LDAP based repositories for Metadata and Ontologies

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Peter Gietz

Peter.gietz@DAASI.de

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Agenda

- An Introduction to LDAP
- LDAP, Common Indexing Protocol and Metadata
- LDAP, Common Information Model and Ontologies

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Directory in German Research environment

- Since 1994 DFN research projects at University of Tübingen:
  - AMBIX an Email directory
  - DFN Directory Services (DDS)
    - Directory competence center
- Since January 2001: DAASI International GmbH
  - Directory Applications for Advanced Security and Information Management
  - Design, implementation and management of directory services
  - Main Customers: Research Institutions in Europe (NRNs, Universities, etc.)

An Introduction to LDAP

Features of a Directory service

- It is a database
  - for storing and retrieving information
- It is a specialized database
  - designed for fast reading, writing is slower
  - static view on the data
  - simple updates without transactions
- It has a network protocol for access
- A Directory Service may include
  - distribution in the net (scalable!)
  - replication of the data (reliable)

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What kind of data can you store?

- Text data
  - names, addresses, descriptions, numbers, etc.
- Pointers
  - URIs, pointers to other data, etc.
- Public key certificates
- Graphics
  - photos, diagrams, etc.
- Other binary data
- Anything else you can think of

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Directory Information Tree

- Data are stored in entries
- Entries are ordered as tree nodes
- In the Directory Information Tree (DIT)
  - Every node has 0 to n children nodes
  - Every node except root has 1 parent node

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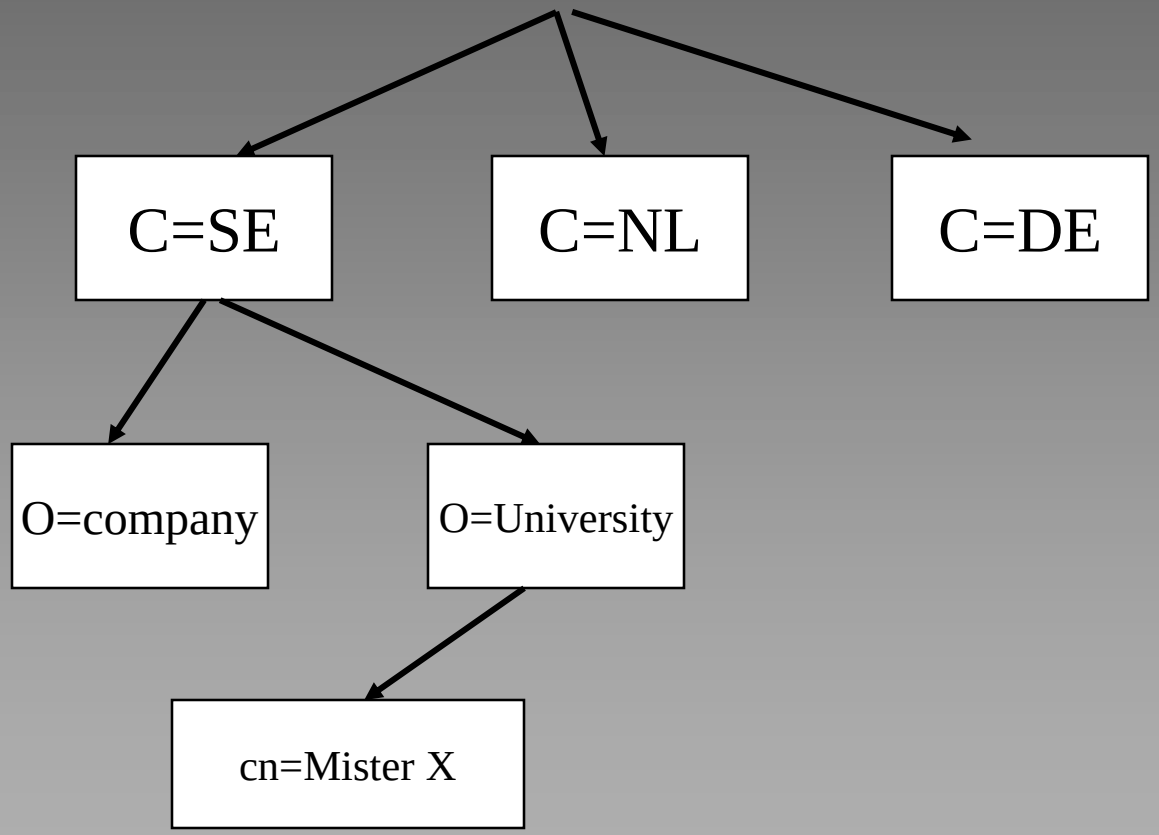
Directory Information Tree (DIT)



