the directory to mount.

The *mount_options* field begins with a hyphen ("–"). This is followed by a comma-separated list (with no spaces) of the mount options to use when mounting the directory. These options also apply to any subcontexts of *composite_name/name* that do not specify mount options of their own.

If *mount_options* and *mount_location* are both omitted, then no reference is bound to *composite_name/name*. Any existing reference is unbound.

Using the example from Figure 8-1 on page 118, suppose you want `jsmith`'s file system to be an NFS mount of the directory `/export/home/jsmith` from host `svr1`. The command would be run as follows:

```
% fncreate_fs -f infile user/jsmith/fs
```

with `infile` containing

```
.     svr1:/export/home/jsmith
```

To set up the file system illustrated in Figure 8-2 on page 119, run the command

```
% fncreate_fs -f infile org/engineering/fs
```

with `infile` containing

```
tools/db      svr1:/export/db
project       svr1:/export/proj
project/src   svr2:/export/src
```

To change the NFS mounts for `project` and its subcontext `src` to be read-only, you can change `infile` as follows:

```
tools/db       svr1:/export/db
project -ro    svr1:/export/proj
project/src    svr2:/export/src
```

The `-ro` is unnecessary in the third line. Since `src` is a subcontext of `project`, it will inherit the `-ro` mount option from above.

The following input file would make all of the mounts read-only except for `org/engineering/fs/project/src`.

```
.          -ro
tools/db           svr1:/export/db
project            svr1:/export/proj
project/src -rw    svr2:/export/src
```

Using Command-line Input

The `fncreate_fs(1M)` command also allows the binding description to be provided on the command line:

```
fncreate_fs composite_name [mount_options] [mount_location ...]
```

This is equivalent to using the first form of the command and providing a one-line input file containing "`.`" in the *name* field, and the given mount options and locations. The previous example in which `jsmith`'s file system was set could be set from the command line as follows:

```
% fncreate_fs user/jsmith/fs svr1:/export/home/jsmith
```

Similarly, the hierarchy in Figure 8-2 on page 119 could have been set up by running the sequence of commands:

```
% fncreate_fs org/engineering/fs/tools/db svr1:/export/db
% fncreate_fs org/engineering/fs/project svr1:/export/proj
% fncreate_fs org/engineering/fs/project/src svr2:/export/src
```

To make all three of the mounts read-only, you would run this command:

```
% fncreate_fs org/engineering/fs -ro
```

Advanced Input Formats

The following two sections apply to both input file and command-line input formats.

Multiple Mount Locations

Multiple *mount_location* fields may be specified for NFS file systems that are exported from multiple, functionally equivalent locations:

```
% fncreate_fs org/sales/fs svr1:/sales svr2:/sales
```

The automounter will attempt to choose the best server from among the alternatives provided. If several locations in the list share the same path name, they may be combined using a comma-separated list of host names:

```
% fncreate_fs org/sales/fs svr1,svr2:/sales
```

The hosts may be weighted, with the weighting factor appended to the host name as a nonnegative integer in parentheses: the lower the number, the more desirable the server. The default weighting factor is zero (most desirable).

The following example illustrates one way to indicate that `svr2` is the preferred server:

```
% fncreate_fs org/sales/fs svr1(2),svr2(1):/sales
```

See *NFS Administration Guide* for additional information on how the automounter interprets the *mount_location* field.

Variable Substitution

Variable names, prefixed by `$`, may be used in the *mount_options* or *mount_location* fields of `fncreate_fs`. For example, a mount location may be given as

```
svr1:/export/$CPU
```

The automounter will substitute client-specific values for these variables when mounting the corresponding file systems. In the above example, `$CPU` is replaced by the output of `uname -p`; for example, `sparc`.

See *NFS Administration Guide* for additional information on how the automounter treats variables substitution.

Backward Compatibility Input Format

For additional compatibility with automount maps, the following input file format is also accepted by `fncreate_fs`:

```
name                    [mount_options] [mount_location ...] \
        /offset1        [mount_options1] mount_location1 ... \
        /offset2        [mount_options2] mount_location2 ... \
        ...
```

where each *offset* field is a slash-separated hierarchy. The backslash (\) indicates the continuation of a single long line. This is interpreted as being equivalent to

```
name                    [mount_options] [mount_location ...]
name/offset1            [mount_options1] mount_location1 ...
name/offset2            [mount_options2] mount_location2 ...
...
```

The first line is omitted if both *mount_options* and *mount_location* are omitted. This format is for compatibility only. It provides no additional functionality, and its use is discouraged.

Administering File Contexts

File contexts may be inspected using the `fnlist(1)` and `fnlookup(1)` commands, and may be pruned or destroyed using `fnunbind(1)` and `fndestroy(1M)`. These commands and sample output are described in Chapter 6, "Administering FNS on NIS+." Refer also to the man page for each command.

Administering the Printer Namespace 9

This chapter describes the administration of the printer namespace. The `printer` context is not part of the XFN policies. It is provided in FNS in order to store printer bindings.

The Printer Namespace

FNS provides the capability to store printer bindings in the FNS namespace. This gives print servers the means to advertise their services and allow users to browse and choose amongst the available printers without client side administration.

Printer bindings are stored in printer contexts, which are associated with organizations, users, hosts, and sites. Hence, each organization, user, host, and site has its own `printer` context.

The `printer` context is created under the `service` context of the respective composite name. For example, the composite name shown below has the following `printer` context:

```
org/wiz.com./service/printer
```

The name of a printer for a host, `labpc`, with a printer context might look like this:

```
host/labpc/service/printer/laser
```

Administering Printer Contexts

Currently, printer contexts are supported for name service of files, NIS, and NIS+. The manner in which the bindings are stored in the `printer` context varies according to the underlying name service used for implementing FNS. For NIS and files, printer bindings are only associated with organizations and all the bindings exist in one printer context. NIS+, however, stores the printer bindings in the `printer` context, which allows the printer namespace to be arranged hierarchically and be associated with the `org`, `host`, `user`, and `site` contexts.

Using Files

Files are used as the default name service if neither NIS nor NIS+ is present. The printer bindings are stored in the `/etc/printers.conf` file, which is the printer configuration database used to describe printers. Each printer binding requires its own entry in this file. For example, if you have a printer named `printer1`, with the alias `ps`, you would add an entry to the `printers.conf` file in this format:

```
printer1|ps:bsdaddr=server_name,printer_name
```

In this example, when a lookup is performed on and address containing `printer1`, the address type of `onc_printers_bsdaddr` is returned. For more information about the required file format in `printers.conf`, see the `printers.conf(4)` man page.

Using NIS

If NIS is the underlying name service, the NIS map that is used to store the printer configuration is called `printers.conf.byname`. Each printer binding has an entry in this file. For example, if you have a printer named `printer2`, with the alias `lp`, you would add an entry to the `printers.conf.byname` file in this format:

```
printer2|lp:bsdaddr=server_name,printer_name
```

For more information about the syntax required, see the `printers.conf.byname(4)` man page.

When you list or look up the available printers (using `lpstat`(1), `fnlist`(3N) or `fn_ctx_lookup()` for example), the results are created by merging the list of printers included in the files name service (`/etc/printers.conf`) with the list of printers included in the NIS name service map (`/etc/printers.conf.byname`).

Using NIS+

If NIS+ is the underlying name service for FNS, administering printer contexts is simplified by the `fncreate_printer` command, which creates the `printer` context for organization, users, hosts, and sites.

The `fncreate_printer` command takes the following arguments:

```
fncreate_printer composite_name printer_name printer_address
```

where *printer_address* is in the form *addresstype=address*. In the next example, the *printer_address* is `bsdaddr=labpc,laser-jet`. For more information, see the `fncreate_printer(1)` man page.

In this example, a printer binding for the printer `laser-jet` for the user `jsmith` is created:.

```
% fncreate_printer user/jsmith laser-jet bsdaddr=labpc,laser-jet
```

The new binding, `user/jsmith/service/printer/laser-jet`, has the address type `onc_printers_bsdaddr`, and the address `labpc,laser-jet`. FNS adds the prefix `onc_printers_` to the address type.

In NIS+, it is possible to organize printers hierarchically. For example, printers can be listed under the `printer` context, as shown by the following commands:

```
% fncreate_printer org/wiz.com. color/lpq bsdaddr=colorful,lpq
% fncreate_printer org/wiz.com. color/laser bsdaddr=colorprt,laser
% fncreate_printer org/wiz.com. color/inkj bsdaddr=colorjet,inkj
```

The `fncreate` command added the printer bindings for the printers, `lpq`, `laser`, and `inkj` to the context `color` present under the `printer` context. The result looks like this:

```
org/wiz.com./service/printer/color/lpq
org/wiz.com./service/printer/color/laser
org/wiz.com./service/printer/color/inkj
```

Similarly, color printers, `green`, `red`, and `blue` for user `jsmith` can be organized as follows:

```
user/jsmith/service/printer/color/green
user/jsmith/service/printer/color/red
user/jsmith/service/printer/color/blue
```

Printer bindings (contexts) in NIS+ can be removed using the `fndestroy` command. For example, to remove the `printer` context in this example, use the command:

```
% fndestroy user/jsmith/service/printer/laser-jet
```

When you list or look up the available printers (using `lpstat`(1), `fnlist`(3N) or `fn_ctx_lookup()` for example), the results are created by merging the list of printers included in the files name service (`/etc/printers.conf`) with the list of printers included in the NIS+ tables generated by `fncreate`(1) or `fncreate_printer`(1).

Part 4 — Application Programming

These chapters present information for the application developer.

Interfaces for Writing XFN Applications 10

This chapter describes the client programming interfaces for XFN. Additional information on the XFN interfaces is available in the man pages.

XFN Interface Overview

The XFN client interface consists of the base context interface, the base attribute interface, and a number of supporting interfaces. The base context interface provides the basic operations for naming, such as binding a name to a reference, looking up the reference bound to a name, and unbinding a name. The base attribute interface provides operations to examine and modify attributes associated with named objects. The supporting interfaces contain

- Operations on the status object and status codes used in the context and attribute operations.
- A number of abstract data types defined to represent objects passed to and returned from the context and attribute operations, such as composite names, references, and attributes.

- A standard model and operations for parsing compound names, whose syntax is specific to a naming system. These are of primary interest to service implementers.

"API Usage Model" on page 22 summarizes how an application typically uses the programming interface.

Interface Conventions

The XFN interface is presented in ISO standard C, which is equivalent to ANSI standard C. The symbols defined by the interface are prefixed by `fn` or `FN`, for federated naming.

- The `FN_` prefix is used for both data types and predefined constants. In addition, data types have a `_t` suffix, such as `FN_ref_t`. Predefined constants appear in all–uppercase characters, such as `FN_ID_STRING`.
- The `fn_` prefix is used for function names. Names of functions in the base context interface have the prefix `fn_ctx_`, such as `fn_ctx_lookup`. Names of functions in the base attribute interface have the prefix `fn_attr_`, such as `fn_attr_get`.

Usage

The XFN header file must be included in code as shown for compilation.

```
#include <xfn/xfn.h>
```

The XFN library must be included in the link line as shown.

```
cc -o program_name file1.c file2.c -lxfn
```

Abstract Data Types

Except for `FN_attrvalue_t` and `FN_identifier_t`, the types defined in the interface hide their actual data representation from the client. The client performs every operation on an object of one of these types through a well-defined interface for that data type.

When the client accesses these objects, the client refers to the objects solely through a *handle* to an object. Operations are provided to create objects of each type and to destroy them. The creation operation returns a handle to the new object. The destroy operation releases all resources associated with the object. The only information about this handle revealed to the client is that it is a pointer type. The client cannot assume what this handle points to. In particular, the handle may not point directly to the memory containing the object's actual state.

The value 0 is defined for all pointer types. The functions that return handles in the interface return the value 0 as an indication of failure. The values 0 and NULL are equivalent.

