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L. Daigle
Thinking Cat Enterprises
R. Hedberg
Catalogix

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TISDAG - Technical Infrastructure for Swedish Directory Access Gateways

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Abstract

The strength of the TISDAG (Technical Infrastructure for Swedish Directory Access Gateways) project's DAG proposal is that it defines the necessary technical infrastructure to provide a single-access-point service for information on Swedish Internet users. The resulting service will provide uniform access for all information -- the same level of access to information (7x24 service), and the same information made available, irrespective of the service provider responsible for maintaining that information, their directory service protocols, or the end-user's client access protocol.

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1.0 Introduction

1.1 Project Goal

The overarching goal of this project is to develop the necessary technical infrastructure to provide a single-access-point service for searching for whitepages information on Swedish Internet users. The service must be uniform for all information -- the same level of access to information (7x24 service), and the same whitepages information made available, irrespective of the service provider responsible for maintaining that information.

1.2 Executive Summary of Technical Study Result

The strength of the TISDAG project's DAG proposal is that it defines the necessary technical infrastructure to provide a single-access-point service for information on Swedish Internet users. The resulting service will provide uniform access for all information --

the same level of access to information (7x24 service), and the same information made available, irrespective of the service provider responsible for maintaining that information, their directory service protocols, or the end-user's client access protocol.

Instead of requiring centralized mirroring of complete information records from Swedish directory service providers, the DAG system uses a well-defined index object summary of that data, updated at the directory service provider's convenience. When an end-user queries the DAG, the referral information is used (by the end-user's software, or by a module within the DAG, as appropriate) to complete the final query directly at the directory service provider's system. This ensures that the end-user gets the most up-to-date complete information, and promotes the directory service provider's main interest: its service. The architecture of the DAG itself is very modular; support for future protocols can be added in the operational system.

1.3 Document Overview

This document is broken into 5 major sections:

Requirements: As a service, the DAG system will have several different types of users. In order to be successful, those users' needs (requirements) must be met. This in turn defines certain constraints, or system requirements, that must be met. This section aims to capture the baseline requirement assumptions to be addressed by the system, and thus lays the groundwork on which the rest of the proposed system is built.

Functional Specification Overview: Working from the users' requirements, specific technologies and functionality details are outlined to architect a system that will meet the stated requirements. This includes a conceptual architecture for the system. While the Requirements section outlines the needs the different users have for the eventual DAG system, implementing and providing the eventual service will entail constraints or conditions that need to be met in order to be able to participate in the overall system.

Architecture: Once the system has been defined conceptually, a proposed software architecture is specified to produce the desired functionality and meet the stated requirements.

Software Specifications: This section provides the specifications for software components to meet the architecture described above.

Service Specifications: Once the software has been designed, the success of the DAG system will rest on its operational characteristics. Details of service requirements are given in this section.

1.4 Terminology

DAG-CAP: Client Access Point -- point of communication between client-access software and the DAG system.

DAG-System: The Directory Access Gateway system resulting from the TISDAG project. A collection of infrastructural software and services for the purpose of providing unified access to Swedish whitepages information.

DAG/IP: DAG-Internal Protocol -- communication protocol used between software components of the DAG.

End-User: People performing White Pages searches and look-ups (via various forms of client software).

DAG-SAP: Service Access Point -- point of communication between the DAG and WDSP software.

WDSP: Whitepages Directory Service Provider -- ISPs, companies, or other interested entities.

Whitepages Information: Collected information coordinates for individual people. This typically includes (but is not limited to) a person's name, and e-mail address.

2.0 Requirements

There are 2 primary classes of users for the proposed Whitepages directory access gateway:

- End-users
- WDSPs

As outlined below, needs of each of these user classes imposes a set of constraints on the design of the DAG system itself. Some of the requirements shown below are assumed starting criteria for the DAG service; others have been derived from data collected in the Technical Survey or other expertise input.

2.1 End-User Requirements

The End-User is to be provided with a specific set of search types:

Name
Name + Organization
Role + Organization
Name + Locality
Name + Organization + Locality
Role + Organization + Locality

The search results will, if available, include the following information for each "hit":

- Full name
- E-mail address
- Role
- Organization
- Locality
- Full address
- Telephone numbers

Access to the service must be available through reasonable and current protocols -- such that directory-service-aware software can make use of it seamlessly, and there are no reasonable technological impediments to making this service useful to all Swedish Internet users.

Following on that, its responses are expected to be timely; a standard search should not take more time than the average access to a web-server.

2.2 WDSPs Requirements

Given that the WDSPs that participate in this service are already in the business of providing a service of whitepages information, they have certain requirements that must be respected in order to make this a successful and useful service to all concerned.

The DAG system must provide reasonable assurances of data integrity for WDSPs; the information the End-User sees should correspond directly to that provided by the WDSPs. The DAG system should be non-preferential in providing whitepages information -- the service is to the End-User, and the source of whitepages information should not influence the search and information presentation processes.

The DAG system must be able to reflect information updates within a reasonable time after receipt from WDSPs; on the flip side, while the DAG system will function best with regular updates from WDSPs, the update and participation overhead for WDSPs should be held within reasonable bounds of what the WDSP should do to support regular access to its information.

Furthermore, given that WDSPs provide directory service information with an eye to value-added service, wherever possible End-Users should be redirected to the WDSP responsible for individual directory service entries for final and further information.

2.3 DAG-System Requirements

In order to address the requirements of End-Users and WDSPs, the DAG system itself has certain design constraints that must be taken into account.

The system must be implementable/operational by Dec 31/98 -- which implies that it must be designed and constructed with already extant technologies.

The System will have certain requirements for participation -- e.g., 7x24 WDSP availability.

In terms of scaling, the system should be able to handle 8M records at the outset, with a view to handling larger information systems in the future.

The system must also be capable of extension to other, related applications (e.g., serving security certificate information).

3.0 Functional Specification

In the TISDAG pilotservice we have decided to apply some limitations as to what is specified for the DAG/IP. These limitations are presented in this text in the following manner:

   TISDAG: This is a TISDAG comment

3.1 Overview

The conceptual environment of the DAG system can be described in three major components:

- client access software for end-users
- the DAG system core
- WDSP directory service software

This is illustrated in Figure 3.1

The DAG (Directory Access Gateway) is the infrastructural core of the service; it maintains the necessary data and transformation facilities to permit the smooth connection of diverse directory service Client Software to the existing WDSPs' directory servers. The key challenges in designing this portion of the system are:

Quantity of data -- the quantity of whitepages information that will be made available, and diversity of its sources (different WDSPs) introduce challenges in terms of finding a structure that will allow efficient searching, and facilitate the timeliness of updating the necessary information.

Multiplicity of access protocols -- in order to support the use of existing whitepages-aware software with a minimum of perturbation, the DAG system will have to present a uniform face in several different access protocols, each with its own information search and representation paradigm.

This specification will outline the following areas:

- the functioning of the DAG core itself
- the interface between the DAG core and End-Users' Directory Service Access software
- the interface between the DAG core and Directory Services Servers

3.2 The DAG Core

In order to reduce the quantity of data the DAG itself must maintain, and to keep the maintenance of the whitepages information as close as possible to the source of information (the WDSPs themselves), the DAG will only maintain index information and will use "query routing" to efficiently refer End-User queries to WDSPs for search refinement and retrieval of information. Although originally developed for the Whois++ protocol, query routing is being pursued in a protocol-independent fashion in the IETF's FIND WG, so the choice of this approach does not limit the selection and support of whitepages access protocols.

The DAG will look after pursuing queries for access protocols that do not support referral mechanisms. In order to achieve the support of multiple access protocols and differing data paradigms, the DAG will be geared to specifically support a limited set of whitepages queries.

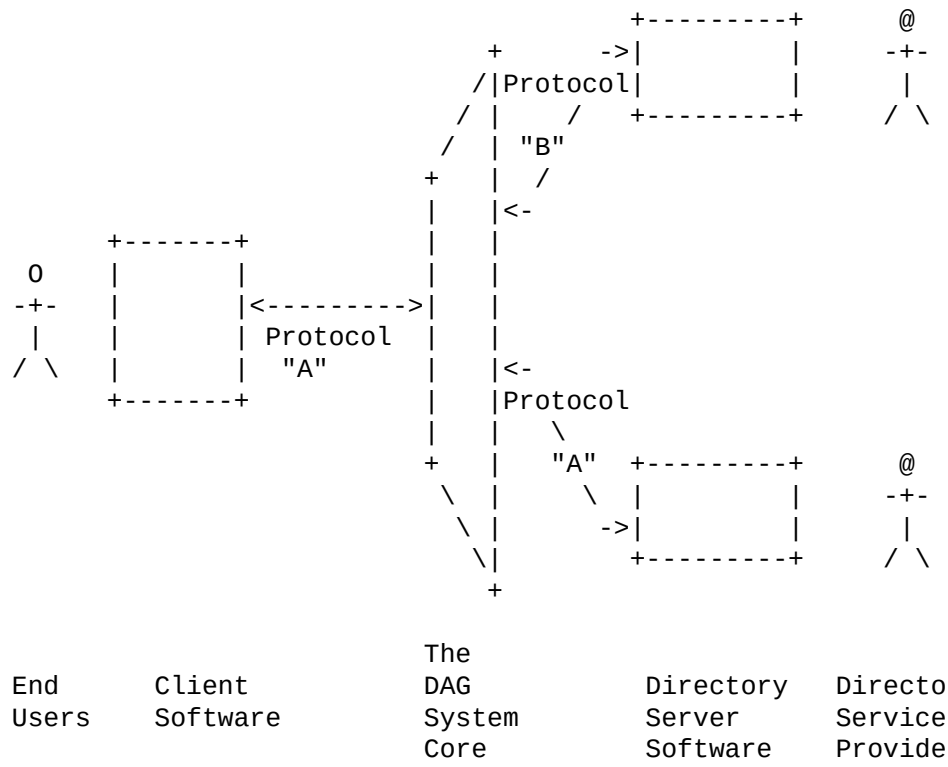


Figure 3.1 The role of the DAG system

3.3 Client Interface

The DAG will respond to End-User queries in

- e-mail (SMTP)
- WWW (HTTP)
- LDAPv2
- Whois++
- LDAPv3

The DAG will provide responses including the agreed-upon data. For access protocols that can handle referrals, responses will be data and/or referrals in that query protocol. These are Whois++ and LDAPv3. N.B.: the LDAPv3 proposal defines a referral as a URL; no limitation is placed on the access protocol. However it cannot be assumed that all clients will be able to handle all access protocols, so only referrals to LDAPv3 servers will be returned.

3.3.1 Acceptable User Input

User Input is defined in terms of

- Searchable Attributes
- Matching semantics
- Character sets

These, in conjunction with the DAG schema, defined in Appendix A, form the basis of the required query expression. Individual queries are discussed in more detail in the Client Access Point (DAG-CAP) component descriptions for supported protocols.

Supported Query Types

The DAG system is designed to support fragment-matching queries on a limited set of data attributes -- "Name", "Organizational Role", "Organization", and "Locality". The selected permissible query combinations of attributes are listed in Table 3.1. From the table it can be seen that not all combinations of the three attributes are supported -- only those that are needed for the desired functionality.

Symbol	Description
N	Name
NL	Name + Locality
NO	Name + Organization
NOL	Name + Organization + Locality
RO	Role + Organization
ROL	Role + Organization + Locality

Table 3.1 DAG-supported queries

The RO and ROL queries are separated from the rest as they are searches for "virtual" persons -- roles within an organization (e.g., president, or customer service desk) for which one might want to find contact information.

Matching Semantics

As befits the individual client query protocols, more string matching expressions may be provided. The basic semantics of the DAG expect the following to be available in all client access software (as relevant):

- Full word, exact match
- Word substring match (E.g., "cat" would match "scatter")
- Case-sensitive and case-insensitive matching

   TISDAG: LDAP/X.500, supports case-sensitivity as such but some of the most used attributes, such as the commonName attribute, are defined in the standard to be of the case-insensitive attributetypes. The impact on the DAG system is that even if the index collected from a LDAP/X.500 server might have upper and lower case letters in the tokens, they can not be handled as such since that would be inferring meaning in something which is natively regarded as meaningless. The conclusion of the above is that The Referral Index should be case-insensitive and case-sensitivity should be supported by the SAPs if the native access protocol supports it.

Character Sets

Wherever possible, the DAG System supports and promotes the use of Unicode Version 2.0 for character sets (see [21]) specifically the UTF-8 encoding (see Appendix A.2 of [21] or [20]) Accommodation is made, where necessary, to support the deployed base of existing software.

Specifically:

DAG/IP: All internal communications using the DAG/IP are carried out in UTF-8.

   TISDAG: not just UTF-8, but UTF-8 based on composed UNICODE version 2 character encodings.

DAG-CAP input: Where specific access protocols permit selection of character sets, DAG-CAPs must support UTF-8. They may additionally support other anticipated character set encodings.

DAG-SAP communications with WDSPs: Where specific access protocols permit selection of character sets, DAG-SAPs must support UTF-8 and use UTF-8 whenever the remote WDSP supports it. They may additionally support other character set encodings.

CIP Index Objects: The Index Objects supplied by the WDSPs to the DAG system shall contain data encoded in UTF-8.

   TISDAG: The same limitation as for DAG/IP, that is the basic data should be UTF-8 encoded composed UNICODE version 2 character encodings.

3.3.2 Data Output Spec

Schema Definition

The schema used for the DAG service is defined in Appendix A. This is a very basic information schema, intended to carry the necessary information for the DAG service, and not more. Although generic "whitepages" schema definitions do exist the more sophisticated and detailed the information presentation, the more difficult it is to map the schema seamlessly across protocols of different paradigms. Thus, the "KISS" ("Keep it simple, sir") principle seems appropriate here.

Individual DAG-CAPs define how they express this schema.

Referral Definition

For client access protocols that make use of the concept of referrals, DAG-CAP definitions will define the expression of referrals in those protocols. The DAG/IP defines the expression of referrals (see Appendix C).

Error conditions

Each DAG-CAP may provide more detailed error messages, but will define minimally the support for the following error conditions:

- unrecognized query
- too many hits

Apart from these errors, the DAG-CAP may choose to refuse a query by redirecting the end-user to a different DAG-CAP of the same protocol.

3.4 Directory Server Interface

The DAG will use the Common Indexing Protocol (CIP) server-server protocol to obtain updated index objects from WDSPs. For query-routing purposes, WDSPs are expected to provide Whois++, LDAPv2 or LDAPv3 interface to their data (although their preferred access may be something completely different). N.B.: In the responses from the technical survey, all respondents currently provide access to their service in one of these protocols.

In order to provide a useful and uniform service, WDSPs are expected to provide 7x24 access to their whitepages information. WDSPs are also expected to implement operations, administration, maintenance, and provisioning processes designed to minimize service down time for both planned and unplanned administration and maintenance activities.

4.0 Architecture

4.1 Software Components

The conceptual architecture of the DAG is represented in Figure 4.1. General architectural specifications are described below, followed by individual component specifications Sections 5.5 through 5.12.

4.1.1 Internal Communications

Communications between components of the DAG will be by TCP/IP connections, using the DAG-Internal Protocol (DAG/IP). DAG/IP is used by DAG-CAPs to communicate with the Referral Index and DAG-SAPs. Thus, the DAG/IP defines

- the DAG-CAPs' range of query ability in the Referral Index (to gather referrals in response to the end-user's requests)
- the responses (and their formats) of the Referral Index to the DAG-CAP requests
- the DAG-CAPs' range of query ability to the DAG-SAPs for pursuing referrals when the DAG-CAP needs to do chaining for the client access software
- the responses (and their formats) of the DAG-SAPs to the DAG-CAPs.

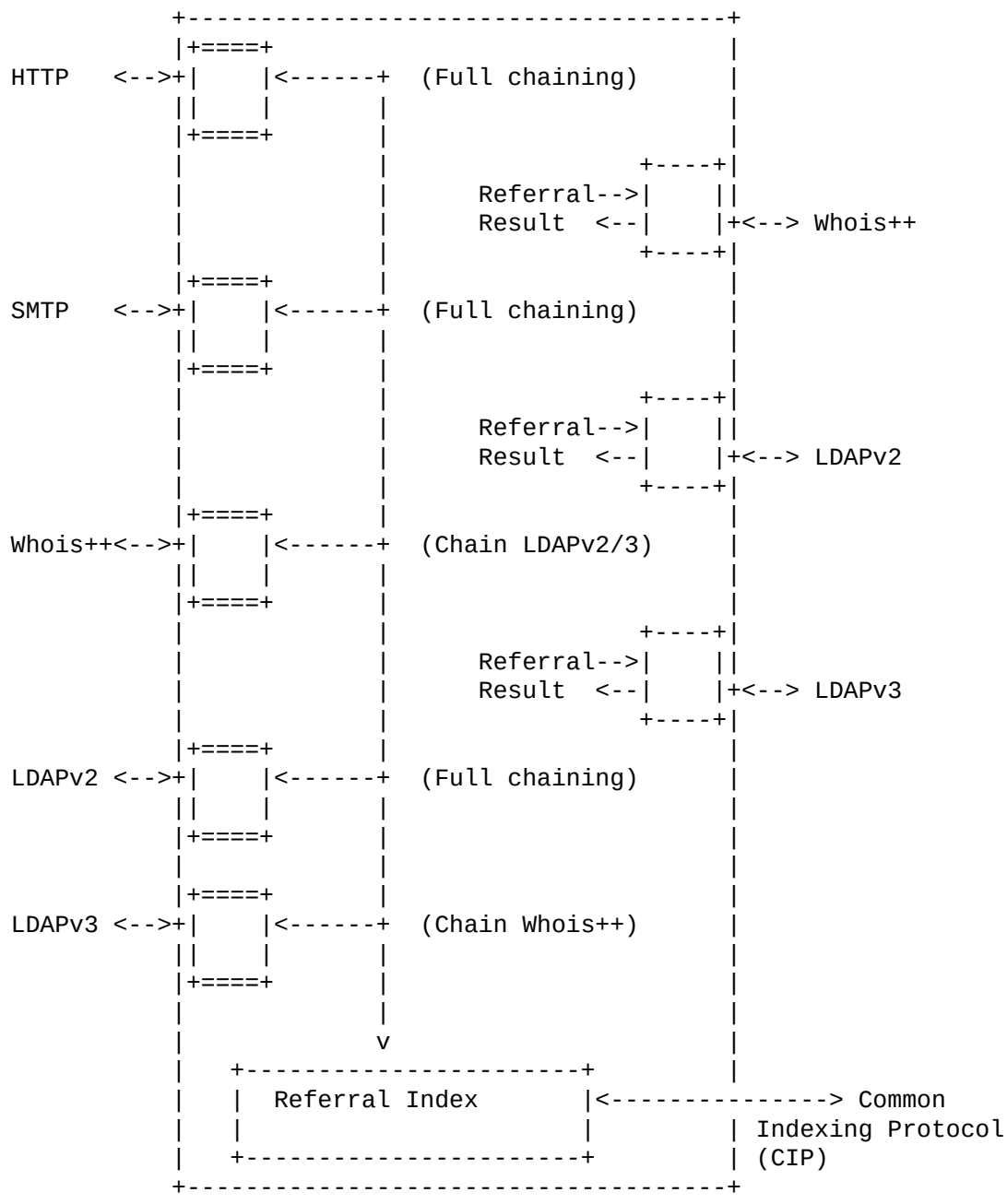
The detail of the planned DAG/IP is given in Appendix C. The detail of the DAG-CAP--Referral Index and DAG-CAP--DAG-SAP interactions is given in the definitions of individual DAG-CAPs and DAG-SAPs, below (Sections 5.5 through 5.12).