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DN Distinguished Name

- An entry has a distinguished name
  - **in its hierarchy level: Relative Distinguished Name (RDN)**
  - **all RDNs from root onwords build the Distinguished Name (DN)**
- No two entries in one hierarchy level can have the same RDN
- Thus no two entries in the whole Directory can have the same DN

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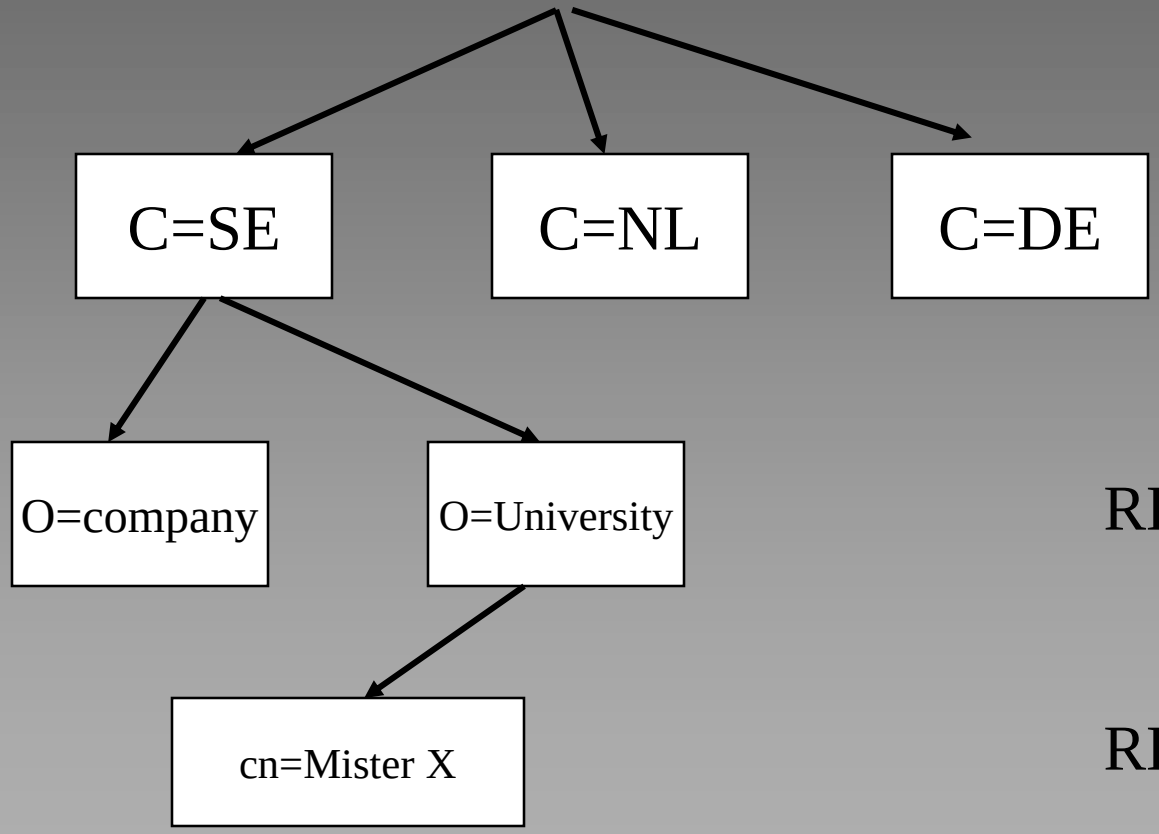
Directory Information Tree (DIT)



RDN: C=NL

RDN: o=University

RDN: cn=Mister X

DN: c=NL,o=University,cn=Mister X

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OIDs

- An Entry is an information object
- The mechanisms for representing the data are objects as well, identified by an OID (Object Identifier)
  - E.g.: 1.234.567.8.123
- OIDs are again represented in an hierarchical tree
- OIDs are world wide unique

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X.500 Information Model

- An Entry contains a number of Attributes
- An Attribute consists of:
  - Attribute Type
  - Attribute Value
- An Attribute Type has an associated Attribute Syntax
- The Attribute Value has to conform to that syntax
- To compare Attributes there are Matching Rules

Special Attributes

- One or more Attribute Types form the RDN
  - The Naming Attributes or
  - The Distinguished Attributes
- An Entry must have one or more Objectclass Attributes which:
  - Characterizes the Entry, e.g. Person
  - Defines a set of usable Attributes the entry may contain and must contain
- Objectclasses can inherit Attributes from other Objectclasses
- A set of Objectclasses, Attributes and Syntaxes for a special purpose are called schema