Memory–Management Policies

The following memory–management policies are used for all client interfaces described in this chapter:

- When a function returns a non-`const` pointer to an object, the client "owns" the object. The client may alter the object and is responsible for freeing the space allocated to it when the object is no longer required.
- When a function returns a `const` pointer to an object, the service "owns" the object. The client must neither modify the object in any way, nor free the space allocated to it. If the client needs to control a copy, it must make one for itself.
- When a function takes a non-`const` parameter that is passed by reference, the service "borrows" the object during the period of the function's execution. It may modify the object during this period, but it does not retain any reference to the object passed in beyond this period.
- When a function takes a `const` parameter that is passed by reference, the service reads but does not modify the object. The service does not keep any reference to the object beyond the period of the function's execution.

The Base Context Interface

This section describes the operations in the base context interface. The interfaces to the objects used in the operations are described in "Parameters Used in the Interface" on page 153.

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Names in Context Operations

In most of the operations of the base context interface, the caller supplies a context and a composite name argument. The supplied composite name is always interpreted relative to the supplied context.

The operation may eventually be effected on a different context called the operation's *target context*. Each operation has an initial resolution phase that conveys the operation to its target context, following which the operation is applied. The effect (but not necessarily the implementation) is that of

- Doing a lookup on that portion of the name that represents the target context, and then
- Invoking the operation on the target context.

The contexts involved only in the resolution phase are called *intermediate contexts*. Normal resolution of names in context operations always follows *XFN links*, which are defined in “XFN Links” on page 15.

Requirements for Supporting the Context Operations

The lookup operation `fn_ctx_lookup()` must be supported by all contexts. Contexts may indicate that they do not support other operations by returning an `FN_E_OPERATION_NOT_SUPPORTED` status code (see Table 10-3 on page 151).

XFN contexts are required to support the resolution phase of every operation in the base context and attribute interface when involved in the operation as intermediate contexts. That is, each intermediate context must participate in the process of conveying the operation to the target context, even if it does not support that operation itself. For example, not all contexts need allow binding and listing names. However, all contexts must fully support the resolution phase of these operations.

Composite names are passed to an XFN context implementation in a structural form as an ordered sequence of components. When resolving a name the context implementation is responsible for

- Determining which set of leading components it must resolve
- Resolving that portion to a reference
- Returning a status object containing this reference and the portion of the name unresolved

Composite name resolution is further discussed in “Composite Name Resolution” on page 163.

Status Objects

In each context operation, the caller supplies an `FN_status_t` parameter. The called function sets this status object as described in “Status Objects and Status Codes” on page 150. All status objects are handled in this manner for each operation in the base context interface; this will not be restated in the individual operation descriptions.

Getting Context Handles

All operations on a context require a context handle. There are two ways of obtaining a context handle. If you have a reference, you can use it to construct a context handle. Otherwise, you must call `fn_ctx_handle_from_initial()` to get a handle to the initial context.

Construct Handle to Initial Context

```
FN_ctx_t *fn_ctx_handle_from_initial(FN_status_t *status);
```

This operation returns a handle to the caller's initial context. On successful return, the context handle points to a context containing the bindings described in “Initial Context Bindings for Naming Within the Enterprise” on page 54 and “Initial Context Bindings for Global Naming” on page 62.

Construct Context Handle From Reference

```
FN_ctx_t *fn_ctx_handle_from_ref(
    const   FN_ref_t *ref,
    FN_status_t *status);
```

This operation returns a handle to an `FN_ctx_t` object given a reference, *ref*, for that context.

Lookup and List Contexts

Lookup

```
FN_ref_t *fn_ctx_lookup(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    FN_status_t *status);
```

This operation returns the reference bound to *name* relative to the context *ctx*.

List Names

```
FN_nameslist_t* fn_ctx_list_names(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    FN_status_t *status);

FN_string_t *fn_namelist_next(
    FN_namelist_t *nl,
    FN_status_t *status);


void fn_namelist_destroy(
    FN_namelist_t *nl,
    FN_status_t *status);
```

This set of operations is used to list the set of names bound in the context named *name* relative to the context *ctx*. *name* must name a context. If the intent is to list the contents of *ctx*, *name* should be an empty composite name.

The call to `fn_ctx_list_names()` initiates the enumeration process for the target context. It returns an `FN_nameslist_t` object that can be used for the enumeration.

The operation `fn_namelist_next()` returns the next name in the enumeration identified by *nl* and updates *nl* to indicate the state of the enumeration marker. Successive calls to `fn_namelist_next()` using *nl* return successive names and further update the state of the enumeration. `fn_namelist_next()` returns a NULL pointer when the enumeration has been completed.

`fn_namelist_destroy()` is used to release resources used during the enumeration. This may be invoked at any time to terminate the enumeration.

The names enumerated using the list names operations are not ordered in any way. There is no guaranteed relation between the order in which names are added to a context and the order names are obtained by enumeration. There is no guarantee that any two enumerations will return the names in the same order.

When a name is added to or removed from the context, this may not necessarily invalidate the enumeration handle that the client holds for that context. If the enumeration handle remains valid, the update may or may not be visible to the client.

List Bindings

```
FN_bindinglist_t* fn_ctx_list_bindings(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    FN_status_t *status);

FN_string_t *fn_bindinglist_next(
    FN_bindinglist_t *bl,
    FN_ref_t ** ref,
    FN_status_t *status);

void fn_bindinglist_destroy(
    FN_bindinglist_t *bl,
    FN_status_t *status);
```

This set of operations is used to list the set of names and bindings in the context named by *name*, relative to the context *ctx*. *name* must name a context. If the intent is to list the contents of *ctx*, *name* should be an empty composite name.

The semantics of these operations are similar to those for listing names. In addition to a name string being returned, `fn_bindinglist_next()` also returns the reference of the binding for each member of the enumeration.

Lookup Link

```
FN_ref_t *fn_ctx_lookup_link(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    FN_status_t *status);
```

This operation returns the XFN link bound to *name*. The terminal atomic part of *name* must be bound to an XFN link.

The normal `fn_ctx_lookup()` operation follows all XFN links encountered, including any bound to the terminal atomic part of *name*. This operation differs from the normal lookup in that when the terminal atomic part of *name* is an XFN link, this last link is not followed, and the operation returns the link.

Updating Bindings

Bindings can be added, overwritten, removed, or renamed.

Bind

```
int fn_ctx_bind(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    const   FN_ref_t *ref,
    unsigned int exclusive,
    FN_status_t *status);
```

This operation binds the supplied reference *ref* to the supplied composite name *name*, taken relative to *ctx*. The binding is made in the target context—that named by all but the terminal atomic part of *name*. The operation binds the terminal atomic name to the supplied reference in the target context. The target context must already exist.

The value of *exclusive* determines what happens if the terminal atomic part of the name is already bound in the target context. If *exclusive* is nonzero and *name* is already bound, the operation fails. If *exclusive* is zero, the new binding replaces any existing binding.

The value of *ref* cannot be NULL. If the intent is to reserve a name using the `fn_ctx_bind()` operation, a reference containing no address should be bound. This reference may be naming service-specific or it may be the conventional NULL reference.

Unbind

```
int fn_ctx_unbind(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    FN_status_t *status);
```

This operation removes the terminal atomic name in *name* from the target context—that named by all but the terminal atomic part of *name*.

This operation is successful even if the terminal atomic name was not bound in target context, but fails if any of the intermediate names are not bound. `fn_ctx_unbind()`operations are idempotent.

Rename

```
int fn_ctx_rename(
    FN_ctx_t *ctx,
    const FN_composite_name_t *oldname,
    const FN_composite_name_t *newname,
    unsigned int exclusive,
    FN_status_t *status);
```

This operation binds the reference currently bound to *oldname*, resolved relative to *ctx* to *newname*, and unbinds *oldname*. The *newname* is resolved relative to the target context—that named by all but the terminal atomic part of *oldname*.

If *exclusive* is zero, this operation overwrites any old binding of *newname*. If *exclusive* is nonzero, the operation fails if *newname* is already bound.

The only restriction that XFN places on *newname* is that it be resolved relative to the target context. For example, in some implementations, *newname* might be restricted to be a name in the same naming system as the terminal component of *oldname*. In another implementation, *newname* might be restricted to an atomic name.

Managing Contexts

Contexts can be created or destroyed.

Create Subcontext

```
FN_ref_t *fn_ctx_create_subcontext(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    FN_status_t *status);
```

This operation creates a new context of the same type as the target context—that named by all but the terminal atomic part of *name*—and binds it to the composite name *name* resolved relative to the context *ctx*, and returns a reference to the newly created context.

As with the bind operation, the target context must already exist. The new context is created and bound in the target context using the terminal atomic name in *name*.

The operation fails if the terminal atomic name already exists in the target context.

The new subcontext exports the context interface and is created in the same naming system as the target context. XFN does not specify any further properties of the new subcontext. Other properties of the subcontext are determined by the target context and its naming system.

Destroy Subcontext

```
int fn_ctx_destroy_subcontext(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    FN_status_t *status);
```

This operation destroys the subcontext named by *name*, interpreted relative to *ctx*, and unbinds the name.

As with the unbind operation, the operation succeeds if the terminal atomic name is not bound in the target context—that named by all but the terminal atomic part of *name*.

Some aspects of this operation are determined by the target context and its naming system. For example, XFN does not specify what happens if the named subcontext is not empty when the operation is invoked.

Other Context Operations

Get Reference to Context

```
FN_ref_t *fn_ctx_get_ref(
    const FN_ctx_t *ctx,
    FN_status_t *status);
```

This operation returns a reference to the supplied context object.

Get Syntax Attributes of Context

```
FN_attrset_t *fn_ctx_get_syntax_attrs(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    FN_status_t *status);
```

This operation returns the syntax attributes associated with the context named by *name*, relative to the context *ctx*.

This operation is different from other XFN attribute operations in that these syntax attributes could be obtained directly from the context. Attributes obtained through other XFN attribute operations may not necessarily be associated with the context; they may be associated with the reference of the context, rather than the context itself (see “Relationship to Naming Operations” on page 144).

Destroy Context Handle

```
void fn_ctx_handle_destroy(FN_ctx_t *ctx);
```

This operation destroys the context handle *ctx* and allows the implementation to free resources associated with the context handle. This operation does not affect the state of the context itself.

The Base Attribute Interface

This section describes the operations in the base attribute interface. The interfaces to the objects used in operations in this interface are described in “Parameters Used in the Interface” on page 153.

XFN Attribute Model

In the XFN attribute model, a set of zero or more attributes can be associated with a named object. Each attribute in the set has a unique attribute identifier, an attribute syntax, and a set of zero or more distinct attribute values. Each attribute value has an opaque data type. The attribute identifier serves as a name for the attribute. The attribute syntax indicates how the attribute values are encoded.

The operations in the base attribute interface may be used to examine and modify the settings of attributes associated with existing named objects. These objects may be contexts or other types of objects. The attribute operations do not create names or remove names in contexts.

The range of support for attribute operations may vary widely. Some naming systems may not support any attribute operations. Other naming systems may support only read operations or operations on attributes whose identifiers are in some fixed set. A naming system may limit attributes to have a single value or may require at least one value. Some naming systems may only associate attributes with context objects, while others may allow associating attributes with noncontext objects.

Typically, attributes of an object are manipulated through operations that operate on a single attribute, such as reading or updating a single attribute. Moreover, the client is typically expected to be able to read all attribute values of a single attribute in one call. However, sometimes there is a requirement to manipulate several attributes of a single object or to obtain individual attribute values of a single attribute from the name service. To address these requirements, two kinds of attribute operations are defined:

- Single-attribute operations
- Multiple-value and multiple-attribute operations

Relationship to Naming Operations

An XFN attribute operation may not necessarily be equivalently expressed as an independent `fn_ctx_lookup()` operation followed by an attribute operation in which the caller supplies the resulting reference and an empty name. The reason is that in some attribute models, attributes are associated with a named object in the context in which the object is named. In others an object's attributes are stored in the object itself. XFN accommodates both these models.

Note – Invoking an attribute operation using the target context and the terminal atomic name accesses either the attributes that are associated with the terminal name or the object named by the terminal name—this is dependent upon the underlying attribute model. This document uses the term “attributes associated with a named object” to refer to all of these cases.

