Grid Security, an introduction

- Introduction to security issues in grid infrastructures and cross-domain user collaborations

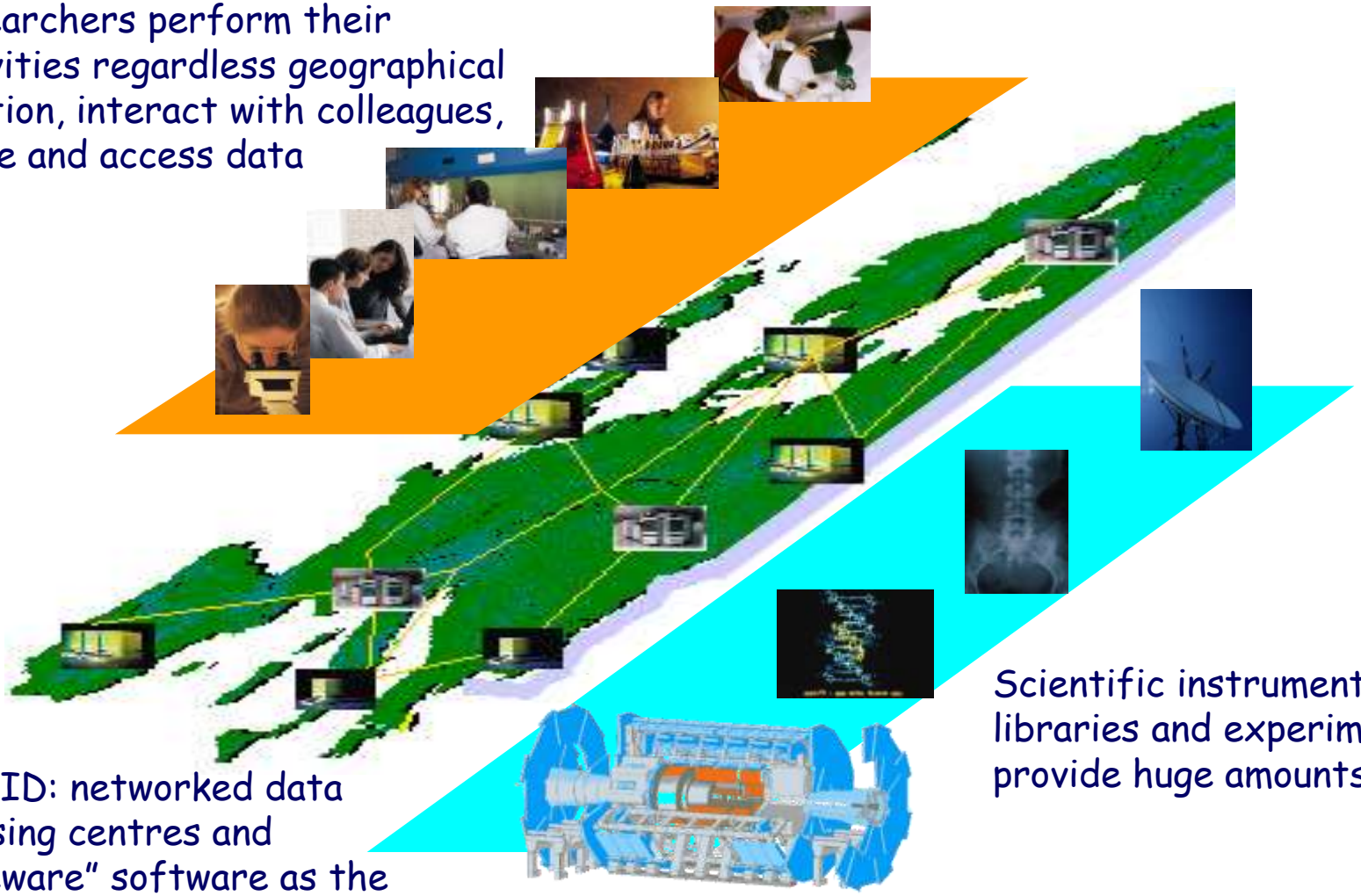
NIKHEF pdp David Groep, Nikhef

BiG Grid
the dutch e-science grid


Enabling Grids for E-sciencE
Scheduled = 9740
Running = 11034
Grid Security
dealing with user-centric collaborations
Imperial College London

Grid from 10 000 feet

Researchers perform their activities regardless geographical location, interact with colleagues, share and access data



Scientific instruments, libraries and experiments provide huge amounts of data

The GRID: networked data processing centres and "middleware" software as the "glue" of resources.

based on: Federico.Carminati@cern.ch

Grid: following research collaborations

Some things that may make a grid a bit 'special' compared to other distributed computing efforts

- collaboration of individuals from different organisations
  - most of the scientific grid communities today consist of people literally 'scattered' over many home organisations … internationally
- delegation – programs and services acting on your behalf – are an integral part of the architecture
  - unattended operation
  - resource brokering
  - integrating compute, data access, and databases in the same task

But … what is Grid?

The word '*grid*' has been used in many ways

- cluster computing
- cycle scavenging
- **cross-domain resource sharing**
- …

A clear definition for the grid?

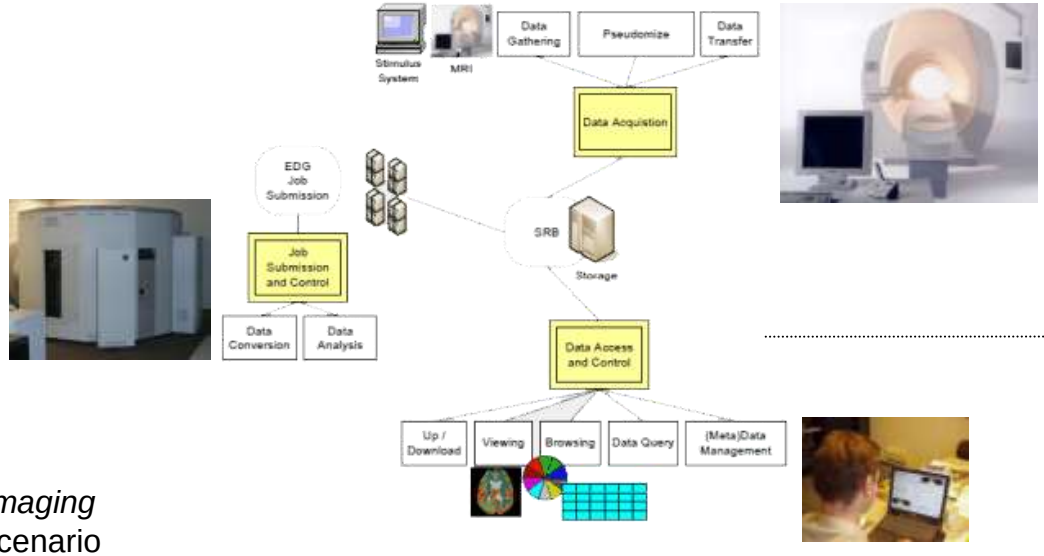
- Coordinates resources not subject to centralised control
- Using standard, open and generic protocols & interfaces
- Provides non-trivial qualities of collective service

www.ogf.org

Definition from Ian Foster in *Grid Today*, July 22, 2002; Vol. 1 No. 6, see http://www-fp.mcs.anl.gov/~foster/Articles/WhatIstheGrid.pdf

Example: a biomedical imaging project

- On functional MRI studies run from a ‘standardized’ workflow
- People and systems involved (the ‘vlemed’ VO)
  - medical doctors and the fMRI apparatus: AMC hospital
  - data storage service: SARA Compute and Network services
  - Compute services: Nikhef, Philips Research, SARA
  - algorithm developers: University of Amsterdam
  - Medical doctors and analysts (MD): AMC