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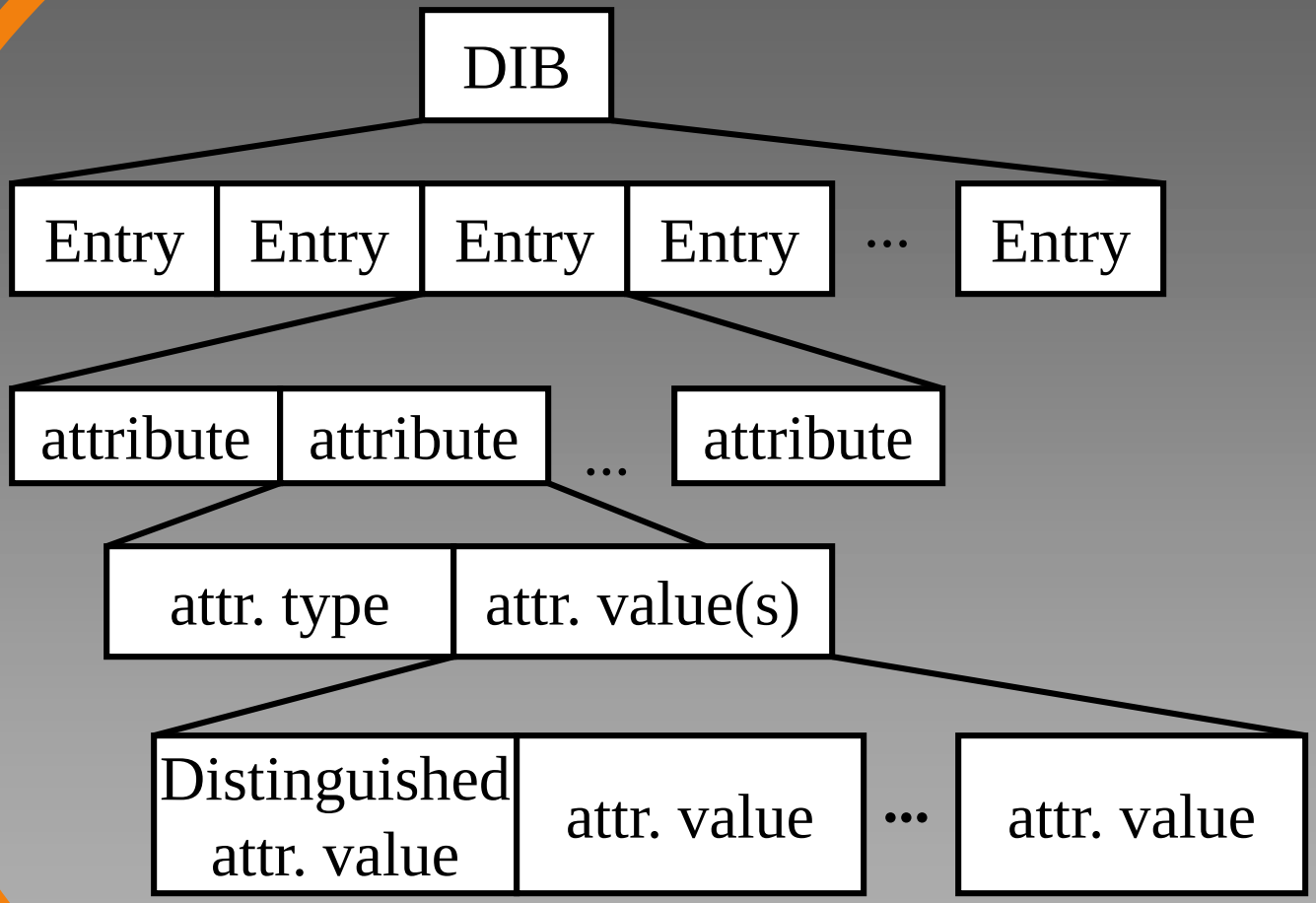
Special Attributes contd.

- aliasObjectName Attribute
  - **Alias Entries have a DN and point to another DN via aliasObjectName Attribute**
- seeAlso Attribute
  - **Entry contains data and a seeAlso pointer to another DN with related data**

