Infrastructure Systems: The Globus Toolkit

BRIITE Meeting - Nov 2-4, 2005

2-4 Nov 2005, Salk Institute, La Jolla, CA

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Outline

- Globus Alliance
- Grids
- Globus Toolkit Introduction

- Virtual Organizations
- GT's BIG Security "Issue"

- Questions & Discussion

The Globus Alliance

Making Grid computing a reality

- Close collaboration with real Grid projects in science and industry
- Development and promotion of standard Grid protocols (e.g. OGSA) to enable interoperability and shared infrastructure
- Development and promotion of standard Grid software APIs and SDKs to enable portability and code sharing
- The Globus Toolkit®: Open source, reference software base for building Grid infrastructure and applications
- Global Grid Forum: Development of standard protocols and APIs for Grid computing

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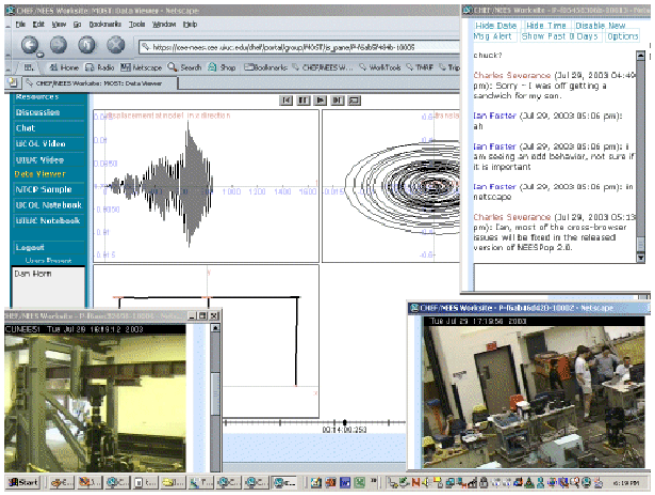
How Globus Works

- **Globus** is a distributed open source community with many contributors & users
  - CVS, documentation, bugzilla, email lists
  - Modular structure allows many to contribute
- **Globus Alliance Board** provides governance when needed
  - Meritocracy: individuals who demonstrate ongoing contributions & commitment
  - Primarily: what to include, when to release
- **Globus Alliance** is an informal partnership of organizations led by Board members

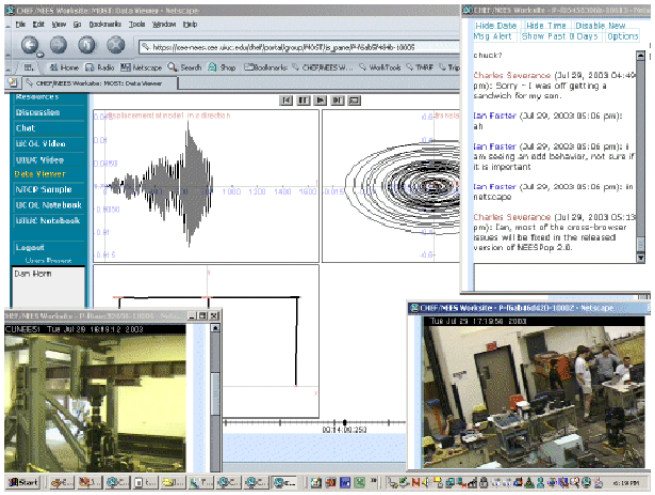

On April 29, 2005 the Globus Alliance released the finest version of the Globus Toolkit to date!
GT-4.0