4.1.2 Referral Index

The Referral Index is responsible for maintaining the index of WDSP information, and providing a list of reasonable referrals in response to DAG-CAP search requests. These "referrals" provide pointers to identify WDSPs that may have information that matches the end-user's query.

4.1.3 DAG-CAPs

Individual DAG-CAPs are responsible for providing a particular client access protocol interface to the DAG service. DAG-CAPs receive end-user queries in a particular query access protocol, convert the request into a query for the Referral Index (i.e., expressed in DAG/IP), and then convert the Referral Index's response into a form that is appropriate for the client access protocol. This may mean passing back the referrals directly, calling on DAG-SAPs to do the work of translating the referral into results ("chaining"), or a combination of both.



All internal communications are in DAG/IP.

Figure 4.1 Conceptual Architecture of the DAG

4.1.4 DAG-SAPs

Individual DAG-SAPs are called upon (by DAG-CAPs) to take DAG-generated referrals and pursue them -- issuing the indicated query at the specified WDSP service. Results from individual WDSPs are converted back into DAG/IP-specific format for the DAG-CAP that made the request. Each DAG-SAP is responsible for handling referrals to WDSPs of a particular protocol (e.g., LDAPv2, Whois++, etc).

4.2 Important Architectural Notes

This section notes some of the thinking that has driven the architectural and software design specification for the DAG system. This helps to provide the context in which to understand the software specifications that follow, and should give clues for the eventual extension of the DAG system. This section also acts, in some ways, as an FAQ (Frequently Asked Questions) section, as the content is shaped by questions received during the tech spec development phase. It attempts to illuminate context that may not otherwise be apparent on a first reading of the software specifications.

4.2.1 2 Distinct Functions: Referrals and Chaining

At all times, it must be kept in mind that the primary function of the DAG system is to provide users with referrals to WDSP services that may have the information they seek. Since it is the case that not all supported client protocols can handle referrals, the DAG system also provides a chaining service to pursue referrals that the user's client software cannot handle itself. This chaining service does attempt to match the user's query against data from WDSPs, but this is to be seen as a secondary, or support function of the DAG system. In the perfect future, all access protocols will be able to handle all referrals!

4.2.2 Limited Query and Response Semantics

The DAG system does not attempt to be a chameleon, or the ultimate whitepages query service. It focuses on providing referrals for information on the limited number of query types outlined in the functional specifications of the DAG service. This makes the DAG system a good place to start a search, but refinements and detailed inquiries are beyond its scope.

4.2.3 Visibility

Given the limited query syntax of the DAG system it will not always be possible to exactly match a query posed to a CAP into a query posed to a SAP. This will have the effect that for instance a LDAPv2

client that issues a query to the DAG system which by the DAG system is chained to a LDAP server might not get the same results as if the client where directly connected to the server in question.

4.2.4 Richness of Query semantics

Even the limited query syntax of the DAG system is capable of expressing queries that might NOT be possible to represent in the access protocols to the WDSPs. In these cases the DAG-SAP either can refuse the query or try to emulate it.

4.2.5 N+M Protocol Mappings

As part of the chaining service offered by the DAG system, a certain amount of mapping between protocols is required -- in theoretical terms, there are "N" allowable end-user query access protocols, and "M" supported WDSP server protocols. The architecture of the software is constructed to use a single internal protocol (the DAG/IP) and data schema, providing a common language between all components. Without this, each input protocol module (DAG-CAP) would have to be constructed to be able to handle every WDSP protocol -- NxM protocol mappings. This would make the system complex, and difficult to expand to include new protocols in future.

4.2.6 DAG-CAPs and DAG-SAPs are completely independent of each other

For the above reasons, the DAG-CAP and DAG-SAP modules are intended to be completely independent of each other. A DAG-SAP responds to a query that is posed to it in the DAG/IP, without regard to the protocol of the DAG-CAP that passed the query.

4.2.7 The Role of the DAG-CAP

Thus, the DAG-CAP is responsible for using the DAG/IP to obtain referral information and, where necessary, chained responses. Where necessary, it performs adjustments to accommodate the differences in semantics between the DAG/IP and its native protocol. This might involved doing post-filtering of the results returned by the DAG-SAPs since the query issued in DAG/IP to the DAG-SAP might be "broader" then the original query.

Thus, the DAG-CAP "knows" only 2 protocols: its native protocol, and the DAG/IP.

4.2.8 The Role of the DAG-SAP

Similarly, the DAG-SAP is responsible for responding to DAG/IP queries by contacting the designated WDSP server. Where necessary, it performs adjustments to accommodate the differences in semantics between the DAG/IP and its native protocol. These adjustments might mean that, as a consequence, the DAG-SAP will receive results that do not match the original query. In such cases the DAG-SAP should attempt to do post-pruning in order to reduce the mismatch between the original query and the results returned.

Thus, the DAG-SAP "knows" only 2 protocols: its native protocol, and the DAG/IP.

4.2.9 DAG/IP is internal

No module outside of the DAG system should be aware of the DAG/IP's construction. End-users use the query protocols supported by DAG-CAPs; WDSPs are contacted using the query protocols supported in the DAG-SAPs.

4.2.10 Expectations

The expectation is that the DAG system, although defined as a single construct, will operate by running modules on several different, perhaps widely distributed (in terms of geography and ownership), computers. For this reason, the DAG/IP specified in such a way that it will operate on inter-machine communications.

4.2.11 Future Extensions

The DAG system architecture was constructed with a specific view to extensibility. At any time, an individual component may be improved (e.g., the Mail DAG-CAP may be given a different query interface) without disrupting the system.

Additionally, future versions of the DAG system may support other access protocols -- for end-users, and for WDSPs.

5.0 Software Specifications

5.1 Notational Convention

It is always a challenge to accurately represent text protocol in a printed document; when is a new line a "newline", and when is it an effect of the text formatter?

In order to be adequately illustrated, this document includes many segments of protocol grammars, sample data, and sample input/output in a text protocol. In order to distinguish newlines that are significant in a protocol, the symbol

<NL>

is used. For example,

This is an example of a very long line of input. There is only one newline in it (at the end), in spite of the fact that this document shows it spanning several lines of text.<NL>

5.2 DAG-CAP Basics

5.2.1 Functionality

Every DAG-CAP must support the full range of DAG queries, as defined in 3.3.1.

Each DAG-CAP accepts queries in its native protocol. Individual DAG-CAP definitions define the expected expression of the DAG queries in the native protocol.

The DAG-CAP is then responsible for:

- converting that expression into a query in the DAG/IP to obtain relevant referrals from the Referral Index. This might mean that parts of the original query are disregarded (e.g., if the query included attributes not supported by the DAG application, or if the query algebra was not supported by the DAG application);
- returning referrals in the client's native protocol, where possible;
- expressing the client query to the necessary DAG-SAPs, given the limitations mentioned above, to chain those referrals not usefully expressible in the client's native protocol;
- possibly doing post-filtering on the DAG-SAP results; and
- converting the collected DAG-SAP results for expression in the client's native protocol (and schema, where applicable).

Each DAG-CAP defines the nature of the interaction with the end-user (e.g., synchronous or asynchronous, etc). Additionally, each DAG-CAP must be able to carry out the following, in order to permit load-limiting and load-balancing in the DAG system:

- direct the client to a different DAG-CAP of the same type (for load-balancing)

- decline to return results because too many referrals were generated (to discourage data-mining). Ideally, this should include the generation of a message to refine the query in order to produce a more manageable number of referrals/replies.

DAG-CAPs must be capable of accepting and respecting DAG-SAP service referrals (for DAG-SAP load-sharing).

In protocols that permit it, the DAG-CAP should indicate to the end-user which services were unavailable for chaining referrals (i.e., to indicate there were parts of the search that could not be completed, and information might be missing).

> TISDAG: Any CAP that receives commands other than queries, like help, answers those on its own. A CAP should not pass any system command on to the RI.

5.2.2 Configuration

It must be possible to change the expected address of the DAG-CAP by configuration of the software (i.e., host and port, e-mail address, etc).

For DAG-CAPs that need to access DAG-SAPs for query chaining, for each type (protocol) of DAG-SAP that is needed, the DAG-CAP must be configurable in terms of:

- at least one known DAG-SAP of every necessary protocol to contact
- for each DAG-SAP, the host and port of the DAG-SAP software

The DAG-CAPs must also be configurable in terms of a maximum number of referrals to handle for a user transaction (i.e., to prevent data mining, the DAG-CAP will refuse to reply if the query is too general and too many hits are generated at the Referral Index).

The DAG-CAP must be configurable in terms of alternate DAG-CAPs of the same type to which the end-user software may be directed if this one is too busy.

5.2.3 Error handling

Apart from error conditions arising from the operation of the DAG-CAP itself, DAG-CAPs are responsible for communicating error conditions occurring elsewhere in the system that affect the outcome of the user’s query (e.g., in the DAG-RI, or in one or more DAG-SAPs).

If the DAG-CAP sends a query to the DAG-RI and receives an error message, it should attempt to match the the received DAG errorcode into its native access protocol's error codes. The same action is appropriate when the DAG-CAP is "chaining" the query to one DAG-SAP.

There are also occasions when the DAG-CAP may have to combine multiple errorcodes into a single expression to the user. When the DAG-CAP is "chaining" the query through DAG-SAPs to one or more WDSPs, situations can arise when there is a mix of responsecodes from the DAG-SAPs. If this happens, the DAG-CAP should try to forward information to the end-user software that is as specific as possible, for instance which of the WDSPs has not been able to fulfill the query and why.

See Appendix D for more information concerning error condition message mappings.

5.2.4 Pruning of results

Since there is no perfect match between the query syntaxes of the DAG system on one hand and the different access protocols that the DAG-CAPs and DAG-SAPs supports on the other, there will be situations where the results a DAG-CAP has to collect is "broader" then what would have been the case if there had been a perfect match. This might have adverse effects on the system to the extent that administrative limits will "unnecessary" be exceeded on WDSPs or that the collected results exceeds the sizelimit of the DAG-CAP.

Since the DAG-CAP is the only part of the DAG system that actually knows what the original query was, the DAG-CAP can prune the results received from the DAG-SAPs in such a way that the results presented to the client better matches the original question.

5.3 DAG-SAP Basics

5.3.1 Functionality

Every DAG-SAP must support the full range of DAG queries, as defined in 3.3.1. Results must be complete DAG schemas expressed in well-formed DAG/IP result formats (see Appendix C). Each DAG-SAP accepts queries in DAG/IP and converts them to the native schema and protocol for which it is designed to proxy.

The DAG-SAP is then responsible for

- converting the query into the native schema and protocol of the WDSP to which the referral points. (If the query is not representable in the native protocol, it must return an error

message. If it is emulatable, the DAG-SAP can attempt emulate it by posing a related query to the WDSP and post-pruning the results received);
- contacting that WDSP, using the host, port, and protocol information provided in the referral;
- negotiating the query with the remote WDSP;
- accepting results from the WDSP, possibly doing post-filtering on the result set; and
- conveying the results back to the calling DAG-CAP using the DAG/IP and its schema.

Note that this implicitly means that the DAG-SAP is responsible for chaining and pursuing any referrals it receives from WDSP services. The DAG-SAP returns only search results to the DAG-CAP that called it.

5.3.2 Configuration

DAG-SAPs must be configurable to accept connections only from recognized DAG components.

DAG-SAPs that have service limits must be configurable to redirect DAG-CAPs to alternate DAG-SAPs of the same type when necessary.

5.3.3 Error handling

A DAG-SAP must translate error codes received from a WDSP server to DAG error codes according to Appendix D.

5.3.4 Pruning of results

Since it might not be possible to exactly map a DAG query into a query in the access protocol supported by the a DAG-SAP, the DAG-SAP should try to translate it into a more general query (or if necessary into a set of queries). If so, the DAG-SAP must then prune the result set received before furthering it to the DAG-CAP.

5.3.5 Constraint precedence

Some constraints, search and case, can appear both as local and global constraints. If this happens in a query then the local constraint specification overrides the global. For a query like the following:

fn=leslie;search=exact and org=think:search=substring

the resulting search constraint for "fn=leslie" will be "exact" while it for "org=think" will be "substring".

5.4 The Referral Index

5.4.1 Architecture

The Referral Index contains (only) information necessary to deliver referrals to DAG-CAPs based on the query types supported by the DAG itself. The Referral Index creates an index over these objects so that it can respond to DAG-CAP queries using the DAG/IP. The information is drawn directly from interactions with participating WDSPs' software, using the Common Indexing Protocol (CIP).

5.4.2 Interactions with WDSPs (CIP)

WDSPs that wish to participate in the DAG system must register themselves (see Section 5.4.6). Once registered, the Referral Index will interact with the WDSPs using the Common Indexing Protocol as defined in [1], using the Index Object defined in Section 5.4.3.

5.4.3 Index Object Format

The CIP index object type is based on the Tagged Index Object as defined in [12]. Appendix E details the expected content of the index objects as they are to be provided by the WDSPs.

> TISDAG: The tokens in the Tagged Index Object should be UTF-8 encoded composed UNICODE version 2 character encoding.

5.4.4 DAG-Internal I/O

The Referral Index interacts with the rest of the DAG internal modules (DAG-CAPs) by listening for queries and responding in the DAG/IP (defined in Appendix C).

5.4.5 The Index Server

The Referral Index must index the necessary attributes of the CIP index object in order to respond to queries of the form described in Table 3.1.

The semantics of the chosen CIP object (defined in Appendix E) are such that a referral to a WDSP server is sent back if (and only if)

- the index object of the WDSP contains all the tokens of the query, in the attributes specified, according to the logic of the DAG/IP query, and
- all of those tokens are found with a common tag.

This means that a query for the name "Fred Flintstone" (2 tokens) will yield a referral to a server that has a record for "Fred Amadeus Flintstone", but not to a WDSP with 2 differently tagged records, for "Fred Amadeus" and "Julie Flintstone". Depending on the access protocol being used and the original end-user query, the referral to the WDSP with "Fred Amadeus Flintstone" may yield a successful result, or it may not. But, it is known that the other WDSP would not have yielded successful searches. That is, the referral approach may yield false-positive results, but will not miss appropriate WDSPs.

5.4.6 Configuration

The Referral Index must provide the ability to register interested WDSPs, as outlined in Appendix E.

The Referral Index must be able to configure the port for DAG/IP communications. Also, it must be configurable to recognize only registered DAG-CAPs.

5.4.7 Security

The Referral Index will accept queries only from recognized (registered) DAG-CAPs. This will reduce "denial of service" attack types, but is also a reflection on the fact that the Referral Index uses the DAG/IP, (i.e., internal) protocol, which should not be exposed to non-DAG software.

The Referral Index must be able to use authenticated communication to receive data from WDSPs (see Appendix E).

5.5 Mail (SMTP) DAG-CAP

This is the default Mail DAG-CAP. More sophisticated ones could certainly be written -- e.g., for pretty-printed output, or for handling different philosophies of case-matching.

This DAG-CAP has been designed on the assumption that mail queries will be human-generated (i.e., using a mail program/text editor), as opposed to being queries formulated by software agents. The input grammar should therefore be simple and liberal in acceptance of variations of whitespace formatting.

5.5.1 Mail DAG-CAP Input

Mail DAG-CAP input is expected to be a regular or MIME-encoded (see [9] and [10]) SMTP mail message, sent to an advertised mail address. The mail DAG-CAP parses the message and replies to it with a MIME-encoded message containing the results of the DAG search.

One query is accepted per e-mail message -- text after a single valid query has been read is simply ignored.

The body of the query message must follow the syntax defined below. Note that all input control terms ("type=", "name=" etc) are shown in lower case for convenience, but could be upper case or mixed case on input.

```
mailquery       = [mnl] [controls] mnl terms mnl
controls        = [msp] "searchtype" [msp] "=" [msp]
                      ( matchtype /
                        casetype /
                        matchtype msp casetype /
                        casetype msp matchtype /
                        <nothing> )
matchtype       = "substring" / "exact"
                ; default:  substring
casetype        = "ignore" / "sensitive"
                ; default:  ignore

terms           = n / n-l / n-o / n-o-l / r-o / r-o-l

n               = n-term
n-l             = ( n-term l-term  / l-term n-term)
n-o             = ( n-term o-term  / o-term n-term )
n-o-l           = ( n-term o-term l-term /
                  n-term l-term o-term /
                  l-term n-term o-term /
                  l-term o-term n-term /
                  o-term l-term n-term /
                  o-term n-term l-term )
r-o             = ( r-term o-term / o-term r-term )
r-o-l           = ( r-term o-term l-term /
                  r-term l-term o-term /

                  l-term o-term r-term /
                  l-term r-term o-term /
                  o-term l-term r-term /
                  o-term r-term l-term )
n-term          = [msp] "name" [msp] "=" [msp] string mnl
o-term          = [msp] "org" [msp] "=" [msp] string mnl
```

```
   l-term          = [msp] "loc" [msp] "=" [msp] string mnl
   r-term          = [msp] "role" [msp] "=" [msp] string mnl

   string          = <US-ASCII or quoted-printable encoded
                   ISO-8859-1 or UTF-8 except nl and sp>
   msp             = 1*(sp)
    sp              = " "
   mnl             = 1*(nl)

   nl              = <linebreak>
```

The following are valid mail queries:

Example 1:

```
searchtype =   <NL>
name = thinking cat<NL>
```

Example 2:

```
searchtype = exact ignore<NL>
name=thinking cat<NL>
```

Example 3:

```
role=thinking cat<NL>
org =space colonization<NL>
```

Example 4:

```
name=thinking cat <NL>
<NL>
<NL>
My signature line follows here in the most annoying
fashion <NL>
```

Note that the following are not acceptable queries:

Example 5:

```
searchtype= exact substring <NL>
name = thinking cat <NL>
```

Example 6:

```
name=thinking cat org= freedom fighters anonymous<NL>
```

In Example 5, two conflicting searchtypes are given. In Example 6, no linebreak follows the n-term.