XFN does not provide any guarantee about the relationship between the attributes and the reference associated with a given name. Some naming systems may store the reference bound to a name in one or more attributes associated with a name. Attribute operations might affect the information used to construct a reference.

To avoid undefined results, programmers must use the operations in the context interface and not the attribute operations when manipulating references. Applications should avoid the use of specific knowledge about how an XFN context implementation over a particular naming system constructs references.

Status Objects

In each attribute operation, the caller supplies an `FN_status_t` parameter. The called function sets this status object as described in “Status Objects and Status Codes” on page 150. All status objects are handled in this manner for each operation in the base attribute interface; this will not be restated in the individual operation descriptions.

Single-Attribute Operations

Each of these operations takes as arguments a context and composite name relative to this context and manipulates the attributes associated with the named object. Each operation sets a status object to describe the status of the operation.

Get Attribute

```
FN_attribute_t *fn_attr_get(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    const FN_identifier_t *attribute_id,
    FN_status_t *status);
```

This operation returns the identifier, syntax, and values of a specified attribute, *attribute_id*, for the object named *name* relative to the context *ctx*. If *name* is empty, the attribute associated with *ctx* is returned.

`fn_attr_get_values()` and its related functions are for getting individual values of an attribute and should be used if the combined size of all the values are expected to be too large to be returned in a single invocation of `fn_attr_get()`.

Modify Attribute

```
int fn_attr_modify(
    FN_ctx_t *ctx,
    const FN_composite_name_t *name,
    unsigned int mod_op,
    const   FN_attribute_t *attr,
    FN_status_t *status);
```

This operation modifies according to *mod_op* the attribute *attr* associated with the object named *name*, relative to *ctx*. If *name* is empty, the attribute associated with *ctx* is modified.

Table 10-1 XFN Attribute -Modification Operations

Operation Code	Meaning
FN_ATTR_OP_ADD	Add an attribute with given attribute identifier and set of values. If an attribute with this identifier exists already, replace the set of values with those in the given set. The set of values may be empty if the target naming system permits.
FN_ATTR_OP_ADD_EXCLUSIVE	Add an attribute with the given attribute identifier and set of values. The operation fails if an attribute with this identifier exists already. The set of values may be empty if the target naming system permits.
FN_ATTR_OP_ADD_VALUES	Add the given values to those of the given attribute (resulting in the attribute having the union of its prior value set with the set given). Create the attribute if it does not exist already. The set of values may be empty if the target naming system permits.
FN_ATTR_OP_REMOVE	Remove the attribute with the given attribute identifier and all its values. The operation succeeds even if the attribute does not exist. The values of the attribute supplied with this operation are ignored.
FN_ATTR_OP_REMOVE_VALUES	Remove the given values from those of the given attribute (resulting in the attribute having the set difference of its prior value set and the set given). This succeeds even if some of the given values are not in the set of values that the attribute has. In naming systems that require an attribute to have at least one value, removing the last value will remove the attribute as well.

Get Attribute Values

This set of operations allows the caller to obtain attribute values associated with a single attribute individually.

```
FN_valuelist_t *fn_attr_get_values(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    const   FN_identifier_t *attribute_id,
    FN_status_t *status);

FN_attrvalue_t *fn_valuelist_next(
    FN_valuelist_t, *vl
    FN_identifier_t **attr_syntax,
    FN_status_t *status);

void fn_valuelist_destroy(
    FN_valuelist_t *vl,
    FN_status_t *status);
```

This set of operations is used to obtain the set of values of a single attribute, identified by *attribute_id*, associated with *name*, relative to *ctx*. If *name* is empty, the attribute associated with *ctx* are obtained.

This interface should be used instead of `fn_attr_get()` if the combined size of the all the values is expected to be too large to be returned by `fn_attr_get()`.

The operation `fn_attr_get_values()` initiates the enumeration process. It returns a handle to an `FN_valuelist_t` object that can be used for subsequent `fn_valuelist_next()` calls to enumerate the values requested.

The operation `fn_valuelist_next()` returns the next attribute value in the enumeration and updates *vl* to indicate the state of the enumeration.

The operation `fn_valuelist_destroy()` frees the resources associated with the enumeration. This may be invoked at any time in order to terminate the enumeration.

Multiple-Attribute Operations

These operations allow the caller to specify an operation that operates on multiple attributes using one or more calls.

The failure semantics may vary widely across naming systems. In some systems the single function call may comprise multiple individual naming system operations, with no guarantees of atomicity.

Get Attribute Identifiers

```
FN_attrset_t *fn_attr_get_ids(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    FN_status_t *status);
```

This operation gets a list of all the attribute identifiers that are associated with the object named *name* relative to the context *ctx*. If *name* is empty, the attribute identifiers associated with *ctx* are returned.

Get Multiple Attributes

```
FN_multigetlist_t *fn_attr_multiget(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    const   FN_attrset_t *attr_ids,
    FN_status_t *status);
FN_attribute_t *fn_multigetlist_next(
    FN_multigetlist_t *ml,
    FN_status_t *status);

void fn_multigetlist_destroy(
    FN_multigetlist_t *ml,
    FN_status_t *status);
```

This set of operations gets one or more attributes associated with the object named *name* relative to the context *ctx*. If *name* is empty, the attributes associated with *ctx* are returned.

The attributes returned are those specified in *attr_ids*. If the value of *attr_ids* is 0, all attributes associated with the named object are returned. Any attribute values in *attr_ids* provided by the caller are ignored; only the identifiers are relevant for this operation. Each attribute (identifier, syntax, and values) is returned one at a time using an enumeration scheme similar to that for listing a context. `fn_attr_multi_get()` initiates the enumeration process. It returns a handle to an `FN_multigetlist_t` object that can be used for subsequent `fn_multigetlist_next()` calls to enumerate the attributes requested.

The operation `fn_multigetlist_next()` returns the next attribute (identifier, syntax, and values) in the enumeration and updates *ml* to indicate the state of the enumeration. Successive calls to `fn_multigetlist_next()` using *ml* return successive attributes in the enumeration and further update the state of the enumeration.

The operation `fn_multigetlist_destroy()` frees the resources used during the enumeration. This may be invoked at any time to terminate the enumeration.

Implementations are not required to returned all attributes requested by *attr_ids*. Some may choose to return only the attributes found successfully; such implementations may not necessarily return identifiers for attributes that could not be read.

Modify Multiple Attributes

```
int fn_attr_multi_modify(
    FN_ctx_t *ctx,
    const   FN_composite_name_t *name,
    const   FN_attrmodlist_t *mods,
    FN_attrmodlist_t **unexecuted_mods,
    FN_status_t *status);
```

This operation modifies the attributes associated with the object named *name*, relative to *ctx*.

In the *mods* parameter, the caller specifies a sequence of modifications that are to be done in order on the attributes. Each modification in the sequence specifies a modification operation code (shown in Table 10-1 on page 146) and an attribute on which to operate.

If all the modifications were performed successfully, *unexecuted_mods* is a NULL pointer.

If an error is encountered while performing the list of modifications, *status* indicates the type of error and *unexecuted_mods* is set to point to a list of unexecuted modifications. The contents of *unexecuted_mods* do not share any state with *mods*; items in *unexecuted_mods* are copies of items in *mods* and appear in the same order in which they were originally supplied in *mods*. The first operation in *unexecuted_mods* is the first one that failed, and the code in *status* applies to this modification operation in particular. If *status* indicates a failure and a NULL pointer is returned in *unexecuted_mods*, that indicates no modifications were executed.

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Status Objects and Status Codes

The result status of operations in the context interface and the attribute interface is encapsulated in an `FN_status_t` object. This object contains information about how the operation completed: whether an error occurred in performing the operation, the nature of the error, and information that helps locate where the error occurred. If the error occurred while resolving an XFN link, the status object contains additional information about that error.

The status object consists of several items of information.

Table 10-2 Status Object

Information Type	Description
Primary status code	An `unsigned int` code describing the disposition of the operation.
Resolved name	In the case of a failure during the resolution phase of the operation, this is the leading portion of the name that was resolved successfully. Resolution may have been successful beyond this point, but the error might not be pinpointed further.
Resolved reference	The reference to which the resolved name is bound.
Remaining name	The remaining unresolved portion of the name.
Diagnostic message	Any diagnostic message returned by the context implementation.
Link status code	If an error occurs while resolving an XFN link, the primary status code has the value `FN_E_LINK_ERROR`, and this code describes the error that occurred while resolving the XFN link.
Resolved link name	In the case of a link error, this contains the resolved portion of the name in the XFN link.
Resolved link reference	In the case of a link error, this contains the reference to which the resolved link name is bound.
Remaining link name	In the case of a link error, this contains the remaining resolved portion of the name in the XFN link.
Link diagnostic message	Any diagnostic message related to the resolution of the link.

Both the primary status code and the link status code are values of type `unsigned int` that are drawn from the same set of meaningful values. XFN reserves the values 0 through 127 for standard meanings. Currently values and interpretations for the codes in Table 10-3 are determined by XFN.

Table 10-3 Status Codes

Code	Meaning
`FN_SUCCESS`	The operation succeeded.
`FN_E_ATTR_NO_PERMISSION`	The caller did not have permission to perform the attempted attribute operation.
`FN_E_ATTR_VALUE_REQUIRED`	The operation attempted to create an attribute without a value, and the specific naming system does not allow this.
`FN_E_AUTHENTICATION_FAILURE`	The identity of the client principal could not be verified.
`FN_E_COMMUNICATION_FAILURE`	An error occurred in communicating with one of the contexts involved in the operation.
`FN_E_CONFIGURATION_ERROR`	A problem was detected that indicated an error in the installation of the XFN interfaces.
`FN_E_CONTINUE`	The operation should be continued using the remaining name and the resolved reference returned in the status.
`FN_E_CTX_NO_PERMISSION`	The client did not have permission to perform the operation.
`FN_E_CTX_NOT_EMPTY`	Applies only to `fn_ctx_destroy_subcontext()`. The naming system required that the context be empty before its destruction, and it was not empty.
`FN_E_CTX_UNAVAILABLE`	Service could not be obtained from one of the contexts involved in the operation. This may be because the naming system is busy or is not providing service. In some implementations this may not be distinguished from a communication failure.
`FN_E_ILLEGAL_NAME`	The name supplied to the operation was not a well-formed composite name, or one of the component names was not well formed according to the syntax of the naming systems involved in its resolution.
`FN_E_INCOMPATIBLE_CODE_SETS`	The operation involved character strings of incompatible code sets or the supplied code set is not supported by the implementation.
`FN_E_INSUFFICIENT_RESOURCES`	Either the client or one of the involved contexts could not obtain sufficient resources (on memory, file descriptors, communication ports, stable media space, for example) to complete the operation successfully.

Table 10-3 Status Codes *(Continued)*

Code	Meaning
FN_E_INVALID_ATTR_VALUE	One of the values supplied was not in the appropriate form for the given attribute.
FN_E_INVALID_ENUM_HANDLE	The enumeration handle supplied was invalid, either because it was from another enumeration, because an update operation occurred during the enumeration, or for some other reason.
FN_E_INVALID_SYNTAX_ATTRS	The syntax attributes supplied are invalid or insufficient to fully specify the syntax.
FN_E_LINK_ERROR	An error occurred while resolving an XFN link encountered during resolution of the supplied name.
FN_E_LINK_LOOP_LIMIT	A nonterminating loop (cycle) in the resolution is suspected. This arises due to XFN links encountered during the resolution of a supplied composite name. This code indicates either the definite detection of such a cycle, or that resolution exceeded an implementation-defined limit on the number of XFN links allowed for a single operation invoked by the caller (and thus a cycle is suspected).
FN_E_MALFORMED_LINK	A malformed link reference was encountered. For `fn_ctx_lookup_link()`, the name supplied resolved to a reference that was not a link.
FN_E_MALFORMED_REFERENCE	A context object could not be constructed from the supplied reference because the reference was not properly formed.
FN_E_NAME_IN_USE	(Only for operations that bind names.) The supplied name was already in use.
FN_E_NAME_NOT_FOUND	Resolution of the supplied composite name proceeded to a context in which the next atomic component of the name was not bound.
FN_E_NO_SUCH_ATTRIBUTE	The object does not have an attribute with the given identifier.
FN_E_NO_SUPPORTED_ADDRESS	A context object could not be constructed from a particular reference. The reference contained no address type over which the context interface was supported.
FN_E_NOT_A_CONTEXT	Either one of the intermediate atomic names did not name a context, and resolution could not proceed beyond this point, or the operation required that the caller supply the name of a context, and the name did not resolve to a reference for a context
FN_E_OPERATION_NOT_SUPPORTED	The operation attempted is not supported.
FN_E_PARTIAL_RESULT	The operation attempted is returning a partial result.

