The Role of Directories in emerging network technologies

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Directory Applications for Advanced Security and Information Management

Agenda

- Introduction to LDAP
- LDAP based Directory Services
  - 1. Classical Services
  - 2. Indexbased services
  - 3. PKI Services
  - 4. Information Services (metadata, ontologies)
  - 5. Policy data service
  - 6. Services for Grid Computing
- Visions for the future

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Introduction to LDAP

What is a Directory?

- Information stored in a hierarchical System
- Examples:
  - File directory of an operating system (MS/DOS, Unix)
  - Domain Name Service (DNS)
  - Network Information System (NIS)
  - X.500 is *the* Directory
  - Lightweight Directory Access Protocol (LDAP) = The Internet (IETF) version of X.500
  - Novell Directory Service (NDS)
  - Microsoft Active Directory (AD)

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What is LDAP

- Lightweight Directory Acess Protocol
  - In Version 3 not only access protocol, but whole client-Server system
- It is a sort of 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

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What is LDAP (contd)

- It has a well defined and standardized network protocol for access
- It has inbuilt security features
- The technology allows for
  - distribution on the net
  - replication of the data
- Thus comparable to WWW, but:
  - It is well structured (as a database)
  - It can be accessed by humans *and* applications

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What kind of data can you store?

- Text data
  - names, addresses, descriptions, numbers, etc.
- Pointers
  - URLs, 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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Qualities of LDAP

- Any amount of data can be stored
- On any number of servers
- Data look the same everywhere
- Open model for any kind of data
- High scalability through distribution
- High accessability through replication
- High security through inbuilt authentication mechanisms

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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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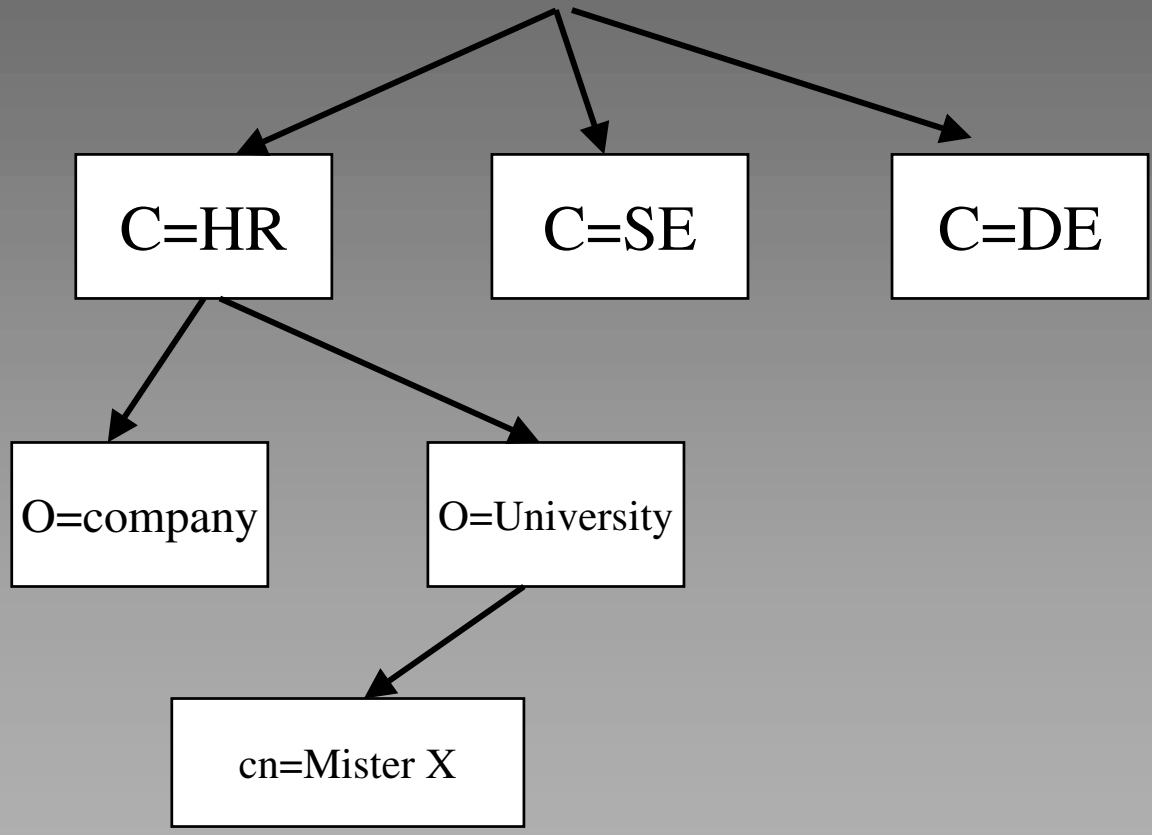
Directory Information Tree (DIT)



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DN Distinguished Name

- An entry has a distinguished name
  - in its hierarchy level: Relative Distinguished Name (RDN)
  - all RDNs on the path from root form the Distinguished Name (DN)
- No two siblings, i.e. entries with a common parent can have the same RDN
- Thus no two entries in the whole Directory can have the same DN

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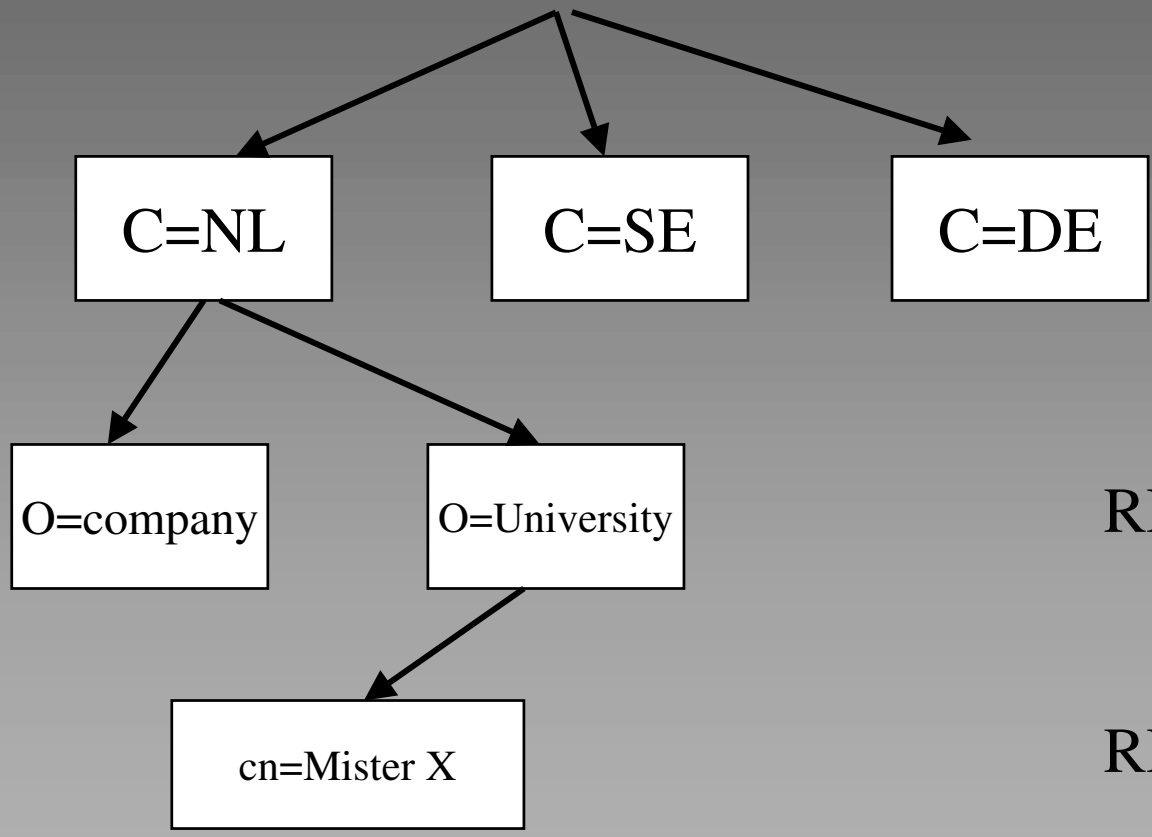
Relative Distinguished Name (RDN) and Distinguished Name (DN)