Directory Information Base



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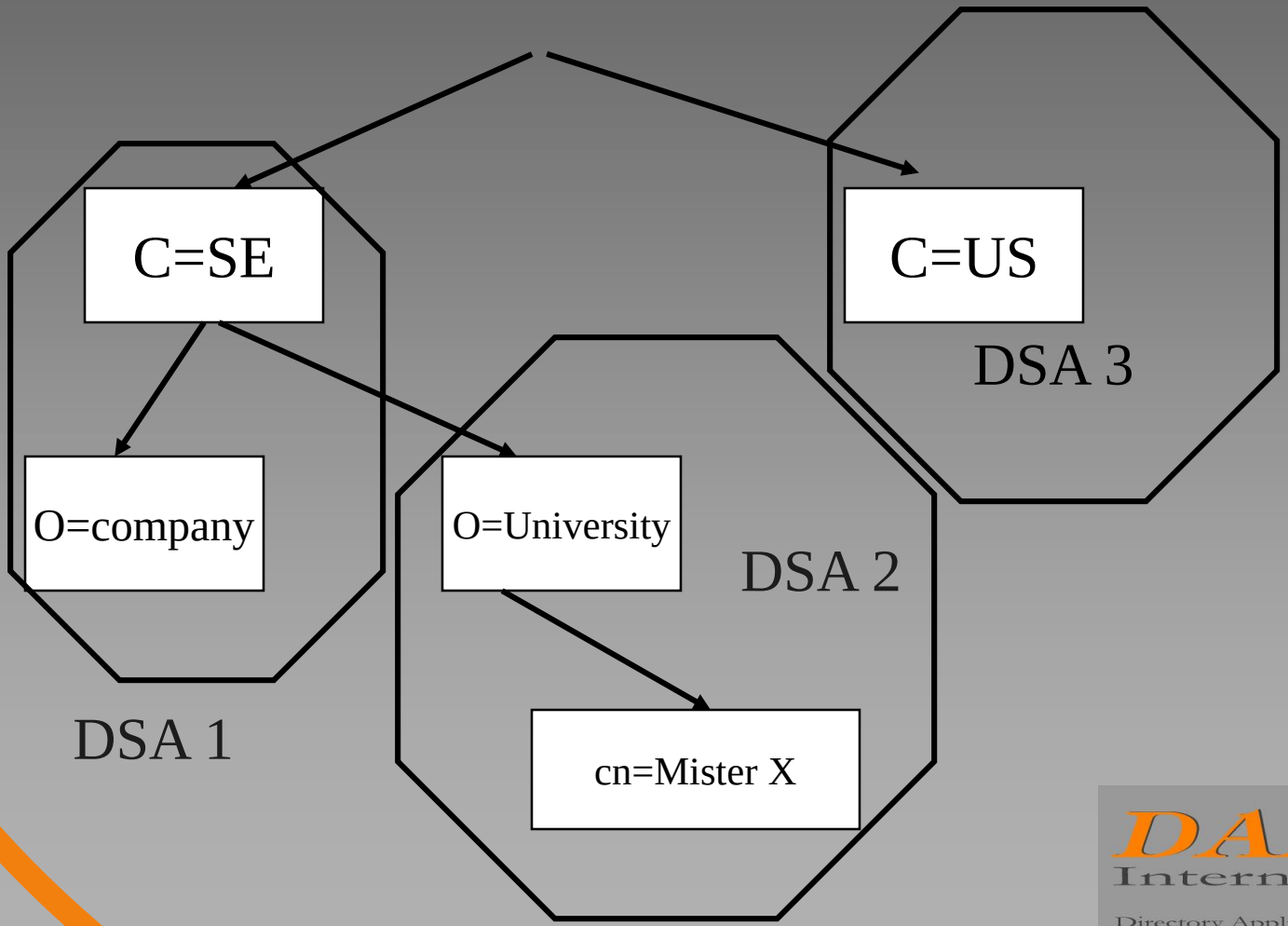
Distribution of the data among DSAs



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Client Server System

- Originally (v1,v2) LDAP was just a client access protocol for X.500
- LDAP v3 is a whole client server system
  - LDAP does not provide a chaining mechanism
  - Instead server can send referrals to clients
  - Referral is part of LDAPresult structure to indicate that the server does not have the requested data but the servers referred to might have it
- Implementations have server replication mechanisms

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Security Mechanisms

- Several Authentication mechanisms
  - Bind with password
  - SASL mechanisms
- Session encryption
  - TLS
- Access control mechanism
  - On subtree, entry and attribute level
  - Different identifications
    - AuthenticationID, IP address, ...
  - Not yet standardized

LDAP Functional Model

- Authentication and control operations:
  - **bind**
  - **unbind**
  - **abandon**
- Interrogation operations:
  - **search**
  - **compare**
- Update operations:
  - **add**
  - **delete**
  - **modify**
  - **modifyDN**

Search Filter Operators

- **Equality**
  - **e.g.: (cn=Mister X) only entries with common name equals “Mister X”**
- **Negation operator**
  - **e.g. (!(cn=Mister X)) all entries but the one with cn equals “Mister X”**
- **Substring**
  - **e.g. (cn=Mister*) all entries with cn beginning with “Mister”**
- **Approximate**
  - **e.g.: (cn~=Mister) all entries with cn sounding similiar to “Mister”**

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Search Filter Operators (contd.)