5.5.2 Translation from Mail query to DAG/IP

Querying the Referral Index

A key element of translating from the Mail DAG-CAP input into the DAG/IP query format is to "tokenize" the input terms into single token elements for the DAG/IP query. For example, the n-term

name= thinking cat<NL>

is tokenized into 2 n-tokens:

thinking
cat

which are then mapped into the following in the DAG/IP query (dag-n-terms):

FN=thinking and FN=cat<NL>

The same is true for all r-terms, l-terms and o-terms. The primary steps in translating the mail input into a DAG/IP query are:

translate quoted-printable encoding, if necessary
translate base64 encoding, if necessary
tokenize the strings for each term
construct the DAG/IP query from the resulting components, as described in more detail below

DAG/IP constraints are constructed from the searchtype information in the query.

```
dag-matchtype = "search=" <matchtype> /
             "search=substring"  ; if matchtype not
                                 ; specified

dag-casetype  = "case=ignore"  /    ; if casetype not
                                 ; specified or
                                 ; casetype=ignore
             "case=consider"     ; if casetype=sensitive

constraints   = ":" dag-matchtype ";" dag-casetype
```

The terms for the DAG/IP query are constructed from the tokenized strings from the mail input.

```
dag-n-terms   = "FN=" n-token 0*( " and FN=" n-token)
dag-o-terms   = "ORG=" o-token 0*( " and ORG=" o-token)
dag-l-terms   = "LOC=" l-token 0*( " and LOC=" l-token)
dag-r-terms   = "ROLE=" r-token 0*( " and ROLE=" r-token)
```

This means that the relevant DAG/IP queries are formulated as one of two types:

```
dagip-query   = ( ( ( n-query / nl-query / no-query /
                      nol-query ) [" and template=DAGPERSON"]":"
                    dag-matchtype ";" dag-casetype) /
                  ( ( ro-query / rol-query )
                    [" and template=DAGORGROLE"]":"
                    dag-matchtype ";" dag-casetype)  )

n-query       = dag-n-terms
nl-query      = dag-n-terms " and " dag-l-terms
no-query      = dag-n-terms " and " dag-o-terms
nol-query     = dag-n-terms " and " dag-o-terms " and "
              dag-l-terms
ro-query      = dag-r-terms " and " dag-o-terms
rol-query     = dag-r-terms " and " dag-o-terms " and "
              dag-l-terms
```

The examples given earlier are then translated as follows.

Example 1:

```
FN=thinking and FN=cat:search=substring;case=ignore<NL>
```

Example 2:

```
FN=thinking and FN=cat:search=exact;case=ignore<NL>
```

Example 3:

```
ROLE=thinking and ROLE=cat and ORG=space and
ORG=colonization:search=substring;case=ignore<NL>
```

Querying a DAG-SAP

In querying a DAG-SAP (irrespective of the protocol of that DAG-SAP), the DAG/IP query must include information about the target WDSP server. This information is drawn from the Referral Index SERVER-TO-ASK referral information, and is appended to the query as specified in Appendix C):

":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

where the response from the Referral Index included:

"# SERVER-TO-ASK " serverhandle nl
" Server-info: " serverinfo nl
" Host-Name: " hostname nl
" Host-Port: " number nl

" Protocol: " prot nl
" Source-URI: " source nl
" Charset: " charset nl
"# END" nl

and the "quoted-hostname" and "quoted-serverinfo" are obtained from "hostname" and "serverinfo" respectively, by quoting the DAG/IP special characters.

For example, the referral

SERVER-TO-ASK dagsystem01<NL>
 Server-info: o=thinkingcat, c=se<NL>
 Host-Name: thinkingcat.com<NL>
 Host-Port: 2839<NL>
 Protocol: ldapv2<NL>
 Source-URI: http://www.thinkcat.com
 Charset: T.61<NL>
 # END<NL>

would yield the addition

:host=thinkingcat\.com;port=2839;server-info=o\=thinkingcat\,\
c\=se;charset=T\.61

in its query to an LDAPv2 DAG-SAP.

(N.B.: See Appendix C for further definitions of the terms used in the SERVER-TO-ASK response).

Note that it is the DAG-SAP's responsibility to extract these terms from the query and use them to identify the WDSP server to be contacted. See the individual DAG-SAP definitions, below.

5.5.3 Chaining queries in Mail DAG-CAP

The Mail DAG-CAP has to chain all referrals -- to the Whois++ DAG-SAP, LDAPv2 DAG-SAP, or LDAPv3 DAG-SAP as appropriate for the referral.

5.5.4 Expression of results in Mail DAG-CAP

The results message is sent to the "Reply-To:" address of the originating mail, if available (see [4] for appropriate interpretation of mail originator headers). The original query is repeated, along with the message-id. The remainder of the body of the mail message is the concatenation of responses from the DAG-SAP calls, each result having the WDSP's SOURCE URI (from the referral) appended to it, and the system messages also having been removed.

At the end of the message, the WDSP servers that failed to respond (i.e., the DAG-SAP handling the referral returned the "% 403 Information Unavailable" message) are listed with their server-info.

5.5.5 Expression of Errors in Mail DAG-CAP

If the mail DAG-CAP receives a message that is not parsable using the query grammar described above, it returns an explanatory message to the query mail's reply address saying that the query could not be interpreted, and giving a description of valid queries.

If the number of referrals sent by the Referral Index is greater than the pre-determined maximum (for detecting data-mining efforts, or otherwise refusing over-general queries, such as "FN=svensson"), the mail DAG-CAP will send an explanatory message to the query mail's reply address describing the "over-generalized query" problem, suggesting the user resubmit a more precise query, and describing the list of valid query types.

If the mail DAG-CAP receives several different result codes from the DAG-SAPs it should represent those in an appropriate manner in the response message.

A mail DAG-CAP may redirect a connection to another mail DAG-CAP for reasons of load-balancing. This is done simply by forwarding the mail query to the address of the alternate mail DAG-CAP.

5.6 Web (HTTP) DAG-CAP

5.6.1 Web DAG-CAP Input

The web DAG-CAP provides its interface via standard HTTP protocol. The general expectation is that the web DAG-CAP will provide a form page with radio buttons to select "substring or exact match" and "consider case or ignore case". Other information (about name, role, organization, locality) is solicited as free-form text.

The DAG-CAP receives queries via an HTTP "post" method (the outcome of the form action for the page described above, or generated elsewhere). The rest of this section describes the variables that are to be expressed in that post. The actual layout of the page and most user interface issues are left to the discretion of the builder. Note that the Web DAG-CAP may be called upon to provide responses in different content encoding, and must therefore address the "Accept-Encoding:" request header in the HTTP connection.

Although the Web protocol, HTTP, is not itself capable of handling referrals, through the use of two extra variables this client is given the option of requesting referral information and then pursuing individual referrals through the Web DAG-CAP itself, as a proxy for those referrals. This is handled through the extra "control variables" to request referrals only, and to indicate when the transaction is a continuation of a previous query to pursue a referral.

There has been call to have a "machine-readable" version of the search output. As HTML is geared towards visual layout, user agents that intend to do something with the results other than present them in an HTML browser have few cues to use to extract the relevant information from the HTML page. Also, "minor" visual changes, accomplished with extensive HTML updates, can disrupt user agents that were built to blindly parse the original HTML. Therefore, provision has been made to return "raw" format results. These are requested by specifying "Accept-Content: application/whoispp-response" in the request header of the HTTP message to the HTTP DAG-CAP.

The variables that are expected are:

```
transaction     = "new" / "chain"  ; default is "new". This
                ; should not be user-settable.  It is used
                ; in constructed URLs
resulttype      = "all" / "referrals" ; default is "all"
matchtype       = "substring" / "exact"
casetype        = "case ignore" / "case sensitive"
n-term          = string
o-term          = string
l-term          = string
r-term          = string
host-term       = string
port-term       = string
servinfo-term   = string
prot-term       = string ; the protocol of the referral
string          = <UNICODE-2-0-UTF-8> / <UNICODE-1-1-UTF-8> /
               <ISO-8859-1>
```

5.6.2 Translation from Web query to DAG/IP

Querying a DAG-SAP Directly

If the transaction variable is "chain", the information in the POST is used to pursue a particular referral, not do a search of the Referral Index. The appropriate DAG-SAP (deduced from the prot-term) is contacted and issued the query directly.

Results from this type of query are always full results (i.e., not referrals).

Querying the Referral Index

A key element of translating from the Web DAG-CAP input into the DAG/IP query format is to "tokenize" the input terms into single token elements for the DAG/IP query. For example, the n-term

name= thinking cat

is tokenized into 2 n-tokens:

thinking
cat

which are then mapped into the following in the DAG/IP query (dag-n-terms):

FN=thinking and FN=cat

The same is true for the r-term, l-term and o-term.

The primary steps in translating the HTTP input into a DAG/IP query are:

translate encodings, if necessary
tokenize the strings for each term
construct the DAG/IP query from the resulting components, as described in more detail below

DAG/IP constraints are constructed from the searchtype information in the query.

```
dag-matchtype = "search=" <matchtype> /
             "search=substring"     ; if matchtype not
                                    ; specified

dag-casetype  = "case=ignore"  /       ; if casetype not
                                    ; specified or
                                    ; casetype="case ignore"
             "case=consider"        ; if casetype=
                                    ; "case sensitive"

constraints   = ":" dag-matchtype ";" dag-casetype
```

The terms for the DAG/IP query are constructed from the tokenized strings from the HTTP post input.

```
dag-n-terms   = "FN=" n-token 0*( " and FN=" n-token)
dag-o-terms   = "ORG=" o-token 0*( " and ORG=" o-token)
dag-l-terms   = "LOC=" l-token 0*( " and LOC=" l-token)
dag-r-terms   = "ROLE=" r-token 0*( " and ROLE=" r-token)
```

This means that the relevant DAG/IP queries are formulated as one of two types:

```
dagip-query   = ( ( ( n-query / nl-query / no-query / nol-query )
                    [" and template=DAGPERSON"]":" dag-matchtype
                    ";" dag-casetype) /
                ( ( ro-query / rol-query )
                    [" and template=DAGORGROLE"]":" dag-matchtype
                    ";" dag-casetype)  )

n-query       = dag-n-terms
```

```
nl-query      = dag-n-terms " and " dag-l-terms
no-query      = dag-n-terms " and " dag-o-terms
nol-query     = dag-n-terms " and " dag-o-terms " and "
             dag-l-terms
ro-query      = dag-r-terms " and " dag-o-terms
rol-query     = dag-r-terms " and " dag-o-terms " and "
             dag-l-terms
```

Querying a DAG-SAP

In querying a DAG-SAP (irrespective of the protocol of that DAG-SAP), the DAG/IP query must include information about the target WDSP server. This information is drawn from the Referral Index SERVER-TO-ASK referral information, and is appended to the query as specified in Appendix C:

```
":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset
```

where the response from the Referral Index included:

```
"# SERVER-TO-ASK " serverhandle <NL>
" Server-info: " serverinfo <NL>
" Host-Name: " hostname <NL>
" Host-Port: " number <NL>
" Protocol: " prot <NL>
" Source-URI: " source <NL>
" Charset: " charset <NL>
"# END" <NL>
```

and the "quoted-hostname" and "quoted-serverinfo" are obtained from "hostname" and "serverinfo" respectively, by quoting the DAG/IP special characters.

For example, the referral

```
# SERVER-TO-ASK dagsystem01<NL>
 Server-info: o=thinkingcat, c=se<NL>
 Host-Name: thinkingcat.com<NL>
 Host-Port: 2839<NL>
 Protocol: ldapv2<NL>
 Source-URI: http://www.thinkingcat.com
 Charset: T.61<NL>
# END<NL>
```

would yield the addition

:host=thinkingcat\.com;port=2839;server-info=o\=thinkingcat\,\
c\=se;charset=T\.61

in its query to an LDAPv2 DAG-SAP

(N.B.: See Appendix C for further definitions of the terms used in the SERVER-TO-ASK response).

Note that it is the DAG-SAP's responsibility to extract these terms from the query and use them to identify the WDSP server to be contacted. See the individual DAG-SAP definitions, below.

5.6.3 Chaining queries in Web DAG-CAP

If the resulttype was "all", all of the referrals received from the Referral Index are chained using the appropriate DAG-SAPs. If only referrals were requested, the Referral Index results are returned.

5.6.4 Expression of results in Web DAG-CAP

text/html results

The default response encoding is text/html. If the resulttype was "all", the content of the chaining responses from the DAG-SAPs, without the system messages, is collated into a single page response, one result entry per demarcated line (e.g., bullet item). The FN or ROLE value should be presented first and clearly. The SOURCE URI for each WDSP referral should be presented as an HREF for each of the WDSPs results.

At the end of the message, the WDSP servers that failed to respond (i.e., the DAG-SAP handling the referral returned the "% 403 Information Unavailable" message) are listed with their server-info.

If, however, the resulttype was "referrals", the results from the Referral Index are returned as HREF URLs to the Web DAG-CAP itself, with the necessary information to carry out the query (including the "HOST=", etc, for the referral).

For example, if the original query:

n-term="thinking cat"
resulttype="referrals"

drew the following referral from the Referral Index:

SERVER-TO-ASK DAG-Serverhandle<NL>
Server-Info: c=se, o=tce<NL>

```
 Host-Name: answers.tce.com<NL>
 Host-Port: 1111<NL>

 Protocol: ldapv3<NL>
 Source-URI: http://some.service.se/
 Charset: UTF-8<NL>
# END<NL>
```

the response would be an HTML page with an HREF HTTP "POST" URL to the Web DAG-CAP with the following variables set:

```
n-term="thinking cat"
transaction="chain"
servinfo-term="c=se, o=tce"
host-term="answers.tce.com"
port-term="1111"
prot-term="ldapv3"
```

The Source-URI should be established in the response as its own HREF URI.

application/whoispp-response Results

If Accept-Encoding: " HTTP request header had the value "application/whoispp-response", the content of the HTTP response will be constructed in the same syntax and attribute mapping as for the Whois++ DAG-CAP.

If the resulttype was "all", all the referrals will have been chained by the Web DAG-CAP, and the response will include only full data records.

If the resulttype was "referrals", then all referrals are passed directly back in a single response, in correct Whois++ referral format (conveniently, this is how they are formulated in the DAG/IP). Note that this will include referrals to LDAP-based services as well as Whois++ servers.

5.6.5 Expression of Errors in Web DAG-CAP

A Web DAG-CAP may redirect a connection to another web DAG-CAP for reasons of load-balancing. This is done simply by using an HTTP redirect.

Standard Errors

If the web DAG-CAP receives a message that is not parsable using the query grammar described above, it sends an explanatory HTML page saying that the query could not be interpreted, and giving a description of valid queries.

If the number of referrals sent by the Referral Index is greater than the pre-determined maximum (for detecting data-mining efforts, or otherwise refusing over-general queries, such as "FN=svensson"), the web DAG-CAP will send a page with an explanatory message describing the "over-generalized query" problem, suggesting the user resubmit a more precise query, and describing the list of valid query types.

If the web DAG-CAP receives more than one result code from the DAG-SAPs, it must represent them all in a appropriate manner in the response.

application/whoispp-response Errors

An invalid query is responded to with a simple text response with the error: "% 500 Syntax Error".

If too many referrals are generated from the Referral Index, the simple text response will have the message "% 503 Query too general".

5.7 Whois++ DAG-CAP

TISDAG: The system commands polled-for/-by should elicit the empty set as a return value until we better understand the implications of doing otherwise.

5.7.1 Whois++ DAG-CAP Input

Input to the Whois++ DAG-CAP follows the Whois++ standard ([6]). Minimally, the Whois++ DAG-CAP must support the following queries:

Query Type	Expression in Whois++
N	One or more "name=" and template=USER
NL	One or more "name=" and One or more "address-locality=" and template=USER
NO	One or more "name=" and one or more "organization-name=" and template=USER

NOL	One or more "name=" and one or more "organization-name=" and one or more "address-locality=" and template=USER
RO	One or more "org-role=" and one or more "organization-name=" and template=ORGROLE
ROL	One or more "org-role=" and one or more "organization-name=" and one or more "address-locality=" and template=ORGROLE

Table 5.1 Allowable Whois++ Queries

The following constraints must be supported for queries:

"search=" (substring / exact)
"case=" (ignore / consider)

If no constraints are defined in a query the default is exact and ignore. For example,

FN=foo and loc=kista and fn=bar<NL>

is a perfectly valid Whois++ NL query for "Foo Bar" in "Kista".

5.7.2 Translation from Whois++ query to DAG/IP

Querying the Referral Index

The Whois++ DAG-CAP formulates a DAG/IP query by forwarding the search terms received (as defined in Table 5.1).

For example, the above query would be expressed as:

FN=foo and LOC=kista and FN=bar and template=DAGPERSON<NL>

Querying a DAG-SAP

In querying a DAG-SAP (irrespective of the protocol of that DAG-SAP), the DAG/IP query must include information about the target WDSP server. This information is drawn from the Referral Index SERVER-TO-ASK referral information, and is appended to the query as specified in appendix C:

":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

where the response from the Referral Index included:

```
"# SERVER-TO-ASK " serverhandle<NL>
" Server-info: " serverinfo<NL>
" Host-Name: " hostname<NL>
" Host-Port: " number<NL>
" Protocol: " prot<NL>
" Source-URI: " source<NL>
" Charset: " charset<NL>
"# END"<NL>
```

and the "quoted-hostname" and "quoted-serverinfo" are obtained from "hostname" and "serverinfo" respectively, by quoting the DAG/IP special characters.

For example, the referral

```
# SERVER-TO-ASK dagsystem01<NL>
 Server-info: o=thinkingcat, c=se<NL>
 Host-Name: thinkingcat.com<NL>
 Host-Port: 2839<NL>
 Protocol: ldapv2<NL>
 Source-URI: http://www.thinkingcat.com/
 Charset: T.61<NL>
# END<NL>
```

would yield the addition

```
:host=thinkingcat\.com;port=2839;server-info=o\=thinkingcat\,\
c\=se;charset=T\.61
```

in its query to an LDAPv2 DAG-SAP.