RDN: C=NL

RDN: o=University

RDN: cn=Mister X

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

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DN Pointer

- 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

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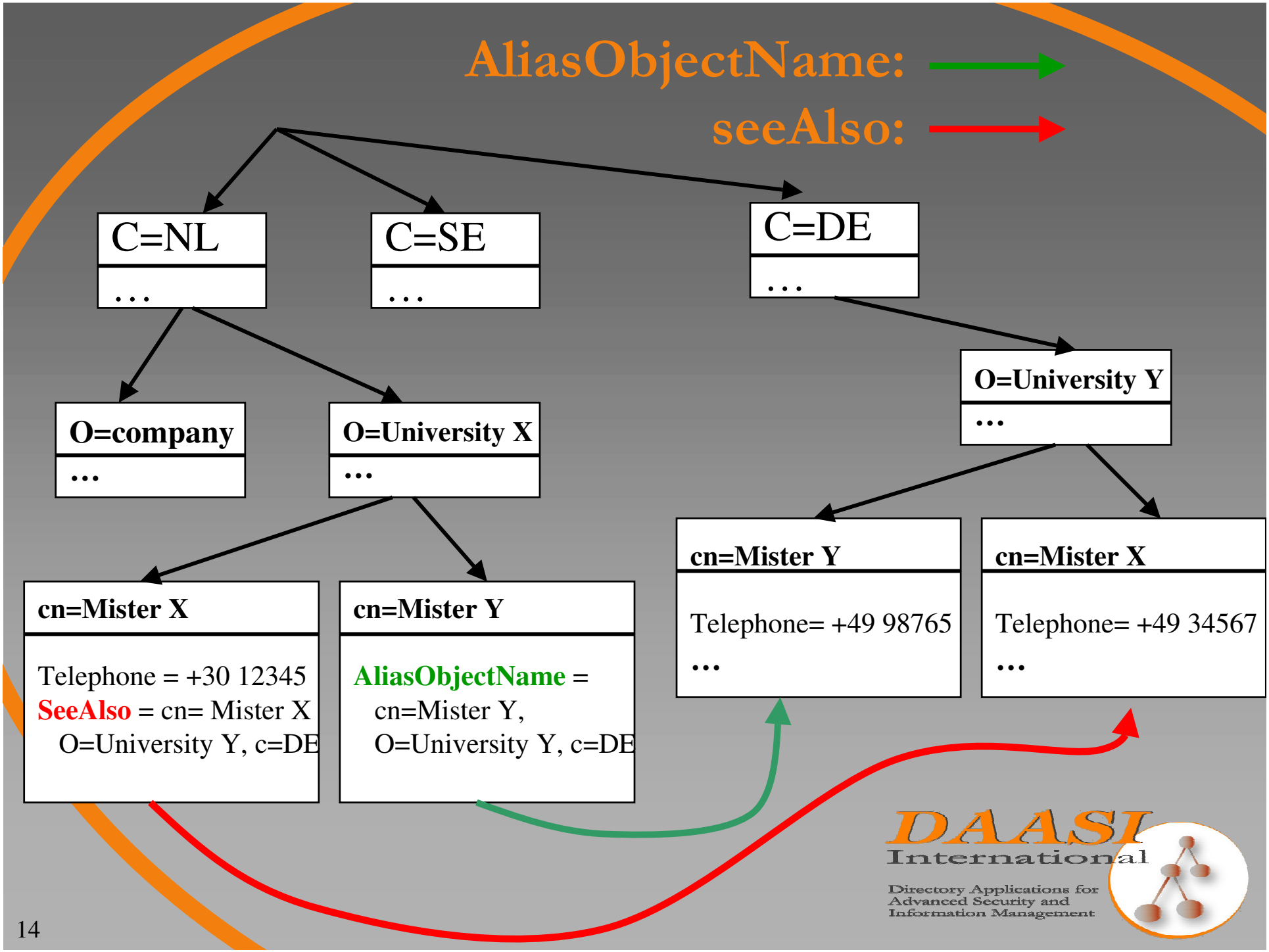
AliasObjectName:
seeAlso:
C=NL
…
C=SE
…
C=DE
…
O=company
…
O=University X
…
O=University Y
…
cn=Mister X
Telephone = +30 12345
SeeAlso = cn= Mister X
O=University Y, c=DE
cn=Mister Y
AliasObjectName =
cn=Mister Y,
O=University Y, c=DE
cn=Mister Y
Telephone= +49 98765
…
cn=Mister X
Telephone= +49 34567
…
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Information Model

- An Entry contains a number of Attributes
- An Attribute consists of:
  - Attribute Type
  - Attribute Value(s)
- An Attribute Type has an associated Attribute Syntax
- The Attribute Value has to conform to that syntax
- Matching Rules to compare Attribute values for
  - equality
  - substring
  - ordering
  - extensible (selfdefined) matching

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Special Attributes

- One or more Attribute type/value pairs 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 is called schema