The Application-Infrastructure Gap



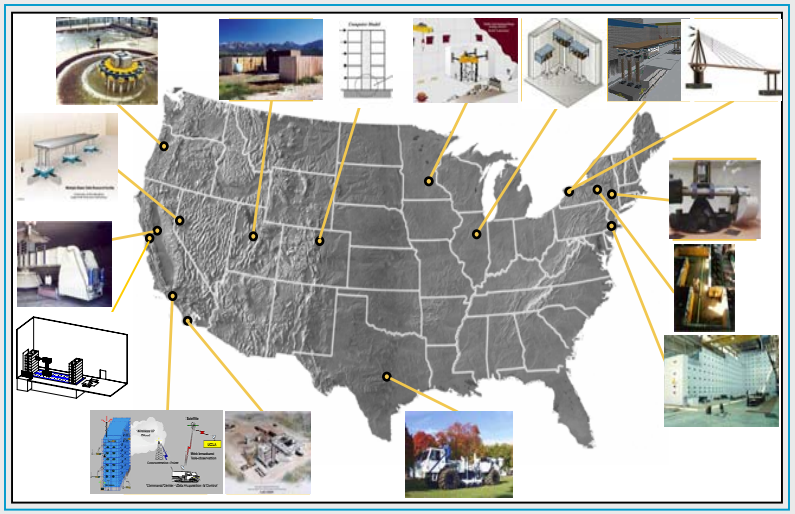
Dynamic and/or Distributed Applications

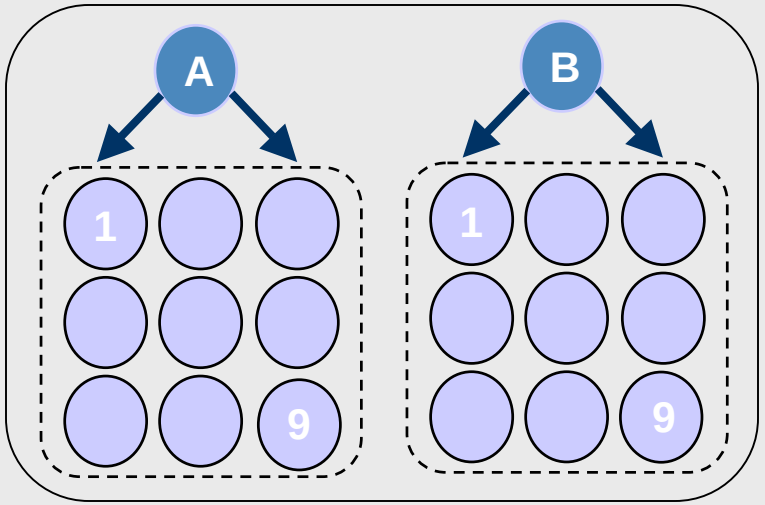
The Application-Infrastructure Gap



Dynamic and/or Distributed Applications

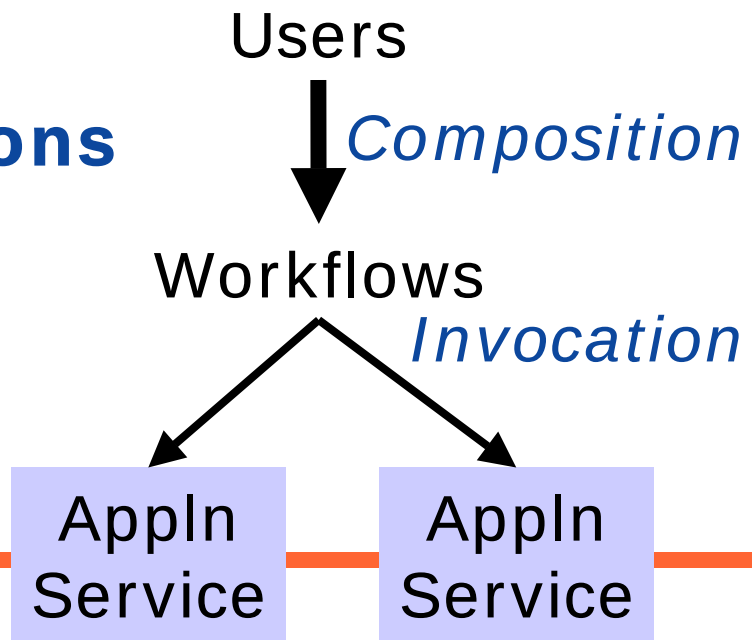
Shared Distributed Infrastructure





Bridging the Gap: Grid Infrastructure

- Service-oriented **applications**
  - Wrap applications as services
  - Compose applications into workflows