SP1.3 Medical Imaging
simplified user scenario

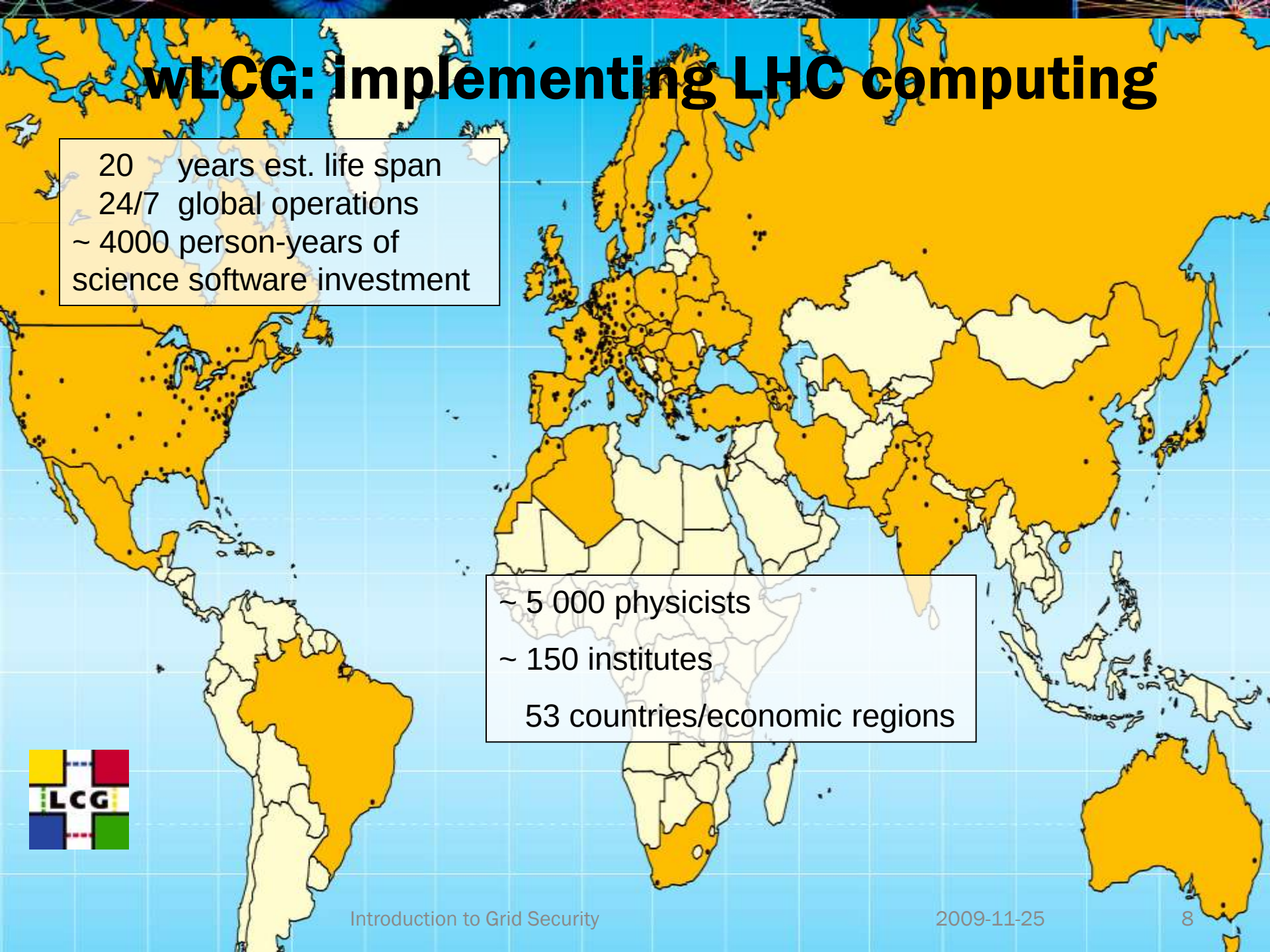
Typical use case: WISDOM

Wide-area In-Silico Docking On Malaria

- people and organisations
  - Bio-informaticians and grid development: IN2P3 (FR)
  - Service systems (brokers) provided by: RAL (UK), NIKHEF (NL)
  - algorithms, and results analysed by: SCAI (DE)
  - Compute resources: provided by over 45 independent organisations in ~15 countries, whose primary mission is usually HE Physics!
  - VO management hosted by CERN (CERN), and the VO itself is managed by Vincent Breton (FR)

wLCG: implementing LHC computing

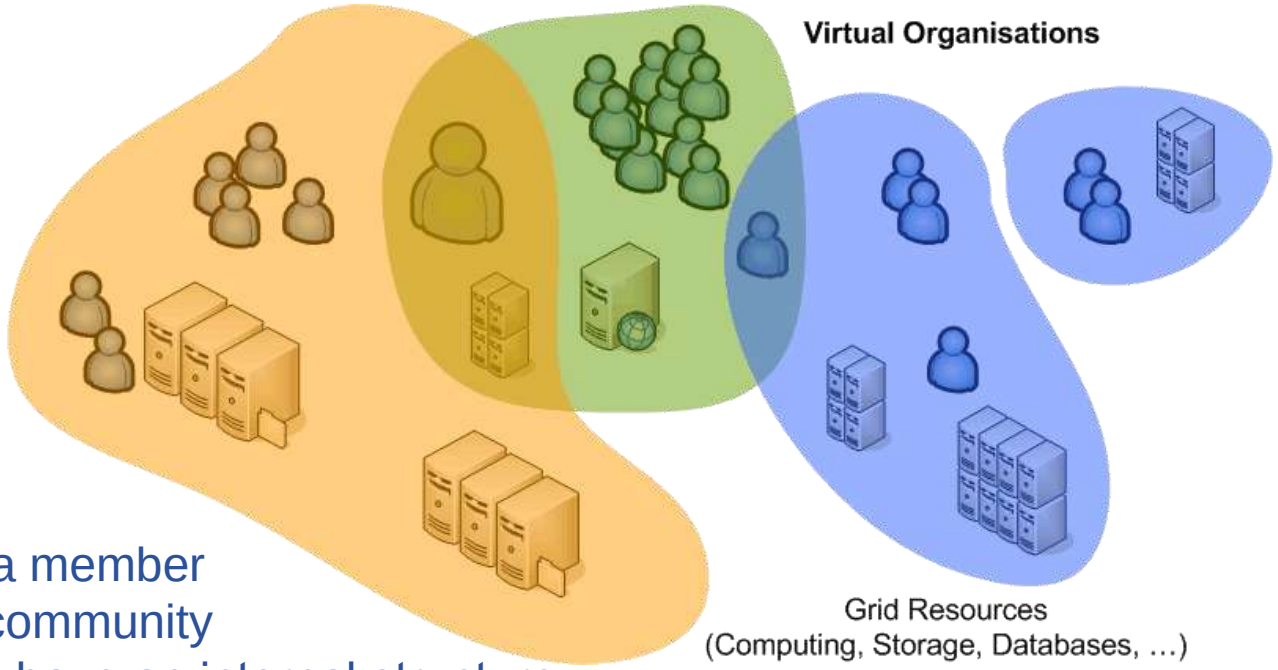
20 years est. life span
24/7 global operations
~ 4000 person-years of science software investment



~ 5 000 physicists
~ 150 institutes
53 countries/economic regions

Virtual Organisation

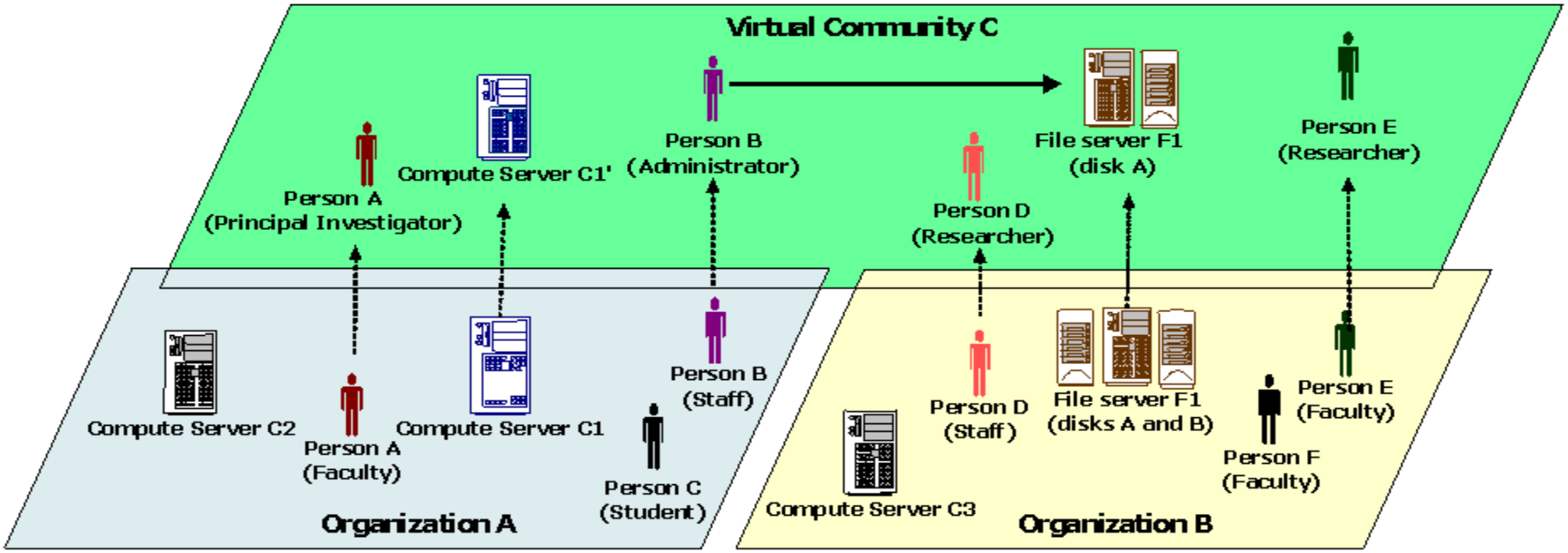
A set of individuals or organisations, **not under single hierarchical control**, (temporarily) **joining forces** to solve a particular problem at hand, bringing to the collaboration a subset of their resources, sharing those **at their discretion** and each **under their own conditions**.