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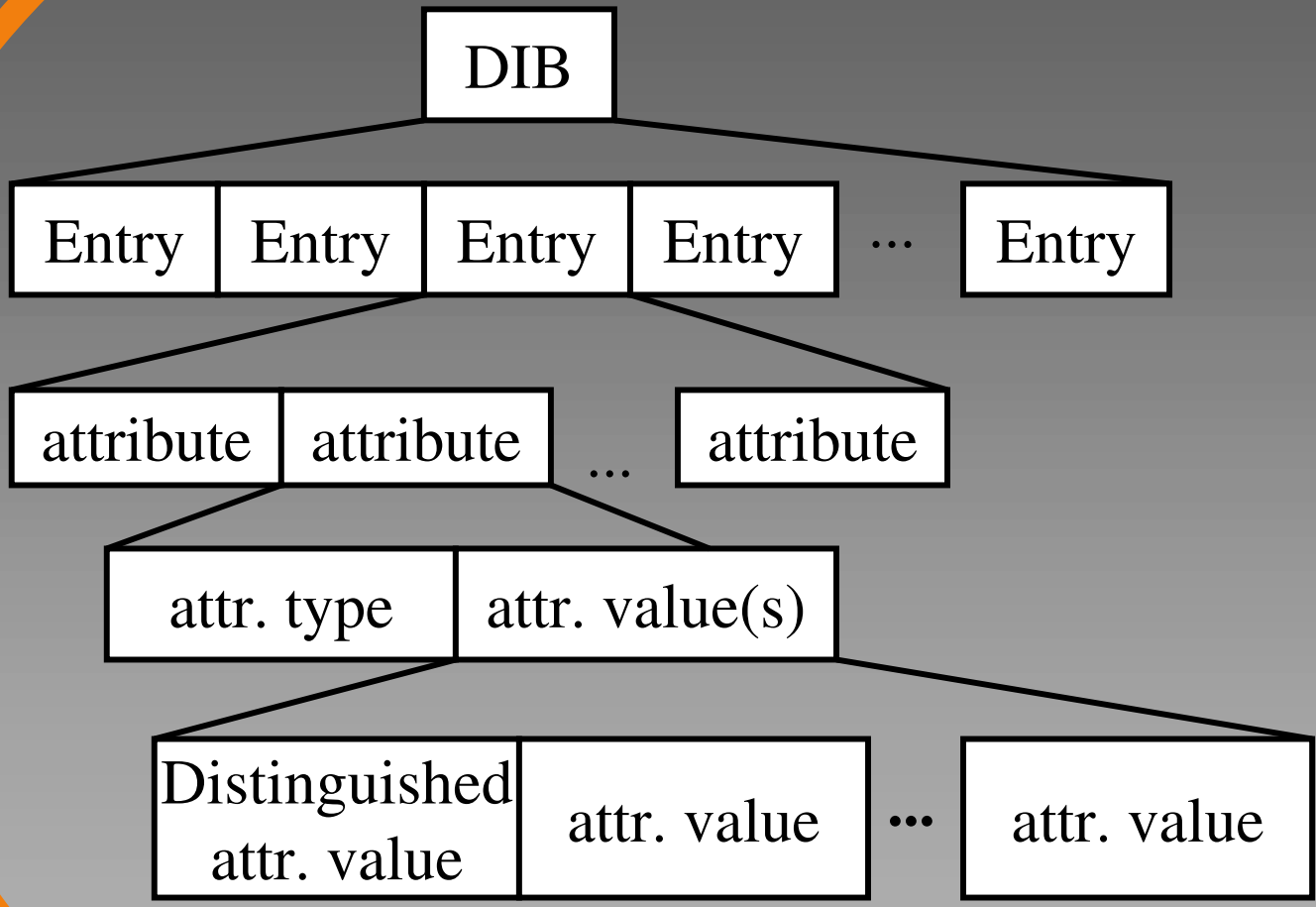
Directory Information Base



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Example:

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

Objectclass=top
Objectclass=person
Objectclass=organizationalPerson
cn=Mister X
cn=Xavier Xerxes
mail=X@dot.com
mail=Mister.X@dot.com
telephoneNumber=1234567

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Open structure

- You can define your own:
  - Object Classes
  - Attribute Types
  - Attribute Syntaxes
  - Matching Rules
- You can locally use self defined schemas
- If you want them to be used globally you have to
  - standardize them (IETF)
  - or at least register them

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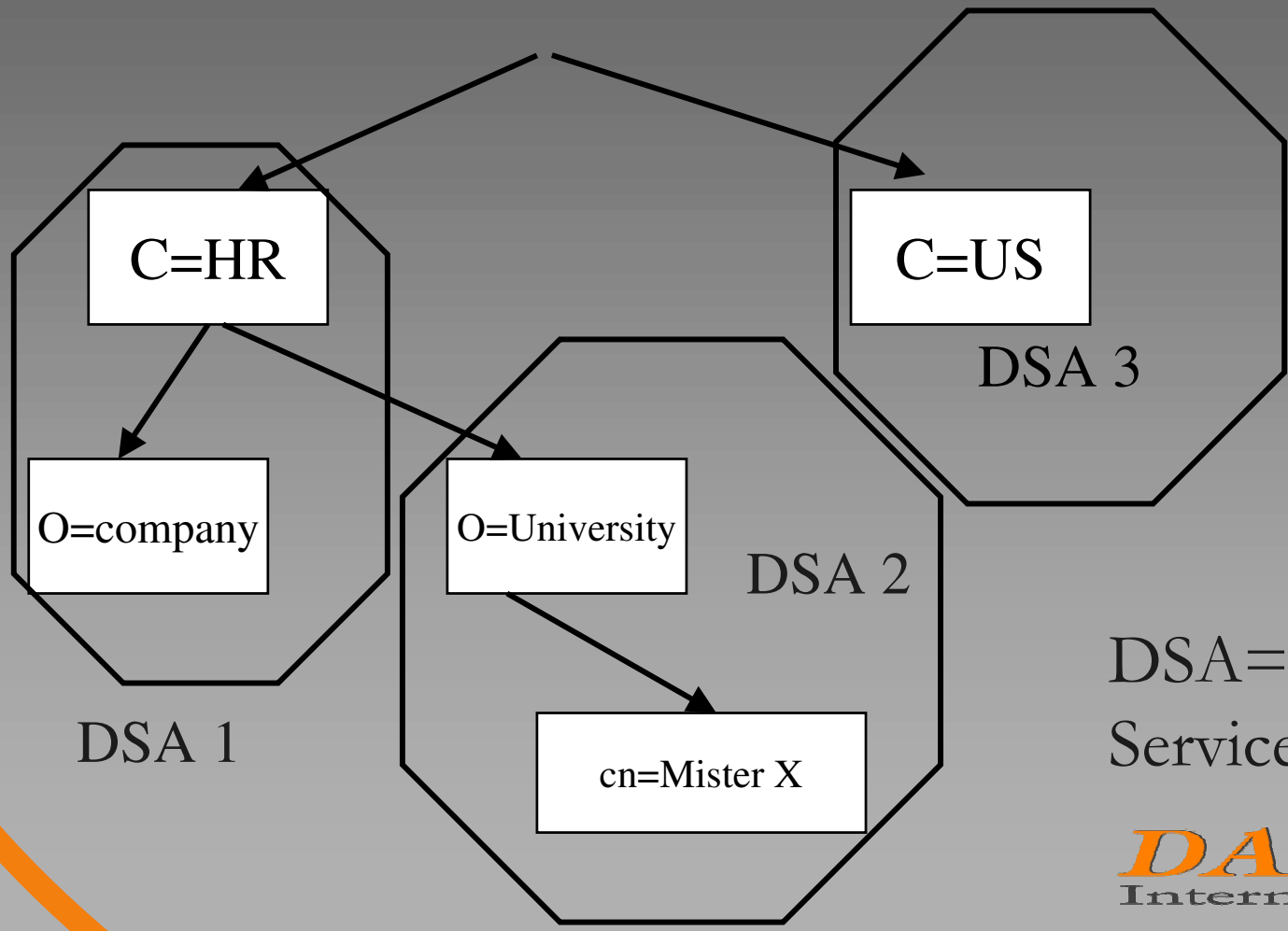
Distribution of the data among Servers