Table 10-3 Status Codes *(Continued)*

Code	Meaning
FN_E_SYNTAX_NOT_SUPPORTED	The syntax type specified is not supported.
FN_E_TOO_MANY_ATTR_VALUES	The operation attempted to associate more values with an attribute than the naming system supported.
FN_E_UNSPECIFIED_ERROR	An error occurred that could not be classified by any of the other error codes.

Parameters Used in the Interface

This section gives an overview of the types of parameters that are passed and returned by operations in the base context and attribute interfaces. Manipulation of these objects using their corresponding interfaces does not affect their representation in the underlying naming system. Changes to objects in the underlying naming system can only be effected through the use of the interfaces described in “The Base Context Interface” on page 135 and “The Base Attribute Interface” on page 143.

Composite Names

A composite name is represented by an object of type `FN_composite_name_t`. A composite name is a sequence of components, where each component is a string (of type `FN_string_t`) intended to contain a name from a single naming system. (See “Syntax” on page 159 for a description of composite name syntax and structure.) Operations are provided to iterate over this sequence, modify it, and compare two composite names.

References and Addresses

A reference is represented by the type `FN_ref_t`. An object of this type contains a reference type and a list of addresses. The ordering in this list at the time of binding might not be preserved when the reference is returned upon lookup.

The reference type is represented by an object of type `FN_identifier_t`. The reference type is intended to identify the class of object referenced, but XFN does not dictate its precise use.

Each address in a reference is represented by an object of type `FN_ref_addr_t`. An address consists of an opaque data buffer and a type field, again of type `FN_identifier_t`. The address type is intended to identify the mechanism that should be used to reach the object using that address. Multiple addresses in a single reference are intended to identify multiple communication endpoints for the same conceptual object. Multiple addresses may arise for various reasons; for example, because the object offers interfaces over more than one communication mechanism.

The client process must interpret the contents of the opaque buffers based on the type of the address and on the type of the reference. However, this interpretation is intended to occur below the application layer. Most applications developers should not have to manipulate the contents of either address or reference objects themselves. These interfaces would generally be used within service libraries.

Identifiers

Identifiers are used to identify reference types and address types in the reference and to identify attributes and their syntax in the attribute operations.

The `FN_identifier_t` type is used to represent an identifier. It consists of an unsigned integer, which determines the format of identifier, and the actual identifier, which is expressed as a sequence of octets.

XFN defines a small number of standard forms for identifiers, as shown in Table 10-4.

Table 10-4 XFN Identifier Formats

Identifier Format	Description
`FN_ID_STRING`	The identifier is an ASCII string (ISO 646).
`FN_ID_DCE_UUID`	The identifier is an OSF DCE UUID in string representation. See the X/Open DCE RPC (ISBN 1-872630-95-2).
`FN_ID_ISO_OID_STRING`	The identifier is an ISO OID in ASN.1 dot-separated integer list string format. See the ISO ASN.1 (ISO 8824).
`FN_ID_ISO_OID_BER`	The identifier is an ISO OID in ASN.1 Basic Encoding Rules (BER) format. See the ISO BER (ISO 8825).

Strings

The `FN_string_t` type is used to represent character strings in the XFN interface. It provides a layer of insulation from specific string representations. The `FN_string_t` operations contain operations for string comparison, substring searches, and manipulation. The `FN_string_t` type supports multiple code sets. In Solaris 2.5, FNS supports ISO 646.

Attributes and Attribute Values

An attribute has an attribute identifier, a syntax, and a set of distinct values. An attribute is represented by the `FN_attribute_t` type. The attribute identifier and its syntax are specified using an `FN_identifier_t`. Each value is a sequence of octets, represented by the `FN_attrvalue_t` type.

There are operations to allow the construction, destruction, and manipulation of an attribute.

Attribute Sets

An attribute set is a set of attribute objects with distinct attribute identifiers. Attribute sets are represented by the `FN_attrset_t` type.

There are operations to allow the construction, destruction, and manipulation of an attribute set.

Attribute-Modification Lists

An attribute-modification list allows you to specify multiple modification operations to be performed on the attributes associated with a single named object. An attribute-modification list is represented by the `FN_attrmodlist_t` type. It consists of an ordered list of attribute-modification specifiers. An attribute-modification specifier consists of an operation and an attribute object. The attribute's identifier indicates the attribute that is to be operated upon. The attribute's values are used in a manner depending on the operation. The operation specifier is one of the values described in Table 10-1 on page 146. The operations are to be done in the order in which they appear in the list.

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Parsing Compound Names

Most applications treat names as opaque data; therefore, the majority of clients of the XFN interface will not need to parse compound names from specific naming systems. Some applications, however, such as browsers, need such capabilities. For these applications, XFN provides support in the form of the `FN_compound_name_t` object.

Syntax Attributes

Each context has an associated set of syntax-related attributes. The attribute `fn_syntax_type` (`FN_ID_STRING` format) identifies the naming syntax supported by the context. The value "standard" (ASCII attribute syntax) in the `fn_syntax_type` attribute specifies that the context supports the XFN standard syntax model that is by default supported by the `FN_compound_name_t` object.

Implementations may choose to support other syntax types in addition to or in place of the XFN standard syntax model, in which case the value of the `fn_syntax_type` attribute would be set to an implementation-specific string and different or additional syntax attributes would be in the set.

Syntax attributes of a context may be generated automatically by a context, in response to `fn_ctx_get_syntax_attrs()`, or may be created and updated using the attribute operations. This is implementation dependent.

XFN Standard Syntax Model

Each naming system in an XFN federation has a naming convention. XFN defines a standard model of expressing compound name syntax that covers a large number of specific name syntaxes. This model is expressed in terms of syntax properties of the naming convention and it uses XFN attributes to describe properties of the syntax.

Unless otherwise qualified, the syntax attributes described in this section have attribute identifiers that use the `FN_ID_STRING` format. This does not specify or restrict the use of other formats for identifiers of additional syntax attributes supported by specific implementations.

In the XFN standard syntax model these attributes are interpreted according to the following rules:

- In a string without quotes or escapes, any instance of the separator string delimits two atomic names.
- A separator, quotation mark, or escape string is escaped if preceded immediately (on the left) by the escape string.
- A non-escaped begin-quote that precedes a component must be matched by a non-escaped end-quote at the end of the component. Quotes embedded in nonquoted names are treated as simple characters and do not need to be matched. An unmatched quotation fails with the status code `FN_E_ILLEGAL_NAME`.
- If there are multiple values for begin-quote and end-quote, a specific begin-quote value must be matched with its corresponding end-quote value.
- When the separator appears between a (nonescaped) begin-quote and the end-quote, it is ignored.
- When the separator is escaped, it is not treated as a separator. An escaped begin-quote or end-quote string is not treated as a quotation mark. An escaped escape string is not treated as an escape string.
- A non-escaped escape string appearing within quotes is interpreted as an escape string. This can be used to embed an end-quote within a quoted string.

After constructing a compound name from a string, the resulting component atoms have one level of escape strings and quotations interpreted and consumed.

Code set mismatches that occur during the construction of the compound name's string form are resolved in an implementation-dependent way. When an implementation discovers that a compound name has components with incompatible code sets, it returns the error code `FN_E_INCOMPATIBLE_CODE_SETS.`

Table 10-5 lists all the XFN standard syntax model attributes.

Table 10-5 XFN Syntax Attributes

Attribute Identifier	Attribute Value
`fn_syntax_type`	Its value is the ASCII string ”standard” if the context supports the XFN standard syntax model. Its value is an implementation-specific value if another syntax model is supported.
`fn_syntax_direction`	Its value is an ASCII string, one of “left-to-right,” “right-to-left,” or “flat.” This determines whether the order of components in a compound name string goes from left-to-right, right-to-left, or whether the namespace is flat (that is, not hierarchical, with all names atomic)
`fn_std_syntax_separator`	Its value is the separator string for this name syntax. This attribute is required unless the `fn_syntax_direction` is flat.
`fn_std_syntax_escape`	If present, its value is the escape string for this name syntax.
`fn_std_syntax_case_insensitive`	If present, it indicates that names that differ only in case are considered identical. If this attribute is absent, it indicates that case is significant. If a value is present, it is ignored.
`fn_std_syntax_begin_quote`	If present, its value is the begin-quote string for this syntax.
`fn_std_syntax_end_quote`	If present, its value is the end-quote string for this syntax.
`fn_std_syntax_ava_separator`	If present, its value is the attribute-value assertion separator string for this syntax.
`fn_std_syntax_typeval_separator`	If present, its value is the attribute type-value separator string for this syntax.
`fn_std_syntax_code_sets`	If present, its value identifies the code sets of the string representation for this syntax. Its value consists of a structure containing an array of code sets supported by the context; the first member of the array is the preferred code set of the context. The values for the code sets are defined in the X/Open code set registry currently defined in DCE RFC 40.1. If this attribute is not present, or if the value is empty, the default code set is ISO 646 (same encoding as ASCII).
`fn_std_syntax_locale_info`	If present, its value identifies locale information, such as character set information, of the string representation for this syntax. The interpretation of its value is implementation dependent.

XFN Composite Names 11

This chapter describes XFN composite names in detail.

Syntax

The standard string form for XFN composite names is the concatenation of the components of a composite name from left to right, with the XFN component separator character (/) separating each component. Components can be quoted using either double-quote ("") or single-quote ('') pairs. The XFN component separator or quote characters may be escaped using a backslash character (\) if the intention is for these characters not to behave as separators or quotes. Note that quotation marks and escape characters are interpreted as such only when they appear in places that need quotes or escapes. For example, a quote appearing in an unquoted component is not interpreted as a quote.

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XFN defines an abstract data type, `FN_composite_name_t`, for representing the structural form of a composite name. XFN also defines the syntax of how component string names are composed into an XFN composite name and the corresponding rules for converting an XFN composite name to its structural form from its string form, and vice versa. The XFN client interface includes operations that perform these conversions.

Table 11-1 contains some examples of how the string form of XFN composite names are decomposed into components according to the syntax of XFN composite names. See also Appendix A, "XFN Composite Names Syntax," for more information.

Table 11-1 String and Structural Forms of XFN Composite Names

Stringform	**Components in** `FN_composite_name_t`
`a`	`a`
`a/b/c`	`a, b, c`
`a/`	`a, ""`
`/a`	`"", a`
`a//`	`a, "", ""`
`a//b`	`a, "", b`
`""`	`""`
`/`	`"", ""`
`//`	`"", "", ""`
`"a/b/c"/d`	`a/b/c, d`
`"a.b.c"/d`	`a.b.c, d`
`a.b.c/d`	`a.b.c, d`
`a"b/c`	`a"b, c`
`a'b/c`	`a'b, c`
`"a/b/c`	illegal name
`\"a/b/c`	`"a, b, c`
`a\b\c/d`	`a\b\c, d`
`a\b\/c`	`a\b/c`

Table 11-1 String and Structural Forms of XFN Composite Names *(Continued)*

Stringform	**Components in** `FN_composite_name_t`
`"a\"b"/c`	`a"b, c`
`'"a/b/c"'`	`"a/b/c"`
`'a\/b'/c`	`a\/b, c`
`a\\b/c`	`a\b, c`
`a/\"b`	`a, "b`

Composite Name and Naming System Boundaries

There may not be a one-to-one correspondence between component separators and naming system boundaries if a composite name contains names from naming systems that use the same character as the XFN component separator to separate their atomic names. Consequently, a component of a composite name may represent an atomic name from a hierarchical naming system that uses the XFN component separator or a compound name. S*trong separation* and *weak separation* refer to whether a context always treats the XFN component separator as a naming system boundary.