- User driven
- Users are usually a member of more than one community
- Any “large” VO will have an internal structure, with groups, subgroups, and various roles

Virtual vs. Organic structure

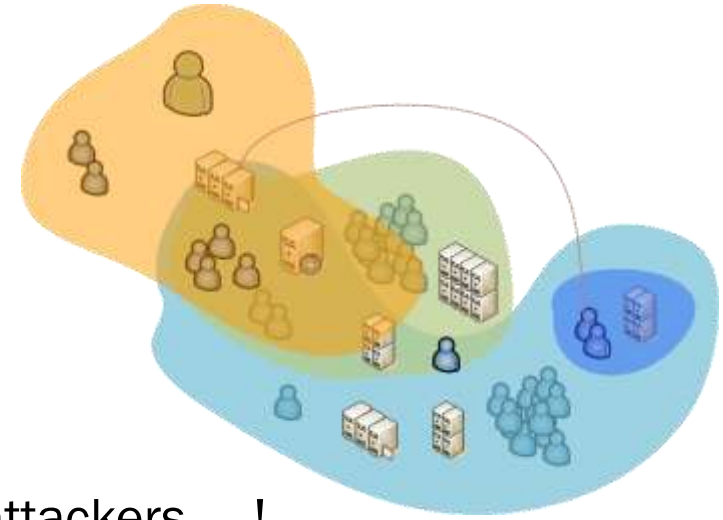
- Virtual communities ("virtual organisations") are many
- An person will typically be part of many communities
  - has different roles in different VOs (distinct from organisational role)
  - all at the *same time*, at the *same set of resources*, with SSO



graphic: OGSA Architecture 1.0, OGF GFD-I.030

Before and parallel to the Grid …

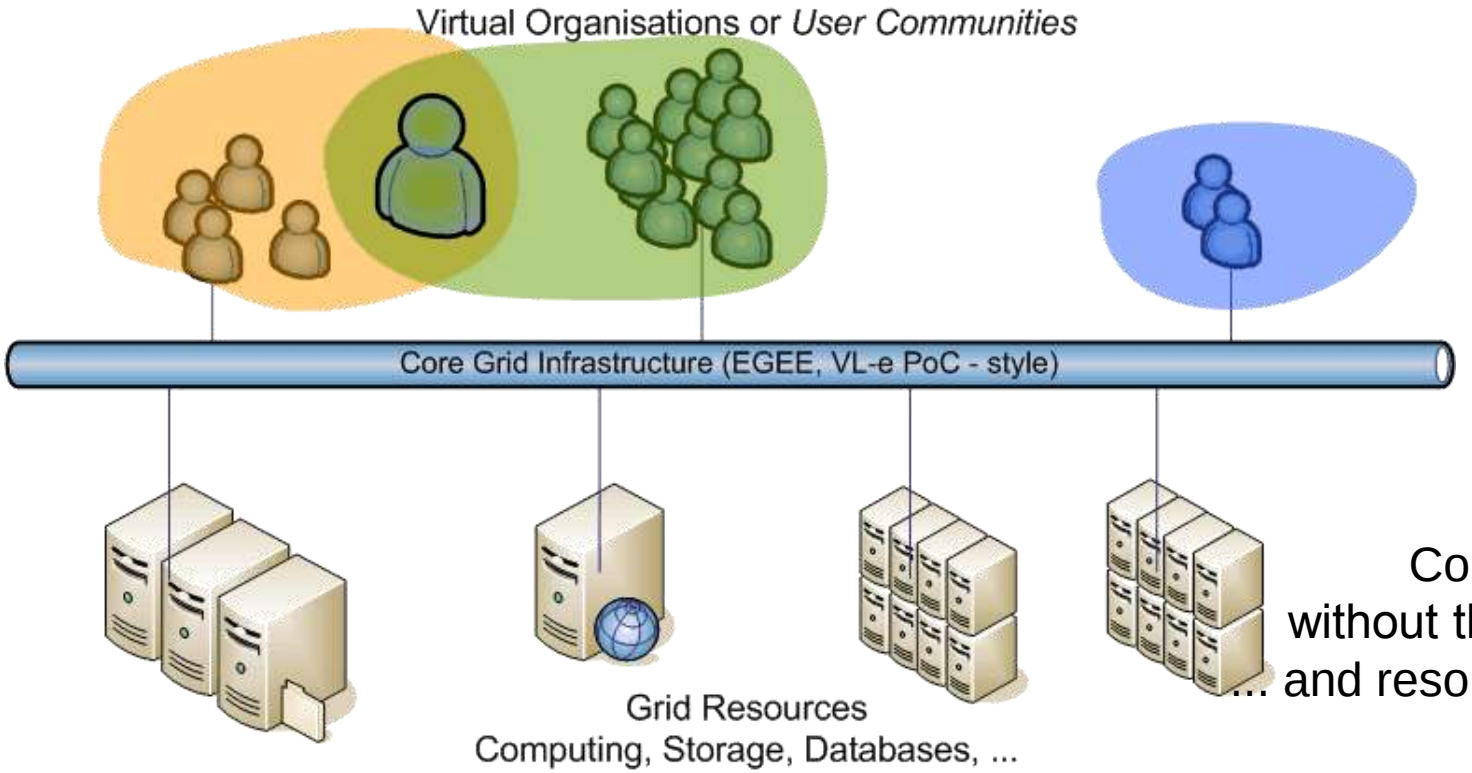
- Each user in a collaboration gets *individual* access to many or most of the ICT resources of all participating groups
  - Shared group accounts
  - Individual accounts with the same name (and password)
  - Permissive password sharing



- Characteristics
  - Gets more access than needed
  - No centralized management
  - Easy ‘hopping’ between sites, also for attackers … !

Grid 'VOs': structuring communities on a sustainable infrastructure

- Virtual Organisations as groupings of users
  - E-infrastructures (EGI, BiG Grid) provide persistent infrastructure with a "bus-like" view for VOs: essentially *user communities*



Communities can exist without their 'own' resources ... and resource centres can do without local users

Granting Access

Policy framework

Authentication

Authorization and Virtual Organisation membership

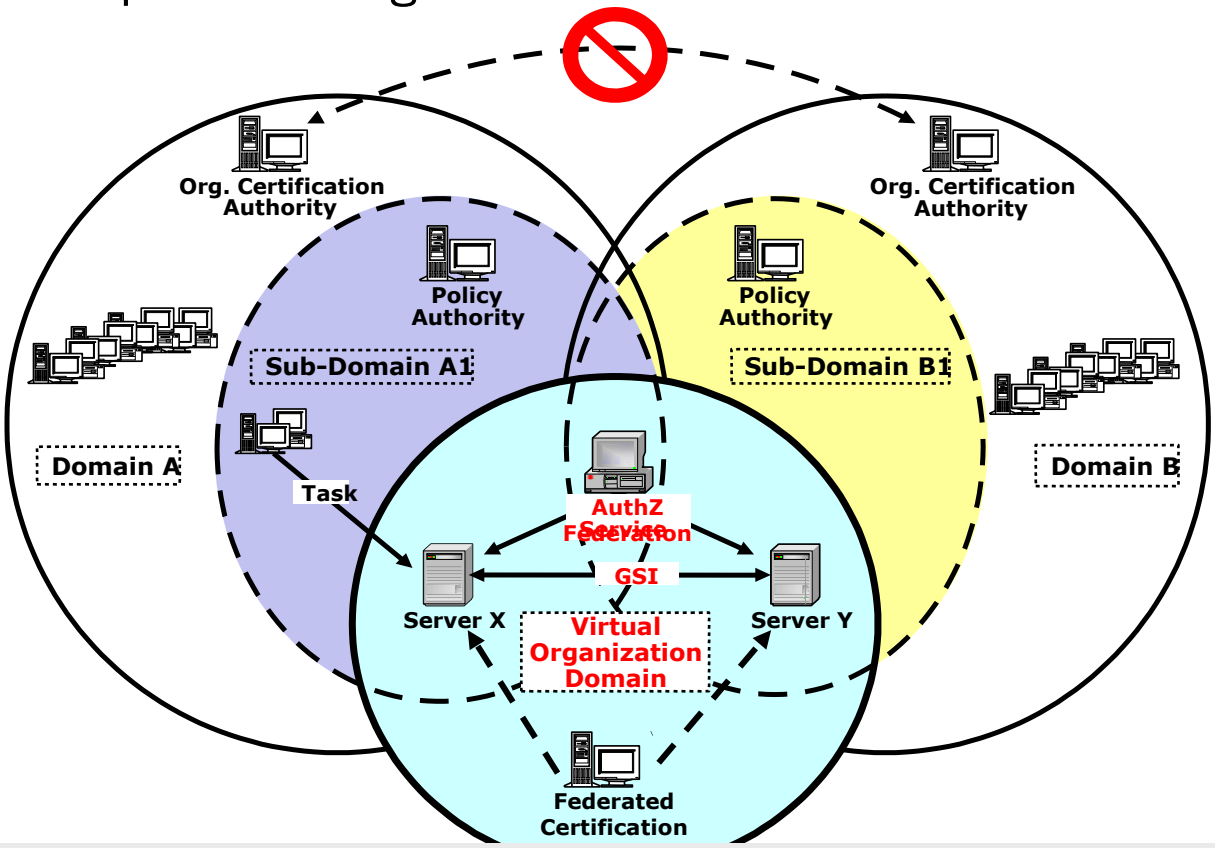
GRID SECURITY MECHANISMS

V Access and Allocation

- But: why grant access to a user or community?
  - Joint research programme
  - Joint funding in projects
  - Economic models,
    either virtual ‘pot money’ or proper billing & settlement
- Not too different from ‘conventional’ models
  - ‘Get an account because we work together’
  - Allocations on supercomputers or large clusters
  - Pay-per-use infrastructure (AWS EC2 & S3, etc…)