DSA=Directory Service Agent

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LDAP Features

- The LDAP standard defines...
  - a network protocol for accessing information in the directory
  - an information model defining the form and character of the information
  - a namespace defining how information is referenced and organized
  - secure authentication mechanisms
  - an emerging distributed operation model defining how data may be distributed and referenced (v3)
  - Both the protocol itself and the information model are extensible
  - A C API and a Java API

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LDAP Functional Model

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

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LDAPv3 Extension mechanisms

- LDAP controls
  - All 9 LDAP operation (bind, search, add, ...) can be extended
  - controls modify behavior of operation
  - client and server must support the control

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LDAPv3 Extension mechanisms contd.

- LDAP extended operations
  - New defined protocol operation in addition to the nine
- SASL mechanisms
  - Simple Authentication and Security Layer
  - Framing for support of different authentication mechanisms

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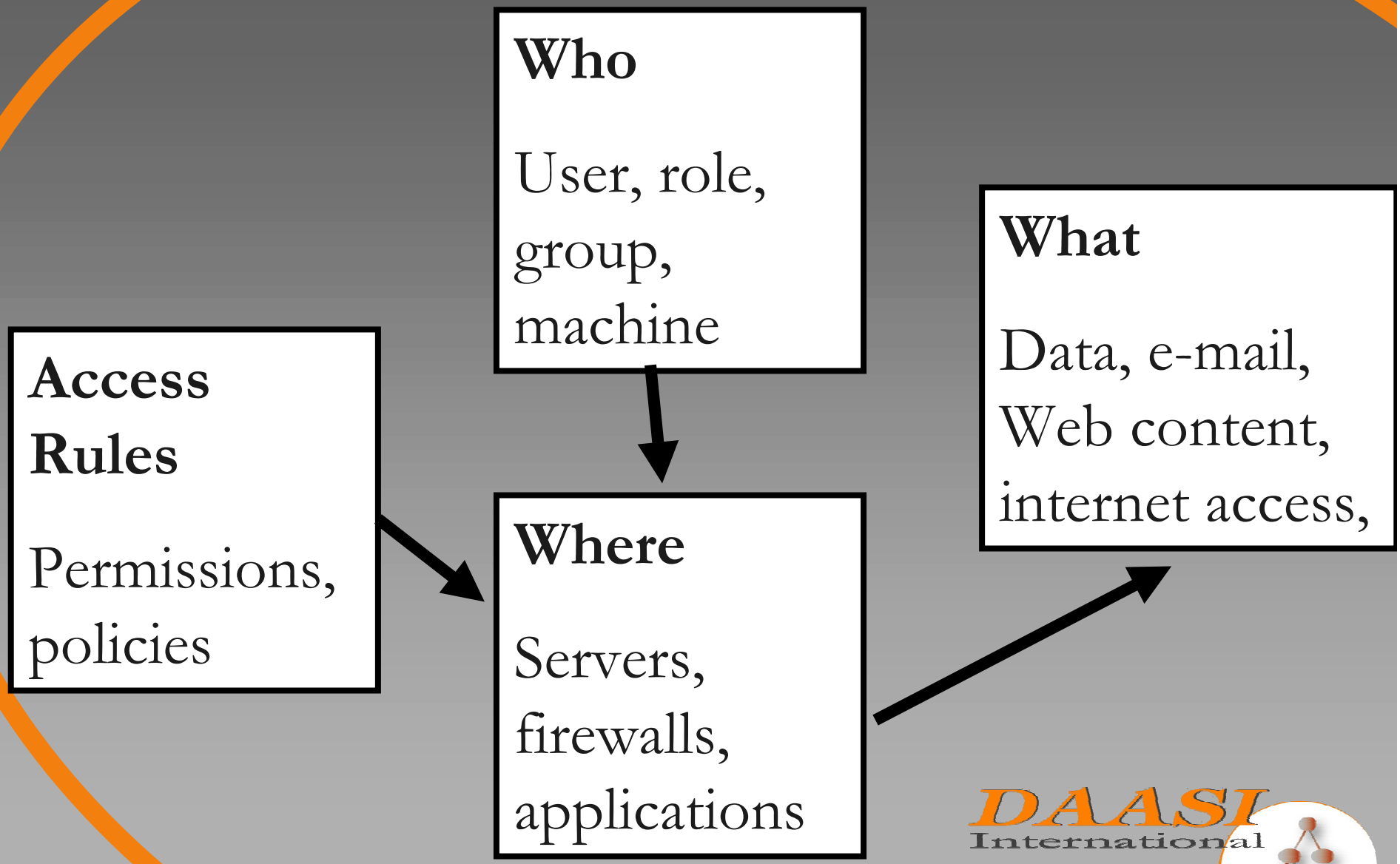
Access Control



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From RL Morgan, PKI Standards Overview