Strong Separation

An XFN context that treats the XFN component separator as a naming system boundary supports strong separation. An XFN component separator that appears *within* a component to be resolved by the context must be escaped or quoted.

Support for strong separation is a property of a context. A context that supports strong separation expects to receive the name that it is going to resolve entirely in one component of the composite name structure. When a composite name is supplied to such a context, it consumes the leading component of the name; any remaining components are left to be resolved by subordinate naming systems.

An XFN context with a name syntax that is either flat or hierarchical, and does not use the XFN component separator as its atomic separator, supports strong separation. Examples of naming systems that support strong separation are

DNS and NIS+, both of which have right-to-left dot-separated names. The following are examples of names with DNS and NIS+ components, respectively.

```
.../wiz.com/orgunit/ppt
orgunit/accountspayable.finance/user/jsmith
```

Weak Separation

An XFN context that does not always treat the XFN component separator as a naming system boundary supports weak separation. This arises when the component naming system associated with the context uses the same character as the XFN component separator as its atomic component separator, and the context allows its atomic separator to appear unescaped and unquoted in its compound names when they occur in composite names. This means that an XFN component separator may not necessarily signify a naming system boundary.

Support for weak separation is a property of a context. A context that supports weak separation expects to receive its atomic names in separate components of the composite name structure. When a composite name is supplied to a context that supports weak separation, the context consumes the leading components of the name (and treats them as atomic components); any remaining components are resolved by subordinate naming systems. The number of components consumed is determined either syntactically or dynamically.

CDS names and X.500 names are examples of names that use the XFN component separator as their atomic name separator. X.500 supports weak separation using a syntactic method (by scanning for typed names) while CDS supports weak separation by determining the naming system boundary dynamically.

The following example shows a composite name with an X.500 component.

```
.../c=us/o=wiz.com/orgunit/ppt
```

Note – An XFN context that supports weak separation using only syntax-specific discovery of its naming system boundary may not always be able to be federated with arbitrary subordinate naming systems. If the subordinate

naming system has a naming syntax that is indistinguishable from that of the superior naming system, the superior naming system would not be able to identify the naming system boundary.

Naming systems that use the same character as the XFN component separator as their atomic separator, and which cannot support weak separation because it cannot use a syntactic or dynamic method to determine the naming system boundary, must provide context implementations that support strong separation. This means that occurrences of atomic separators must be quoted or escaped when they appear in compound names within composite names.

Composite Name Resolution

Composite name resolution combines resolution in each component naming system and resolution across federated naming system boundaries. There are several techniques for resolving an XFN composite name in the underlying federation of naming systems.

This section describes two implementation techniques for composite name resolution across a naming system boundary. One technique uses an *explicit* next naming system pointer (NNSP) to resolve across a naming system boundary. The other uses an *implicit* NNSP to resolve across a naming system boundary.

An NNSP is the XFN reference of an XFN context in which composite name components from subordinate naming systems are to be resolved. NNSPs are entities that "tie" naming systems together into a federated system. NNSPs can be bound to names, in which case they are *explicit* NNSPs or *junctions*. NNSPs can also be nameless, in which case they are *implicit* NNSPs.

Explicit NNSPs: Junctions

A junction is an atomic name that is bound to an NNSP. It is a terminal name in the superior naming system. There is no limit on the number of junctions bound in a single context, except that imposed by the context. A context may reserve certain names for use as junctions or have other policies for selecting names for use as junction. The conventions used for identifying junctions and their references are context-specific.

Composite name resolution involving junctions proceeds as follows, depending on whether the context supports strong or weak separation.

A context that supports strong separation and junctions consumes the first component of the composite name supplied to it. The last atomic name of the first component must be a junction. Any remaining components are resolved in the context named by the junction.

A context that supports weak separation and junctions resolves a composite name by consuming leading components until a junction is reached, at which point resolution of any remaining components is continued in the context resolved to by the junction. Determination of whether a component is a junction can be done statically using a syntactic policy or dynamically during resolution.

Implicit NNSPs

When a context does not want to use part of its namespace for junctions, it uses implicit NNSPs for federating subordinate naming systems. An implicit NNSP is named using the XFN component separator. For example, the name `wiz.com/` names the implicit NNSP of `wiz.com`. Each context can have one implicit NNSP.

Composite name resolution involving implicit NNSPs proceeds as follows, depending on whether the context supports strong or weak separation.

A context that supports strong separation and resolves composite names using an implicit NNSP consumes the first component of the composite name supplied to it. Any remaining components are resolved in the context pointed to by the implicit NNSP of the first component.

A context that supports weak separation and implicit NNSPs in its implementation needs to distinguish the use of the XFN component separator character as an XFN component separator or an atomic separator. This means that such a context needs to know when to exit the current (native) naming system and follow the NNSP. This can be achieved using a static, syntactic policy or a dynamic, resolution-based policy.

With the syntactic policy, a context syntactically discovers where the boundary between its naming system and the subordinate naming system lies. This may impose certain restrictions on the syntax of subordinate naming systems. Subordinate naming systems must not permit as valid top-level names that are

syntactically indistinguishable from names allowed in the superior naming system. For example, assume the superior naming system has a name syntax whose distinguishing feature is that each atomic part must have an equal sign (=). The superior naming system might impose as a policy that subordinate naming systems must not have top-level names that have an equal sign in them. Resolution in the superior naming system continues until all leading components of the supplied composite name fitting the syntactic rule are consumed. Any remaining components are resolved in the context of the NNSP of the last component fitting the syntactic rule.

If a context is not able to syntactically differentiate between atomic components and composite name components, or does not want to impose any syntactic restrictions, it may be able to determine the naming system boundary at runtime during resolution. The policy is to continue resolution in the current naming system until resolution fails, at which point the implicit NNSP associated with the last context at which resolution succeeded is used to continue the resolution. A conflict arises if the same atomic name is bound both in the last context and the context pointed to by the last context's implicit NNSP. In this case, the binding in the last context takes precedence. Note that this way of supporting weak separation requires the context to have the capability of returning remaining unresolved parts of a given name.

Coexistence of Explicit and Implicit NNSPs

Naming systems that implement either technique may coexist in a federation. A naming system that supports composite name resolution using junctions can be federated with one that supports implicit NNSPs, and vice versa.

XFN Links

An XFN link affects name resolution in the following way. Suppose *lname* is a link bound to the atomic name *aname* in the context *ctx*. If at some point resolution of a composite name *cname* reaches the context *ctx* and the next atomic name is *aname*, resolution of *aname* results in the resolution of the link name *lname*. This is termed "following the link." If the first component of the link *lname* is the atomic name "`.`," the remaining components of *lname* are resolved relative to *ctx*; otherwise, *lname* is resolved from the initial context. The resolution of any remaining portion of the name *cname* proceeds from the reference that results by resolving *lname*.

The link name may itself cause resolution to resolve through other links. This gives rise to the possibility of a cycle of links whose resolution could not terminate normally. As a simple means to avoid such nonterminating resolutions, implementations may define limits on the number of XFN links that may be resolved in any single operation invoked by the caller.

XFN Programming Examples 12

This chapter presents self-contained executable programs for a namespace browser and a printer client and server.

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Namespace Browser Example

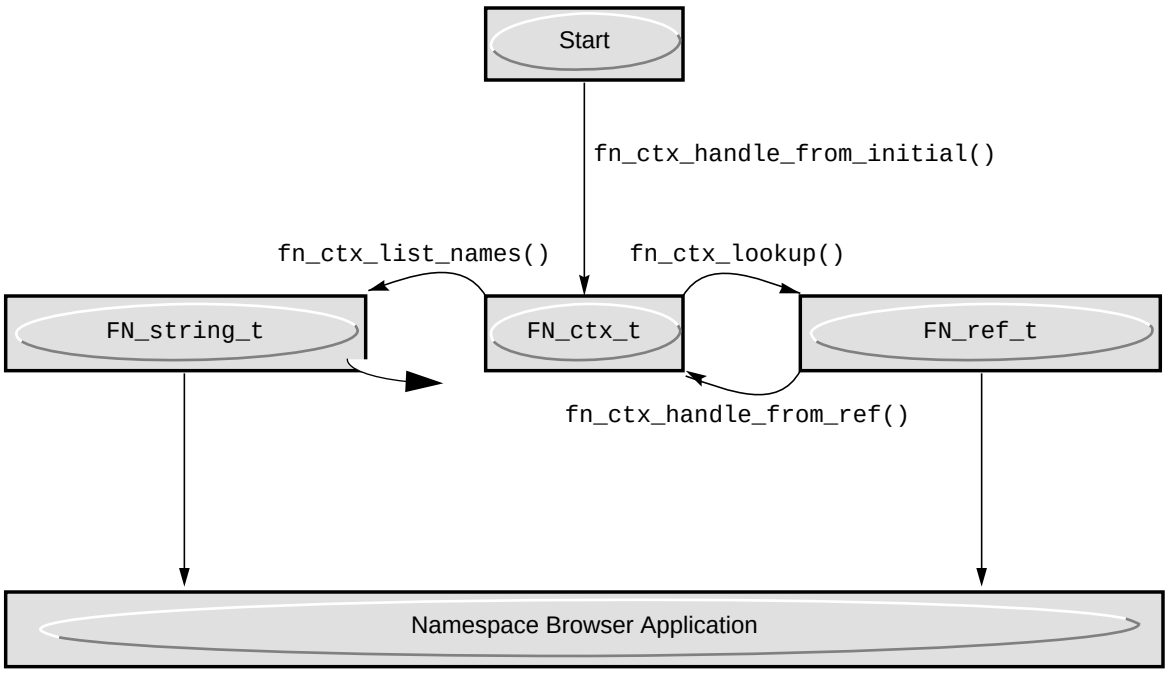

Figure 12-1 Diagram of `fnbrowse` Program

The first example is a browser that lists all names that it finds in the namespace. When the program is invoked, the browser is set at the initial context or the composite name given on the command line.

Figure 12-1 illustrates the XFN APIs that are used by the browser application.

See “Commands” on page 175” and “Sample Output” on page 176”.