(N.B.: See Appendix C for further definitions of the terms used in the SERVER-TO-ASK response).

Note that it is the DAG-SAP's responsibility to extract these terms from the query and use them to identify the WDSP server to be contacted. See the individual DAG-SAP definitions, below.

5.7.3 Chaining in Whois++ DAG-CAP

The Whois++ DAG-CAP relies on DAG-SAPs to chain any non-Whois++ referrals (currently, the LDAPv2 and LDAPv3 DAG-SAPs).

5.7.4 Expression of results in Whois++

Results are expressed in Whois++ by collating the DAG/IP results received from DAG-SAPs (using the FULL response), and using the template and attribute mappings defined in Appendix B. For each result from a given referral, the SOURCE attribute is added, with the value of the SOURCE-URI from the referral.

Any referrals to other Whois++ servers provided by the Referral Index are sent directly to the Whois++ client as follows:

```
server-to-ask   =   "# SERVER-TO-ASK " DAG-Serverhandle<NL>
                  " Server-Handle: " SERVER-INFO<NL>
                  " Host-Name: " HOST<NL>
                  " Host-Port: " PORT<NL>
                  " Protocol: " PROTOCOL<NL>
                  "# END"<NL>
```

where SERVER-INFO, HOST, PORT, PROTOCOL are drawn from the referral provided in the DAG/IP, and the SOURCE-URI information is lost.

5.7.5 Expression of Errors in Whois++ DAG-CAP

As appropriate, the Whois++ DAG-CAP will express operational errors following the Whois++ standard. There are 4 particular error conditions of the DAG system that the DAG-CAP will handle as described below.

When the Whois++ DAG-CAP receives a query that it cannot reply to within the (data) constraints of the DAG, it sends an error message and closes the connection. The error message includes

% 502 Search expression too complicated<NL>

If the number of referrals sent by the Referral Index is greater than the pre-determined maximum (for detecting data-mining efforts, or otherwise refusing over-general queries, such as "FN=svensson"), the Whois++ DAG-CAP will send an error message and close the connection. The error message includes

% 503 Query too general<NL>

(N.B.: this is different from the "Too many hits" reply, which does send partial results.)

A Whois++ DAG-CAP may redirect a connection to another Whois++ DAG-CAP for reasons of load-balancing. This is expressed to the end-user client software using the SERVER-TO-ASK response with appropriate information to reach the designated alternate DAG-CAP.

If a Whois++ DAG-CAP receives several different response codes from DAG-SAPs it should try to represent them all in the response to the end-user client.

The proposed mapping between DAG/IP response codes and Whois++ response codes are given in Appendix D.

5.8 LDAPv2 DAG-CAP

5.8.1 LDAPv2 DAG-CAP Input

Input to the LDAPv2 DAG-CAP follows the LDAPv2 standard ([19]). Minimally, the LDAPv2 DAG-CAP must support the following queries (adapted from the ASN.1 grammar of the standard):

```
BindRequest ::=
      [APPLICATION 0] SEQUENCE {
                  version   INTEGER (1 .. 127),
                  name      LDAPDN,
                  authentication CHOICE {
                        simple        [0] OCTET STRING,
                        krbv42LDAP    [1] OCTET STRING,
                        krbv42DSA     [2] OCTET STRING
                   }

      }

BindResponse ::= [APPLICATION 1] LDAPResult

SearchRequest ::=
 [APPLICATION 3] SEQUENCE {
     baseObject    "dc=se",
     scope         wholeSubtree          (2),
     derefAliases  ENUMERATED {
                  neverDerefAliases     (0),
                  derefInSearching      (1),
                  derefFindingBaseObj   (2),
                  derefAlways           (3)
     },
     sizeLimit     INTEGER (0 .. maxInt),
     timeLimit     INTEGER (0 .. maxInt),
     attrsOnly     BOOLEAN,
     filter        Filter,
```

```
        attributes    SEQUENCE OF AttributeType
    }

    Filter ::=
     CHOICE {
        and               [0] SET OF Filter,
        or                [1] SET OF Filter,
        not               [2] Filter,
        equalityMatch     [3] AttributeValueAssertion,
        substrings        [4] SubstringFilter
     }

    SubstringFilter ::=
     SEQUENCE {
        type              AttributeType,
        SEQUENCE OF CHOICE {
            initial       [0] LDAPString,
            any           [1] LDAPString,
            final         [2] LDAPString
        }
     }
```

Queries against attributes in the prescribed LDAP standard schema (see Appendix B) are accepted.

N.B., this is a minimal set of supported queries, to achieve the basic DAG-defined queries. An LDAP DAG-CAP may choose to support more complex queries than this, if it undertakes to do the translation from the DAG/IP to the LDAPv2 client in a way that responds to the semantics of those queries.

> TISDAG: Since LDAPv2 didn't specify any characterset but relied on X.500 to do so, in practice several different charactersets are in use in Sweden today. That the LDAPv2 CAP has no way of knowing which characterset that are in use by a connecting client is a problem that the TISDAG project can not solve.
>
> Users of the DAG system will have to configure their specific client according to information on the TISDAG web page. That page provides very specific information (including port number) that can be given to LDAPv2 users. The LDAP DAG-CAP listening on the default port (389) will be the LDAPv3 one.

5.8.2 Translation from LDAPv2 query to DAG/IP

Querying the Referral Index

The essential stratagem for mapping LDAP queries into DAG/IP Referral Index queries is to tokenize the string-oriented LDAP AttributeValueAssertions or SubstringFilters and construct an appropriate DAG/IP token-oriented query in the DAG/IP. This will generalize the LDAP query and yield false-positive referrals, but should not miss any appropriate referrals.

There are 3 particular cases to be considered:

equalityMatch queries
substring queries
combination equalityMatch and substring queries

> TISDAG: If the LDAP filter contains a cn-term and no objectclass specification it is unclear if the search is for a person or a role. When this happens the DAG query should cover all bases and map the query into a query for both people and roles.

EqualityMatch queries can be handled by simply tokenizing the AttributeValueAssertions, making one DAG/IP query term per token (using the appropriate DAGSchema attribute) and carrying out an exact match in the DAG/IP.

Consider the following example, represented in the ASCII expression of LDAP Filters as described in [13]):

(& (cn=Foo Bar)(objectclass=inetOrgPerson))

This query can be represented in the DAG/IP as

FN="Foo" and FN="Bar":search=exact<NL>

N.B.
The search is set up to be "case=ignore" (the DAG/IP's default) because the relevant LDAP schema attributes are all derivatives of the "name" attribute element, which is defined to have a case insensitive match.

If no objectclass were defined the query in DAG/IP would have been

(FN="Foo" and FN="bar") or (ROLE="Foo" and ROLE="bar"):search=exact

inetOrgPerson is used as the objectclass in this and the following examples, although person or organizationalPerson could also have been used.

This query will yield false-positive referrals; the original LDAP query should only match against records for which the "cn" attribute is exactly the phrase "Foo Bar", whereas the DAG/IP query will yield referrals any WDSP containing records that include the two tokens "foo" and "bar" in any order.

For example, this DAG/IP query will yield referrals to WDSPs with records including:

cn: Bar Foo
cn: Le Bar Foo
cn: Foo Bar AB

LDAP substring queries must also be tokenized in order to construct a DAG/IP query. The additional point to bear in mind is that LDAP substring expressions are directed at phrases, which obscure potential token boundaries. Consequently, all points between substring components must be considered as potential token boundaries.

Thus, the LDAP query

(& (cn=black) (o=c*t) (objectclass=inetOrgPerson))

could be expressed as a DAG/IP query with 3 tokens, in a substring search:

FN=black and ORG=c and ORG=t:search=substring<NL>

This query will yield false-positive results as the tokenized query does not preserve the order of appearance in the LDAP substring, and it doesn't preserve phrase-boundaries. That is,

ORG=c and ORG=t:search=substring

will match

tabacco

which is not a match by the LDAP query semantics.

Combined EqualityMatch and Substring queries need special attention. When an LDAP query includes both EqualityMatch components and substring filter components, the DAG/IP query to the Referral Index

can be constructed by following the same mechanisms of tokenization, but the whole search will become a substring search, as the DAG/IP defines only search types across the entire query for Referral Index queries.

Thus,

(& (cn=Foo Bar) (o=c*t) (objectclass=inetOrgPerson))

can be expressed as

FN=Foo and FN=Bar and ORG=c and ORG=t:search=substring<NL>

Alternatively, the LDAP DAG-CAP could conduct two separate queries and take the intersection (the logical "AND") of the two sets of referrals returned by the Referral Index.

Note that DAG/IP can accept phrases for searches -- the query

FN=Foo\ bar<NL> (note the escaped space)

is perfectly valid. However, it would match only those things which have been tokenized in a way that preserves the space, which is the empty set in the case of the data stored here.

Querying a DAG-SAP

It is never invalid to use the same substantive query to a DAG-SAP as was used to obtain referral information from the Referral Index. However, the over-generalization of these queries may yield excessive numbers of results, and will necessitate some pruning of results in order to match the returned results against the semantics of the original LDAP query. It is the LDAP DAG-CAP that is responsible for this pruning, as it is the recipient of the original query, and responsible for responding to its semantics.

In concrete terms, when making the DAG/IP query which is to be sent to a DAG-SAP the above mentioned queries are still valid queries, but an alternative finer-grained query is also possible, namely:

FN=foo and FN=bar and ORG=c;search=lstring and ORG=t;search=tstring

Particularly in the case of the LDAPv2 DAG-CAP, however, there will be cause to use LDAP(v2/v3) DAG-SAPs. Since these DAG-SAPs also deal in phrase-oriented data, a less-over-generalized query can be passed to them:

FN=Foo\ Bar:search=exact<NL>

In querying a DAG-SAP (irrespective of the protocol of that DAG-SAP), the DAG/IP query must include information about the target WDSP server. This information is drawn from the Referral Index SERVER-TO-ASK referral information, and is appended to the query as specified in Appendix C:

":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

where the response from the Referral Index included:

"# SERVER-TO-ASK " serverhandle<NL>
" Server-info: " serverinfo<NL>
" Host-Name: " hostname<NL>
" Host-Port: " number<NL>
" Protocol: " prot<NL>
" Source-URI: " source<NL>
" Charset: " charset<NL>
"# END<NL>

and the "quoted-hostname" and "quoted-serverinfo" are obtained from "hostname" and "serverinfo" respectively, by quoting the DAG/IP special characters.

For example, the referral

SERVER-TO-ASK dagsystem01<NL>
 Server-info: o=thinkingcat, c=se<NL>
 Host-Name: thinkingcat.com<NL>
 Host-Port: 2839<NL>
 Protocol: ldapv2<NL>
 Source-URI: http://www.thinkingcat.com <NL>
 Charset: T.61<NL>
END<NL>

would yield the addition

:host=thinkingcat\.com;port=2839;server-info=o\=thinkingcat\,\
c\=se;charset=T\.61

in its query to an LDAPv2 DAG-SAP.

(N.B.: See Appendix C for further definitions of the terms used in the SERVER-TO-ASK response).

Note that it is the DAG-SAP's responsibility to extract these terms from the query and use them to identify the WDSP server to be contacted. See the individual DAG-SAP definitions, below.

5.8.3 Chaining queries in LDAPv2 DAG-CAP

The LDAPv2 DAG-CAP relies on DAG-SAPs to resolve every referral.

5.8.4 Expression of results in LDAPv2

As described above, results from DAG-SAPs will have to be post-processed in cases where the original query was generalized for expression in DAG/IP.

Acceptable results are expressed in the LDAP search response:

```
SearchResponse ::=
 CHOICE {
      entry       [APPLICATION 4] SEQUENCE {
                objectName   LDAPDN,
                attributes   SEQUENCE OF SEQUENCE
                         {
                                  AttributeType,
                                  SET OF AttributeValue
                         }
                },
      resultCode  [APPLICATION 5] LDAPResult
 }
```

where

```
LDAPDN = DN / "cn=" (FN/ROLE) [",o="ORG] ",dc=se"
attributes = <all attributes mapped from DAG schema, and
                "objectClass = inetOrgPerson",
                "objectClass = top",
                "objectClass = person" or
                "objectClass = organizationalRole", as
                appropriate, and "labeledURI = <SOURCE-URI>"
                for each result from a given referral>
```

(Where DN,FN,ORG and ROLE are the values from the DAG schema).

I.e., where available, the entry's true DN is used; otherwise (e.g., for data coming from Whois++ servers), a reasonable facsimile is constructed.

5.8.5 Expression of Errors in LDAPv2 DAG-CAP

As appropriate, the LDAPv2 DAG-CAP will express system responses following the LDAPv2 standard.

Appendix D gives the proposed mapping between DAG/IP response codes and LDAPv2 resultcodes.

There are 4 particular error conditions of the DAG system that the DAG-CAP will handle as described below.

When the LDAPv2 DAG-CAP receives a query that it cannot reply to within the (data) constraints of the DAG queries, it sends an error message and closes the connection. The error message includes the LDAPv2 resultCode:

```
noSuchAttribute        (for incorrect schema attributes)
inappropriateMatching  (when a match type other than those
                        supported is used, e.g. approxMatch)
unwillingToPerform     (when the query is not one of the
                        defined types)
```

If the number of referrals sent by the Referral Index is greater than the pre-determined maximum (for detecting data-mining efforts, or otherwise refusing over-general queries, such as "FN=svensson"), the LDAPv2 DAG-CAP will send an error message. The error message includes one of the following resultCodes:

```
sizeLimitExceeded
timeLimitExceeded
```

An LDAPv2 DAG-CAP may redirect a connection to another LDAPv2 DAG-CAP for reasons of load-balancing. This is expressed to the end-user client software using the "umich referral" convention to direct the client software to an alternate DAG-CAP by passing the URL in an error message.

Since a LDAPv2 DAG-CAP only can send one resultcode back to a client; If a LDAPv2 DAG-CAP receives several different result codes from the DAG-SAPs it will have to construct a resultmessage that to some extent represents the combination of those. It is proposed that in these cases the following actions are taken:

- All the response codes are collected
- Each response code are translated into the corresponding LDAPv2 resultcode.
- A resultcode is chosen to represent the collected response on the following grounds:
  If "success" is the only resultcode represented after these steps the return that result code.
  If apart from "success" there is one other resultcode represented return that other resultcode.

If apart from "success" there are two or more resultcodes represented return the resultcode "other".

5.9 LDAPv3 DAG-CAP

5.9.1 LDAPv3 DAG-CAP Input

Input to the LDAPv3 DAG-CAP follows the LDAPv3 definition (currently defined in [17]). Minimally, the LDAPv3 DAG-CAP must support the following queries (adapted from the ASN.1 grammar of the standard):

```
BindRequest ::= [APPLICATION 0] SEQUENCE {

             version                 INTEGER (1 .. 127),
             name                    LDAPDN,
             authentication          AuthenticationChoice }

     AuthenticationChoice ::= CHOICE {
             simple                  [0] OCTET STRING,
                                      -- 1 and 2 reserved
             sasl                    [3] SaslCredentials }

     SaslCredentials ::= SEQUENCE {
             mechanism               LDAPString,
             credentials             OCTET STRING OPTIONAL }

BindResponse ::= [APPLICATION 1] SEQUENCE {
          COMPONENTS OF LDAPResult,
          serverSaslCreds    [7] OCTET STRING OPTIONAL }

SearchRequest ::= [APPLICATION 3] SEQUENCE {
     baseObject      c=se,
     scope           wholeSubtree            (2) },
     derefAliases    ENUMERATED {
             neverDerefAliases       (0),
             derefInSearching        (1),
             derefFindingBaseObj     (2),
             derefAlways             (3) },
      sizeLimit       INTEGER (0 .. maxInt),
     timeLimit       INTEGER (0 .. maxInt),
     typesOnly       BOOLEAN,
     filter          Filter,
     attributes      AttributeDescriptionList }
```

```
Filter ::= CHOICE {
     and             [0] SET OF Filter,
     or              [1] SET OF Filter,
     not             [2] Filter,
     equalityMatch   [3] AttributeValueAssertion,
     substrings      [4] SubstringFilter }

SubstringFilter ::= SEQUENCE {
     type            AttributeDescription,
     -- at least one must be present
     substrings    initial [0] LDAPString,
     substrings    any     [1] LDAPString,
     substrings    final   [2] LDAPString}
```

Queries against attributes in the proscribed LDAP standard schema (see Appendix B) are accepted.

N.B., this is a minimal set of supported queries, to achieve the basic DAG-defined queries. An LDAP DAG-CAP may choose to support more complex queries than this, if it undertakes to do the translation from the DAG/IP to the LDAPv3 client in a way that responds to the semantics of those queries.

5.9.2 Translation from LDAPv3 query to DAG/IP

Querying the Referral Index

The essential stratagem for mapping LDAP queries into DAG/IP Referral Index queries is to tokenize the string-oriented LDAP AttributeValueAssertions or SubstringFilters and construct an appropriate DAG/IP token-oriented query in the DAGschema. This will generalize the LDAP query and yield false-positive referrals, but should not miss any appropriate referrals.

There are 3 particular cases to be considered:

equalityMatch queries
substring queries
combination equalityMatch and substring queries

> TISDAG: If the LDAP filter contains a cn-term and no objectclass specification it is unclear if the search is for a person or a role. When this happens the DAG query should cover all bases and map the query into a query for both people and roles.

EqualityMatch queries can be handled by simply tokenizing the AttributeValueAssertions, making one DAG/IP query term per token (using the appropriate DAGSchema attribute) and carrying out an exact match in the DAG/IP.

Consider the following example, represented in the ASCII expression of LDAP Filters as described in [13]):

(& (cn=Foo Bar)(objectclass=person))

This query can be represented in the DAG/IP as

FN="Foo" and FN="Bar":search=exact<NL>

N.B.
The search is set up to be "case=ignore" (the DAG/IP's default) because the relevant LDAP schema attributes are all derivatives of the "name" attribute element, which is defined to have a case insensitive match.

If no objectclass where defined the query in DAG/IP would have been

(FN="Foo" and FN="bar") or (ROLE="Foo" and ROLE="bar"):search=exact

Although person is used as objectclass in this and the following examples, inetOrgPerson or organizationalPerson could also have been used.

This query will yield false-positive referrals; the original LDAP query should only match against records for which the "cn" attribute is exactly the phrase "Foo Bar", whereas the DAG/IP query will yield referrals any WDSP containing records that include the two tokens "foo" and "bar" in any order.