LDAP Data Interchange Format LDIF

- RFC 2849:
- Format for exchanging data
- Example:

```
dn: cn=Mister X, o=University, c=NL
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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Replication

- Vital missing part in LDAP standardization
- Needed to really replace X.500
- Current LDAP implementations have
  - Either proprietary replication mechanisms
  - Or stick to the pseudo standard of University of Michigan implementation (SlurpD)
  - Or just use plain LDIF
  - New possibility: XML (DSML)

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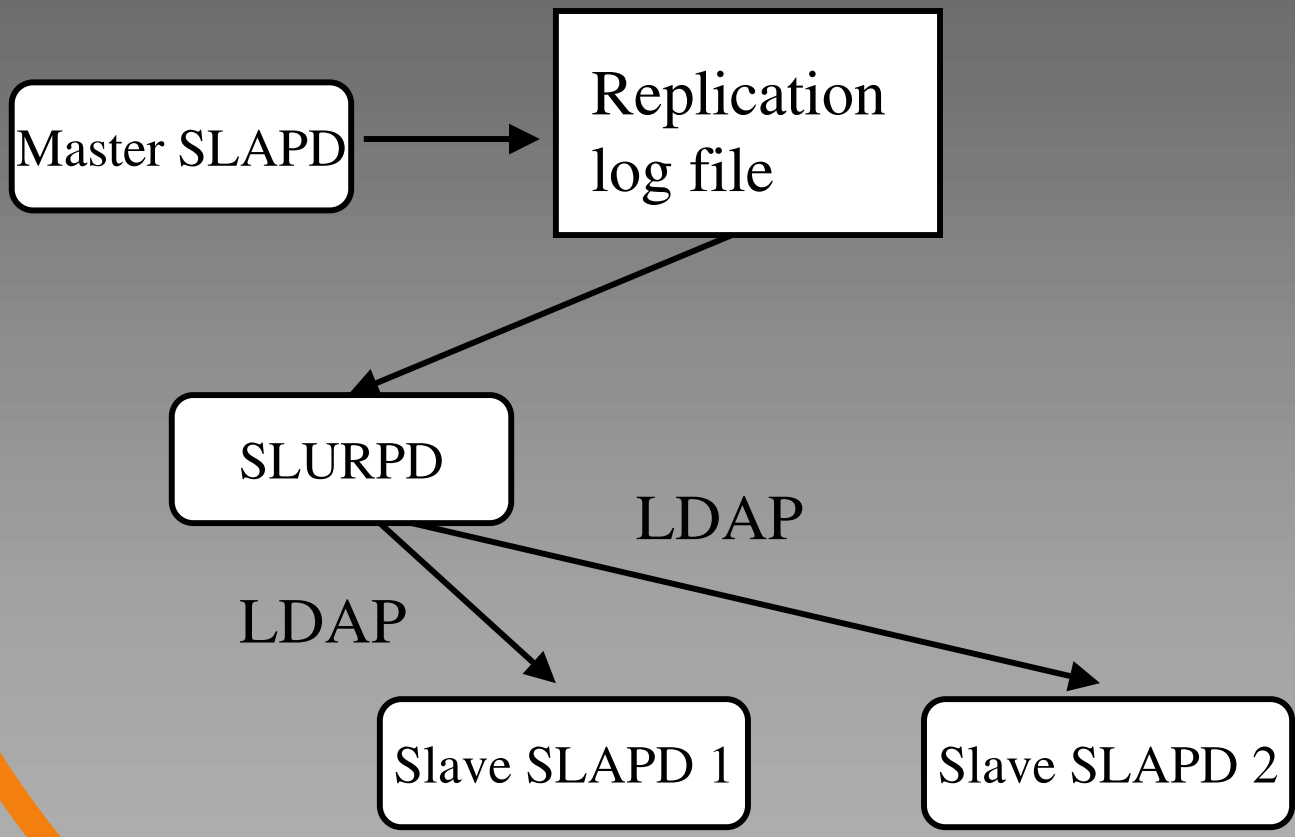
Non Standard LDAP Replication



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Replication log file format

```
replica: host1.hu:9999
replica: host2.hu:8888
time: 960373276
dn: cn=Mister X, o=University, c=HU
changetype: delete