- **Greater than or equal to and less than or equal to**
  - **e.g. (sn<=Smith) all entries where sn equals "Smith" or is lexicographically above "Smith" (from sn=Adam to sn=smirnow)**
  - **e.g. (age>21) is not possible, use (!(age<=21)) instead**
- **Presence**
  - **e.g. (telephoneNumber=*) all entries that contain a telephone number**
  - **e.g. (objectclass=*) all entries, since every entry contains at least one objectclass**

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Search Filter Extensions

- LDAPv3 defines an extensible matching filter
  - syntax: attr [“:dn”] [“:” matchingrule] “:=“ value
    - attr is an attribute name
    - “:dn” says that also the attribute in the dn should be searched as well
    - matching rule given by an OID or associated descriptive name
  - examples:
    - (cn:1.2.3.4.5.6:=Mister X) use matching rule 1.2.3.4.5.6 for comparision
    - (o:dn:=company) search for o=company in attributes and also in DN

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Search filter combinations

- Filters can be combined
  - **AND operator: &**
    - **e.g. (& (cn=Mister X) (mail=*dot.com)) only entries that have both cn=Mister X and a mail address ending with dot.com**
  - **OR operator: |**
    - **e.g.: (| (cn=Mister X) (sn=Xerxes)) all entries that have cn=Mister X or sn=Xerxes**

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LDAP URL (RFC 2255)

- Format:
  - ldap://<host>:<portnumber>/<basedn>?<attrlist>?<scope>?<filter>?<extensions>
- Example:
  - ldap://myhost.org:9999/c=SE,o=University?cn,telephonenumber?subtree?(cn=Mister X)
- LDAP URLs are used as referral

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LDAP Data Interchange Format LDIF

- RFC 2849:
  - The LDAP Data Interchange Format (LDIF) - Technical Specification, G. Good, June 2000
- Format for exchanging data
- Example:

```
dn: cn=Mister X, o=University, c=CE
objectclass=top
objectclass=person
objectclass=organizationalPerson
cn=Mister X
cn=Xavier Xerxes
mail=X@dot.com
mail=Mister.X@dot.com
telephoneNumber=1234567

dn: cn=next entry, ...
```

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Who talks LDAP?

- Big number of LDAP implementations
  - OpenLDAP (open source)
  - Implementations e.g. by Sun, IBM, Syntegra, …
- All other directory implementations have an LDAP interface:
  - all X.500(93) implementations
  - Novell Directory Service (NDS)
  - Microsoft Active Directory (AD)
- Many client applications have an LDAP interface:
  - Mail agents
  - Browser
  - PGP clients

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1997: LDAP v3 Proposed Standard

- RFC 2251:
  - Lightweight Directory Access Protocol (v3), M. Wahl, T. Howes, S. Kille. December 1997
- RFC 2252:
  - Lightweight Directory Access Protocol (v3) - Attribute Syntax Definitions, M. Wahl, A. Coulbeck, T. Howes, S. Kille. December 1997
- RFC 2253:
  - Lightweight Directory Access Protocol (v3) - UTF-8 String Representation of Distinguished Names, M. Wahl, S. Kille, T. Howes. December 1997

1997 LDAPv3 contd.

- RFC 2254:
  - The String Representation of LDAP Search Filters, T. Howes. December 1997
- RFC 2255:
  - The LDAP URL Format, T. Howes, M. Smith. December 1997
- RFC 2256:
  - A Summary of the X.500(96) User Schema for use with LDAPv3, M. Wahl. December 1997

IETF WG LDAPbis

- Revision of all LDAP core RFCs
- With references to mandatory security mechanism of RFC 2829 and 2830 possible to go for Draft Standard
- No changes in the data definitions
- Some clarifications in wording
- Some SHOULDS to MUST etc.
- Some additional documents, e.g.:
  - IANA considerations
  - UTF-8 matching

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LDAP, Common Indexing Protocol and Metadata

Common Indexing Protocol CIP

- RFC 2651 – 2655
- Index definitions for any directory technology
- Based on Whois++ Index mesh
  - Server server communication
  - Multiple topologies possible
- MIME wrapper
- Transport protocol

CIP contd.

- Different index object formats
  - SOIF (Summary Object Interchange Format)
  - TIO (Tagged Index Object)
    - Tag identifies common attributes of an entry
- Dataset Identifier (DSI)
  - Identifies server
- Base URI for generating referrals
  - Identifies server and baseDN