Code Example 12-1 `fnbrowse` Source Code

```
*
* fnbrowse.c -- FNS namespace browser.
*
* To keep this example program relatively short, limited error
* checking is done.
*/
```

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <xfn/xfn.h>


#define LINELEN 128 /* maximum length of input line */

typedef enum {CMD_DOWN, CMD_UP, CMD_LIST, CMD_SHOW, CMD_QUIT}
command;


FN_status_t *status;


/* Look up a context named relative to the initial context. */
FN_ctx_t *lookup(const FN_composite_name_t *name);

/* Set the browser's focus to the given context. */
void browse(FN_ctx_t *ctx);

/* Set the browser's focus to a subcontext of the given context. */
void cmd_down(FN_ctx_t *ctx, const FN_composite_name_t *child);

/* Print the names bound within a context. */
void cmd_list(FN_ctx_t *ctx);

/*
 * Print a description of the reference bound to "child" in the given
 * context or, if "child" is the empty string, the reference of the
 * context itself.
 */
void cmd_show(FN_ctx_t *ctx, const FN_composite_name_t *child);

/*
 * Read and parse the next command typed by the user. If the command
 * has an argument, set *argp to point to the argument.
 */
command read_command(FN_string_t **argp);

/* Print an error message and the status description */
void error(const char *msg);
```

```
int
main(int argc, char *argv[])
{
    FN_string_t *arg;


    switch (argc) {
    case 1:
        arg = fn_string_create();
        break;
    case 2:
        arg = fn_string_from_str((unsigned char *)argv[1]);
        break;
    default:
        fprintf(stderr, "Usage: %s [<composite_name>]\n", argv[0]);
        return (1);
    }
    status = fn_status_create();
    browse(lookup(fn_composite_name_from_string(arg)));
    return (0);
}


FN_ctx_t *
lookup(const FN_composite_name_t *name)
{
    FN_ctx_t *ctx;
    FN_ref_t *ref;
    ctx = fn_ctx_handle_from_initial(status);
    if (ctx == NULL) {
        error("Could not construct initial context");
        exit(1);
    }
    if (fn_composite_name_is_empty(name)) {
        return (ctx);
    }
    ref = fn_ctx_lookup(ctx, name, status);
    fn_ctx_handle_destroy(ctx);
    if (ref == NULL) {
        error("Lookup failed");
        exit(1);
    }
```

```
    ctx = fn_ctx_handle_from_ref(ref, status);
    fn_ref_destroy(ref);
    if (ctx == NULL) {
        error("Could not construct context handle");
        exit(1);
    }
    return (ctx);
}

void
browse(FN_ctx_t *ctx)
{
    FN_string_t *arg;
    FN_composite_name_t*child;

    while (1) {
        switch (read_command(&arg)) {
        case CMD_DOWN:
            child = fn_composite_name_from_string(arg);
            fn_string_destroy(arg);
            cmd_down(ctx, child);
            fn_composite_name_destroy(child);
            break;
        case CMD_UP:
            return;
        case CMD_LIST:
            cmd_list(ctx);
            break;
        case CMD_SHOW:
            child = fn_composite_name_from_string(arg);
            fn_string_destroy(arg);
            cmd_show(ctx, child);
            fn_composite_name_destroy(child);
            break;
        case CMD_QUIT:
            exit(0);
        }
    }
}

void
```

```
cmd_down(FN_ctx_t *ctx, const FN_composite_name_t *child)
{
    FN_ref_t *ref;
    FN_ctx_t *subctx;

    ref = fn_ctx_lookup(ctx, child, status);
    if (ref == NULL) {
        error("Lookup failed");
        return;
    }
    subctx = fn_ctx_handle_from_ref(ref, status);
    fn_ref_destroy(ref);
    if (subctx == NULL) {
        error("Could not construct context handle");
        return;
    }
    browse(subctx);
    fn_ctx_handle_destroy(subctx);
}

void
cmd_list(FN_ctx_t *ctx)
{
    FN_string_t *empty_string = fn_string_create();
    FN_composite_name_t *empty_name;
    FN_namelist_t *children;
    FN_string_t *child;
    unsigned int statcode;
    int has_children = 0;

    empty_name = fn_composite_name_from_string(empty_string);
    fn_string_destroy(empty_string);

    children = fn_ctx_list_names(ctx, empty_name, status);
    fn_composite_name_destroy(empty_name);

    if (children == NULL) {
        error("Could not list names");
        return;
    }
```

```
    while ((child = fn_namelist_next(children, status)) != NULL) {
        has_children = 1;
        printf("%s  ", fn_string_str(child, &statcode));
        fn_string_destroy(child);
    }
    if (has_children) {
        printf("\n");
    }
    fn_namelist_destroy(children, status);
}

void
cmd_show(FN_ctx_t *ctx, const FN_composite_name_t *child)
{
    FN_string_t *desc;
    FN_ref_t *ref;
    unsigned int statcode;

    ref = fn_ctx_lookup(ctx, child, status);
    if (ref == NULL) {
        error("Lookup failed");
        return;
    }

    desc = fn_ref_description(ref, 2, NULL);
    fn_ref_destroy(ref);
    if (desc != NULL) {
        printf("%s", fn_string_str(desc, &statcode));
        fn_string_destroy(desc);
    } else {
        printf("[No description]\n");
    }
}

command
read_command(FN_string_t **argp)
{
    char buf[LINELEN + 1];
    char *cmd;
    char *child;
```

```
    while (printf("\n> "), fflush(stdout), gets(buf) != NULL) {
        cmd = strtok(buf, " \t");
        if (cmd == NULL) {
            continue;
        }
        if (strcmp(cmd, "down") == 0) {
            child = strtok(NULL, " \t");
            if (child != NULL) {
                *argp =
                    fn_string_from_str((unsigned char *)child);
                return (CMD_DOWN);
            }
        }
        if (strcmp(cmd, "up") == 0) {
            return (CMD_UP);
        }
        if (strcmp(cmd, "list") == 0) {
            return (CMD_LIST);
        }
        if (strcmp(cmd, "show") == 0) {
            child = strtok(NULL, " \t");
            *argp = (child != NULL)
                ? fn_string_from_str((unsigned char *)child)
                : fn_string_create();
            return (CMD_SHOW);
        }
        if (strcmp(cmd, "quit") == 0) {
            return (CMD_QUIT);
        }
        fprintf(stderr, "Valid commands are:  "
            "down <child>, up, list, show [<child>], quit\n");
    }
    return (CMD_QUIT);/* EOF */
}


void
error(const char *msg)
{
    FN_string_t *reason;
    unsigned int statcode;
    fprintf(stderr, "%s", msg);
    reason = fn_status_description(status, 0, NULL);
    if (reason != NULL) {
        fprintf(stderr, ": %s",
```

```
            (const char *)fn_string_str(reason, &statcode));
        fn_string_destroy(reason);
    }
    fprintf(stderr, "\n");
}
```

Compiling and Executing Browser Example

To compile Code Example 12-1, type:

```
% cc -o fnbrowse fnbrowse.c -lxfn
```

To browse the namespace starting from the initial context, the program is invoked as

```
% fnbrowse
```

Or to browse a composite name and its descendents, type

```
% fnbrowse composite_name
```

Commands

The commands supported by the `fnbrowse` program are summarized in Table 12-1.

Table 12-1 Namespace Browser Commands

Command	Usage
`down` *child*	Sets the browser at the subcontext of the child
`up`	Sets the browser at one level higher than the current context
`list`	Lists the names bound within the current context
`show`	Prints the reference of the current context
`show` *child*	Prints the reference of the current context's child
`quit`	Exits the browser

Sample Output

Sample output for navigating the entire namespace is displayed here.

Note the following:

- The first `list` command shows the initial context bindings.
- The `fnbrowse` program lists all names it finds in the namespace, including names with underscores. These names are explained in "Initial Context Bindings for Naming Within the Enterprise" on page 54.
- The three dots (`...`) represent the global namespace.

```
% fnbrowse
> list
_myorgunit  ...  _myself  thishost  myself  _orgunit  _host
_thisens  myens  thisens  org  orgunit  thisuser  _thishost
myorgunit  _user  thisorgunit  host  _thisorgunit  _myens  user
```

Navigating the namespace is accomplished with the `up` and `down` commands. In the following output, the `down` command brings the focus of the browser to the enterprise root of the namespace, `thisens` (can also be `myens`). The `show` command displays information about the reference and address type for `thisens`.

```
> down thisens
> show
Reference type: onc_fn_enterprise
Address type: on_fn_nisplus
  length: 20
  context type: enterprise root
  representation: normal
  version: 0
  internal name: eng.wiz.com

> up
> down thisorgunit
```

Continuing with the example, this `list` command shows the contexts for `thisorgunit`.

```
> list
service  _fs  _host  _service  _site  site  _user  host  fs  user

> down usr
Lookup failed: Name Not Found: 'usr'

> down service
> list
printer

> down printer
```

The `list` command shows the printer names that are bound in the `printer` context. The `show` command displays the reference for the child, `colorful`.

```
> list
celeste  _default  color  colorful  quartz  nuttree  puffin

> show colorful
printer
Reference type: onc_printers
Address type: onc_printers_bsdaddr
  length: 12
  data: 0x00 0x00 0x00 0x08 0x62 0x6c 0x61 0x63 0x6b 0x63
....blackc 0x61 0x74 at

> down colorful
Could not construct context handle: No Supported Address
> quit
%
```

12

Printer Programming Example

Printer client and server software can take advantage of FNS to advertise and to browse the printers available with respect to organizations, sites, users and hosts. The APIs used by the server and the client are XFN APIs, thereby ensuring that the application will be portable across the different naming services used for storing printer bindings.

The programming example in this section shows how printer clients and servers obtain and store printer bindings. Users can then make use of the FNS commands, `fnlist` and `fnlookup`, to browse the `printer` context.

For example, use `fnlist` to look at the user `printer` context for `jsmith`:

```
% fnlist user/jsmith/service/printer
celeste
lp
_default
myprinter
```

Similarly, you can look at the organization's printers:

```
% fnlist org/wiz.com/service/printer
sales_printer
mktg_printer
eng_printer
```

Alternatively, you can type

```
% fnlist thisorgunit/service/printer
```

You can look at the printers at a specific site, for example, the printers in the `MTV` site:

```
% fnlist thisorgunit/site/MTV/service/printer
b1_printer
b2_printer
```

Client

The scenario for Code Example 12-2 is a user who would like to print to a printer named `colorful` in his organization's context, `thisorgunit/service/printer/colorful`. The example printer client illustrates how the bindings for a specific printer are obtained.

The variable *printer_binding* contains the reference (the binding information) of the named printer. Using the binding information, the printer client can connect to the server and send the printer request. Note that the `fn_ctx_lookup()` function can be replaced by `fn_ctx_list_name()` or `fn_ctx_list_bindings()` to list all the names and their bindings.

Code Example 12-2 Printer Client

```
#include <stdio.h>
#include <xfn/xfn.h>
#include <string.h>
#include <stdlib.h>

/* Routine to obtain the address of a specific printer */

/* This routine takes the printer name and the address type
   as the input arguments and returns the address of the requested
   printer */

char *

get_address_of_printer(const char *printer_name,
    const char *address_type)

{
    /* Variable list */
    FN_string_t *printer_name_string;
    FN_composite_name_t *printer_name_comp;
    FN_status_t *status;
    FN_ctx_t *initial_context;
    FN_ref_t *printer_ref;
    const FN_identifier_t *addr_id;
    const FN_ref_addr_t *address;
    char *addr_data; /* Return value */
    void *ip;
    size_t address_type_len, addr_len;

    /* Convert the printer name to a composite name */
    printer_name_string =
        fn_string_from_str((unsigned char *) printer_name);
```

```
printer_name_comp =
    fn_composite_name_from_string(printer_name_string);
fn_string_destroy(printer_name_string);

/* Get the initial context */
status = fn_status_create();
initial_context = fn_ctx_handle_from_initial(status);
/* Check status for any error messages */
if (!fn_status_is_success(status)){
    fprintf(stderr, "Unable to obtain the initial context\n");
    return (0);
}
/* Perform a lookup for the printer name */
printer_ref = fn_ctx_lookup(initial_context,
    printer_name_comp, status);
/* Check status for any error messages */
if (!fn_status_is_success(status)){
    fprintf(stderr, "Lookup failed on: %s\n",
        printer_name);
    return (0);
}
fn_ctx_handle_destroy(initial_context);
fn_composite_name_destroy(printer_name_comp);
address_type_len = strlen(address_type);

/* Obtain the requested address from the address type */
for (address = fn_ref_first(printer_ref, &ip);
    address != NULL;
    address = fn_ref_next(printer_ref, &ip)) {
        addr_id = fn_ref_addr_type(address);
        if (addr_id->length == address_type_len &&
            strncmp(address_type, (char *)addr_id->contents,
                    address_type_len) == 0)
                break;
}
if (address == NULL)
    return (0);

addr_len = fn_ref_addr_length(address);
addr_data = (char *)(malloc(addr_len + 1));
strncpy(addr_data,(char*)(fn_ref_addr_data(address)),
        addr_len);
addr_data[addr_len] = '\0';
```

```
    fn_ref_destroy(printer_ref);
    return (addr_data);
}
```

Calling the Printer Client Function

The following code could be used to call the `get_address_of_printer()` routine shown above.