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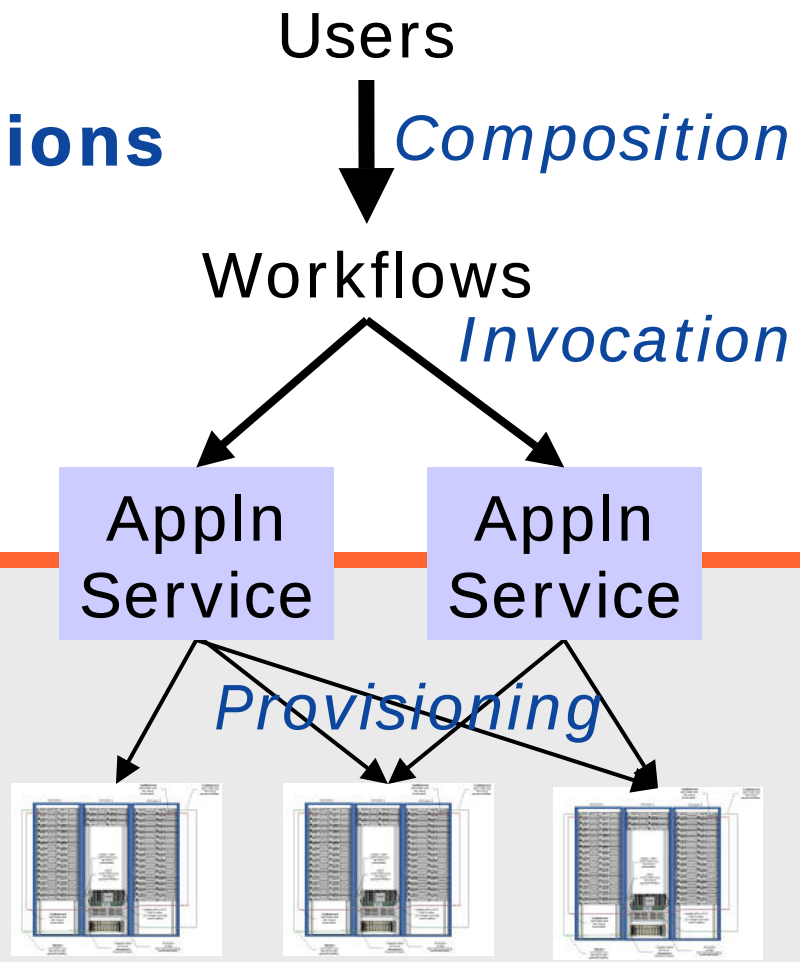
Bridging the Gap: Grid Infrastructure

- Service-oriented **applications**
  - Wrap applications as services
  - Compose applications into workflows
- Service-oriented **Grid infrastructure**
  - Provision physical resources to support application workloads



Globus is Grid Infrastructure

- Software for Grid infrastructure
  - Service enable new & existing resources
  - E.g., GRAM on computer, GridFTP on storage system, custom application service
  - Uniform abstractions & mechanisms
- Tools to build applications that exploit Grid infrastructure
  - Registries, security, data management, ...
- Open source & open standards
  - Each empowers the other
- Enabler of a rich tool & service ecosystem