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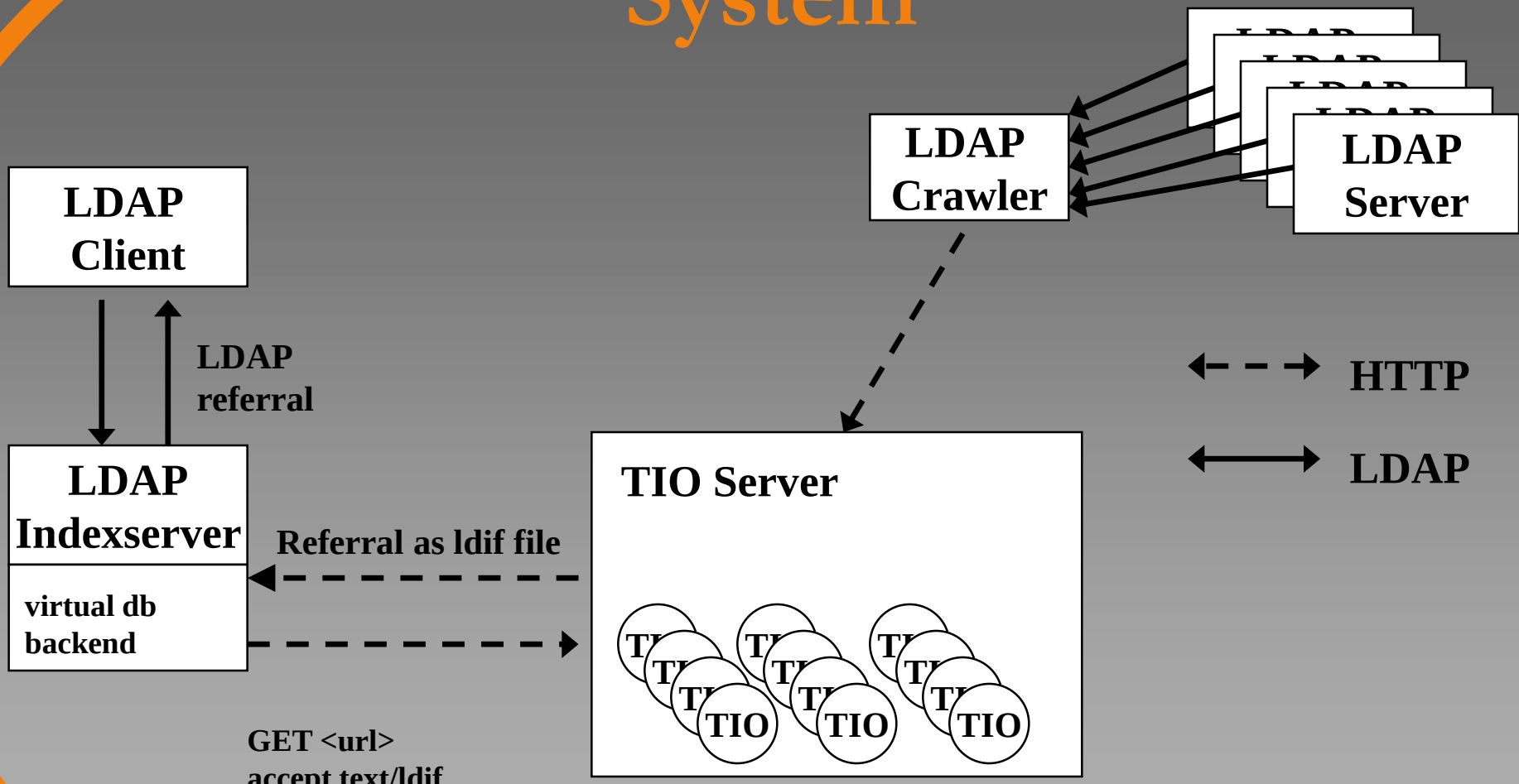
The LDAP Indexing System



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What can the index system be used for?

- White Pages Service
- Metadata indexing service
- Certificate indexing service
  - Based on Internet Draft on X.509certificate object class (draft-klasen-x509certificate-schema-00.txt)
- Web Services repository (with or without a UDDI frontend)
- …

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DSML

- Directory Service Markup Language v1
- Means for representing directory information as an XML document
- Directory enhancement for XML based applications
- Can be used to convert XML data to directory data
- A DSML document can describe directory entries, directory schema or both
- DSML v2 will define LDAP operational model

DSML Example

```
<dsml:dsml xmlns:dsml="http://www.dsml.org/DSML">
  <dsml:directory-schema>
    <dsml:class id="person" superior="#top"
     type="structural">
      <dsml:name>person</dsml:name>
      <dsml:description>objectclass for Person
      </dsml:description>
      <dsml:object-identifier>2.5.6.6
      </dsml:object-identifier>
      <dsml:attribute ref="#cn" required="true">
      ...
      <dsml:attribute ref="#description"
      required="false"/>
      ...
    </dsml:class>
  <dsml:directory-schema>
```

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DSML Example contd.

```
<dsml:directory-entries>
  <dsml:entry dn="cn=Damy Mahl, o=Brunel
   University,c=GB">
    <dsml:objectclass>
      <dsml:oc-value>top</dsml:oc-value>
      <dsml:oc-value>person</dsml:oc-value>
    </dsml:objectclass>
    <dsml:attr name="cn">
      <dsml:value>Damy Mahl</dsml:value>
    </dsml:attr>
    <dsml:attr name="mail">
      <dsml:value>damy@brunel.gb</dsml:value>
    </dsml:attr>
  </dsml:entry>
</dsml:directory-entries>
</dsml:dsml>
```