replica: host1.hu:9999
replica: host2.hu:8888
time: 960373277
dn: cn=Mister X, o=University, c=HU
changetype: add
objectclass: top
objectclass: person
objectclass: organizationalPerson
cn: Xavier Xerxes
mail=X@dot.com
mail=Mister.X@dot.com
telephoneNumber=1234567
```

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Who talks LDAP?

- All 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:
  - mailagents
  - browsers
  - PGP clients

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Who talks LDAP? (contd.)

- Many Programs use LDAP for user authentication
  - SMTP auth for outgoing emails
  - IMAP Servers for managing emails
  - Apache Webserver
  - …

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More Information on LDAP ?

- Go to the the Workshop ! ;-)
  - Today 15:00-17:00
  - *Room: TCR*
  - Beware: you will see some slides again that you have seen here

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LDAP based Directory Services 1

Classical Services

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Classical Services 1

- Contact information of people
  - Name, address, telephone number, email address, ...
  - White Pages Directory Service
- Contact information of Organisations
  - Organisational structure, addresses, telephone numbers, email address, ...
  - Yellow Pages Directory Service

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Classical Services 2

- User management
  - Network Information Service
    - replacement of Unix /etc/passwd, groups, services, etc.
  - Authentication service
    - Unified login
    - Web authentication etc.

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BTW: Good News!

- You can build up different Services with the same data
  - E.g. combine White Pages, Yellow Pages and User management in one Directory Information Tree on one or several Servers
  - Just add appropriate Objectclasses and data to your entries and set up a new user interface to the new data
  - This sincerly reduces management costs!

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LDAP based Directory Services 2

Indexing for providing central services on distributed data

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Common Indexing Protocol CIP (RFC 2651 – 2655)

- Index definitions for any directory technology
- Index meshs
- MIME wrapper
- Several Transport protocols (email, FTP, HTTP)
- Several Index Object Formats
  - E.g.: Tagged Index Object (TIO)

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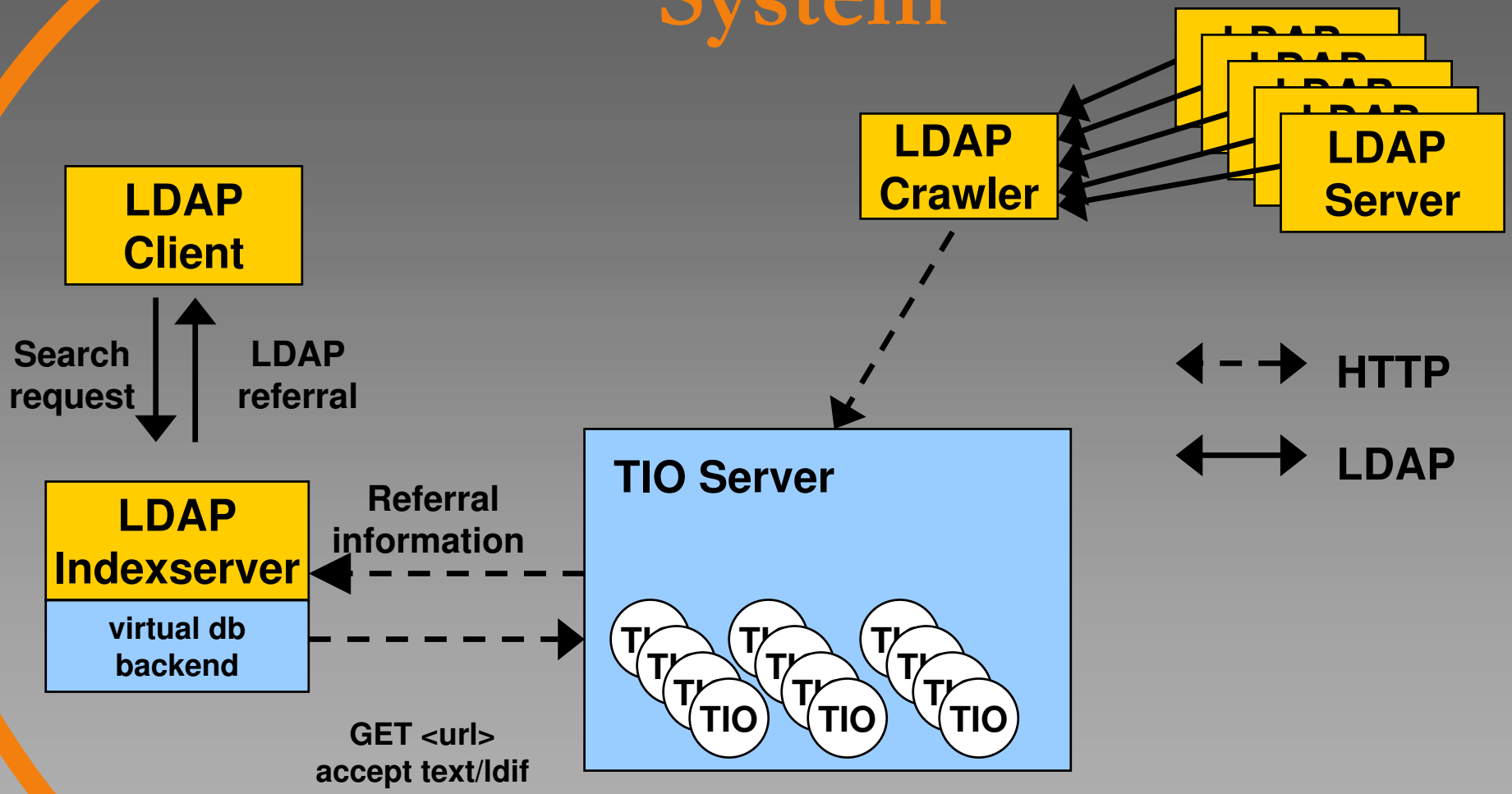
The LDAP Indexing System



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What can the index system be used for?

- White Pages Service
- Metadata Service
- Certificate Service
- Every wide scale service on distributed data

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LDAP based Directory Services 3

Public Key Infrastructure

PKI and Directory

The Burton Group: Network Strategy Report, PKI Architecture, July 1997: (Quoted after: S. Zeber, X.500 Directory Services and PKI issues, http://nra.nacosa.nato.int/pki/hdocs/pkiahwg30/index.htm)

" ... Customers should always consider PKI a directory-enabled set of services and infrastructure. Without directory services, PKI will be exponentially harder to implement and manage. Consequently, customers should't deploy PKI widely without an accompanying directory plan"

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Directory as Key Server Requirements

- Publishing medium for public keys and certificates
- Gets public keys from user
- Gets certificates from CA
- Documents revocation of keys/certificates (CRL)
- Documents status of a certificate at a specific time

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Motivation

- Address problem of multiple certificates for one entity
  - How can the client find the right certificate?
- Find a simple and easy to implement solution
- Solution should be usable in the frame of a large scale distributed LDAP / Common Indexing Protocol (CIP) based certificate repository

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Schema as a simple solution

- Find a set of certificate fields and extensions that one might want to search upon
  - Meta-data approach
- Parse the certificate and store this set as LDAP attributes
- Advantages:
  - no new server features needed
  - easy to implement in clients