Globus as Service-Oriented Infrastructure

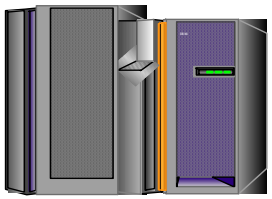
User Application

User Application

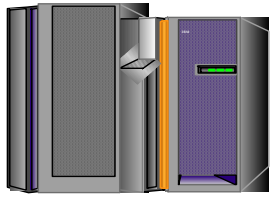
User Application

Computers

Specialized Resource

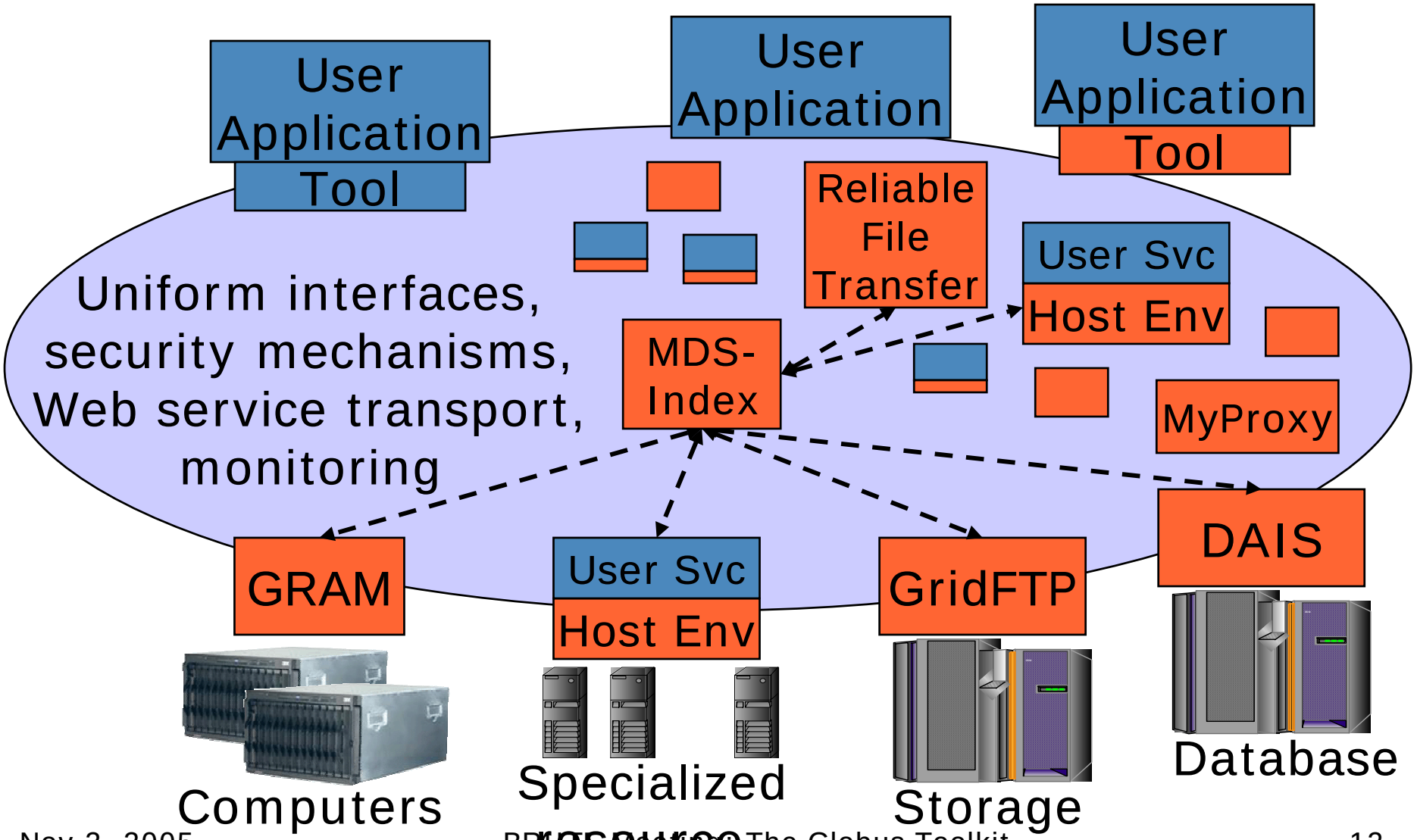


Storage

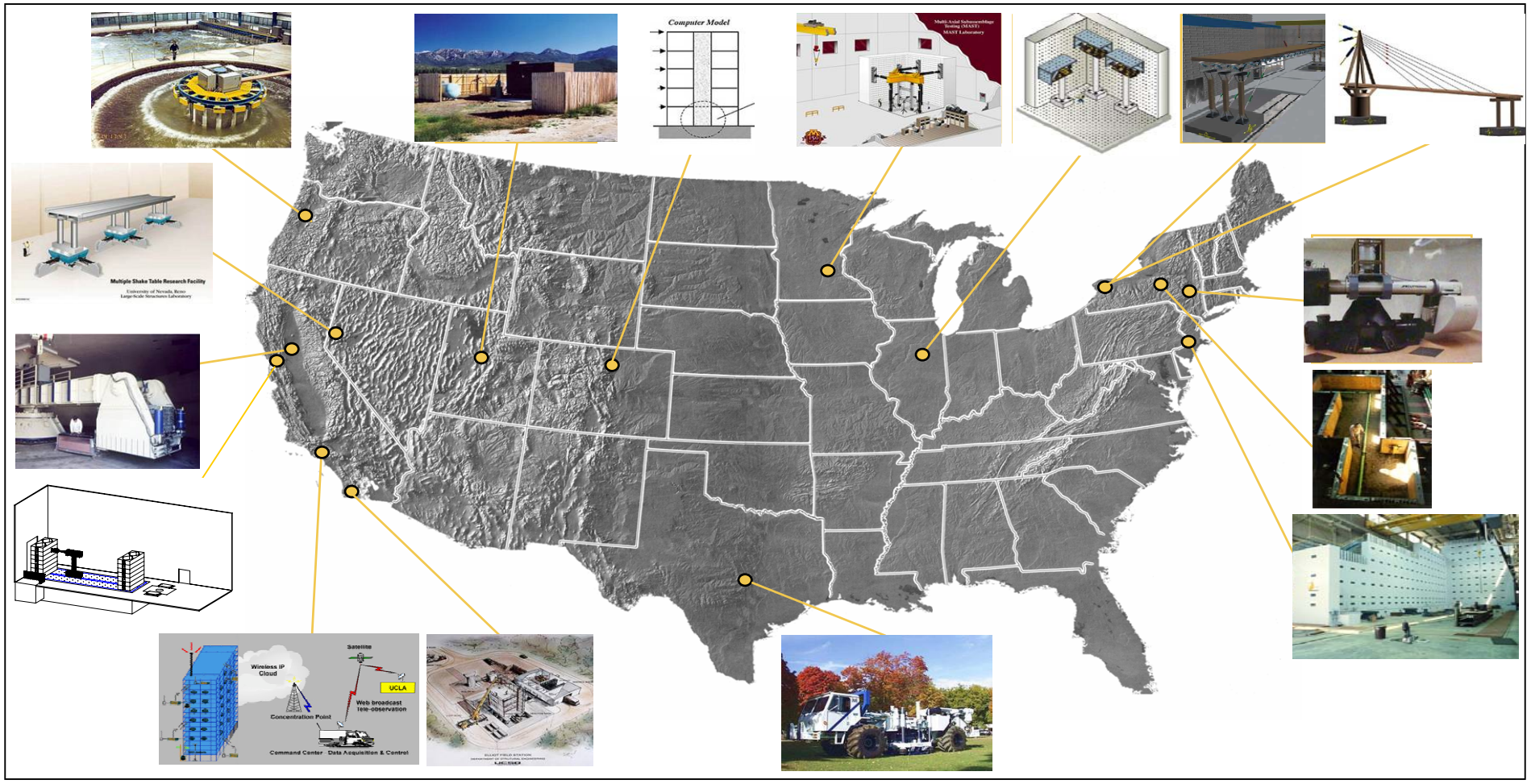


Database

Globus as Service-Oriented Infrastructure



A Typical eScience Use of Globus: Network for Earthquake Eng. Simulation