Trust relationships

- For the VO model to work, parties need a trust relationship
  - the alternative: every user would need to register at every resource!
  - need to provide a 'sign-on' for users that works across VOs



graphic from: Frank Siebenlist, Argonne Natl. Lab, *Globus Alliance*

Elements of Trust

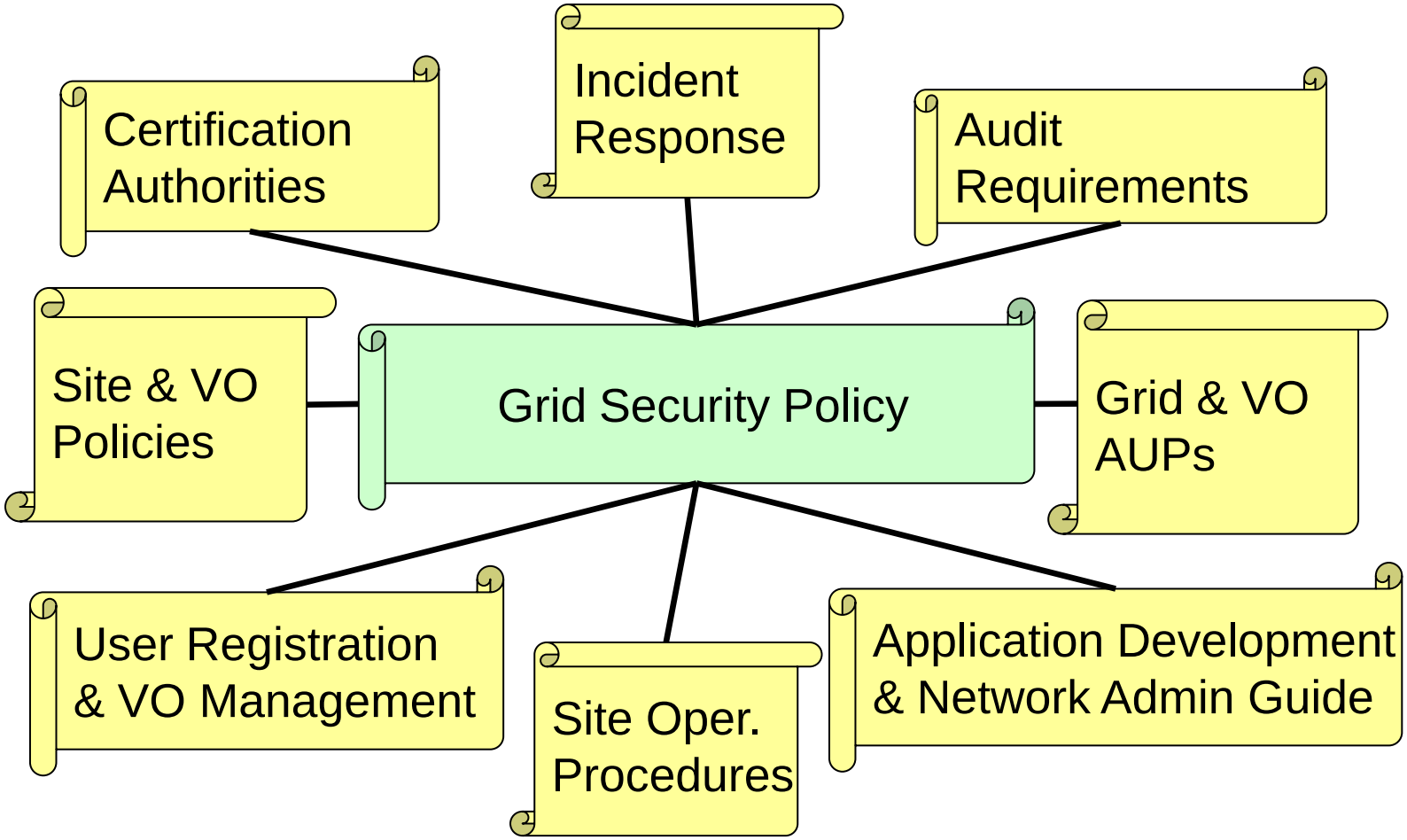
- Authentication
  - Who are you?
  - Who says so?

- Authorization
  - Why should I let you in? What are you allowed to do?
  - By whom? *Who* said you could do that?
  - Community management and registration

- Accounting (billing and settlement)
- Incident Response
- Compliance

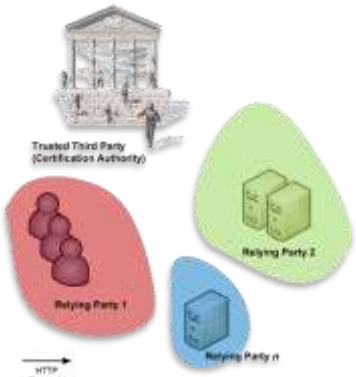
Grid Security Policy ecosystem

- A User and VO directed policy implementation



Authentication models

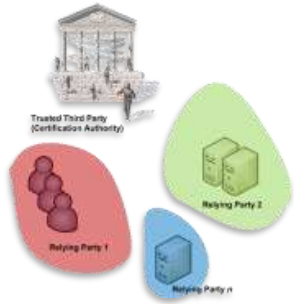
- Direct user-to-site
  - passwords, enterprise PKI, Kerberos
  - Usually with implicit authZ
- PKI with trusted third parties
- Federated access
  - Controlled & policy based
  - ‘Free-for-all’, e.g., OpenID
- Identity meta-systems
  - Infocard type systems



Typical application domains

- Web access and direct user interactions
  - Moving towards WebSSO & federations
  - Or use client PKI where users already have certificates

- Task delegation (compute, data management)
  - PKI 'Trusted Third Party' based
  - Augmented with 'proxy' (RFC3820) delegation



Grid authentication

With emergence of production grids: need for providing *cross-national* trust

Driven by resource owner – 'relying party' – needs

- independent of users and Vos, who have a conflict of interest

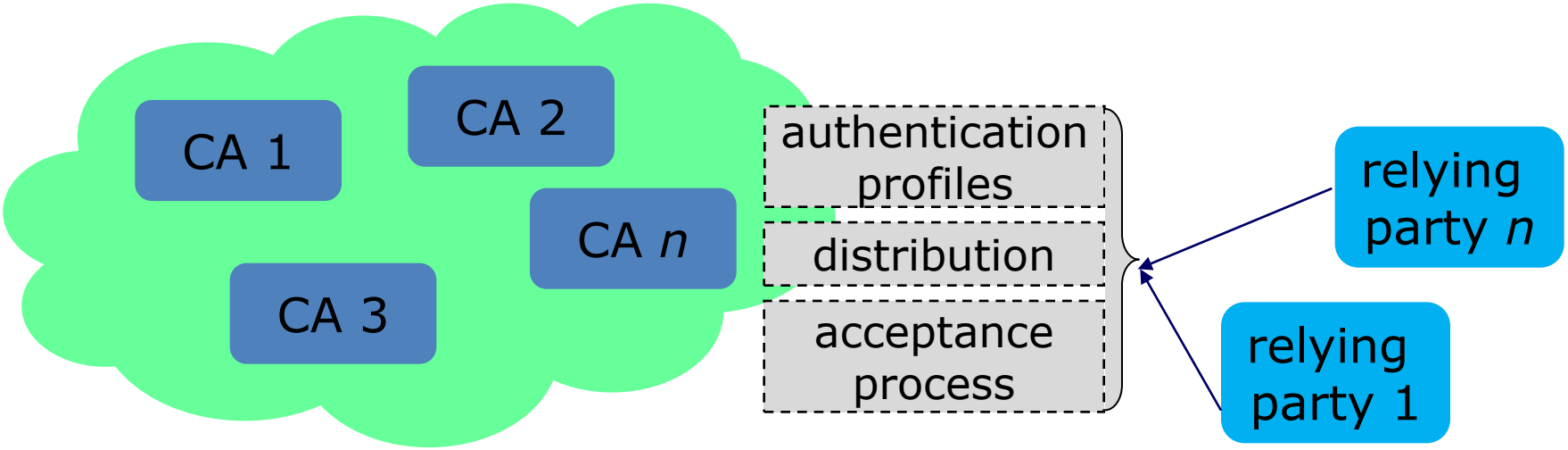
- National PKI?
  - in general uptake of 1999/93/EC and e-Identification is (too) slow
- Various commercial providers?
  - Main commercial drive: secure web servers based on PKI
  - Comodo, Verisign, Global Sign, Thawte, Verisign, SwissPost, ...
  - primary market is *server* authentication, not end-user identities
  - use of commercial CAs solves the 'pop-up' problem
    ... so for (web) servers a pop-up free service is actually needed
- Grass-roots CAs?
  - usually project specific, and without documented policies
  - unsuitable for the 'production' infrastructure