```
char* printer_server;

printer_server = get_address_of_printer(
    "thisorgunit/service/printer/colorful",
    "onc_bsdaddr");
```

Server

Using the XFN APIs, print servers can advertise their services. Code Example 12-3 illustrates a host, `labpc`, that would like to advertise the binding for the color printer `colorful`. The FNS name for this printer is `thisorgunit/service/printer/colorful`.

The main tasks are to obtain the composite name for the printer name, to generate the binding (reference) for the printer, and to bind the name and references to the FNS namespace.

Code Example 12-3 Printer Server

```
#include <stdio.h>
#include <xfn/xfn.h>
#include <string.h>

/* Routine to export the printer binding to the FNS name space */

/* This routine takes the printer name along with its reference type,
   address type, and address. Returns the status. */

int
export_printer_to_fns(const char *printer_name,
             const char *reference_type,
             const char *address_type,
             const char *address_data)
{
    /* Variable list */
```

```
int return_status;
FN_string_t *printer_name_string;
FN_composite_name_t *printer_name_comp;
FN_identifier_t ref_id, addr_id;
FN_status_t *status;
FN_ref_t *printer_ref;
FN_ref_addr_t *address;
FN_ctx_t *initial_context;

/* Obtain the initial context */
status = fn_status_create();
initial_context = fn_ctx_handle_from_initial(status);
/* Check status for any error messages */
if ((return_status = fn_status_code(status)) != FN_SUCCESS) {
    fprintf(stderr, "Unable to obtain the initial context\n");
    return (return_status);
}

/* Construct the composite name for the printer name */
printer_name_string =
    fn_string_from_str((unsigned char *) printer_name);
printer_name_comp =
    fn_composite_name_from_string(printer_name_string);
fn_string_destroy(printer_name_string);

/* Construct the printer address */
addr_id.format = FN_ID_STRING;
addr_id.length = strlen(address_type);
addr_id.contents = (void *) address_type;
address = fn_ref_addr_create(&addr_id,
    strlen(address_data), (const void *) address_data);

/* Construct the printer reference */
ref_id.format = FN_ID_STRING;
ref_id.length = strlen(reference_type);
ref_id.contents = (void *) reference_type;
printer_ref = fn_ref_create(&ref_id);

/* Add the printer address to the printer reference */
fn_ref_append_addr(printer_ref, address);

/* Bind the reference to the context */
```

```
    fn_ctx_bind(initial_context, printer_name_comp, printer_ref, 0,
            status);

    /* Check the error status and return */
    return_status = fn_status_code(status);
    fn_composite_name_destroy(printer_name_comp);
    fn_ref_addr_destroy(address);
    fn_ref_destroy(printer_ref);
    fn_status_destroy(status);
    fn_ctx_handle_destroy(initial_context);
    return (return_status);
}
```

Calling the Printer Server Function

The following code could be used to call the `export_printer_to_fns` routine shown above.

```
export_printer_to_fns(
    "thisorgunit/service/printer/colorful",
    "onc_printers",
    "onc_bsdaddr",
    "labpc");
```

12

XFN Composite Names Syntax

A

This appendix provides supplemental information about XFN composite name syntax.

Composite Name Encoding

All XFN implementations are required to support the ISO 646 portable representation (same encoding as ASCII) for XFN composite names. All other representations are optional.

All characters of the string form of an XFN composite name use a single encoding. There cannot be characters with different encodings in the same name string. This does not preclude component names of a composite name in its structural form from having different encodings. Code set mismatches that occur during the process of converting a composite name structure to its string form are resolved in an implementation-dependent way. Strings with code sets that are determined by the implementation to be compatible are converted without loss of information into a single representation, which is also determined by the implementation. When an implementation discovers that a composite name has components with incompatible code sets, it returns the error code `FN_E_INCOMPATIBLE_CODE_SETS`.

A

Backus-Naur Form (BNF)

The following defines the standard string form of XFN composite names in Backus-Naur Form (BNF). Note that all the characters of the string representation of one name must uniformly use the same encoding and locale information. The notations used are as follows:

Table 12-2 Backus-Naur Notation

Symbol	Meaning
::=	Is defined to be
|	Alternatively
<*text*>	Nonterminal element
‘‘ ’’	Literal expression
*	The preceding syntactic unit can appear 0 or more times.
+	The preceding syntactic unit can appear 1 or more times.
{}	The enclosed syntactic units are grouped as a single syntactic unit (can be nested).

The XFN composite name syntax in BNF is as follows.

Table 12-3 XFN Composite Name Syntax Using BNF

XFN Composite Name	BNF Syntax
NULL ::=	/ / Empty set
<PCS> ::=	/ / Portable Character Set The set consists of the glyphs: / /!"#$%&'()*+,\0123456789:;<=>? / /@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_’ / /abcdefghijklmnopqrstuvwxyz{|}~
<CharSet> ::=	<PCS> | Characters from the repertoire of a string representation
<EscapeChar> ::=	\
<ComponentSep>::=	/
<Quote1>::=	"
<Quote2> ::=	‘

Table 12-3 XFN Composite Name Syntax Using BNF *(Continued)*

XFN Composite Name	BNF Syntax
<MetaChar> ::=	<EscapeChar> | <ComponentSep>
<SimpleChar> ::=	/ / any character from <CharSet> with <MetaChar>, <Quote1>, / / and <Quote2> excluded. An<EscapeChar> <MetaChar>, or / / <EscapeChar> <Quote1>, or <EscapeChar> <Quote2> is equivalent to / / <SimpleChar>.
<Component> ::=	<SimpleChar>* | <SimpleChar>+ {<Quote1> | <Quote2> | <SimpleChar>}* | <Quote1> <CharSet>* {<EscapeChar> <Quote1>}* <Quote1> / / <CharSet> must not contain unescaped <Quote1> / / (note that <Quote2> can appear unescaped) | <Quote2> <CharSet>* {<EscapeChar> <Quote2>}* <Quote2> / / <CharSet> must not contain unescaped <Quote2> / / (note that <Quote1> can appear unescaped)
<CompositeName> ::=	NULL | <Component> {<ComponentSep> <Component>}*

Decomposing the Composite Name String

The function `fn_composite_name_from_string()` returns an XFN composite name in its structural form, `FN_composite_name_t`, given the composite name's string representation. The syntax rules used by `fn_composite_name_from_string`() are as follows.

An XFN composite name is decomposed into an ordered set of components (<Component>). Each component represents a compound name, or a single atomic name of a compound name if the compound name's syntax uses the XFN component separator (/) as a separator for its atomic parts and the compound name is not quoted.

The following are the rules for parsing a composite name.

1. Any <ComponentSep> character that is neither escaped nor enclosed in quoted strings is considered to be a component separator.
2. Any string enclosed by component separators is a component (<Component>).

3. A composite name is parsed and decomposed into components from left to right:
   a. The first component is the string preceding the first occurrence of a component separator.
   b. Empty components are processed as follows:
      i. A leading component separator (the composite name begins with a component separator) means a leading null component.
      ii. A trailing component separator (the composite name ends with a component separator) means a trailing null component.
   c. Two consecutive component separators mean a null component.
   d. The name string that immediately follows the last component separator of the composite name is the final component.
4. A component string is evaluated from left to right and converted into its standard form according to the following rules:
   a. A component string is considered to be quoted if it is enclosed in a pair of matching unescaped quote characters (either a <Quote1> or a <Quote2> pair). The quoted string must represent the full component; that is, a begin quote must immediately be preceded by a component separator or no character, and the end quote must immediately be followed by a component separator or no character.
   b. If a component does not contain a valid begin quote (a <Quote1> or <Quote2>immediately preceded by either a component separator or no character), any occurrence of <Quote1> or <Quote2> within that component is treated just as any other <SimpleChar>.
   c. An unmatched begin quote (missing or misplaced end quote) fails with an FN_E_ILLEGAL_NAME status.
   d. Quotes are considered to be escaped in quoted strings if a matching quote character is preceded immediately by the unescaped <EscapeChar>.
   e. Quoted components are resolved by eliminating the quote characters from the component name and substituting possibly escaped quotes by simple quote characters. <MetaChar>s and the nonmatching quote characters enclosed in quoted strings are treated just as any other <SimpleChar>.

f. Any of the defined metacharacters (<ComponentSep> and <EscapeChar>) is considered to be escaped in an unquoted component name string if preceded immediately by the unescaped <EscapeChar> (for instance, the sequence <EscapeChar> <EscapeChar> <ComponentSep> denotes an escaped <EscapeChar> but an unescaped <ComponentSep>).

g. <Quote1> and <Quote2> are considered to be escaped in an unquoted component if and only if <EscapeChar> is preceded by a component separator (that is, sequences <ComponentSep> <EscapeChar> <Quote1> or <ComponentSep> <EscapeChar> <Quote2>). Other occurrences of <Quote1> and <Quote2> in an unquoted component are treated just as any other <SimpleChar>.

h. Any occurrence of escaped <MetaChar>, escaped <Quote1>, or escaped <Quote2> in unquoted components is substituted by the corresponding unescaped character.

i. No substitution is done for <EscapeChar> <SimpleChar>. <EscapeChar> <SimpleChar> simply maps to <EscapeChar> <SimpleChar>.

Composing the Composite Name String

The function `fn_string_from_composite_name`() returns the string representation of an XFN composite name given its structural form (`FN_composite_name_t`). The following are the rules used by `fn_string_from_composite_name`().

1. The components are added to the composite name string in left to right order (that is, rightmost is the tail).

2. Successive components are separated by the component separator (<ComponentSep>).

3. Empty components are handled in the following way:

   a. A leading empty component is represented by a leading <ComponentSep>.

   b. A trailing empty component is represented by a trailing <ComponentSep>.

   c. An empty component occurring within a composite name is represented by two consecutive <ComponentSep>s.

4. A composite name denoting a single non-empty component does not contain any unescaped component separator.
5. Any occurrence of <ComponentSep> in a component is escaped by inserting <EscapeChar> immediately preceding <ComponentSep>.
6. If the first character of a component is either <Quote1> or <Quote2>, it will be escaped by inserting <EscapeChar> immediately preceding the quote.
7. Any occurrence of <EscapeChar> before <ComponentSep> in a component is escaped by inserting <EscapeChar> immediately preceding the <EscapeChar>.
8. Any occurrence of <EscapeChar> as the first character of a component with <Quote1> or <Quote2> as the second character in a component is escaped by inserting <EscapeChar> immediately preceding the <EscapeChar>. Subsequent <EscapeChar> occurring before any matching quote character is also escaped by inserting <EscapeChar> immediately preceding the <EscapeChar>.

DNS Text Record Format for XFN References

This appendix contains supplemental information about the use of DNS text (TXT) records in XFN references. The required procedures for federating DNS are contained in Chapter 7, “Federating NIS+ With Global Naming Systems.”

The Solaris environment conforms to the XFN specification for federating global naming systems within DNS. In order to federate a naming system under DNS, you will need to enter information into DNS TXT resource records. This information will then be used to construct an XFN reference for that subordinate naming system. This appendix describes the format of these DNS TXT records. For details on how to manipulate records in DNS in general, see *DNS and BIND in a Nutshell* by Paul Albitz and Crickett Liu (O'Reilly and Associates, 1992).

The reference type of an XFN reference is constructed from a TXT record that begins with the `XFNREF` tag. It has the following format:

```
TXT "XFNREF rformat reftype"
```

If spaces occur within the string appearing after `TXT`, such spaces must be escaped, or the entire string must be enclosed within double quotation marks. The three fields, `XFNREF`, *rformat* and *reftype*, are separated using space (spaces and tabs). *rformat* specifies format of the reference type identifier. It can be one of

- `STRING` – Maps to `FN_ID_STRING` format
- `OID` – Maps to `FN_ID_ISO_OID_STRING` format

- `UUID` – Maps `FN_ID_DCE_UUID` format

reftype specifies the contents of the reference type identifier.

If no `XFNREF` TXT record exists, the reference type defaults to an identifier `XFN_SERVICE`, with an `FN_ID_STRING` format. If more than one `XFNREF` TXT record exists, the handling of the record is undefined. The following TXT record is equivalent to the default `XFNREF`:

```
TXT "XFNREF STRING XFN_SERVICE"
```

The address information for an XFN reference is constructed using TXT records with tags prefixed with the `XFN` string. Multiple addresses may be specified for a single reference. Records with the same tag are grouped and passed to the handler for each group. Each handler generates zero or more addresses from its group of TXT records and appends the addresses to the reference. The `XFNREF` tag is special in that it is used only to construct the reference type and thus, it is excluded from the address-construction process.

The syntax of address TXT records is as follows:

```
XFNaddress_type_tag   address_specific_data
```

The two fields, *XFN_address_type_tag* and *address_specific_data*, are separated using space (spaces and tabs). *address_type_tag* specifies the handler to be used for *address_specific_data*.

TXT records have a limitation of 2Kbytes of characters per record. If the address-specific data is too long to be stored in a single TXT record, multiple TXT records may be used, as shown:

```
TXT "XFNaddress_type_tag  address_specific_data1"
TXT "XFNaddress_type_tag  address_specific_data2"
```

When the tag-specific handler is called, both records are passed to it. The handler is responsible for determining the order in which these two lines need to be interpreted.

The order in which TXT records appear is not significant. If lines with different tags are present, lines with the same tag are grouped together before the tag-specific handler is called. In the following example, the handler for *tag1* will be called with two text lines, and the handler for *tag2* will be called with three text lines.