Links instruments, data, computers, people

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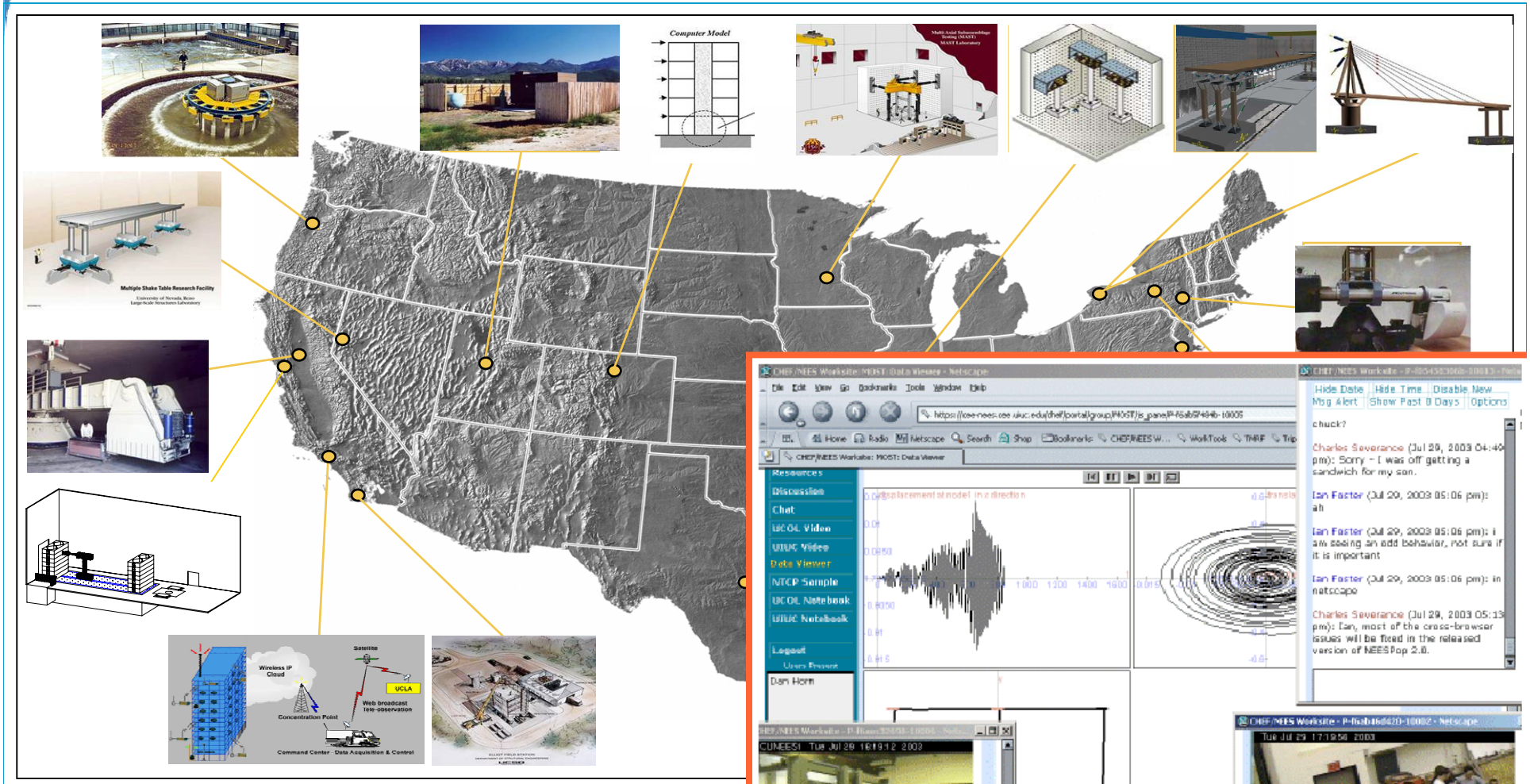
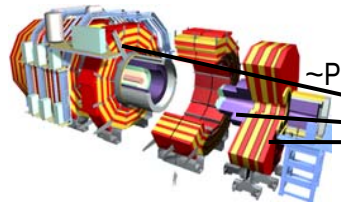