Building a grid authentication infrastructures

- Grid research/academic PKIs
  - started off with pre-existing CAs, and some new ones
  - 'reasonable' assurance based on documented procedures
  - single assurance level inspired by grid-relying party** requirements
  - using a threshold model: *minimum requirements*

- Grid CA coordination driven by 2000 need to solve cross-national authentication issues *right now*
  - separation of AuthN and AuthZ allowed progress in the area
  - the policies convinced enough resource providers to 'trust' the AuthN assertions
  - there were and are individuals all over Europe (and the world) that need access to these resource providers

Federation Model for Grid Authentication



- Federation of independent CAs
  - common **minimum requirements** (in various flavours)
  - trust domain as required by users and relying parties
    where relying party is (an assembly of) resource providers
  - defined and peer-reviewed acceptance process

- No single top
  - leverage of national efforts and complementarities
  - Allow paced regional development, organisation and customisation

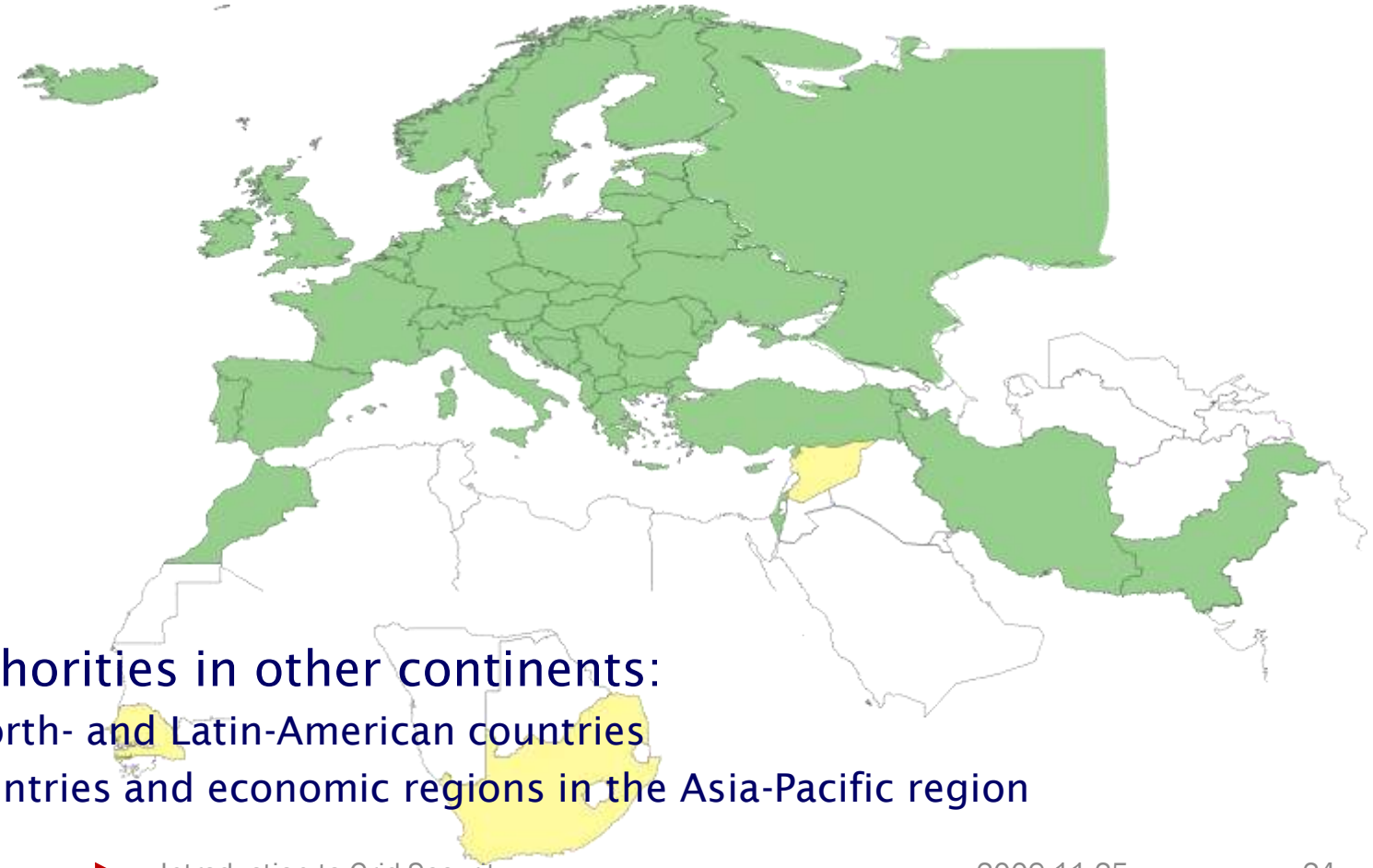
Guidelines: common elements in the IGTF

- Coordinated namespace
  - Subject names refer to a unique entity (person, host)
  - Usable as a basis for authorization decisions
  - This name uniqueness is essential for *all authentication profiles*!
- Trust anchor repository
  - Coordinated distribution for all trust anchors in the federation
  - Trusted, redundant, sources for download, verifiable via TACAR
- Concerns, risk assessment, and incident handling
  - Guaranteed point of contact
  - Forum to raise issues and concerns
- Documented processes of federation and authorities
  - Detailed policy and practice statement
  - Auditing by federation peers

Geographical coverage

Green: EMEA countries with an Accredited Authority

- 23 of 25 EU member states (all except LU, MT)
- + AM, BY, CH, HR, IL, IR, IS, MA, MD, MK, NO, PK, RS, RU, TR, …



More Authorities in other continents:

- Most North- and Latin-American countries
- 13+ countries and economic regions in the Asia-Pacific region

Grouping users

VO management technologies

Delegation and access scenarios

AUTHORIZATION AND VIRTUAL ORGANISATIONS

Authorization: VO representations

- VO is a directory (database) with members, groups, roles
- Based on identifiers issues at the authentication stage

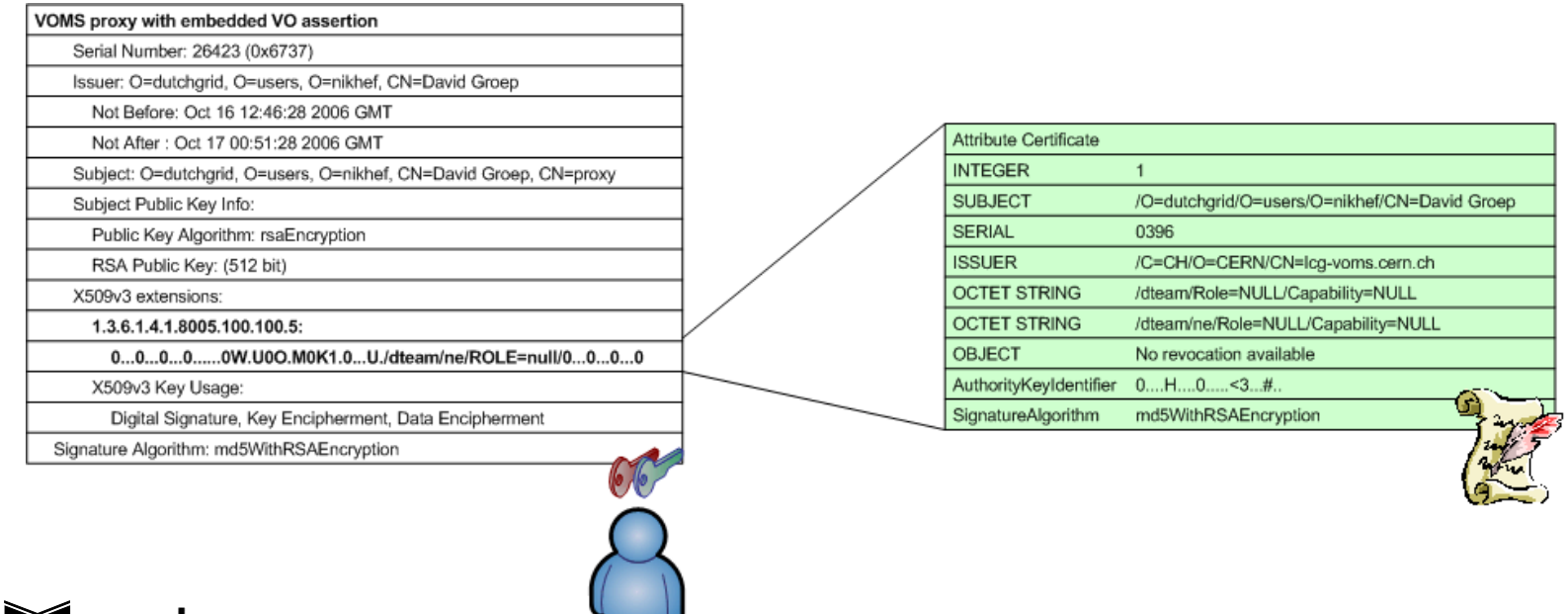
- Membership information is then to be conveyed to the resource providers
  - configured statically, out of band
  - in advance, by periodically pulling membership lists
    LDAP directories, replicated databases (GUMS)
  - in VO-signed assertions pushed with the request:
    VOMS, Community AuthZ Service