For example, this DAG/IP query will yield referrals to WDSPs with records including:

cn: Bar Foo
cn: Le Bar Foo
cn: Foo Bar AB

LDAP substring queries must also be tokenized in order to construct a DAG/IP query. The additional point to bear in mind is that LDAP substring expressions are directed at phrases, which obscure potential token boundaries. Consequently, all points between substring components must be considered as potential token boundaries.

Thus, the LDAP query

(& (cn=black) o=c*t) (objectclass=person))

should be expressed as a DAG/IP query with 3 tokens, in a substring search:

FN=black and ORG=c and ORG=t:search=substring<NL>

This query will yield false-positive results as the tokenized query does not preserve the order of appearance in the LDAP substring, and it doesn't preserve phrase-boundaries. That is,

ORG=c and ORG=t:search=substring

will match

tabacco

which is not a match by the LDAP query semantics.

Combined EqualityMatch and Substring queries need special attention. When an LDAP query includes both EqualityMatch components and substring filter components, the DAG/IP query to the Referral Index can be constructed by following the same mechanisms of tokenization, but the whole search will become a substring search, as the DAG/IP defines search types across the entire query.

Thus,

(& (cn=Foo Bar) (o=c*t) (objectclass=person))

can be expressed as

FN=Foo and FN=Bar and ORG=c and ORG=t:search=substring<NL>

Alternatively, the LDAP DAG-CAP could conduct two separate queries and take the intersection (the logical "AND") of the two sets of referrals returned by the Referral Index.

Note that DAG/IP can accept phrases for searches -- the query

FN=Foo\ bar<NL> (note the escaped space)

is perfectly valid. However, it would match only those things which have been tokenized in a way that preserves the space, which is the empty set in the case of the data stored here.

Querying a DAG-SAP

It is never invalid to use the same substantive query to a DAG-SAP as was used to obtain referral information from the Referral Index. However, the over-generalization of these queries may yield excessive numbers of results, and will necessitate some pruning of results in order to match the returned results against the semantics of the original LDAP query. It is the LDAP DAG-CAP that is responsible for this pruning, as it is the recipient of the original query, and responsible for responding to its semantics.

In concrete terms, when making the DAG/IP query which is to be sent to a DAG-SAP the above mentioned queries are still valid queries, but an alternative finer-grained query is also possible, namely:

FN=foo and FN=bar and ORG=c;search=lstring and ORG=t;search=tstring

In querying a DAG-SAP (irrespective of the protocol of that DAG-SAP), the DAG/IP query must include information about the target WDSP server. This information is drawn from the Referral Index SERVER-TO-ASK referral information, and is appended to the query as specified in Appendix C):

"host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

where the response from the Referral Index included:
"# SERVER-TO-ASK " serverhandle <NL>
" Server-info: " serverinfo<NL>
" Host-Name: " hostname<NL>
" Host-Port: " number<NL>
" Protocol: " prot<NL>
" Source-URI: " source<NL>
" Charset: " charset<NL>
"# END"<NL>

and the "quoted-hostname" and "quoted-serverinfo" are obtained from "hostname" and "serverinfo" respectively, by quoting the DAG/IP special characters.

For example, the referral

SERVER-TO-ASK dagsystem01<NL>
Server-info: o=thinkingcat, c=se<NL>
Host-Name: thinkingcat.com<NL>
Host-Port: 2839<NL>
Protocol: ldapv2<NL>
Source-URI:http://www-thinkingcat.se/

```
 Charset: T.61<NL>
# END<NL>
```

would yield the addition

```
:host=thinkingcat\.com;port=2839;server-info=o\=thinkingcat\,\
c\=se;charset=T\.61
```

in its query to an LDAPv2 DAG-SAP.

(N.B.: See Appendix C for further definitions of the terms used in the SERVER-TO-ASK response).

Note that it is the DAG-SAP's responsibility to extract these terms from the query and use them to identify the WDSP server to be contacted. See the individual DAG-SAP definitions, below.

5.9.3 Chaining queries in LDAPv3 DAG-CAP

The LDAPv3 DAG-CAP relies on DAG-SAPs to resolve all referrals except those to LDAPv3 servers (i.e., Whois++ referrals, currently).

5.9.4 Expression of results in LDAPv3

As described above, results from DAG-SAPs will have to be post-processed in cases where the original query was generalized for expression in DAG/IP. Acceptable results are expressed in LDAPv3 messages containing search result entries (see the standard for more detail):

```
SearchResultEntry ::= [APPLICATION 4] SEQUENCE {
     objectName      LDAPDN,
     attributes      PartialAttributeList }

PartialAttributeList ::= SEQUENCE OF SEQUENCE {
     type    AttributeDescription,
     vals    SET OF AttributeValue }

SearchResultReference ::= [APPLICATION 19] SEQUENCE OF LDAPURL
-- at least one LDAPURL element must be present

SearchResultDone ::= [APPLICATION 5] LDAPResult

where

LDAPDN = DN / "cn=" (FN/ROLE) [",o=" ORG] ",dc=se"
```

```
attributes = <all attributes mapped from the DAG schema, and
               "objectClass = inetOrgPerson",
               "objectClass = person",
               "objectClass = top" or
               "objectClass = organizationalRole", as
               appropriate, and "labeledURI = <SOURCE-URI>"
               for each result from a given referral>
LDAPResult = success
```

(Where DN, FN, ROLE, and ORG are the values from the DAG schema).

I.e., where available, the entry's true DN is used; otherwise (e.g., for data coming from Whois++ servers), a reasonable facsimile is constructed.

Referral URLs are constructed from the DAG/IP's SERVER-TO-ASK information as follows:

```
refurl = "ldap://" HOST [":" PORT] "/" (SERVER-INFO / "dc=se")
```

The intention is that WDSPs using LDAPv3 servers will provide an appropriate LDAPDN for their server in the SERVER-INFO. Clients are then expected to repeat their query at the server designated by this URL (i.e., the refURL does not include the query).

5.9.5 Expression of Errors in LDAPv3 DAG-CAP

As appropriate, the LDAPv3 DAG-CAP will express operational errors following the LDAPv3 standard. There are 4 particular error conditions of the DAG system that the DAG-CAP will handle as described below.

When the LDAPv3 DAG-CAP receives a query that it cannot reply to within the (data) constraints of the DAG queries, it sends an error message and closes the connection. The error message includes the LDAPv3 resultCode

```
noSuchAttribute        (for incorrect schema attributes chosen)
inappropriateMatching  (when a match type other than those
supported is used e.g., approxMatch)
unwillingToPerform     (when the query is not one of the defined
types)
```

If the number of referrals sent by the Referral Index is greater than the pre-determined maximum (for detecting data-mining efforts, or otherwise refusing over-general queries, such as "FN=svensson"), the LDAPv3 DAG-CAP will send an error message. The error message includes the following resultCode:

adminLimitExceeded

An LDAPv3 DAG-CAP may redirect a connection to another LDAPv3 DAG-CAP for reasons of load-balancing. In this case, the LDAPv3 DAG-CAP sends a result message including only

SearchResultReference ::= [APPLICATION 19] AltURL

SearchResultDone ::= referral

where

AltURL = "ldap://" <althostport> ":" <altbase>

Since a LDAPv3 DAG-CAP only can send one resultcode back to a client; If a LDAPv3 DAG-CAP receives several different result codes from the DAG-SAPs it will have to construct a resultmessage that to some extent represents the combination of those. It is proposed that in these cases the following actions are taken:

- All the response codes are collected
- Each response code are translated into the corresponding LDAPv3 resultcode.
- A resultcode is chosen to represent the collected response on the following grounds:
  If "success" is the only resultcode represented after these steps the return that result code.
  If apart from "success" there is one other resultcode represented return that other resultcode.
  If apart from "success" there are two or more resultcodes represented return the resultcode "other".

5.10 Whois++ DAG-SAP

5.10.1 Input

The Whois++ DAG-SAP expects valid DAG/IP communications. Queries must include referral information (see below) and search terms that conform to the DAG-allowed query types (e.g., not searches for organization alone, etc).

The referral information is added to the end of the DAG-SAP query, as defined in the DAG-CAP definition sections:

":host=" quoted-hostname ";port=" number ";server-info=" quoted-serverinfo ";charset=" charset

5.10.2 Translation from DAG/IP to Whois++ query

The HOST and PORT information are used to make a TCP/IP-based connection to the remote (presumed) Whois++ server. The query expressed to the remote Whois++ server is the remainder of the DAG/IP query the Whois++ DAG-SAP received, with the following template ID translations:

template=DAGPERSON becomes template=USER

and

template=DAGROLE becomes template=ORGROLE

Additional mappings for attributes are defined in Appendix B.

Note that the search types used in the DAG/IP are not all required by the Whois++ syntax. Therefore, some Whois++ WDSPs may be using servers that do not support searches other than "exact" and "lstring" (the search types required by the Whois++ protocol standard). The Whois++ DAG-CAP may

- send the DAG/IP query as constructed (e.g., with "search=substring"), and pass back the "% 502 Search expression too complicated" from the WDSP's server,
- translate the DAG/IP query into a construct using only these search types (which will yield incomplete results, as not all queries are expressible with those search types),
- attempt to ascertain what search types are supported by the remote server and reformulate using them (e.g., regular expressions). This would work, but would entail an excessively complicated Whois++ DAG-SAP, and might not yield any better results if the remote server doesn't support any optional search types.

5.10.3 Translation of Whois++ results to DAG/IP

Any referrals that the remote WDSP server returns are pursued, following the usual Whois++ (client) fashion, by the Whois++ DAG-SAP.

If it is not possible to establish a Whois++ session with the remote server, or if the session is interrupted, before results are received, the DAG-SAP will itself return no results and an error message, including

% 403 Information Unavailable<NL>

If the remote server issues any other Whois++ error message and does not yield any results, the remote server's error message will be included in the DAG-SAP's own error message; no results will be returned.

If results are successfully received from the remote server, they will be expressed using the DAG/IP -- essentially passing through all FULL response information received from the remote server, mapped into the DAGSchema using the mappings defined in Appendix A.

5.11 LDAPv2 DAG-SAP

5.11.1 Input

The LDAPv2 DAG-SAP expects valid DAG/IP communications. Queries must include referral information (see below) and search terms that conform to the DAG-allowed query types (e.g., not searches for organization alone, etc).

The referral information is added to the end of the DAG-SAP query, as defined in the DAG-CAP definition sections (as additional terms in the DAG/IP query):

":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

5.11.2 Translation from DAG/IP to LDAPv2 query

The HOST and PORT information are used to make a TCP/IP-based connection to the remote (presumed) LDAPv2 server. The DAG-SAP will establish a connection with the remote server, following standard LDAPv2 message exchanges.

The search request itself will be constructed from the DAG/IP query (without the HOST, SERVER-INFO and PORT terms) as follows:

```
SearchRequest ::=
 [APPLICATION 3] SEQUENCE {
     baseObject    LDAPDN,  -- from the DAG/IP query
     scope         baseObject            (0) },
     derefAliases  ENUMERATED {
                           neverDerefAliases     (0),
                           derefInSearching      (1),
                           derefFindingBaseObj   (2),
                           derefAlways           (3)

                       },
     sizeLimit     INTEGER (0 .. maxInt),
```

```
        timeLimit     INTEGER (0 .. maxInt),
        attrsOnly     FALSE
        filter        Filter,
        attributes    SEQUENCE OF AttributeType
                           -- all DAGschema attributes
                              equivalents in  the defined
                              standard LDAP schema
   }

   Filter ::=
    CHOICE {
        and               [0] SET OF Filter,
        or                [1] SET OF Filter,
        not               [2] Filter,
        substrings        [4] SubstringFilter,
    }

   SubstringFilter
    SEQUENCE {
        type              AttributeType,

        SEQUENCE OF CHOICE {
        substrings    initial [0] LDAPString,
        substrings    any     [1] LDAPString,
        substrings    final   [2] LDAPString}
    }
```

where and, or and not filters are constructed to preserve the logic of the DAG/IP query.

For the purposes of matching token-based DAG/IP queries to reasonable LDAP queries, all searches should be passed to the LDAP WDSP as substring searches. The WDSP results must then be pruned to respect token boundaries, where necessary.

So, for example, the DAG/IP query

FN=Foo\ Bar and ORG=Thinking\ Cat:search=substring<NL>

would be sent to the designated LDAP WDSP as

(& (fn=*Foo Bar*) (o=*Thinking Cat*) (objectclass=person))

Interestingly, the query

FN=Foo\ Bar and ORG=Thinking\ Cat:search=exact<NL>

would also be sent to the designated LDAP WDSP as

(& (fn=*Foo Bar*) (o=*Thinking Cat*) (objectclass=person))

but the WDSPs returned results would have to be pruned to remove any results that had non-tokenizing characters on either side of "Foo Bar" and "Thinking Cat".

The final consideration for mapping DAG/IP queries into LDAP queries is the issue of character case. In LDAP, individual attribute syntaxes define the consideration of case. All of the attributes used here are case-insensitive in their definitions. Therefore, all LDAP WDSP queries are inherently case-insensitive; if the DAG/IP query calls for a case-sensitive match, the LDAP DAG-SAP will have to do pruning of the results from the DAG-SAP.

5.11.3 Translation of LDAPv2 results to DAG/IP

If it is not possible to establish an LDAPv2 session with the remote server, or if the session is interrupted before results are received, or if the remote server issues any kind of error message and produces no result, the DAG-SAP will itself return no results and an error message, including

% 403 Information Unavailable<NL>

If results are successfully received from the remote server, the attributes and values that are provided for each result message will be incorporated into the DAG/IP result, according to the schema mappings laid out in Appendix B.

One particular adjustment must be done to accommodate differences between LDAP and the DAG/IP. The attributes on which searches are keyed ("cn", "l", and "o" in the LDAP schemas) are all defined as being case-insensitive for equality matching. Thus, if the DAG/IP query includes the constraint "case=consider", the results from the remote server must be post-processed to remove any wrong-cased ones.

TISDAG: The serverhandle and localhandle in the DAG/IP response should be constructed as follows:

serverhandle is: <hostname-without-periods><port> (because server DN's are not enforceably unique). E.g., a services.bunyip.com server on 7778 would become servicesbunyipcom7778.
localhandle is: the RDN (relative distinguished name), with spaces replaced by "_". E.g., cn=leslie_daigle

5.12 LDAPv3 DAG-SAP

5.12.1 Input

The LDAPv3 DAG-SAP expects valid DAG/IP communications. Queries must include referral information (see below) and search terms that conform to the DAG-allowed query types (e.g., not searches for organization alone, etc).

The referral information is added to the end of the DAG-SAP query, as defined in the DAG-CAP definition sections:

":host=" quoted-hostname ";port=" number ";server-info="
quoted-serverinfo ";charset=" charset

5.12.2 Translation from DAG/IP to LDAPv3 query

The HOST and PORT information are used to make a TCP/IP-based connection to the remote (presumed) LDAPv3 server. The DAG-SAP will establish a connection with the remote server, following standard LDAPv3 message exchanges.

The search request itself will be constructed from the DAG/IP query (without the HOST, SERVER-INFO and PORT terms) as follows:

```
SearchRequest ::=
 [APPLICATION 3] SEQUENCE {
     baseObject    LDAPDN,  -- from the DAG/IP query
     scope         baseObject            (0) },
     derefAliases  ENUMERATED {
                             neverDerefAliases     (0),
                             derefInSearching      (1),
                             derefFindingBaseObj   (2),
                             derefAlways           (3)
                           },
     sizeLimit     INTEGER (0 .. maxInt),
     timeLimit     INTEGER (0 .. maxInt),
     attrsOnly     FALSE
     filter        Filter,
     attributes    SEQUENCE OF AttributeType
                   -- all DAGschema attributes equivalents in
                      the defined standard LDAP schema
}

Filter ::=
 CHOICE {
     and               [0] SET OF Filter,
     or                [1] SET OF Filter,
```

```
        not                [2] Filter,
        substrings         [4] SubstringFilter,
     }

   SubstringFilter
    SEQUENCE {
        type               AttributeType,
        SEQUENCE OF CHOICE {
        substrings    initial [0] LDAPString,
        substrings    any     [1] LDAPString,
        substrings    final   [2] LDAPString}
     }
```

where and, or and not filters are constructed to preserve the logic of the DAG/IP query.

For the purposes of matching token-based DAG/IP queries to reasonable LDAP queries, all searches should be passed to the LDAP WDSP as substring searches. The WDSP results must then be pruned to respect token boundaries, where necessary.

So, for example, the DAG/IP query

FN=Foo\ Bar and ORG=Thinking\ Cat:search=substring<NL>

would be sent to the designated LDAP WDSP as

(&(fn=*Foo Bar*)(o=*Thinking Cat*)(objectClass=person))

Interestingly, the query

FN=Foo\ Bar and ORG=Thinking\ Cat:search=exact<NL>

would also be sent to the designated LDAP WDSP as

(&(fn=*Foo Bar*)(o=*Thinking Cat*)(objectClass=person))

but the WDSP's returned results would have to be pruned to remove any results that had non-tokenizing characters on either side of "Foo Bar" and "Thinking Cat".

The final consideration for mapping DAG/IP queries into LDAP queries is the issue of character case. In LDAP, individual attribute syntaxes define the consideration of case. All of the attributes used here are case-insensitive in their definitions. Therefore, all LDAP WDSP queries are inherently case-insensitive; if the DAG/IP query calls for a case-sensitive match, the LDAP DAG-SAP will have to do pruning of the results from the DAG-SAP.

5.12.3 Translation of LDAPv3 results to DAG/IP

Any referrals that the remote WDSP server returns are pursued, following the usual LDAPv3 (client) fashion, by the LDAPv3 DAG-SAP.

If it is not possible to establish an LDAPv3 session with the remote server, or if the session is interrupted before results are received, or if the remote server issues any kind of error message and produces no result, the DAG-SAP will itself return no results and an error message, including

% 403 Information Unavailable<NL>

If results are successfully received from the remote server, the attributes and values that are provided for each result message will be incorporated into the DAG/IP result, which will be expressed using the DAG/IP and schema mappings as outlined in Appendix A.

One particular adjustment must be done to accommodate differences between LDAP and the DAG/IP. The attributes on which searches are keyed ("cn", "l", and "o" in the LDAP schemas) are all defined as being case-insensitive for equality matching. Thus, if the DAG/IP query includes the constraint "case=consider", the results from the remote server must be post-processed to remove any wrong-cased ones.