Links instruments, data, computers, people

LHC Data Distribution



~PBytes/sec

Online System

~100 MBytes/sec

1 TIPS is approximately 25,000 SpecInt95 equivalents

Offline Processor Farm
~20 TIPS

There is a "bunch crossing" every 25 nsecs.
There are 100 "triggers" per second
Each triggered event is ~1 MByte in size

~100 MBytes/sec

Tier 0

CERN Computer Centre

~622 Mbits/sec
or Air Freight (deprecated)

Tier 1

France Regional Centre

Germany Regional Centre

Italy Regional Centre

FermiLab ~4 TIPS

• • •

~622 Mbits/sec

Tier 2

Caltech
~1 TIPS

Tier2 Centre
~1 TIPS

Centre
TIPS

Centre
1 TIPS

Centre
1 TIPS

~622 Mbits/sec

Institute
~0.25TIPS

tute

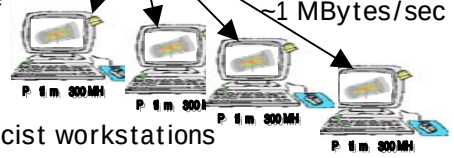
stitute

nstitute

Physics data cache

~1 MBytes/sec

Tier 4

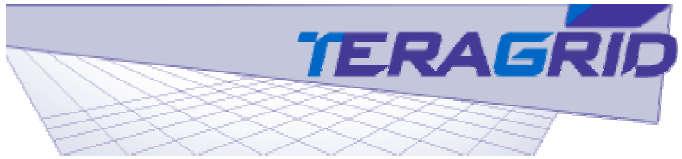


Physicist workstations

Physicists work on analysis "channels".

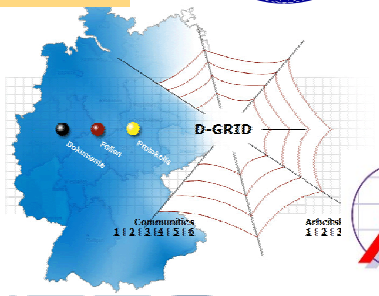
Each institute will have ~10 physicists working on one or more channels; data for these channels should be cached by the institute server

Global Community

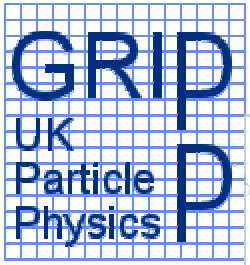


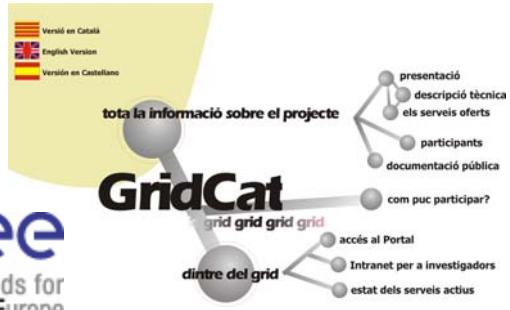
grid.it project

K*GRID



National Grid
NG
SINGAPORE





CERN
openlab for DataGrid applications
Developing Solutions for the Data-Intensive Science of the Large Hadron Collider