- Except for the **CA provided DN**, the VO is all the site will see
  - Since VO is user-centric, it has a potential conflict of interest for identity

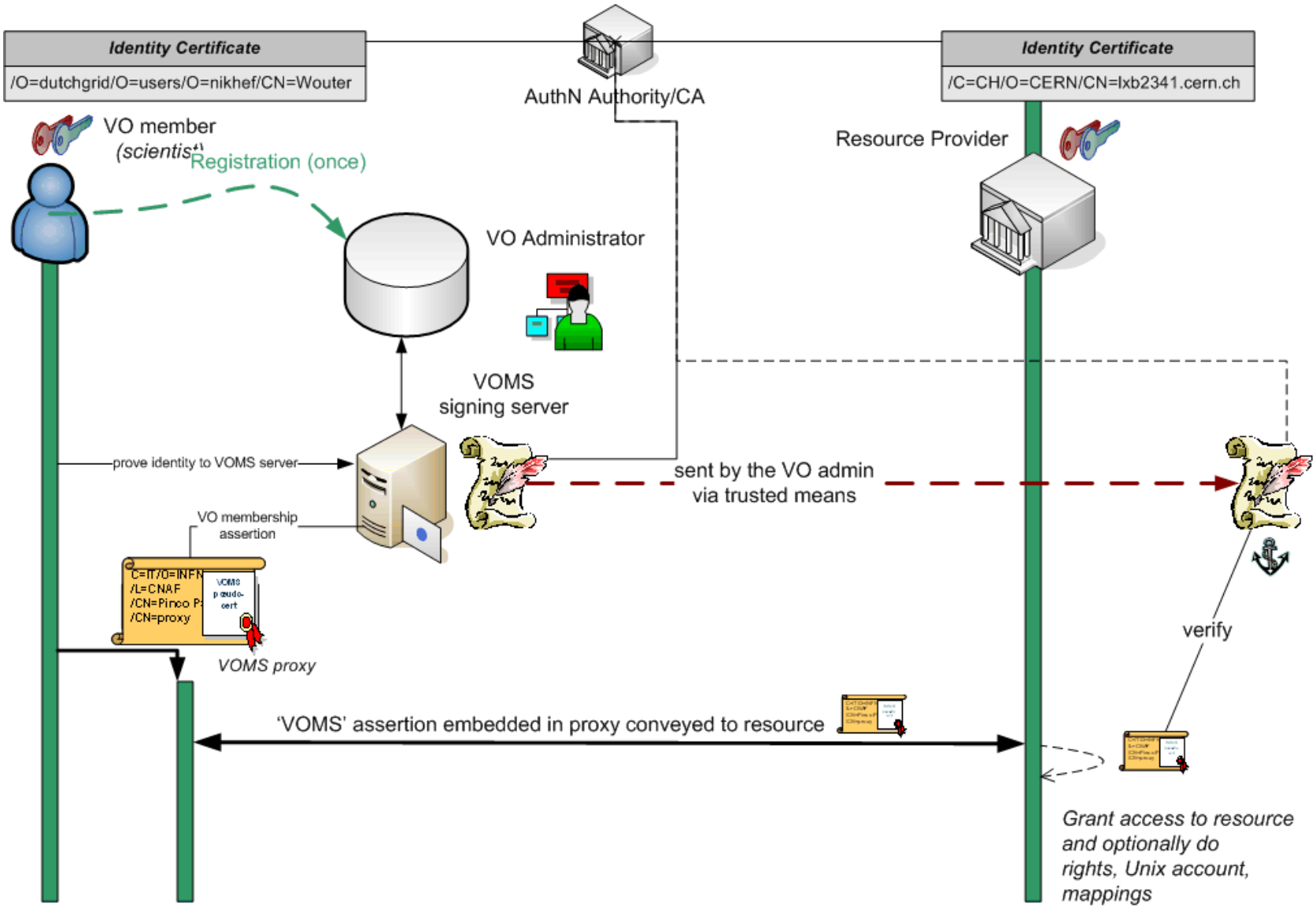
VOMS: VO attributes in a X.509 container

Virtual Organisation Management System (VOMS)

- developed by INFN for EU DataTAG and EGEE
- used by VOs in EGEE, Open Science Grid, NAREGI, …
- push-model signed VO membership tokens
  - using the traditional X.509 ‘proxy’ certificate for trans-shipment
  - fully backward-compatible with only-identity-based mechanisms



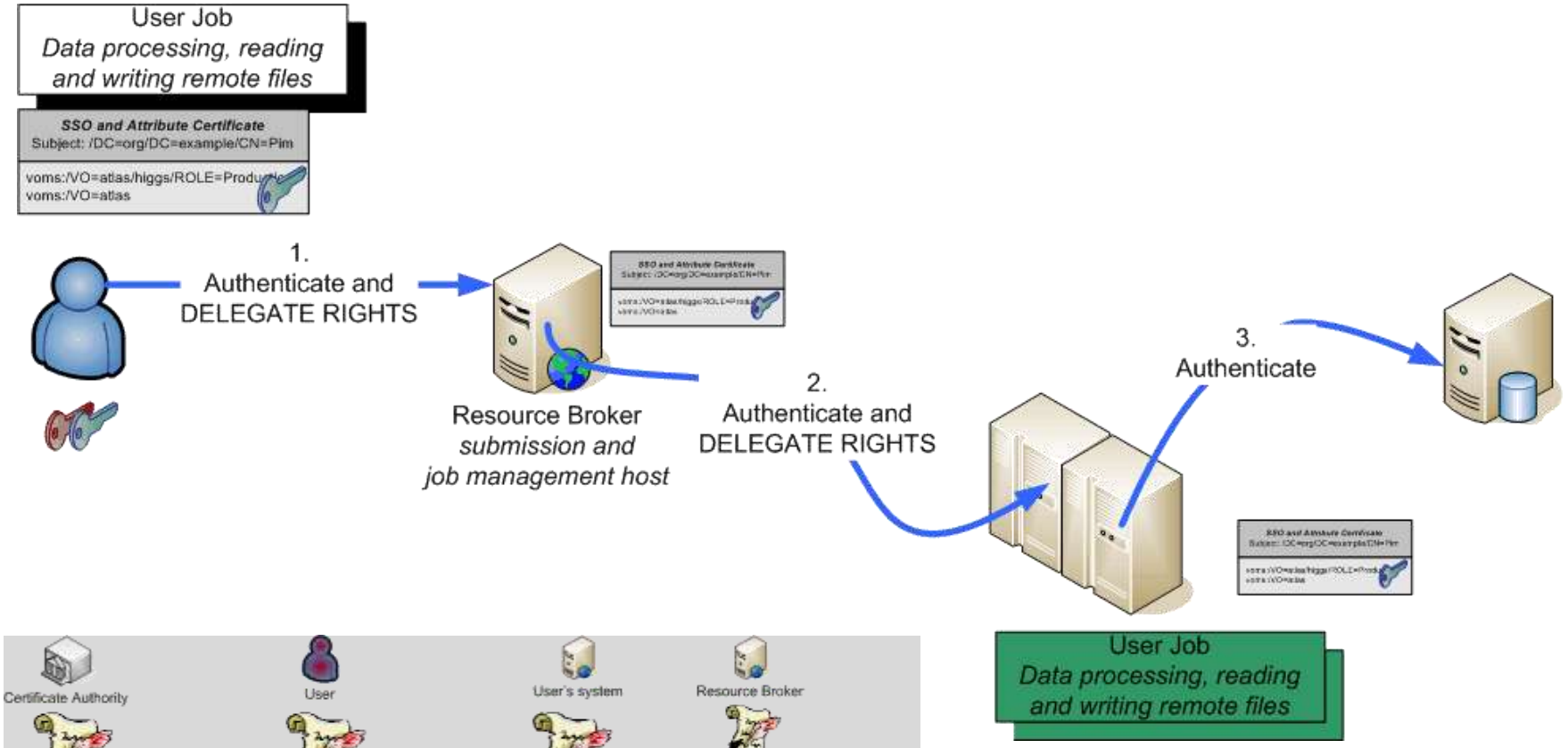
VOMS model


Identity Certificate
/O=dutchgrid/O=users/O=nikhef/CN=Wouter
AuthN Authority/CA
Identity Certificate
/C=CH/O=CERN/CN=lxb2341.cern.ch
VO member
(scientist)
Registration (once)
Resource Provider
VO Administrator
VOMS
signing server
prove identity to VOMS server
sent by the VO admin
via trusted means
VO membership
assertion
/L=CNAF
/CN=proxy
VOMS proxy
verify
'VOMS' assertion embedded in proxy conveyed to resource
Grant access to resource
and optionally do
rights, Unix account,
mappings

Delegation

- Mechanism to have someone, or some-thing – a program – act on your behalf
  - as yourself
  - with a (sub)set of your rights
- Matches model of brokering and non-interactive (automated) operations
- GSI (PKI) and recent SAML drafts define this
  - GSI (PKI) through ‘proxy’ certificates (see RFC3820)
  - SAML through *Subject Confirmation*, (linking to at least one key or name)

Daisy-chaining proxy delegation



V Acceptable Credentials on the Grid

'Let's not make the SSH mistake again'

'All Credentials Have A Life Time'