TISDAG: The serverhandle and localhandle in the DAG/IP response should be constructed as follows:

- serverhandle is: <hostname-without-periods><port> (because server DN's are not enforceably unique). E.g., a services.bunyip.com server on 7778 would become servicesbunyipcom7778.
- localhandle is: the RDN (relative distinguished name), with spaces replaced by "_". E.g., cn=leslie_daigle

5.13 Example Queries

The following sample end-user queries illustrate some of the more delicate steps of query/schema semantics translations in the DAG system.

N.B.: the data presented in these examples is often senseless, provided only to serve as illustrations of matching on word-ordering, case sensitivity, etc.

5.13.1 A Whois++ Query

What the Whois++ DAG-CAP Receives

In this example, the Whois++ DAG-CAP receives the following query:

name=thinking and name=cat:search=exact;case=consider<NL>

The expected answer can be described as:

Any USER templates that contain the tokens "thinking" and "cat" in a name attribute.

For example:

Different records:

name: the thinking cat
name: sublime cat thinking

or a single record with 2 or more name attributes

name: thinking felines
name: erudite cat

but not

name: Thinking Cat Enterprises

This last record would not match because the query called for case sensitivity, and the case of the name attribute’s value does not match the query.

What the Whois++ DAG-CAP sends to the Referral Index

After schema translation, this is sent to the Referral Index as:

fn=thinking and fn=cat:search=exact<NL>

What the Whois++ DAG-CAP Sends to an LDAP DAG-SAP

Note that the Whois++ DAG-CAP will never interact with a Whois++ DAG-SAP as the Whois++ referrals returned by the Referral Index are passed directly back to the Whois++ client.

The Whois++ DAG-CAP should send the same substantive query to the DAG-SAP as it sent to the Referral Index, except that it can include the case sensitivity constraint:

fn=thinking and fn=cat:search=exact;case=consider<NL>

which will be translated by the DAG-SAP into an LDAP query of the form:

(&(cn=*thinking*)(cn=*cat*)(objectclass=inetOrgPerson))

which will match a record with:

cn: Thinking
cn: Cat

(i.e., 2 different cn attributes, with the 2 values; LDAP defines case sensitivity matching by the schema attribute definition).

or a record with:

cn: I wish I had a thinking dog and a singing cat

The first record should be pruned by the LDAP DAG-SAP, in order to respect the semantics of the DAG/IP query.

5.13.2 An LDAP Query

What the LDAP DAG-CAP Receives

In this example, the LDAP DAG-CAP receives the following query (using RFC1960 notation):

(& (cn=th*c*t) (o=green groceries) (objectClass=person))

What the LDAP user is looking for, with this query, is all records within the "green groceries" organization that have a cn attribute starting with "th", ending with "t", and having a "c" somewhere in the middle.

cn values that would match this include:

cn: thinkingcat
cn: Thinking Cat
cn: The Black Cat
cn: Thick Mat

5.13.3 What the LDAP DAG-CAP sends to the Referral Index

The LDAP DAG-CAP must formulate a token-based query to the Referral Index that will not inadvertently exclude records that would match. The first challenge lies in the fact that the "*" characters in the LDAP string-based query can cover token-boundaries.

A suitable query to the Referral Index would be:

FN=th AND FN=C AND FN=T AND ORG=green AND
ORG=groceries:search=substring<NL>

This will generate some false positive referrals, directing the query to WDSPs containing records with the following attribute values (the match letters are in capitals for ease of identification):

cn: wiTH three blaCk poTs

o: peaGREEN and cyan GROCERIES
o: GROCERIES are GREENer than electronics

Alternative approaches include breaking the original query into several queries to the referral index in such a way that the DAG-CAP can use only those referrals that appear in all the Referral Index responses. However, this is

overkill -- the purpose of the Referral Index is to give direction on where there may be more information

difficult to code into the DAG-CAP in a general way -- it has to identify, by LDAP query type, when and how to do so

likely to generate Referral Index queries that are complex and time-consuming to process.

What the LDAP DAG-CAP Sends to a Whois++ DAG-SAP

The LDAP DAG-CAP may send the same query to a Whois++ DAG-SAP as it sent to the Referral Index. False positives here mean results that are not expected as a match by the LDAP client. The LDAP DAG-CAP should prune these results from the information returned by the Whois++ DAG-SAP.

Or it might rewrite the query into:

FN=th;search=lstring AND FN=C;search=substring AND
FN=T;search=tstring AND ORG=green AND ORG=groceries:case=ignore<NL>

What the LDAP DAG-CAP Sends to an LDAP DAG-SAP

As an architectural principle, it is never wrong to send the same query to a DAG-SAP as was formulated for the Referral Index. It is also noteworthy to keep in memory that all DAG-SAPs are handled equal by all DAG-CAPs therefore a LDAP DAG-CAP will not need to send a different query to a LDAP DAG-SAP then it would to any other DAG-SAP.

So in this case the LDAP DAP-CAP could either send the same query to the LDAP DAG-SAP as it sent to the Referral Index or it could send the augmented version that is allowed to be use with the DAG-SAPs, namely:

FN=th;search=lstring AND FN=C;search=substring AND
FN=T;search=tstring AND ORG=green\ groceries:case=ignore<NL>

Note that this will be translated, by the LDAP DAG-SAP, into a query of the form

(&(cn=*th*)(cn=*c*)(cn=*t*)(o=*green groceries*)
(objectClass=person))

which is still more general than the original query.

Note the translation from "FN=th;search=lstring" into "cn=*th*". This is necessary, as the DAG/IP lstring constraint is based on tokens, whereas "cn=th*" refers to the beginning of the attribute's value (phrase, not token). The DAG-SAP should therefore prune out any results that include things like "oTHer plaCes for visiTors" in order to match the semantics of the DAG/IP query it received.

The DAG-CAP should then prune those results to match the semantics of the original LDAP query.

6.0 Service Specifications

6.1 Overview

To satisfy the requirements laid out for the TISDAG project, the software built for the DAG system must be able to meet the following service specifications:

- primary designated DAG-CAPs of all types (but not necessarily secondary ones set up for load-balancing) must be available to provide service or redirect queries on a 7x24 basis.

- in general, responses to queries should be available in under 10 seconds; very generalized queries (i.e., when the user truly cannot specify enough information to focus the search) can be deferred to take much longer (having results is more important than having a quick answer)
- the data provided from each WDSP should be updated in the DAG at least once every 7 days

6.2 WDSP Participation

WDSPs who wish to participate in the DAG system do so by providing DAG-compatible access to their service, where DAG-compatible means:

- access in (exactly) one of LDAPv2, LDAPv3, or Whois++
  - 7x24 service for responding to referrals generated in the DAG core (minimally) weekly updates of the index object describing the information their service indexes
  - use of USER and ROLE templates for Whois++ servers
  - use of inetorgperson and organizationalrole objectclasses for LDAP servers

To participate, WDSPs must register each DAG-compliant server with the DAG system, providing details for each data set that it covers:

- the host, port and protocol of the server
  - an identifier for the dataset
  - a URL for the service of preference for accessing the data (preferred source)
  - protocol-specific information
  - administrative contact information
  - CIP object exchange information

Note that any WDSP wishing to make data available through the DAG system but unable to support these requirements may provide information through an agreement with a third-party which does meet these requirements. Thus, data can be replicated between cooperating WDSPs. The DAG referral index does not claim ownership of personal information; it directs queries to services that do, by whatever agreements with whichever relevant parties. Note that, in this case, the SOURCE-URI may direct end-users to the WDSP's existing services, not the service of the third party.

6.3 Load Distribution

It is anticipated that the DAG system will be quite popular, and measures must be available to distribute the load of answering queries.

The DAG system is presented as a conceptual whole, made up of several component parts -- DAG-CAPs, DAG-SAPs and the Referral Index. Each of these component parts must be replicable, and service must be shared between replicas.

It may be interesting to consider allowing large-scale service providers (large companies, ISPs) the ability to mirror the Referral Index or provide alternate DAG-CAPs/DAG-SAPs for their personnel/customers. Policies and possibilities for doing that are beyond the scope of this report; however, the software architecture has been designed to support such activity.

Figure 6.1 shows that individual components of the DAG system may each run on non-co-located server hardware, connected by TCP/IP networks. These components can be replicated as needed.

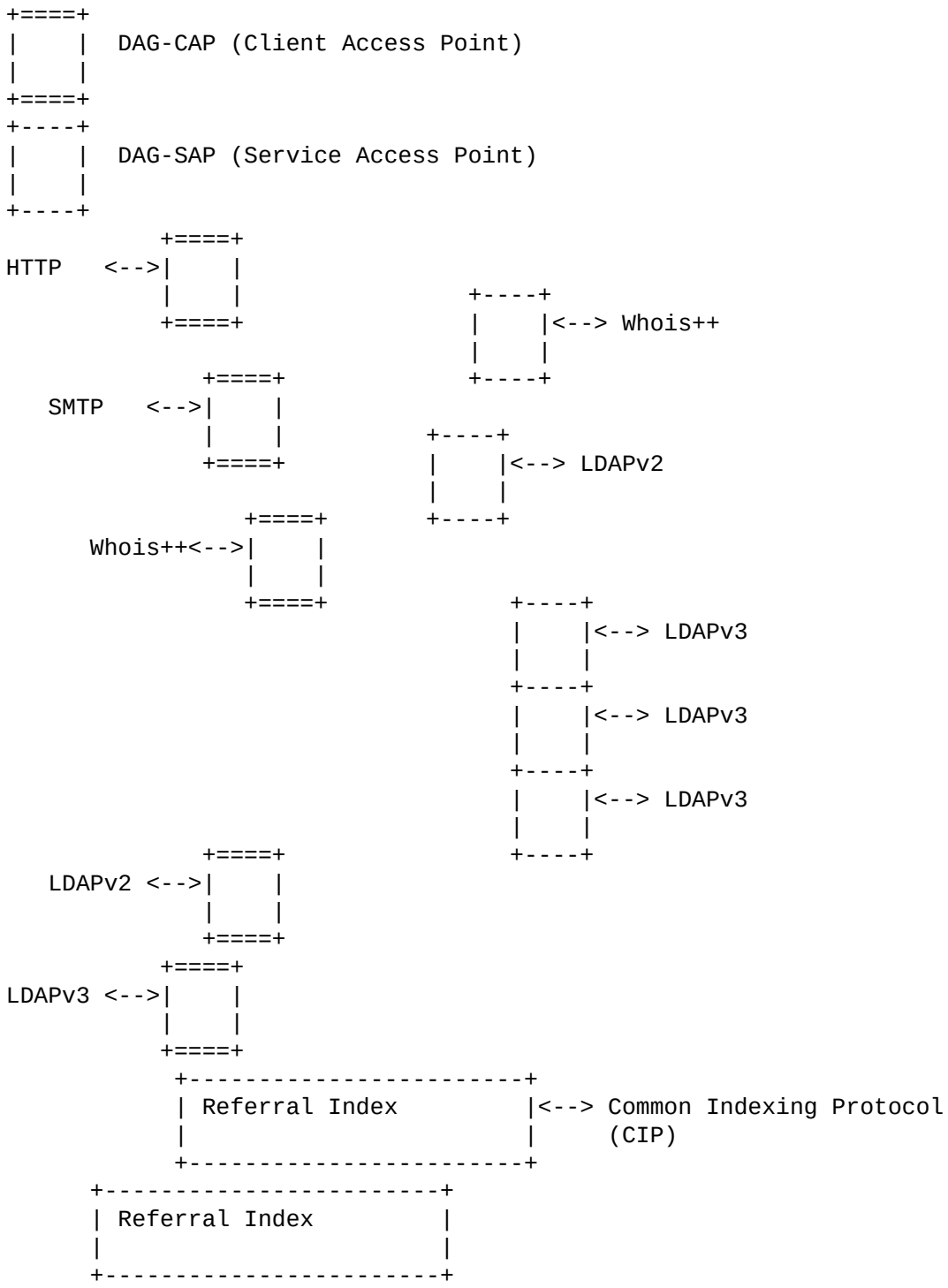


Figure 6.1 Distributable nature of DAG components

Thus, the software built to this specification must be configurable to permit the following actions:

- DAG-CAP software must be able to handle or redistribute the primary load. Depending on the DAG-CAP software, this may be handled by having multiple processes attending to incoming queries, or the DAG-CAP at the primary address for the protocol may be nothing more than a reflector that redirects incoming queries to the address of the least-loaded server at the moment.
- This is particularly necessary in synchronous connection protocols, such as Whois++ and LDAP, where the goal is to minimize the amount of time a requesting client is connected to the well-advertised address port.
- DAG-CAP software must be able to direct referrals to different DAG-SAPs of the same protocol type.
- DAG-CAP software must be able to detect overly general queries (i.e., have some metric to decide that the number of referrals generated by the Referral Index is too great).
- DAG-SAPs must be able to redirect DAG-CAP queries at their discretion, or just refuse service because of loading (therefore DAG-CAPs must also be able to find other DAG-SAPs)

6.4 Extensibility

The DAG system has been designed to allow for extensibility in certain key areas:

It is possible to add new DAG-CAPs and DAG-SAPs transparently. Beyond replicating the software of existing DAG-CAPs, new implementations for particular protocols (e.g., building a more elaborate mail-based query system), or implementations for altogether different protocols (e.g., PH) can be added by adhering to the basic principles of DAG-CAPs and DAG-SAPs defined in the software specification. The new DAG-CAP is responsible for the translation of queries into DAG/IP (post-processing results, if necessary) and results in the new protocol. No other part of the DAG system is affected.

More functionality may be added to the DAG system service (e.g., adding security certificate references to the schema of returned information) by updating the DAG schema.

Depending on how the load on the service goes, it may be interesting to consider reducing the number of queries that are chained for protocols that inherently can handle the concept of pursuing referrals. Specifically, LDAPv3 and Whois++ both handle referrals, but the current system calls for chaining LDAPv3 (and LDAPv2) referrals for the Whois++ DAG-CAP, and vice versa. Alternatively,

"virtual" DAG-CAPs could be established for each participating WDSP for each protocol the WDSP doesn't support, and referrals to those DAG-CAPs could be given to the calling client. For example, a Whois++ client would be given a Whois++ referral to the virtual Whois++ DAG-CAP for a WDSP that supports only LDAP. The importance of having one virtual DAG-CAP per WDSP is that the point of connection is the only way to distinguish which WDSP the Whois++ client thought it was connecting to.

7.0 Security

7.1 Information credibility

Security, in the context of "read-only" directory services, is primarily concerned with maintaining data integrity as it passes from an originating server to the end-user making an inquiry. That is, some server(s) hold correct user information, and a client accessing a directory service should be certain that whichever servers that the information has to pass through before reaching the client, it receives a true representation of the original information.

The DAG system as such MUST be completely invisible as the mediator of the information from the WDSPs to the querying directory access client. The only possible modifications that can appear is translations from one characterset into another. Hopefully, this does not alter the meaning of the information.

7.2 Unauthorized access

In keeping with the public nature of the proposed TISDAG service, the DAG system does not provide any access control system beyond components' configuration to accept connections from recognized other components. For more detailed access control, it is up to the connected WDSPs to apply the access control.

Since the DAG system only supports searching and retrieving information, no updates can occur through the DAG client access points.

Security in updates (CIP index objects) is provided by encryption and signature of objects from registered WDSPs.

8.0 Acknowledgments

This work came from ideas originally put forward by Patrik Faltstrom. The TISDAG project was supported by the Swedish KK Foundation.

Thanks to especially to Jens Lundstrom, Thommy Eklof, Bjorn Larsson and Sandro Mazzucato for their comments on draft versions of this document.

Appendix A - DAG Schema Definitions

The DAG makes use of 2 information schemas -- the DAGPERSON schema for information about specific people, and the DAGORGROLE schema for organizational roles that may or may not be job positions occupied by people at any given time (e.g., an organization's president, customer service desk, etc).

This appendix defines the schemas in terms of the attributes used within the DAG/IP. Mappings to the standard LDAP and Whois++ object classes and templates (respectively) are described in Appendix B.

Because the role of the DAG schemas is to act as an intermediary between information provided in different access protocols, with different underlying schema paradigms, the attributes in the schema are identified as being required or optional. The required attributes are so designated because they are involved in the DAG search types and/or the minimal returned response. They have defined mappings in the selected access protocols. The optional attributes have proposed mappings in those protocols.

It is important to note that the DAG/IP is constructed to carry any alternative attribute information that may be provided by a given WDSP; individual DAG-SAPs and DAG-CAPs may choose to pass along, interpret, or ignore any attributes not defined in this appendix.

Additionally, note that the order of attributes in the DAG/IP is significant, which means that it is possible to use one attribute to carry the information describing the type of subsequent ones (e.g., see the "ADR-TYPE" attribute below).

Finally, attributes may be repeated. For example, this schema structure can carry multiple phone numbers of different types for one person.

A.1 DAG Personal Information Schema (DAGPERSON Schema)

Attribute	Designation	Specific Description
FN	Required	Free-text representation of full name
EMAIL	Required	Internet e-mail address
LOC	Required	Locality -- geographic region
ORG	Required	Person's organization
ADR-TYPE	Optional	Type of address that follows ("org", "home", "org-postal", "home-postal", "unqualified")
ADR	Optional	Full address
ADR-STREET	Optional	Street address component
ADR-ROOM	Optional	Suite or room number component
ADR-CITY	Optional	City name
ADR-STATE	Optional	Region of address
ADR-COUNTRY	Optional	Country
ADR-CODE	Optional	Postal code component
TEL-TYPE	Optional	Type of telephone number ("work", "home", "mobile", "fax" ,"pager", "unqualified") in the following attribute
TEL	Optional	A phone number for the person
SOURCE	Optional	The WDSP's preferred access to their service -- a URL
DN	Optional	Entry's "distinguished name" (for LDAP)

Table A.1 DAGPERSON schema attributes

A.2 DAG Organizational Role Information Schema (DAGORGROLE Schema)

Attribute	Designation	Specific Description
ROLE	Required	Name of organizational role
EMAIL	Required	E-mail address associated with role
ORG	Required	Name of organization
LOC	Required	Locality -- geographic region
TEL-TYPE	Optional	Type of telephone number in the TEL attribute immediately following("org" or "fax")
TEL	Optional	Phone number
FN	Optional	Full name of current role occupant
SOURCE	Optional	The WDSP's preferred access to their service -- a URL
DN	Optional	Entry's "distinguished name" (for LDAP)

Table A.2 DAGORGROLE schema attributes

Appendix B - Schema Mappings for Whois++ and LDAP

The DAG/IP makes use of two specific schemas, as defined above. However, schemas particular to access protocols need to be handled in order to appropriately address incoming user queries, and chaining queries to WDSPs. The recognized standard schemas are:

- the USER template for Whois++ ([8])
- the ORGROLE template for Whois++ ([8])
- the inetOrgperson objectclass for LDAP ([16])
- the organizationalrole objectclass for LDAP ([18])

The DAG/IP schemas were developed based on the information that the TISDAG project requirements wish to return in results, in conjunction with information about standard schemas used in the basic WDSP access protocols (LDAPv2/v3 and Whois++). However, particularly in the case of address information, the schemas used for those protocols allow for considerable scope of information representation. In practice, this means that different WDSPs may choose to use different sub-parts of the schema, or even implement local customizations.