```
TXT "XFNtag1  address_specific_data1"
TXT "XFNtag2  address_specific_data2"
TXT "XFNtag1  address_specific_data3"
TXT "XFNtag2  address_specific_data4"
TXT "XFNtag2  address_specific_data5"
```

Here are some examples of TXT records that can be used for XFN references.

Example 1

```
TXT     "XFNREF STRING XFN_SERVICE"
TXT     "XFNNISPLUS wiz.com. nis_master 129.144.40.23"
```

Example 2

```
TXT     "XFNREF OID 1.3.22.1.6.1.3"
TXT     "XFNDCE (1 fd33328c4-2a4b-11ca-af85-09002b1c89bb...)"
```

The following is an example of a DNS table with a subordinate naming system bound in it.

```
$ORIGIN test.sun.com
@       IN SOA foo root.eng.sun.com
           (
              100    ;; Serial
              3600   ;; Refresh
              3600   ;; Retry
              3600   ;; Expire
              3600   ;; Minimum
           )
        NS     nshost
        TXT    "XFNREF STRING XFN_SERVICE"
        TXT    "XFNNISPLUS wiz.com. nis_master 129.144.40.23"

nshost IN  A 129.144.40.21
```

X.500 Attribute Syntax for XFN References

This appendix contains supplemental information about the use of X.500 attributes for XFN references. The required procedures for federating X.500 are contained in Chapter 7, “Federating NIS+ With Global Naming Systems.”

In order to permit an XFN reference to be stored as an attribute in X.500, the directory schema must be modified to support the object classes and attributes defined in this appendix. *Managing the X.500 Client Toolkit* includes information about modifying the X.500 directory schema.

Object Classes

Two new object classes, XFN and XFN-supplement, are introduced to support XFN references. The XFN object class is not relevant in FNS since SunSoft’s X.500 directory product cannot support the introduction of new compound ASN.1 syntaxes. Instead, FNS uses the XFN-supplement object class.

The two new object classes are defined in ASN.1 as follows:

```
xFN OBJECT-CLASS ::= {
         SUBCLASS OF          { top }
         KIND                 auxiliary
         MAY CONTAIN          { objectReferenceId |
                                objectReference |
                                nNSReferenceId |
                                nNSReference }
         ID                   id-oc-xFN
     }

     id-oc-xFN OBJECT IDENTIFIER ::= {
         iso(1) member-body(2) ansi(840) sun(113536)
         ds-oc-xFN(24)
     }

xFNSupplement OBJECT-CLASS ::= {
         SUBCLASS OF          { top }
         KIND                 auxiliary
         MAY CONTAIN          { objectReferenceString |
                                nNSReferenceString }
         ID                   id-oc-xFNSupplement
     }

     id-oc-xFNSupplement OBJECT IDENTIFIER ::= {
         iso(1) member-body(2) ansi(840) sun(113536)
         ds-oc-xFNSupplement(25)
     }
```

The XFN-supplement object class is defined as an auxiliary object class so that it may be inherited by all X.500 object classes. It is defined with two optional attributes:

- `objectReferenceString` is used to hold an XFN reference to the object itself.
- `nNSReferenceString` is used to hold an XFN reference to a next naming system.

Both attributes are defined in ASN.1 as follows:

```
objectReferenceString ATTRIBUTE ::= {
    WITH SYNTAX             OCTET STRING
    EQUALITY MATCHING RULE  octetStringMatch
    SINGLE VALUE            TRUE
   ID                   { id-at-objectReferenceString }
}

id-at-objectReferenceString OBJECT IDENTIFIER ::= {
    iso(1) member-body(2) ansi(840) sun(113536)
    ds-at-objectReferenceString(30)
}

nNSReferenceString ATTRIBUTE ::= {
    WITH SYNTAX             OCTET STRING
    EQUALITY MATCHING RULE  octetStringMatch
    SINGLE VALUE            TRUE
    ID                      { id-at-nNSReferenceString }
}

id-at-nNSReferenceString OBJECT IDENTIFIER ::= {
    iso(1) member-body(2) ansi(840) sun(113536)
    ds-at-nNSReferenceString(31)
}
```

Both `objectReferenceString` and `nNSReferenceString` store XFN references in a string form. Their octet string syntax is further constrained to conform to the following BNF definition:

```
 <ref>          ::= <id> '$' <ref-addr-set>
<ref-addr-set> ::= <ref-addr> | <ref-addr> '$' <ref-addr-set>
 <ref-addr>     ::= <id> '$' <addr-set>
 <addr>         ::= <hex-string>

 <id>           ::= 'id'   '$' <string> |
                    'uuid' '$' <uuid-string> |
                    'oid'  '$' <oid-string>

 <string>       ::= <char> | <char> <string>
 <char>         ::= <PCS> | '\' <PCS>
 <PCS>          ::= // Portable Character Set:
                    // !"#$%&'()*+,-./0123456789:;<=>?
                    // @ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_
                    // ‘abcdefghijklmnopqrstuvwxyz{|}~

<uuid-string>  ::= <uuid-char>  | <uuid-char> <uuid-string>
 <uuid-char>    ::= <hex-digit> | '-'

 <oid-string>   ::= <oid-char>  | <oid-char> <oid-string>
 <oid-char>     ::= <digit> | '.'

 <hex-string>   ::= <hex-octet> | <hex-octet> <hex-string>
 <hex-octet>    ::= <hex-digit> <hex-digit>
 <hex-digit>    ::= <digit> |
                    'a' | 'b' | 'c' | 'd' | 'e' | 'f' |
                    'A' | 'B' | 'C' | 'D' | 'E' | 'F'
 <digit>        ::= '0' | '1' | '2' | '3' | '4' | '5' |
                    '6' | '7' | '8' | '9'
```

The following example is a string form XFN reference:

```
id$onc_fn_enterprise$id$onc_fn_nisplus_root$0000000f77697a2e636fd2e2062696762696700
```

The example uses an XFN reference of type `onc_fn_enterprise`. It contains the address type `onc_fn_nisplus_root` and a single address value. The address value is an XDR-encoded string, comprising the domain name, `wiz.com`, followed by the host name, `bigbig`.

An XFN reference may be added to an X.500 entry by using the FNS command `fnattr`, as in this example:

```
# fnattr -a .../c=us/o=wiz object-class top organization xfn-supplement
```

creates a new entry called `c=us/o=wiz` and adds an object class attribute with the values `top`, `organization`, and `XFN-supplement`.

The FNS command `fnbind` binds the NIS+ reference to the named entry and links X.500 to the root of the NIS+ namespace. (Note the use of a trailing slash in the name argument to `fnbind`.)

```
# fnbind -r .../c=us/o=wiz/ onc_fn_enterprise onc_fn_nisplus_root "wiz.com. bigbig"
```

C

Glossary

application-level name service

Application-level name services are incorporated in applications offering services such as files, mail, and printing. Application-level name services are bound below enterprise-level name services. The enterprise-level name services provide contexts in which contexts of application-level name services can be bound.

atomic name

An indivisible component of a name as defined by the naming convention.

attribute

Each named object is associated with a set of zero or more attributes. Each attribute in the set has a unique attribute identifier, an attribute syntax, and a set of zero or more distinct attribute values.

binding

The association of an atomic name with an object reference. For simplicity, an object reference and the object it refers to are used interchangeably in this guide.

BNF

Backus-Naur Form.

composite name

A name that spans multiple naming systems. It consists of an ordered list of zero or more components. Each component is a name from the namespace of a single naming system. Composite name resolution is the process of resolving a name that spans multiple naming systems.

compound name

A sequence of atomic names composed according to the naming convention of a naming system.

context

An object whose state is a set of bindings with distinct atomic names. Every context has an associated naming convention. A context provides a lookup (resolution) operation, which returns the reference, and may provide operations such as binding names, unbinding names, and listing bound names.

DNS

Domain Name System. A system that provides the naming policy and mechanisms for mapping domain and machine names to addresses on the Internet.

enterprise-level name service

A name service that names objects within an enterprise. The types of objects named are organizational units, sites, users, hosts, and files. Enterprise-level name services are bound below global name services. Global name services provide contexts in which the root contexts of enterprise-level naming systems can be bound.

enterprise root

The root context of an enterprise. A context for naming objects found at the root of the enterprise namespace.

federated naming service

The service offered by a federated naming system.

federated naming system

An aggregation of autonomous naming systems that cooperate to support name resolution of composite names through a standard interface. Each member of a federation has autonomy in its choice of operations other than name resolution.

federated namespace

The set of all possible names generated according to the policies that govern the relationships among member naming systems and their respective namespaces.

generic context

A context for binding names used in applications.

global context

A context for naming objects that have global names (currently, DNS and X.500 are the only global naming systems specified by XFN).

global name service

A name service that has worldwide scope, such as Internet DNS and X.500. The types of entities named at this global level are typically countries, states, provinces, cities, companies, universities, institutions, and government departments and ministries. Each of these entities can be an enterprise.

host context

A context for naming objects related to a computer.

implicit naming system pointer

An unnamed reference that points to a context in another naming system.

initial context

Every XFN name is interpreted relative to some context, and every XFN naming operation is performed on a context object. The XFN interface provides a function that allows the client to obtain an initial context object that provides a starting point for resolution of composite names.

junction

A name in one namespace bound to a context in the next naming system.

naming convention

Every name is generated by a set of syntactic rules called a naming convention.

namespace

The set of all names in a naming system.

namespace identifier

A special atomic name used to refer to the root of a namespace.

name service

The service offered by a naming system. It is accessed through its interface.

naming system

A connected set of contexts of the same type (having the same naming convention) and providing the same set of operations with identical semantics. In the UNIX operating system, for example, the set of directories in a given file system (and the naming operations on directories) constitutes a naming system.

next naming system pointer (NNSP)
Reference to a context in which composite names from subordinate naming systems are resolved.

organizational units
An enterprise is organized into organizational units such as centers, laboratories, departments, divisions, and so on. An organizational unit is a subunit of an enterprise.

organizational unit context
A context for naming objects related to an organizational unit within an enterprise.

parent context
A context in which this context and its siblings are bound.

reference
The thing bound to a name. It contains addresses identifying the communication endpoints of the object.

root context
A context for naming the objects found in the root of the namespace.

service context
A context for naming objects that provide services.

site context
A context for naming objects related to a physical site.

strong separation
The case where the XFN context treats the XFN component separator as the naming system boundary.

subcontext
A context bound within another context.

user context
A context for naming objects related to a human user.

weak separation
The case where the XFN context does not treat the XFN component separator as the naming system boundary.

XFN link

A special form of reference that has a composite name as an address. Like any other type of reference, an XFN link is bound to an atomic name in a context.

X.500

A global-level directory service defined by an Open Systems Interconnection (OSI) standard.

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