  - usable in a CIP environment

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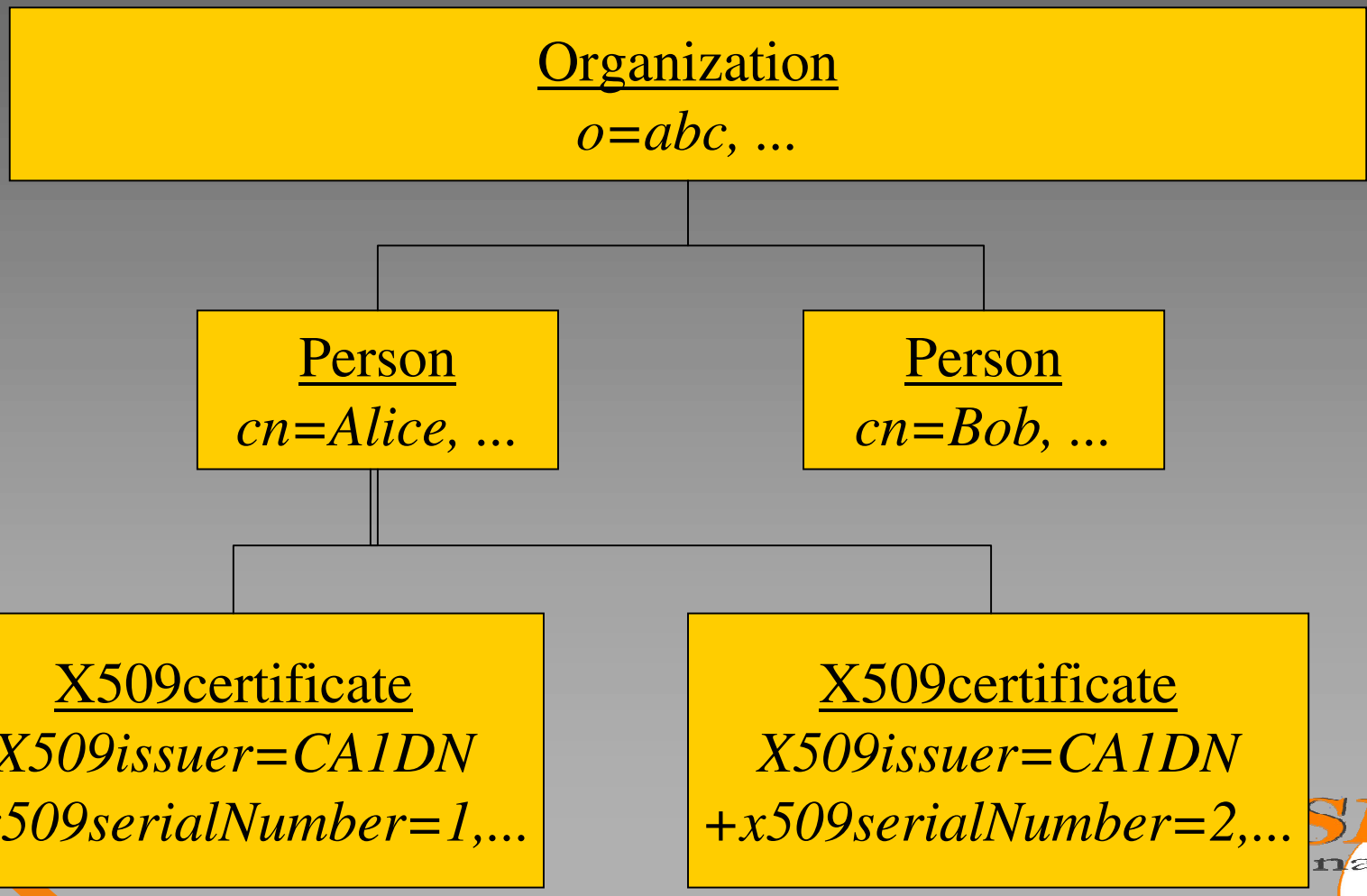
DIT Structure in white-pages services



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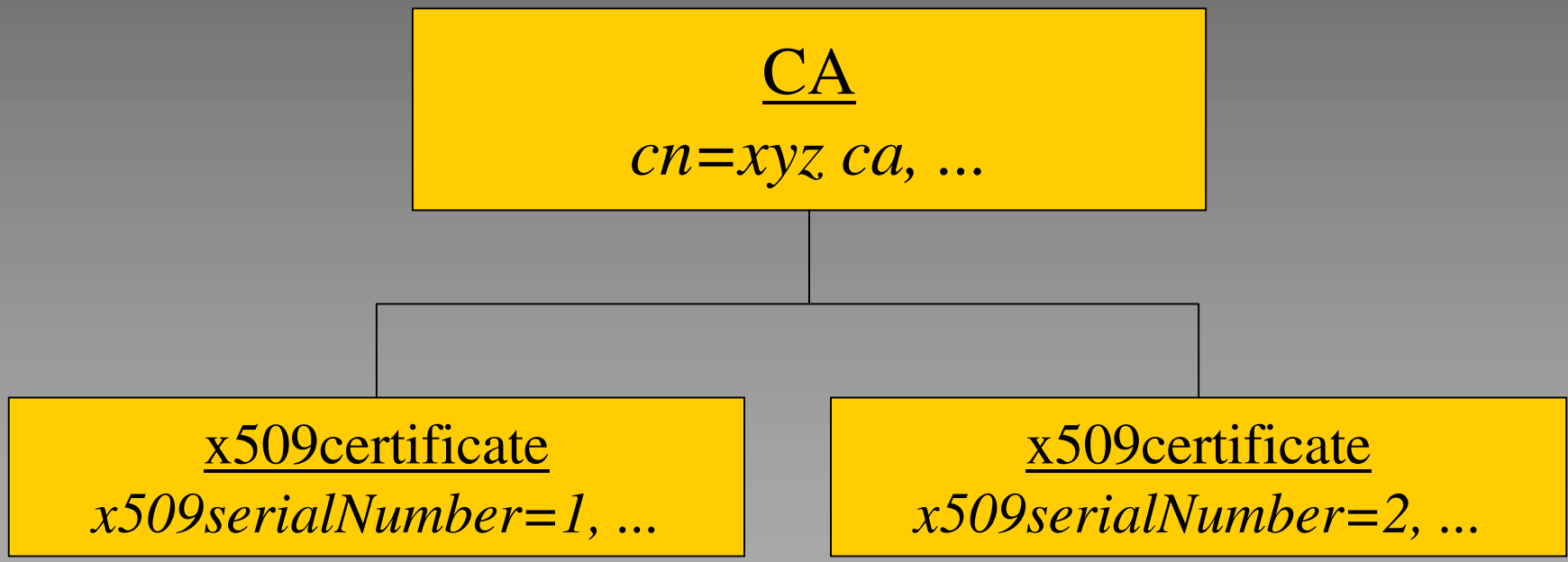
DIT Structure in certificate repositories



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LDAP based Directory Services 4

Metadata Service and the Semantic Web

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Metadata

- Easiest definition: Data about data, e.g.:
  - Data: Texts, i.e. anything that tells us some kind of story (books, articles, webpages, films, etc.)
  - Metadata: Information about the texts (author, title, date of creation, etc.)
- There is one kind of Metadata that is really complicated: Keywords
  - How can we be sure that we use the same keywords for describing the same topics?
  - Controlled vocabularies!

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Controlled Vocabulary

- Classification System
  - E.g. Dewey Decimal Classification
  - Classes, subclasses, subsubclasses, ...
  - One kind of relation between concepts
- Thesaurus
  - Assembly of homonyms
  - Could include antinyms and some more relations
  - A limited set of relations between concepts

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Ontologies

- Again: Concepts and relations between them
- No limitation as to the number of different relations
  - Including sub/superclass
  - Including relationships of thesauri
  - ...
- Thus a perfect knowledge store

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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)

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Visions for the future

- „Semantic Web“ (Tim Berners-Lee)
- Web Services (see below)
- Accessed by humans *and* programs
- Quality content better structured
- Knowlegde enhanced through Ontologies
- Disambigued:
  - Bank (finance institute) is not the same as
  - Bank (river bank)

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How can Ontologies help?

- Remember: 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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Ontologie Storage Proposal

- Combined repository for metadata and ontologies
  - based on LDAP technology
  - thus accessible with the same protocol
- Large scalability
  - by setting up an Indexing system
  - based on Common Indexing Protocol (CIP)

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Ontologie Storage Proposal

- Ontologie data model based on Common Information Model (CIM)
  - provides a model for associations that can be used for mapping the relations between objects
  - CIM is commonly used in Resource management and for Policy data
  - Technology independant modelling language (sort of UML)
  - Mappings to e.g. LDAP and XML

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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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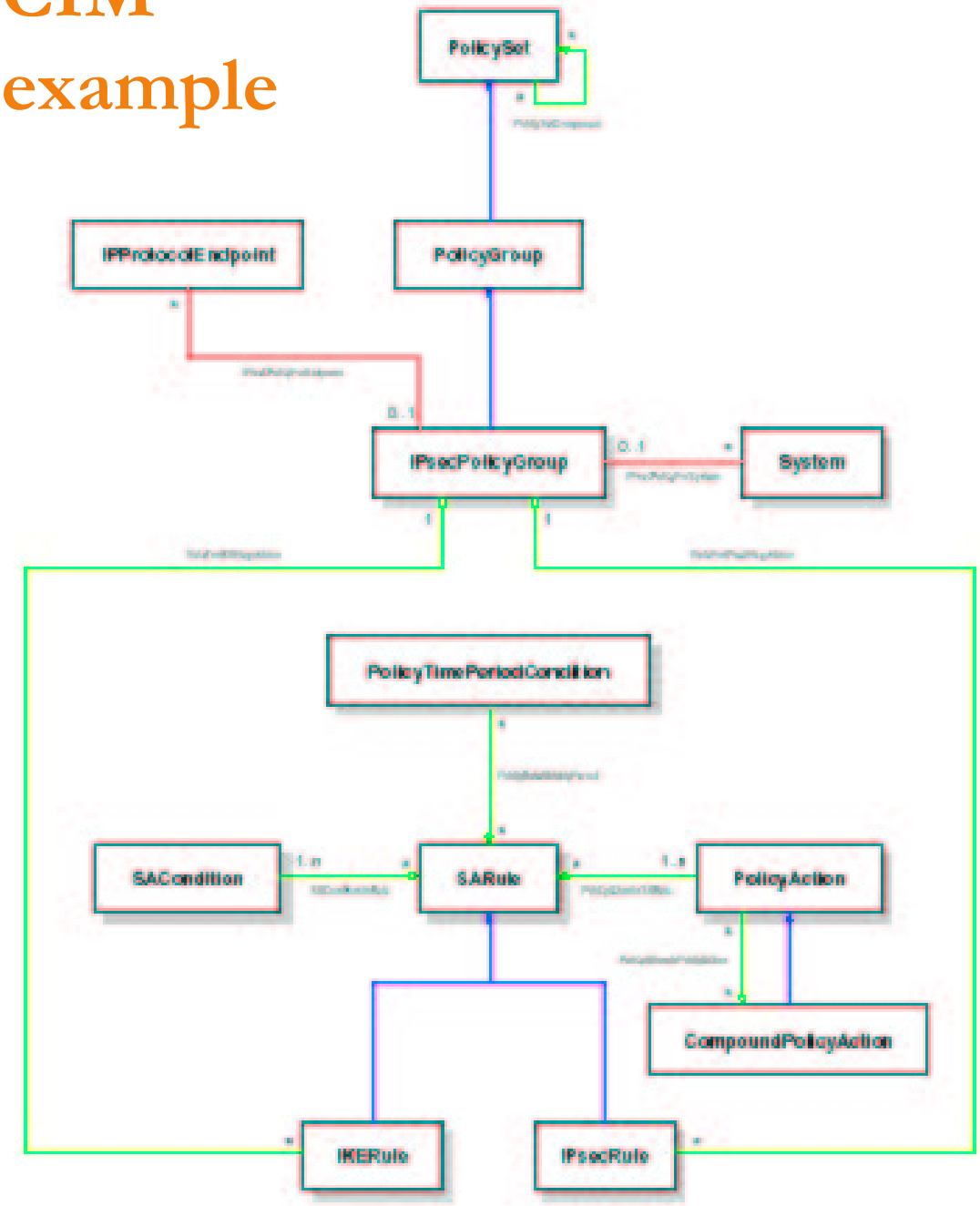
CIM example



objects

inheritance

aggregation

association

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CIM, 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

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Apropos Web Services

- SOAP
  - Simple Object Access Protocol
  - XML based Remote Procedure Calls
- WSDL
  - Web Services Description Language
  - XML based Interface description
- UDDI
  - Universal Description, Discovery and Integration
  - Repository for WSDL descriptions
  - Can be well replaced by LDAP

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LDAP based Directory Services 5

Policy repository

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Policy repository

- Policy for Routers defining which packets to priortise, if and how to check authenticity, etc.
- Based Common Information Model (CIM)
- Directory Enabled Networks (DEN)
  - Quality of Service (QoS)
- IPSec policy
  - IETF WG IPSecpol
- Any other policies

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LDAP based Directory Services 6

- Information for Grid Computing

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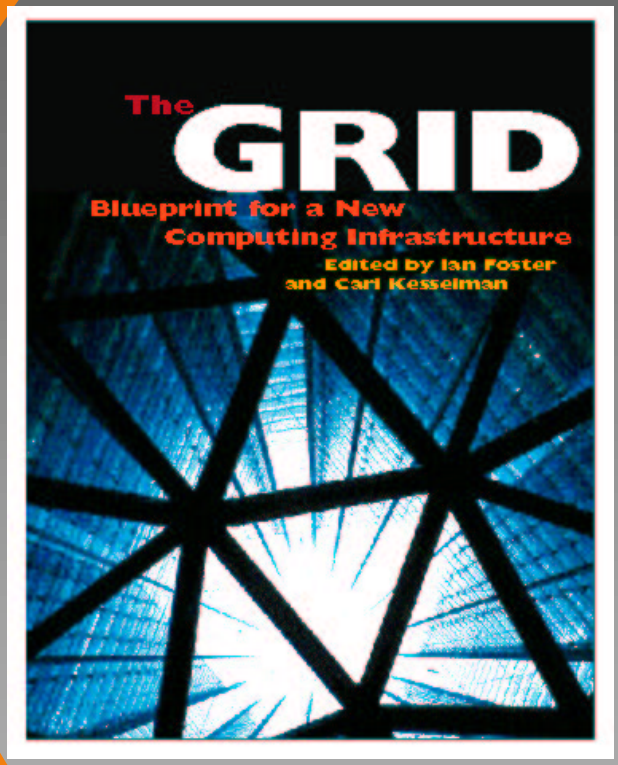
The book



- Ian Foster, Carl Kesselmann (Ed)
  The Grid: Blueprint for a new Computing Infrastructure
  Morgan Kaufman Publishers, 1998