- > Long lived credentials must be revocable
- > Short lived (< 100ks) credentials may be left to expire

So we get

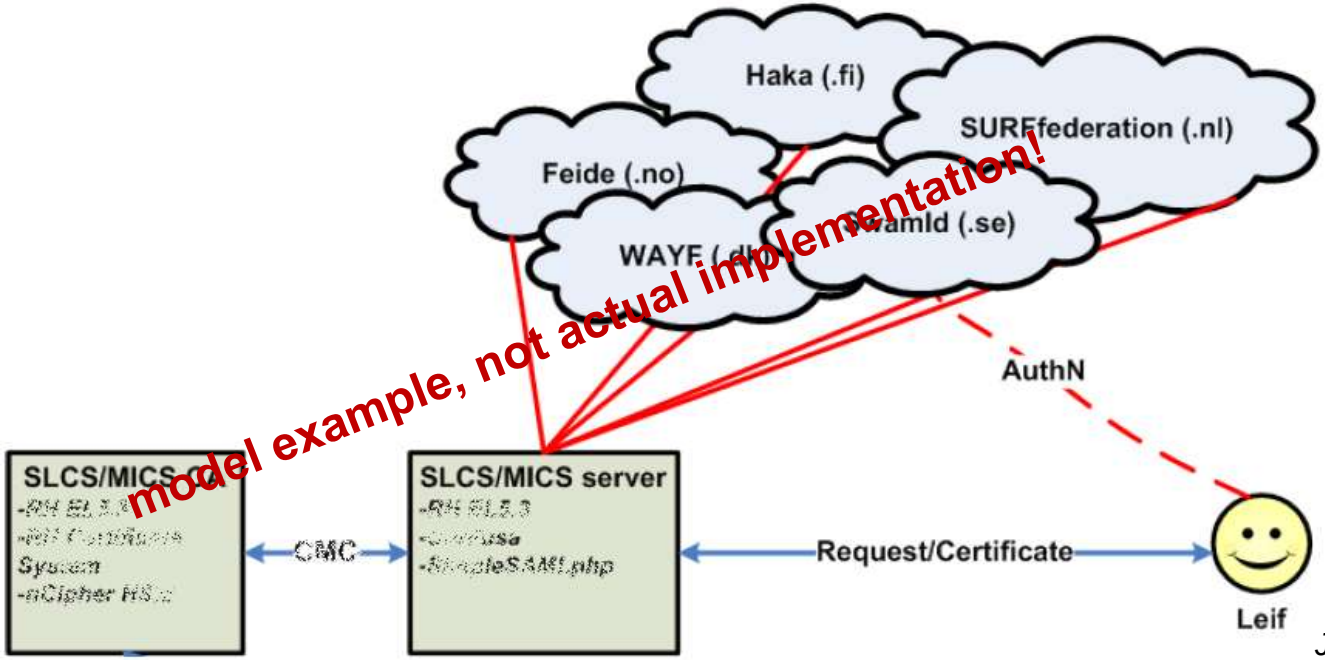
- > X.509 identity certificates: <= 1 year
- > Proxy credentials: between 12 and ~24 hours
- > VOMS attributes: ~ 24 hours
- > Proxies in a managed credential store: 1Ms, ~11 days

- > 'limited delegation' proxies prevents *creeper-reaper*-type exploits

Linking federations to Grid Auth*N*

- Use your federation ID
- … to authenticate to a service
- … that issues a certificate
- … recognised by the Grid today

Implementations:
- *SWITCHaai SLCS*
- *DFN SLCS*
- *TERENA eScience Personal CA*



Graphic from:
Jan Meijer, UNINETT

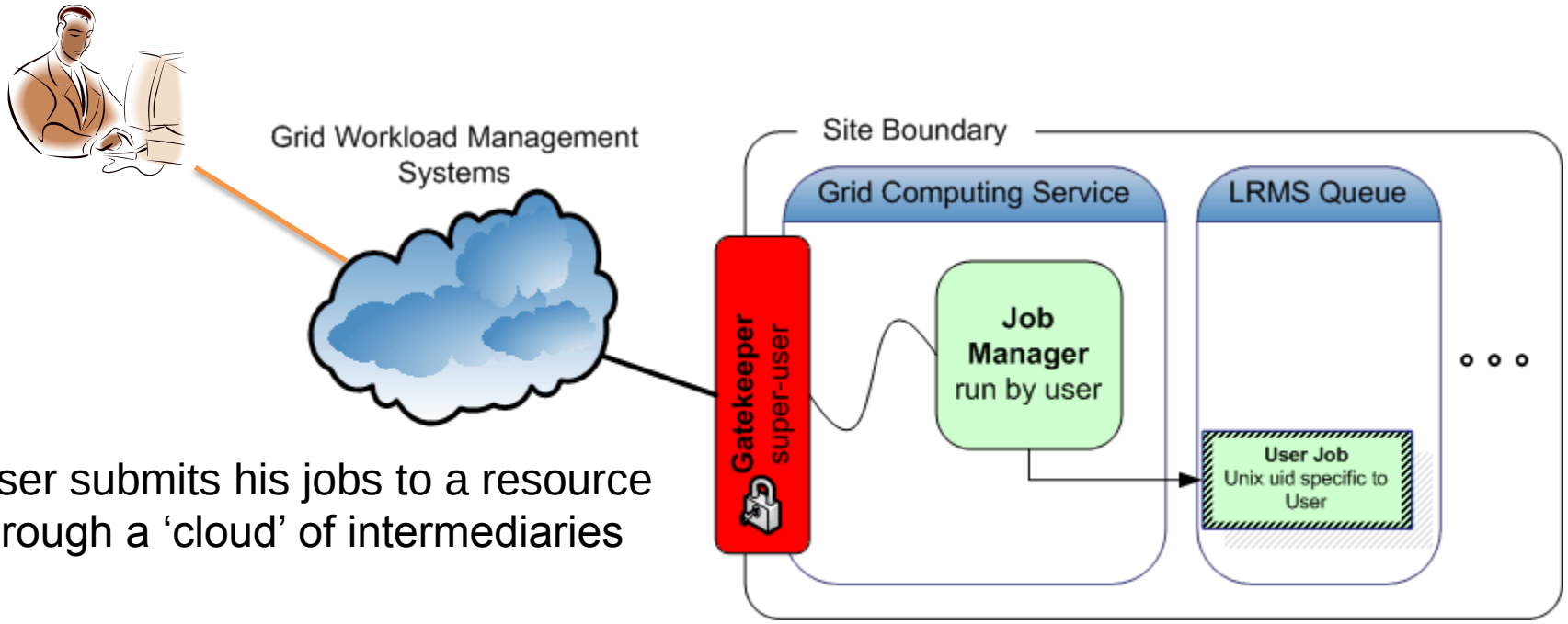
Example: running compute jobs

Tracing users and actions

Storage

ACCESS CONTROL AT THE SITE

Accessing (compute) resources



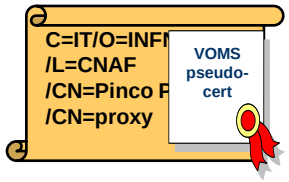
User submits his jobs to a resource through a 'cloud' of intermediaries

Direct binding of payload and submitted grid job

- job contains all the user's business
- access control is done at the site's edge
- inside the site, the user job has a specific, site-local, system identity