Therefore, Appendix A outlines a very basic schema that can carry all the necessary information. The basic DAG-CAPs and DAG-SAPs are designed to work to that information structure. This appendix outlines the expected behaviour for DAG-SAPs mapping into the DAG/IP schema, and DAG-CAPs extracting information to pass along to client software after a chaining operation has returned results.

B.1 LDAP and the DAG Schemas

The only time information is carried in the DAG schemas is when a DAG-SAP is returning information (obtained from WDSPs' servers) to a DAG-CAP using the DAG/IP. The "canonical" mappings between standard LDAP object classes (inetorgPerson, defined in [16] and organizationalRole, defined in [18] and the DAGPERSON schema and DAGORGROLE schema are defined such that information passed from an LDAP DAG-SAP to an LDAP DAG-CAP (e.g., in the case of an LDAPv3 DAG-SAP returning information chained for an LDAPv2 DAG-CAP) will be mapped into the same attributes as it was extracted.

However, the representation of some attributes (such as address) is truly widely varied between protocol paradigms. The goal with the "reasonable approximation" mappings that are provided is to give DAG-CAPs a basic mechanism for communicating information drawn from non-LDAP DAG-SAP sources. The mappings may not be perfect, but they will convey the information to the end-user in some LDAP-understandable fashion, which is the goal of this project's effort.

The canonical mappings for the LDAP inetorgPerson object class and the DAGPERSON schema are given in Table B.1. A few reasonable approximation mappings follow in Table B.2. Beyond that, DAG-SAPs may pass along any additional attributes in the DAG/IP, and DAG-CAPs may elect to forward or interpret any that are recognizable (e.g., the sn ("surname") attribute is not listed here, but a DAG-SAP might return that in the DAG/IP, and a DAG-CAP, recognizing the string representation, could elect to include it in its LDAP response to the client).

DAGPERSON Attribute	LDAP inetorgPerson attribute
FN	cn
EMAIL	mail
LOC	l
ORG	o
ADR-TYPE=org	
ADR-STREET	street
ADR-ROOM	roomNumber
ADR-STATE	st
ADR-COUNTRY	c
ADR-TYPE=org-postal	
ADR	postalAddress
ADR-ROOM	postOfficeBox
ADR-CODE	postalCode

ADR-TYPE=home-postal	
ADR	homePostalAddress
TEL-TYPE=work	
TEL	telephoneNumber
TEL-TYPE=home	
TEL	homePhone
TEL-TYPE=fax	
TEL	facsimileTelephoneNumber
TEL-TYPE=mobile	
TEL	mobile
TEL-TYPE=pager	
TEL	pager
DN	dn
SOURCE	labeledURI

Table B.1 Canonical DAGPERSON schema & LDAP inetorgPerson attributes

DAGROLE Attribute	LDAP organizationalRole attribute
ADR-TYPE=unqualified	
ADR	street
ADR-STREET	street
ADR-ROOM	room
ADR-STATE	st
ADR-COUNTRY	c
TEL-TYPE=unqualified	
TEL	telephoneNumber

Table B.2 Reasonable Approximations for LDAP organizationalRole attributes

For example, consider the following LDAP record information, in LDIF [11] format:

```
dn: cn=Barbara Jensen, ou=Product Development, o=Ace Industry,
c=US
objectclass: top
objectclass: person
objectclass: organizationalPerson
objectclass: inetorgperson
cn: Barbara Jensen
cn: Barbara J Jensen
cn: Babs Jensen
sn: Jensen
uid: bjensen
telephonenumber: +1 408 5551212
description:  A big sailing fan
```

This would validly be carried in the DAGPERSON schema as follows:

```
DN: cn=Barbara Jensen, ou=Product Development, o=Ace Industry,
c=US
FN: Barbara Jensen
FN: Barbara J Jensen
FN: Babs Jensen
SN: Jensen
TEL-TYPE: work
TEL:  +1 408 5551212
```

The canonical mappings for the LDAP organizationalRole object class and the DAGORGROLE schema are given in Table B.3 .Beyond that, DAG-SAPs may elect to send along any attributes, and DAG-CAPs may interpret any that are recognizable. N.B., the organizationalRole class does not include provision for inclusion of an e-mail address. This mapping rather blithely assumes the availability of the mail attribute as defined for inetorgPerson.

DAGORGROLE Attribute	LDAP organizationalRole attribute
ROLE	cn
EMAIL	mail
ORG	o
LOC	l
TEL-TYPE=org	
TEL	telephoneNumber
TEL-TYPE=fax	
TEL	facsimileNumber
FN	roleOccupant
DN	dn
SOURCE	labeledURI

Table B.3 Canonical mappings for LDAP organizationalRole attributes

B.2 Whois++ and the DAG Schemas

The "canonical" mappings between standard Whois++ templates as defined in [8] and the DAGPERSON schema and DAGORGROLE schema are defined in Tables B.4 and B.5. Beyond that, DAG-SAPs may pass along any additional attributes in the DAG/IP, and DAG-CAPs may elect to forward or interpret any that are recognizable.

DAGPERSON Attribute	Whois++ USER template attribute
FN	name
EMAIL	email
LOC	address-locality
ORG	organization-name
ADR-TYPE=unqualified	
ADR	address
ADR-TYPE=org	
ADR	organization-address
ADR-STREET	organization-address-street
ADR-ROOM	organization-address-room
ADR-CITY	organization-address-city
ADR-STATE	organization-address-state
ADR-COUNTRY	organization-address-country
ADR-CODE	organization-address-zip-code

ADR-TYPE=home	address-type=home
ADR	address
ADR-STREET	address-street
ADR-ROOM	address-room
ADR-CITY	address-city
ADR-STATE	address-state
ADR-COUNTRY	address-country
ADR-CODE	address-zip-code
TEL-TYPE=work	phone-type=work
TEL	phone
TEL-TYPE=home	phone-type=home
TEL	phone
TEL-TYPE=fax	
TEL	fax
TEL-TYPE=mobile	
TEL	cellular
TEL-TYPE=pager	
TEL	pager

Table B.4 Canonical DAGPERSON schema & Whois++ USER attributes

DAGORGROLE Attribute	Whois++ ORGROLE attribute
ROLE	org-role
EMAIL	email
ORG	organization-name
LOC	organization-address-locality
FN	name
TEL-TYPE=org	
TEL	phone
TEL-TYPE=fax	
TEL	fax

Table B.5 Canonical mappings for Whois++ ORGROLE attributes

Appendix C - DAG-Internal Protocol (DAG/IP)

The DAG-Internal Protocol (DAG/IP) is currently defined as a derivative of the query-interaction protocol of Whois++ as laid out in RFC1835 ([6]).

C.1 A word on the choice of DAG/IP

The use of the DAG/IP is strictly internal to the DAG system. In that regard, it is possible make use of any query language, or define a new one.

The Whois++ protocol was selected as the basis of the DAG/IP for several reasons:

- it has the power and flexibility to convey all necessary queries
- it is a simple, text-based protocol; clients need not implement the full functionality of the protocol in order to carry out minimal queries
- the power of the full-fledge directory service query protocol will give DAG-CAP writers the ability to express more sophisticated queries if desired (e.g., to produce more intricate "intelligent" matching of spellings, common character substitutions, etc).
- the text-based, delimited attribute results expression facilitates optional inclusion of extra data supplied by WDSPs -- DAG-CAPs can easily ignore any unknown information and continue to interpret the rest of the result information.

Also, the use of an existing protocol leverages the experience and time of the creators of the protocol -- hammering out such elusive and yet necessary details as handling line-endings, quoting special characters, etc.

There is a freely-available test suite of tools for testing servers' Whois++ protocol conformance (for the Referral Index, and for DAG-SAPs). Send mail to digger-info@bunyip.com for further information.

C.2 DAG/IP Input and Output -- Overview

Input interactions in DAG/IP are as defined in RFC1835, "Architecture of the WHOIS++ service" ([6]), sections 2.2 and 2.3. Section C.3 of this document adapts the grammar used in more recent descriptions of the Whois++ protocol to illustrate the syntax of the DAG/IP.

DAG/IP output will be a subset of what is defined in RFC1835, section 2.4, except that referral responses ("SERVER-TO-ASK") contain more information.

C.3 BNF for DAG/IP input and output

The following sections are adapted from the Whois++ grammar. For discussion of the semantic intent of the query protocol, and other matters, see Whois++ RFC 1835 [6].

C.3.1 The DAG/IP Input Grammar

The following grammar, which uses the Augmented BNF (ABNF) notation as defined in [5], defines the set of acceptable DAG/IP input.

N.B.: As outlined in the ABNF definition, rule names and string literals are in the US-ASCII character set, and are case-insensitive. Also, when a character is written explicitly in the grammar, as for example ";", it represents the byte value of that character in all of the allowed character sets in their encodings used in this protocol. Specifically in UNICODE, ";" means the character U+003B, which when encoding the character in UTF-8 will generate the byte value 0x3B which is then used in the DAG/IP protocol.

```
dagip-command   = ( system-command [":" "hold"]
              / ri-query
              / sap-query ) nl

ri-query        =   ri-terms [":" globalcnstrnts]

sap-query       =   sap-terms [":" [sapcnstrnts][ ":" wdspinfo]]

system-command =   "constraints"
                / "describe"
                / "commands"
                / "polled-by"
                / "polled-for"
                / "version"
                / "list"
                / "show" [1*sp datastring]
                / "help" [1*sp datastring]
                / "<NL>" [string]

ri-terms       =   ri-and-expr *(1*sp "or" 1*sp ri-and-expr)

ri-and-expr    =   ri-basic-expr *(1*sp "and" 1*sp ri-basic-
expr)

ri-basic-expr  =   ["not" 1*sp] ri-term / ( "(" ri-terms ")" )

ri-term        =   generalterm / specificterm / combinedterm

sap-terms       =   sap-and-expr *(1*sp "or" 1*sp sap-and-expr)

sap-and-expr    =   sap-basic-expr *(1*sp "and" 1*sp
                    sap-basic-expr)

sap-basic-expr  =   ["not" 1*sp] sap-term / ( "(" sap-terms ")" )
```

```
   sap-term        =   ( generalterm / specificterm / combinedterm)
                       localcnstrnts

   generalterm     =   datastring

      TISDAG: Since the DAG system only supports certain attribute
      combinations in its queries, (Table 3.1).  The use of generalterm
      may lead to unexpected behaviour and is therefore deprecated.
      CAPs should therefore not use it even if it is in the protocol.

   specificterm    =   specificname "=" datastring

   specificname    =   "handle" / "value"

   combinedterm    =   attributename "=" datastring

   sapcnstrnts     =   sapcnstrnt *(";" sapcnstrnt)

   sapcnstrnt      =   localcnstrnt / globalcnstrnt

   localcnstrnts   =   [";search=" sap-searchvalue] [";case="
                       sap-casevalue]

   localcnstrnt    =   "search=" sap-searchvalue / "case="
                       sap-casevalue

      ;N.B.:  in the case where local and global constraints
      ;       conflict, local constraints take precedence
      ;       and overrides the global constraint

   sap-searchvalue =   "tstring" / searchvalue

   sap-casevalue   =   "consider" / "ignore"

   globalcnstrnts  =   globalcnstrnt *(";" globalcnstrnt)

   globalcnstrnt   =   "search" "=" searchvalue
                     / opt-globalcnst

   opt-globalcnst  =   "hold"
                     / "case" "=" casevalue
                     / "maxfull" "=" 1*digit
                     / "maxhits" "=" 1*digit
                     / "language" "=" language
                     / "incharset" "=" characterset
                     / "ignore" "=" attributename
                     / "include" "=" attributename
```

```
   ; N.B.: If an attribute is named both with the "include" and "ignore"
   ; constraints, the attribute is to be included in the result, but the
   ; system message must be "% 112 Requested constraint not fulfilled".

   language        = <The language code defined in RFC1766>

   characterset    =   "UNICODE-2-0-UTF-8"

   searchvalue     =   "exact" / "substring" / "lstring"

   casevalue       =   "ignore" / "consider"

   wdspinfo        =   attrValAss *( ";" attrValAss )

   attrValAss      =   attributename "=" datastring

      TISDAG: Within the boundaries of the TISDAG project it has been
      decided that the only permitted attributes for wdspinfo are
      "host","port","server-info" and "charset".  Regarding "charset"
      the values for this attribute are defined to be one of "UTF-8",
      "ISO8859-1","T\.61" or "US-ASCII".

   datastring      =   1*data-elt

   attributename   =   1*(<%d32-126 except specialbyte>)
                         ; omit 127, which is DEL

   data-elt        =   "\" specialbyte / normalbyte

   normalbyte      =   <%d32-255, except specialbyte>

   specialbyte     =   " " / tab / "=" / "," / ":" / ";" / "\" /
                       "*" / "." / "(" / ")" / "[" / "]" / "^" /
                       "$" / "!" / "<NL>"

   number          =   1*digit

   digit           =   "0" / "1" / "2" / "3" / "4" /
                       "5" / "6" / "7" / "8" / "9"

   tab             =   %d09
   sp              =   %d32                ; space
   nl              =   %d13 %d10           ; CR LF
```

NOTE: Spaces (sp) that are significant to a query must be escaped. The following characters, when significant to the query, may be preceded and/or followed by a single space:
: ; , ( ) = !

C.3.2 The DAG/IP Response Grammar

The following grammar, which uses the Augmented BNF (ABNF) notation as defined in RFC2234 (see [5]),

N.B.: As outlined in the ABNF definition, rule names and string literals are in the US-ASCII character set, and are case-insensitive. Also, when a character is written explicitely in the grammar, as for example ";", it represents the byte value of that character in all of the allowed character sets in their encodings used in this protocol. Specifically in UNICODE, ";" means the character U+003B which when encoding the character in UTF-8 will generate the byte value 0x3B which is then used in the DAG/IP protocol.

```
server-resp     =   goodmessage mnl output mnl endmessage
                 / badmessage nl endmessageclose

output          =   0*(full-record / server-to-ask)

full-record     =   "# FULL " template " " serverhandle " "
                       localhandle system-nl
                  1*fulldata
                   "# END" system-nl
```

TISDAG: serverhandle is:

- Whois++, whatever the server-handle on the record returned by the WDSP.
- LDAP, <hostname-without-periods><port> (because server DN's are not enforceably unique). E.g., a services.bunyip.com server on 7778 would become servicesbunyipcom7778.

localhandle is:
- Whois++: the localhandle on the record returned by the WDSP
- LDAP, it is the RDN (relative distinguished name), with spaces replaced by "_". E.g., cn=leslie_daigle

```
server-to-ask   =   "# SERVER-TO-ASK " serverhandle system-nl
                  server-to-askdata
                  "# END" system-nl

fulldata        =   " " attributename ": " attributevalue
system-nl
```

```
   server-to-ask-data = " Server-Info: " serverinfo system-nl
                        " Host-Name: " hostname system-nl
                        " Host-Port: " number system-nl
                        " Protocol: " prot system-nl
                        " Source-URI: " source system-nl
                        " Charset: " characterset system-nl

   attributename   =   r-string

   attributevalue  =   longstring

   template        =   <%d32-%d255 except specialbyte>

   serverhandle    =   <%d32-%d255 except specialbyte>

   localhandle     =   <%d32-%d255 except specialbyte>

   serverinfo      =   string

   hostname        =   string

   prot            =   string ; currently one of "ldapv2"
                           ; "ldapv3" "whois++"

   characterset    =   "UTF-8" / "T.61" / "ISO8859-1" / "US-ASCII"

   source          =   string

   longstring      =   string 0*( nl ( "+" / "-" ) string )

   string          =   0*(%d32-255)

   r-string        =   0*(<%d32-126 except specialbyte>)
                        ; omit 127 which is DEL

   specialbyte     =   ":" / " "

   mnl             =   1*system-nl

   system-nl       =   nl [ 1*(message nl) ]

   nl              =   %d13 %d10    ; CR and LF

   message         =   [1*( messagestart "-" string nl)]
                       messagestart " " string nl

   messagestart    =   "% " digit digit digit
```

```
goodmessage     =   [1*( goodmessagestart "-" string nl)]
                    goodmessagestart " " string nl

goodmessagestart=   "% 200"

badmessage      =   [1*( badmessagestart "-" string nl)]
                    badmessagestart " " string nl

badmessagestart =   "% 5" digit digit

endmessage      =   endmessageclose / endmessagecont

endmessageclose =   [endmessagestart " " string nl]
                    byemessage

endmessagecont  =   endmessagestart " " string nl

endmessagestart =   "% 226"

byemessage      =   byemessagestart " " string nl

byemessagestart =   "% 203"

number          =   1*( digit )

digit           =   "0" / "1" / "2" / "3" / "4" / "5" / "6" /
                    "7" / "8" / "9"
```

C.4 DAG/IP Response Messages

The following list and discussion of response codes is derived from the Whois++ protocol definition, RFC1835 ([6]).

A system message begins with a '%', followed by a space and a three digit number, a space, and an optional text message. The line message must be no more than 81 bytes long, including the terminating CR LF pair. There is no limit to the number of system messages that may be generated.

A multiline system message have a hyphen instead of a space in column 6, immediately after the numeric response code in all lines, except the last one, where the space is used.

Example 1

```
% 200 Command okay
```

Example 2

```
% 220-Welcome to
% 220-the Whois++ server
% 220 at ACME inc.
```

The client is not expected to parse the text part of the response message except when receiving reply 600 or 601, in which case the text part is in the former case the name of a character set that will be used by the server in the rest of the response, and in the latter case when it specifies what language the attribute value is in. The valid values for characters sets is specified in the "characterset" list in the BNF listing in Appendix C.

The theory of reply codes is described in Appendix E in STD 10, RFC821 ([15]).