  - a summary of the state of the art of super computing,
  - now seen as the beginning of a new vision

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The metapher

- Power Grid is a complex infrastructure that has a very simple user interface: the power outlet. Everything else is hidden from the user
- Grid Computing wants to provide an equally simple interface to computing power (CPUs, data storage, etc.) from the network.

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Definitions

„The Grid is a consistent and standardized environment for collaborative, distributed problem solving that requires high performance computing on massive amounts of data that are stored, and/or generated at high data rates using widely distributed, heterogeneous resources „

„The Grid is an inherently layered architecture that provides for common services and a diversity of middleware that supports building distributed, large-scale, and high performance applications and problem solving systems. „

(W.E. Johnston as quoted by Ian Foster)

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The tasks

- Distribution of data and computing ressources in broadbandwith networks to be able to provide petabyte storage and petaflops computing power
- Promotion of international collaboration
- Optimal utilization of resources (storage, CPUs, measuring devices, experimental devices

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What is new?

- Metacomputing is in existance for quite a while
- New is the concept of standardized interface to meta computing, the so called Middleware
- The Global Grid Forum (GGF) took up the task to create such standards in an IETFish way
- Complicated requirements: “Run program X at site Y subject to community policy P, providing access to data at Z according to policy Q”

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Requirements

- High bandwidth between powerfull systems
  - To specify simulations, initiate and steer computation
- Security
  - Use Encryption, Certificates, Single sign on
  - To Authenticate, negotiate and delegate authorization
- Data management
  - Use Distribution, Replication, Metadata
  - To locate and acquire resources, access remote datasets, collaborate on results

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Grid Resource Information Service

- (Dynamic) Information about specific resources:
  - Load, process information, storage information, etc.
- Supports multiple information providers
- Answers questions like:
  - How much memory does machine have?
  - Which queues on machine allows large jobs?
- LDAP is an ideal technology

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Replica management

- Maintain a mapping between logical names for files and collections and one or more physical locations
- replica cataloging and reliable replication as two fundamental services
  - LDAP is used as catalog format and protocol, for consistency
  - LDAP object classes for representing logical-to-physical mappings in an LDAP catalog

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New Trends in Grid Computing

- Web Services (see above)
  - Open Grid Services Architecture (OGSA)
  - Using SOAP and WSDL
  - A whole set of new GGF working groups
- CIM (see above)
  - Used for modeling grid related data
  - New working group on modelling Job Submission Information
  - CIM will be integrated in OGSA

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Visions for the future

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Well ....

- Almost everything I told you about is in status nascendi
- I didn‘t mention the term middleware
  - Lets have a short definition here:
  - A software layer between the network and network applications that provides standardized interfaces to commonly needed services

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The Vision

- Globally used LDAP based Middleware that provides:
  - The same Authentication services to different applications
  - Ontology information to intelligent services
  - Information about automated services to agents
  - Policy information to network devices for intelligent routing

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The good news:
we are allmost there!

Questions?

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

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