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Distributed Metadata

- Requirements:
  - Data maintained de-central
  - Variety of metadata formats
    - DC, MARC, SOIF, GILS
  - Variety of representation of metadata formats
    - RDF, RDM, LDIF, HTML-header
  - Publishing of schemas via metadata registries
  - Conversion of XML based schemas to LDAP (DSML)
  - LDAP schemas for the metadata formats
  - CIP and TIO

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Isaac Network

- Part of the Internet Scout Project
- Current status unknown
- Distributed architecture for resource discovery using metadata
- Metadata standard DC as common base
- Metadata repository based on LDAP servers
- Indexing service based on CIP with TIO
- Search interface web based (HTTP/HTML)

LDAP, Common Information Model and Ontologies

Current WWW

- Mere publishing medium
- Huge amount of information
- Designed for human access only
- Lack of structure and organization
- Insufficiant access methods
- Ambiguous:
  - **bank (finance institute) the same as**
  - **Bank (river bank)**

Visions for the future

- Web Services
- Accessed by humans *and* programs
- Quality content
- Better structured
- Knowlegde enhanced
- Disambigued:
  - **Bank (finance institute) is not the same as**
  - **Bank (river bank)**

Buzwords for the new visions

- „Semantic Web“ (Tim Berners-Lee)
- Grid
  - Computational Grid (Foster/Kesselman)
    - Computing power out of the wall
  - Information Grid
    - Information about resources, data and the rest
  - Knowledge Grid
    - Knowledge is relations between concepts and information

How to achieve knowledge

- Metadata
  - Data about information
- Ontologies
  - Concepts and relations between them
  - Computer knows more than inputed

```
Input: Parents have children
Input: Mother = female parent
Output: Mothers have children
```

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Ontology Description

- **E.g.: DAML+OIL (predecessor of WebOnt):**

```
<daml:Class rdf:ID="xxx" rdf:about="#xxx" >
    <rdfs:label>xxx</rdfs:label>
    <rdfs:comment>xxx</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#xxx"/>
    <daml:disjointWith rdf:resource="#yyy"/>
    <daml:Restriction>
            <daml:onProperty rdf:resource="#xxx"/>
            <daml:toClass rdf:resource="#xxx"/>
    </daml:Restriction>
</daml:Class>
```

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Ontology Description 2

```
<daml:UniqueProperty rdf:ID="xxx">
    <rdfs:domain rdf:resource="#xxx"/>
    <rdfs:subPropertyOf rdf:resource="#xxx"/>
    <rdfs:range rdf:resource="#xxx"/>
    <daml:inverseOf rdf:resource="#hasParent"/>
</daml:UniqueProperty>
```

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Ontologie Storage Proposal

- Combined repository for metadata and ontologies based on LDAP technology and thus accessible with the same protocol
- Large scalability by setting up an Indexing system based on Common Indexing Protocol (CIP)
- Ontologie data model based on CIM which provides a model for associations that can be used for mapping the relations between objects

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What could you store?

- Multiple ontologies with links between different ontologies
- General ontologies (e.g. WordNet)
- Special ontologies (e.g. on special subjects)

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Common Information Model

- Object oriented meta model for structuring information technology independantly
- Capable of describing the whole computer world
- Basically an Ontology
- Three layers
  - Core: the basic lego bricks
  - Common: standardized descriptions
  - Extesion: vendor‘s extras