System response code	Description
110 Too many hits	The number of matches exceeded the value specified by the maxhits constraint. Server will still reply with as many records as "maxhits" allows.
111 Requested constraint not supported	One or more constraints in query is not implemented, but the search is still done.
112 Requested constraint not fulfilled	One or more constraints in query has unacceptable value and was therefore not used, but the search is still done.
200 Command Ok	Command accepted and executed. The client must wait for a transaction end system message.
201 Command Completed successfully	Command accepted and executed.
203 Bye	Server is closing connection

204 Overgeneralized	The server could not exactly match the DAG query into its native access protocol. The resulting native query was "looser".
220 Service Ready	Greeting message. Server is accepting commands.
226 Transaction complete	End of data. All responses to query are sent.
401 Service not available	
402 Search expression too complicated	
403 Information Unavailable	When a remote service is not (currently) available.
404 Time out	
500 Syntax error	
502 Search expression too complicated	This message is sent when the server is not able to resolve a query (i.e. when a client sent a regular expression that is too deeply nested).
503 Query to general	This is like the "too many hits" situation, but the server does not send along any results. This message is used to deflect data mining.
505 Operations error	Permanent operations error
600 <token>	Subsequent attribute values are encoded in the character set specified by <token>.
601 <token>	Subsequent attribute values are in the language specified by <token>.

601 DEF	Subsequent attribute values are default values, i.e. they should be used for all languages not specified by "601 <token>" since last "601 ANY" message.
601 ANY	Subsequent attribute values are for all languages.

Table C.1 List of system response codes

Appendix D - DAG/IP Response Messages Mapping

LDAPv2/v3			DAG/IP
success	(0)	v2&v3	200 Command Ok
operationsError	(1)	v2&v3	505 Operations error
protocolError	(2)	v2&v3	505 Operations error
timeLimitExceeded	(3)	v2&v3	404 Timeout
sizeLimitExceeded	(4)	v2&v3	110 To many hits
compareFalse	(5)	v2&v3	200 OK
compareTrue	(6)	v2&v3	200 OK
authMethodNotSupported	(7)	v2&v3	505 Operations error
strongAuthRequired	(8)	v2&v3	505 Operations error
referral	(10)	v3	200 OK
adminLimitExceeded	(11)	v3	110 Too many hits
unavailableCriticalExtension	(12)	v3	505 Operations error
confidentialityRequired	(13)	v3	505 Operations error
saslBindInProgress	(14)	v3	N.A.
noSuchAttribute	(16)	v2&v3	200 OK
undefinedAttributeType	(17)	v2&v3	500 Syntax error
inappropriateMatching	(18)	v2&v3	500 Syntax error
constraintViolation	(19)	v2&v3	111 Requested constraint not supported
attributeOrValueExists	(20)	v2&v3	200 OK
invalidAttributeSyntax	(21)	v2&v3	500 Syntax error
noSuchObject	(32)	v2&v3	200 OK
aliasProblem	(33)	v2&v3	505 Operations error
invalidDNSyntax	(34)	v2&v3	500 Syntax error
isLeaf	(35)	v2	N.A.
aliasDereferencingProblem	(36)	v2&v3	505 Operations error
inappropriateAuthentication	(48)	v2&v3	500 Syntax error
invalidCredentials	(49)	v2&v3	403 Information Unavailable
insufficientAccessRights	(50)	v2&v3	403 Information Unavailable
busy	(51)	v2&v3	403 Information Unavailable
unavailable	(52)	v2&v3	401 Service not available
unwillingToPerform	(53)	v2&v3	505 Operations error
loopDetect	(54)	v2&v3	505 Operations error
namingViolation	(64)	v2&v3	N.A.
objectClassViolation	(65)	v2&v3	N.A.
notAllowedOnNonLeaf	(66)	v2&v3	N.A.
notAllowedOnRDN	(67)	v2&v3	N.A.
entryAlreadyExists	(68)	v2&v3	N.A.
objectClassModsProhibited	(69)	v2&v3	N.A.
affectsMultipleDSAs	(71)	v3	N.A.
other	(80)	v2&v3	403 Information Unavailable

Table D.1 LDAPv2/v3 resultcodes to DAG/IP response codes mapping

DAG/IP	LDAP v2/v3
110 Too many hits	sizeLimitExceeded (4)
111 Requested constraint not supported	constraintViolation (19)
112 Requested constraint not fullfilled	constraintViolation (19)
200 Command Ok	Success (0)
201 Command Completed successfully	N.A.
203 Bye	N.A.
204 Overgeneralized	N.A.
220 Service Ready	N.A.
226 Transaction complete	N.A.
401 Service not available	unavailable (52)
402 Search expression too complicated	unwillingToPerform (53)
403 Information Unavailable	busy (51)
404 Time out	timeLimitExceeded (3)
405 Operations error	operationsError (1)
500 Syntax error	protocolError (2)
502 Search expression too complicated	unwillingToPerform (53)
503 Query to general	unwillingToPerform (53)
505 Operations error	operationsError (1)
600 <token>	N.A.
601 <token>	N.A.
601 DEF	N.A.
601 ANY	N.A.

Table D.2 Mapping from DAG/IP response codes to LDAPv2/v3 resultcodes

DAG/IP	Whois++
110 Too Many hits	110 Too Many hits
111 Requested constraint not supported	111 Requested constraint not supported
112 Requested constraint not fullfilled	112 Requested constraint not fullfilled
200 Command Ok	200 Command Ok
201 Command Completed successfully	201 Command Completed successfully
401 Service not available	401 Service not available
403 Information Unavailable	403 Information not available
404 Timeout	404 Timeout
405 Operations error	405 Operations error
500 Syntax error	500 Syntax error
502 Search expression too complicated	502 Search expression too complicated
503 Query to general	506 Query to general
505 Operations error	505 Operations error

Table D.3 Mapping between DAG/IP and Whois++ response codes

Appendix E - DAG CIP Usage

E.1 CIP Index Object

The CIP object used by the DAG system is based on the Tagged Index Object as defined in [12]. The grammar, adapted from that Work in Progress, for the specific object used by the DAG is as follows:

```
index-object = 0*(io-part SEP) io-part
io-part      = header SEP schema-spec SEP index-info
header       = version-spec SEP update-type SEP this-update SEP
               last-update context-size
version-spec = "version:" *SPACE "x-tagged-index-1"
update-type  = "updatetype:" *SPACE ( "total" |
             ( "incremental" [*SPACE "tagbased"|"uniqueIDbased" ])
this-update  = "thisupdate:" *SPACE TIMESTAMP
last-update  = [ "lastupdate:" *SPACE TIMESTAMP SEP]
context-size = [ "contextsize:" *SPACE 1*DIGIT SEP]
schema-spec  = "BEGIN IO-Schema" SEP 1*(schema-line SEP)
             "END IO-Schema"
schema-line  = attribute-name ":" token-type
token-type   = "TOKEN"
index-info   = full-index | incremental-index
full-index   = "BEGIN Index-Info" SEP 1*(index-block SEP)
             "END Index-Info"
incremental-index = 1*(add-block | delete-block | update-block)
add-block    = "BEGIN Add Block" SEP 1*(index-block SEP)
             "END Add Block"
delete-block = "BEGIN Delete Block" SEP 1*(index-block SEP)
             "END Delete Block"
update-block = "BEGIN Update Block" SEP
             0*(old-index-block SEP)
             1*(new-index-block SEP)
              "END Update Block"
old-index-block = "BEGIN Old" SEP 1*(index-block SEP)
             "END Old"
new-index-block = "BEGIN New" SEP 1*(index-block SEP)
             "END New"
index-block  = first-line 0*(SEP cont-line)
first-line   = attr-name ":" *SPACE taglist "/" attr-value
cont-line    = "-" taglist "/" attr-value
taglist      = tag 0*("," tag) | "*"
tag          = 1*DIGIT ["-" 1*DIGIT]
attr-value   = 1*(UTF8)
attr-name    = dag-searchattr / "objectclass"
dag-searchattr = "FN" / "LOC" / "ROLE" / "ORG"
TIMESTAMP    = 1*DIGIT
NAMECHAR     = DIGIT | UPPER | LOWER | "-" | ";" | "."
```

```
SPACE        = <ASCII space, %x20>;
SEP          = (CR LF) | LF
CR           = <ASCII CR, carriage return, %x0D>;

LF           = <ASCII LF, line feed, %x0A>;

DIGIT        = "0" | "1" | "2" | "3" | "4" | "5" | "6" | "7" |
              "8" | "9"

UPPER        = "A" | "B" | "C" | "D" | "E" | "F" | "G" | "H" |
              "I" | "J" | "K" | "L" | "M" | "N" | "O" | "P" |
              "Q" | "R" | "S" | "T" | "U" | "V" | "W" | "X" |
              "Y" | "Z"
LOWER        = "a" | "b" | "c" | "d" | "e" | "f" | "g" | "h" |
              "i" | "j" | "k" | "l" | "m" | "n" | "o" | "p" |
              "q" | "r" | "s" | "t" | "u" | "v" | "w" | "x" |
              "y" | "z"

US-ASCII-SAFE  = %x01-09 / %x0B-0C / %x0E-7F
               ;; US-ASCII except CR, LF, NUL
UTF8           = US-ASCII-SAFE / UTF8-1 / UTF8-2 / UTF8-3
                        / UTF8-4 / UTF8-5
UTF8-CONT      = %x80-BF
UTF8-1         = %xC0-DF UTF8-CONT
UTF8-2         = %xE0-EF 2UTF8-CONT
UTF8-3         = %xF0-F7 3UTF8-CONT
UTF8-4         = %xF8-FB 4UTF8-CONT
UTF8-5         = %xFC-FD 5UTF8-CONT
```

N.B.: The only tokenization type permitted is "TOKEN". While the Tagged Index Object memo permits the use of "FULL" (i.e., the entire value of the attribute is preserved as a single token), that has the danger of yielding a unique token for every record. Studies in the growth of centroid sizes as a function of number of records (see [14]) demonstrate that such unique tokens (e.g., phone numbers) are to be avoided. While storing tag information requires some number of extra bytes of storage per token index entry, using unique tokens causes the number of token entries in the index to continue to grow linearly with the number of records, thereby affecting search efficiency.

Note also that tags are to be applied to the data on a per entry level. Thus, if two index lines in the same index object contain the same tag, then it is always the case that those two lines refer back to the same "record" in the directory. In LDAP terminology, the two lines would refer back to the same directory object.

Additionally if two index lines in the same index object contain different tags, then it is always the case that those two lines refer back to different records in the directory.

The attribute "objectclass" is used to denote the record/object types in the data summarized in this index object.

Values for the objectclass attribute should be restricted to: dagperson or dagrole, the two DAG schema object types.

E.2 CIP Index Object Creation

WDSPs are expected to create index objects following the general principles outlined in the Whois++ protocol documentation (creation of centroids) and the Tagged Index Object documentation ([12]). Following the syntax described above, the index object contains token information for each attribute in the DAGSchema:

- a list of all the unique tokens (strings delimited by the specified characters) that appear in the WDSP database for the attribute
- for each token in that list, which records the token appears in

So, for example,

Record #1:
FN: Foo Bar
ORG: The Snack Bar

Record #2:
FN: Bar Smith
ORG: Snack Shack

yields (conceptually) the following information for the attribute FN:

Foo (1), Bar (1,2), Smith (2)

and the following information for the attribute ORG:

The (1), Snack (1, 2), Bar (1), Shack (2)

Note that the record numbers here are used simply as tags or virtual record identifiers to indicate when 2 tokens appear in the same record. The record identifiers are not used for any part of any query to the WDSP.

There is some discussion as to whether the use of the same record tag for all attributes makes it too easy to "decompile" the index object; i.e., reconstruct a WDSPs data based on re-ordering the tokens associated with each attribute and tag number. However, we are dealing only with the search attributes here, which is a minimal subset of the quantity of data held by the WDSP. The conclusion is then that the improved efficiency given by using the same tag numbers across attributes outweighs the (remote) possibility of information reconstruction.

This would yield the index object:

```
version: x-tagged-index-1
update-type: total
this-update: 855938804

last-update:
context-size:
BEGIN IO-Schema
objectclass: TOKEN

FN: TOKEN
ORG: TOKEN
END IO-Schema
BEGIN Index-Info
objectclass: */dagperson
FN: 1/Foo
-1,2/Bar
 -2/Smith
ORG: 1/The
-1,2/Snack
-1/Bar
-2/Shack
End Index-Info
```

TISDAG: Within the project it has been decided to base consistency between updates on consistent tags. This means that if the update-type is "incremental" the specifier must be "tagbased".

E.3 CIP Index Object Sharing

E.3.1 Registration of Servers

It is beyond the scope of this document to define how WDSP servers shall be registered with the DAG Referral Index. Such a procedure must be defined, and the following information established for each WDSP dataset (adapted from the Tagged Index Object specification, [12]):

dsi: An OID which uniquely identifies the subtree and scope of the dataset for which the index object is created.

base-uri: One or more URI's which will form the base of any referrals created based upon the index object that is governed by this agreement. For example, for LDAP the base-uri would specify (among other items): the LDAP host, the base object to which this index object refers (e.g., c=SE), and the scope of the index object (e.g., single container).

supplier: The hostname and listening port number of the supplier server, as well as any alternative servers holding that same naming contexts, in case the supplier is unavailable.

source-uri: The URI of the WDSP's preferred source of directory service information. This might be, for instance, an HTTP-based service.

consumeraddr: This is a URI of the "mailto:" form, with the RFC 822 email address of the consumer server.

updateinterval: The maximum duration in seconds between occurrences of the supplier server generating an update. If the consumer server has not received an update from the supplier server after waiting this long since the previous update, it is likely that the index information is now out of date. A typical value for a server with frequent updates would be 604800 seconds, or every week.

attributeNamespace: Every set of index servers that together wants to support a specific usage of indices, has to agree on which attributenames to use in the index objects. The participating directory servers also has to agree on the mapping from local attributenames to the attributenames used in the index. Since one specific index server might be involved in several such sets, it has to have some way to connect a update to the proper set of indexes. One possible solution to this would be to use different DSIs.

consistencybase: How consistency of the index is maintained over incremental updates:
complete - every change or delete concerning one object has to contain all tokens connected to that object. This method must be supported by any server who wants to comply with this standard
tagbased - starting at a full update every incremental update referring back to this full updated has to maintain state-information regarding tags, such that a object within the original database is assigned the same tagnumber every time. This method is optional.

uniqueID - every object in the Dataset has to have a unique value for a specific attribute in the index. A example of such a attribute could be the distinguishedName attribute. This method is also optional.

securityoption: Whether and how the supplier server should sign and encrypt the update before sending it to the consumer server. Options for this version of the DAG service are "none": the update is sent in plaintext "PGP/MIME": the update is digitally signed and encrypted using PGP (see [7]). PGP/MIME is recommended.

security credentials: The long-term cryptographic credentials used for key exchange and authentication of the consumer and supplier servers, if a security option was selected. For "PGP/MIME", this will be the trusted public keys of both servers.

E.3.2 Transmission of Objects

CIP Index Objects are sent to the DAG Referral Index by MIME-encoded SMTP, following the Common Indexing Protocol specification (see [2] and [3]).

Appendix F - Summary of Technical Survey Results

As part of the TISDAG project, a technical survey was carried out -- announced on the tisdag@swip.net mailing list, all Swedish WDSPs (and potential WDSPs) were encouraged to fill out and submit the WWW-based survey form (see http://tisdag.sunet.se/tisdag-survey.html).

The survey was carried out in May, 1997. Response was not as good as had been hoped -- in the end, 5 WDSPs participated. We had hoped for more responses than this, in order to have a concrete sense of directory service providers' current and planned status. However, informal "hallway" conversations with a few people at Interoperabilitet'97 in Sollentuna suggest that, while people see the TISDAG project as an important and timely step, they don't necessarily have an immediate understanding of how it will impact them, and what they can/should contribute. So, the results can be seen as informational, though not a definitive statement of the whole directory service picture in Sweden.

Interesting things to note from these results include the fact that, although there were only 5 respondents, these are clearly significant players -- 4 expect to have more than 100 000 records to contribute by 12 months from now. There were no real surprises in terms of the supported protocols or search types.

Table E.1 summarizes information from the survey concerning types of queries currently supported by WDSPs, and planned for the next 12 months. Note that, at the time of the survey, the requirement of searching by ROLE had not been proposed, so the survey did not specifically ask if WDSPs supported both the DAGPERSON schema protocol-equivalents (i.e., USER template in Whois++ and inetorgperson objectclass in LDAP). In the table, the column "Complete info?" describes whether or not the WDSP currently returns at least as much information as is required for a DAG reply.

Resp	Search Types	Complete info?	Access Protocols (now)	Access Protocols (12 months)
1	NOL	Except ROLE	Whois++	Whois++
2	N,NO,NL,NOL	Except ROLE	LDAPv2,DAP,PH, HTTP,Gopher	LDAPv2,LDAPv3,DAP, PH,HTTP,Gopher
3	N,NL,NOL	Except ROLE	LDAPv2,DAP,HTTP	LDAPv2,LDAPv3,DAP, HTTP
4	N,NO,NL,NOL	Except ROLE	Whois++,HTTP	LDAPv3,Whois++, HTTP,E-mail
5	N,NO,NL,NOL	Except ROLE	LDAPv2,Whois Whois++,HTTP	LDAPv2,LDAPv3, Whois,Whois++,PH, Finger,HTTP

Table F.1 Summary of TISDAG Survey Results: Queries

Resp	# of Records (now)	# of Records (12 months)	Character Sets
1	94 280	120 000 - 130 000	ISO-8859-1
2	88 000	100 000	ISO-8859-1
3	N/A	100 000	T.61 (Telex)
4	150 000	250 000	ISO-8859-1 UTF-8 UNICODE
5	4 300	10 000	ISO-8859-1

Table F.2 Summary of TISDAG Survey Results: Operational Information

Appendix G - Useful References

N.B.: The following is a collection of Internet standards documents (RFCs) and Internet-Drafts from which the material in this report was drawn. Internet-Drafts are works-in-progress, and are not meant to be cited. Where they are used in this document, references are to the text contained in the Internet-Draft; i.e., they are not meant to imply standards, so much as useful starting points for the work of this project.

Electronic copies of the version of the Internet-Drafts documents that were used in preparing this report are available from the project web page, http://tisdag.sunet.se.

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Authors' Addresses

Leslie L. Daigle
Thinking Cat Enterprises

EMail: leslie@thinkingcat.com

Roland Hedberg
Catalogix
Jegerveien 25
0777 Oslo
Norway

Phone: +47 23 08 29 96
EMail: Roland@catalogix.se

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