To the Unix world

grid identity



(X509, VOMS)
/dc=org/dc=example/CN=John Doe

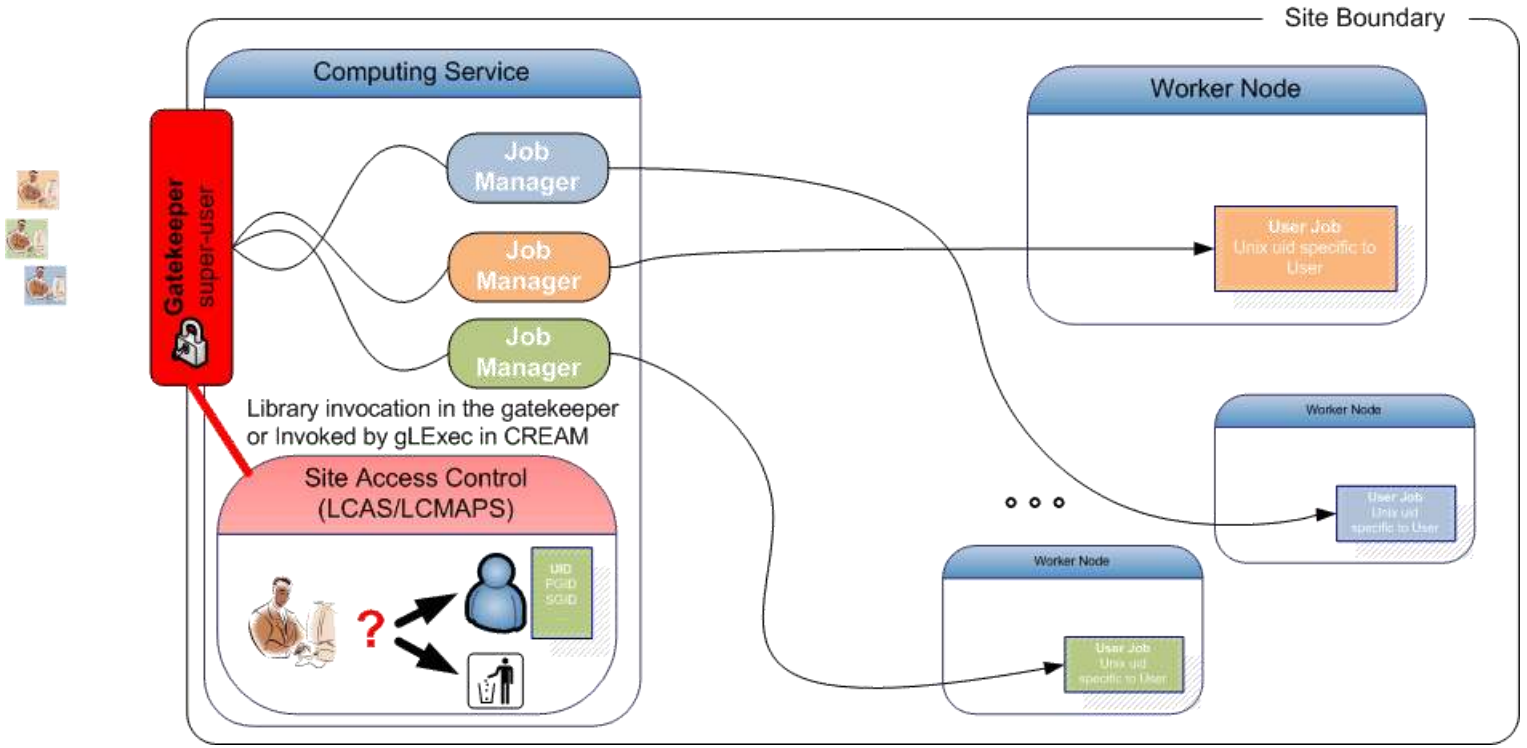
translate

```
enmr001:x:43401:2029:PoolAccount eNMR 001:/home/enmr001:/bin/sh
```

- Unix does not talk Grid, so
  translation is needed between grid and local identity
- this translation has to happen somewhere
  - On entry at the Gatekeeper
  - When running tasks or accessing files

Access Control on the CE

- System access (authorization: LCAS, mapping: LCMAPS)
- Embedded or though ‘call-out hooks’ in Grid middleware



V Access Control

Granting access: grid-mapfile

```
...
"/O=dutchgrid/O=users/O=nikhef/CN=David Groep" .dans
"/O=dutchgrid/O=users/O=nikhef/CN=Sven Gabriel" .dteam
"/O=dutchgrid/O=users/O=wageningen-universiteit/CN=Anonymised User" .lsg
"/O=dutchgrid/O=users/O=wageningen-universiteit/CN=Anonymised User" .lsg
"/alice/Role=lcgadmin" .alisgm
"/alice" .alice
"/atlas/Role=lcgadmin" .atlsm
"/atlas/Role=production" .atlb
"/atlas/Role=pilot" .atlpi
"/atlas/nl" .atlnl
"/atlas" .atlas
```

Denying access: ban_users.db

```
# This file contains the user subject DNs that are BANNED from this fabric
#
"/C=UK/O=eScience/OU=Cambridge/L=UCS/CN=anonymised user"
# from [UPDATE 5] Security incident - XXXXCERT-20080805, 04.Sept. 11:52
"/O=Grid/O=NorduGrid/OU=somesite.se/CN=Olof Palme"
"/O=Grid/O=NorduGrid/OU=somesite.se/CN=Alfred Nobel"
# 16-Jan-2009 banned compromised DN
"/C=CN/O=HEP/O=PKU/OU=PHYS/CN=Mao Zhedong"
# 23-Feb-2009 Security Service Challenge
# SG let Arjen in again after 18.Mar 2009
"/O=dutchgrid/O=users/O=nikhef/CN=Arnold Johan van Rijn"
```

What does the site owner see?

Batch system

```
stro.nikhef.nl:
                                                                  Req'd  Req'd   Elap
Job ID                  Username Queue    Jobname    SessID NDS   TSK Memory Time  S Time
----------------------- -------- -------- ---------- ------ ----- --- ------ ----- - -----
3223967.stro.nikhef.    atlb021  atlas    STDIN       32473     1  --     --  66:00 R   --     wn-val-046
3227086.stro.nikhef.    atlb021  atlas    STDIN       22038     1  --     --  66:00 R   --     wn-val-004
3227691.stro.nikhef.    atlb019  atlas    STDIN       11290     1  --     --  66:00 R   --     wn-lui1-028
3228887.stro.nikhef.    atlb021  atlas    STDIN        1562     1  --     --  66:00 R   --     wn-val-091
3235888.stro.nikhef.    lhcbpi01 lhcb     STDIN       23903     1  --     --  33:00 R 32:11    wn-lui2-014
3236232.stro.nikhef.    atlb019  atlas    STDIN       26115     1  --     --  66:00 R 32:10    wn-bull-011
```

Gatekeeper audit log

```
PID: 13507 -- Requested service: jobmanager-pbs
PID: 13507 -- Authorized as local user: atlb019
PID: 13507 -- Authorized as local uid: 70019
PID: 13507 --           and local gid: 2036
PID: 13507 -- "/C=CA/O=Grid/OU=westgrid.ca/CN=Anony Mous" mapped to atlb019 (70019/2036)
PID: 13507 -- GATEKEEPER_JM_ID 2009-11-16.12:51:40.0000013507.0000000000 for
                /C=CA/O=Grid/OU=westgrid.ca/CN=Anony Mous on 142.90.256.257
PID: 13507 -- Child 13576 started
```

Tracing the job

JobManager log

```
gmtime=20091116115140Z;uniqid=19095.1258344261;ug=70019:2036 2036;
jobid=3243289.stro.nikhef.nl; tag=https://gazon.nikhef.nl:20082/19095/1258344261/;
dry=no;jobtype=single;count=1;
exec=https://condorg.triumf.ca:20014/home/atlasprod/Panda/pyfactory/20091105/runpilot3-
wrapper.sh;
args=;
dir=/home/atlb019//gram_scratch_pCHATpWQJY;log=/home/atlb019/gram_job_mgr_13576.log;
```

Batch system syslog entry

```
Nov 16 11:51:40 gazon jobmanager-pbs[19374]: qsub success (atlb019:atlb)
  /home/atlb019/.globus/job/gazon.nikhef.nl/19095.1258344261/scheduler_pbs_job_script:
  3243289.stro.nikhef.nl
```

As well as regular entries created by the batch system(s) and any auditing data

Storage: Virtual Ids or Unix domain?

- Mapping to Unix credentials
  - Lacks expression of VO attributes and rights
  - Allows joint native and grid use of storage systems

- Grid storage systems with grid meta-layer access control
  - No need to allocate Unix-level resources or mappings
  - Expresses both VO and site-level policies and ACLs
  - Access *must* be via grid-aware mechanisms

Example: Disk Pool Manager DPM:

- mapped to ‘virtual UIDs’: created on the fly first time system sees DN
- VOMS roles are mapped to virtual GIDs
- User can have one DN and several roles,
  so may be mapped to one UID and several GIDs

Example Access Control Lists

- LFC and DPM support Posix ACLs based on Virtual Ids
  - Access Control Lists on files and directories
  - Default Access Control Lists on directories: they are inherited by the sub-directories and files under the directory
- Example
  - dpns-mkdir /dpm/cern.ch/home/dteam/jpb
  - dpns-setacl -m d:u::7,d:g::7,d:o:5 /dpm/cern.ch/home/dteam/jpb
  - dpns-getacl /dpm/cern.ch/home/dteam/jpb

```
# file: /dpm/cern.ch/home/dteam/jpb
# owner: /C=CH/O=CERN/OU=GRID/CN=Jean-Philippe Baud 7183
# group: dteam
user::rwx
group::r-x                      #effective:r-x
other::r-x
default:user::rwx
default:group::rwx
default:other::r-x
```

V Handling E2E incidents in this system

- Detection and coordination
  - Globally unique identifiers (subject DNs, VO names)
  - Policy ecosystem guidelines for auditing, log retention, and information exchange between participants
  - Periodically tested through SSCs
- Revocation
  which, e.g., ssh keys don't have, but federated access does
  - At the identity level, the Grid implements working revocation and CRL support for the PKI
  - At the authorization level: VO-level banning, site bans
- Recovery
  - De-facto, the only transparent recovery is by revocation of identity
  - Subject name (DN) is persistent for the user across incidents, so no re-registration needed

SUMMARY

Summary

- Grid and the VO make collaboration explicit at systems level
  - Structure of researchers themselves drives VO structure
  - This discloses the ‘interconnected vulnerabilities’ & incidents issue
- Threats in distributed computing exist irrespective of Grid
  - Multiple accounts across organisations, usually ill-managed
  - Shared or semi-public group accounts or shared storage
  - Grid middleware gives some additional handles …
  - … but also exposes new risk surfaces
- We have yet to see a grid-specific incident
  - Many ‘traditional’ incidents propagate along research collaborations
  - Using non-grid attack vectors, and without ‘grid’ controls to help