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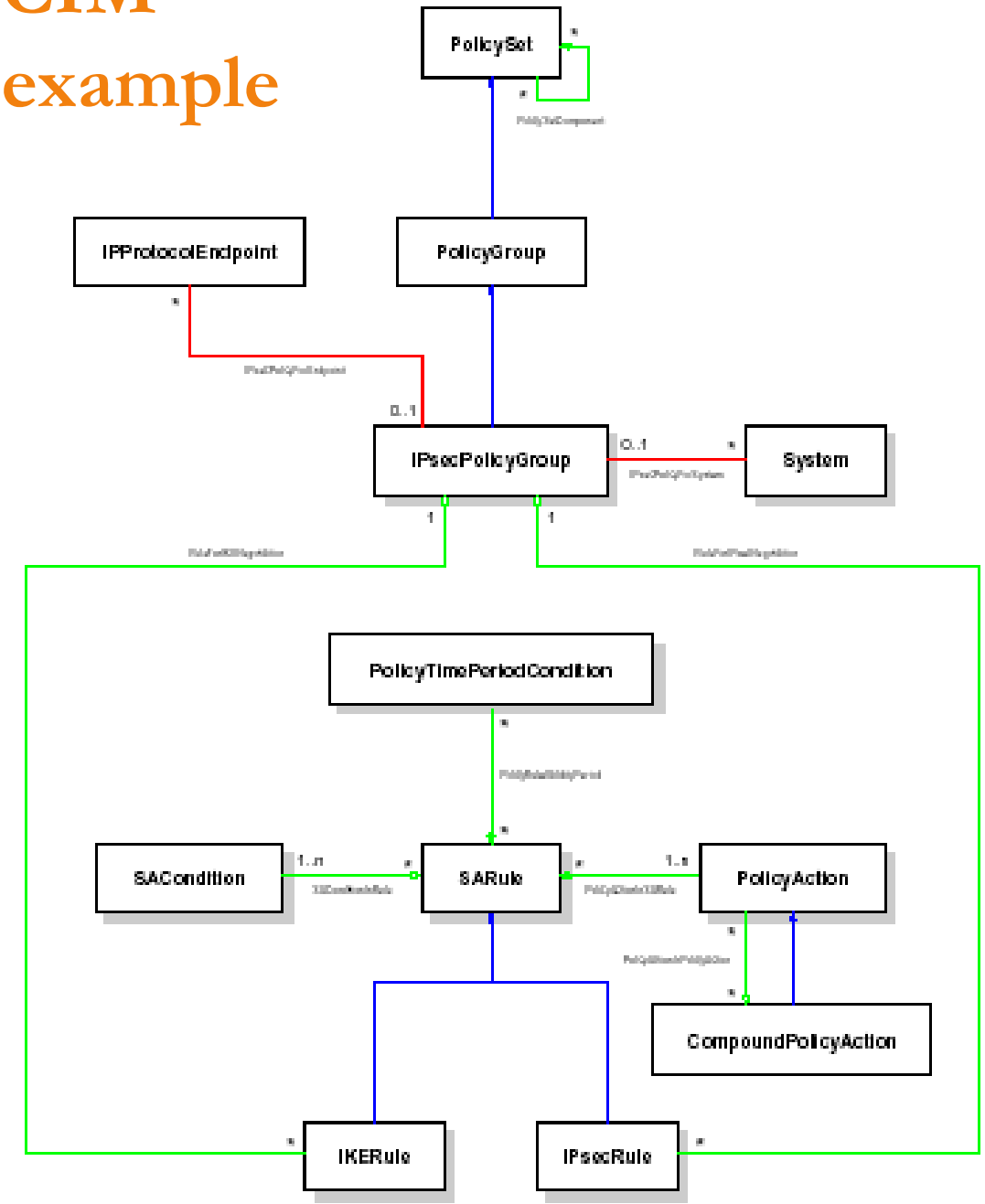
CIM example



objects

inheritance

aggregation

association

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CIM mapped to LDAP 1

- **objectClass** (1.3.6.1.4.1.412.100.2.1.3.60 NAME ' dlm1MemberOfCollection ,
  DESC ' MemberOfCollection is an aggregation used to establish membership of ManagedElements in a Collection .,
  SUP top ABSTRACT)

CIM mapped to LDAP 2

- **attributetype** (1.3.6.1.4.1.412.100.2.2.186 NAME ' dlmMemberOfCollectionCollectionRef ,
  DESC ' The Collection that aggregates members . Values of this attribute point to entries of class dlmCollection .,
  SYNTAX 1.3.6.1.4.1.1466.115.121.1.12
  EQUALITY distinguishedNameMatch)
- **attributetype** (1.3.6.1.4.1.412.100.2.2.187 NAME ' dlmMemberOfCollectionMemberRef ,
  DESC ' The aggregated member of the collection . Values of this attribute point to entries of class dlmManagedElement .,
  SYNTAX 1.3.6.1.4.1.1466.115.121.1.12
  EQUALITY distinguishedNameMatch)

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CIM mapped to LDAP 3

- **objectClass** (1.3.6.1.4.1.412.100.2.1.3.61 NAME ' dlm1MemberOfCollectionAuxClass , DESC ' MemberOfCollection is an aggregation used toestablish membership of ManagedElements in a Collection ., SUP dlm1MemberOfCollection AUXILIARY MAY (dlmMemberOfCollectionCollectionRef $ dlmMemberOfCollectionMemberRef))

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CIM, LDAP and Ontologies

- Any kind of relations can be defined with CIM and mapped to LDAP
- LDAP provides:
  - Object Class inheritance
  - Attribute inheritance
- Associations and aggregations can be mapped by object classes

Questions?

- DFN Directory Services
  - peter.gietz@directory.dfn.de
  - www.directory.dfn.de
- DAASI International GmbH
  - Info@daasi.de
  - www.daasi.de