APEC APGrid Asia-Pacific Grid Implementation Project

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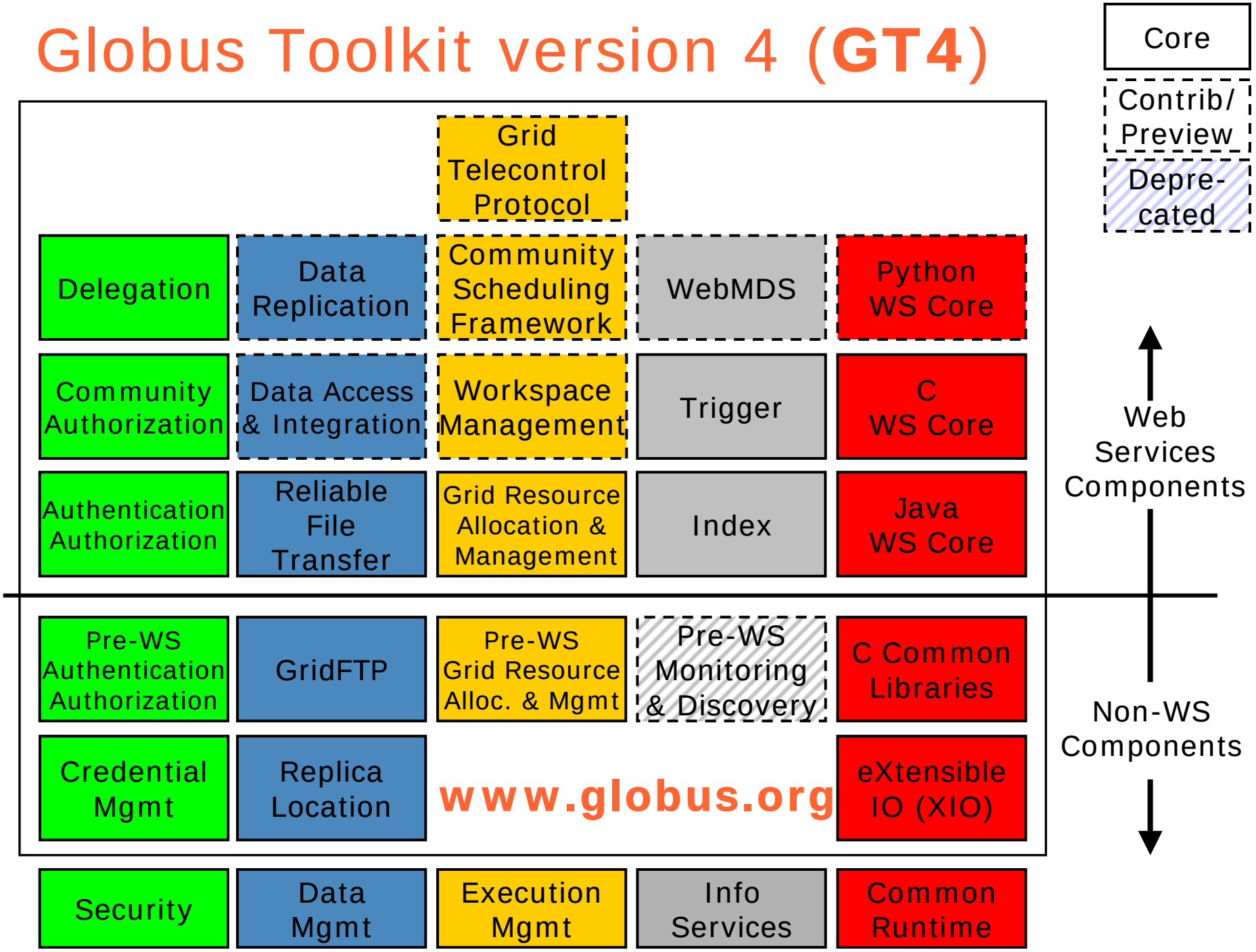
Globus Toolkit

- Core Web services
  - Infrastructure for building new services
- Security
  - Apply uniform policy across distinct systems
- Execution management
  - Provision, deploy, & manage services
- Data management
  - Discover, transfer, & access large data
- Monitoring
  - Discover & monitor dynamic services

WSRF & WS-Notification

- Naming and bindings (basis for virtualization)
  - Every resource can be uniquely referenced, and has one or more associated services for interacting with it
- Lifecycle (basis for fault resilient state management)
  - Resources created by services following factory pattern
  - Resources destroyed immediately or scheduled
- Information model (basis for monitoring & discovery)
  - Resource properties associated with resources
  - Operations for querying and setting this info
  - Asynchronous notification of changes to properties
- Service Groups (basis for registries & collective svcs)
  - Group membership rules & membership management
- Base Fault type

Globus Toolkit version 4 (**GT4**)



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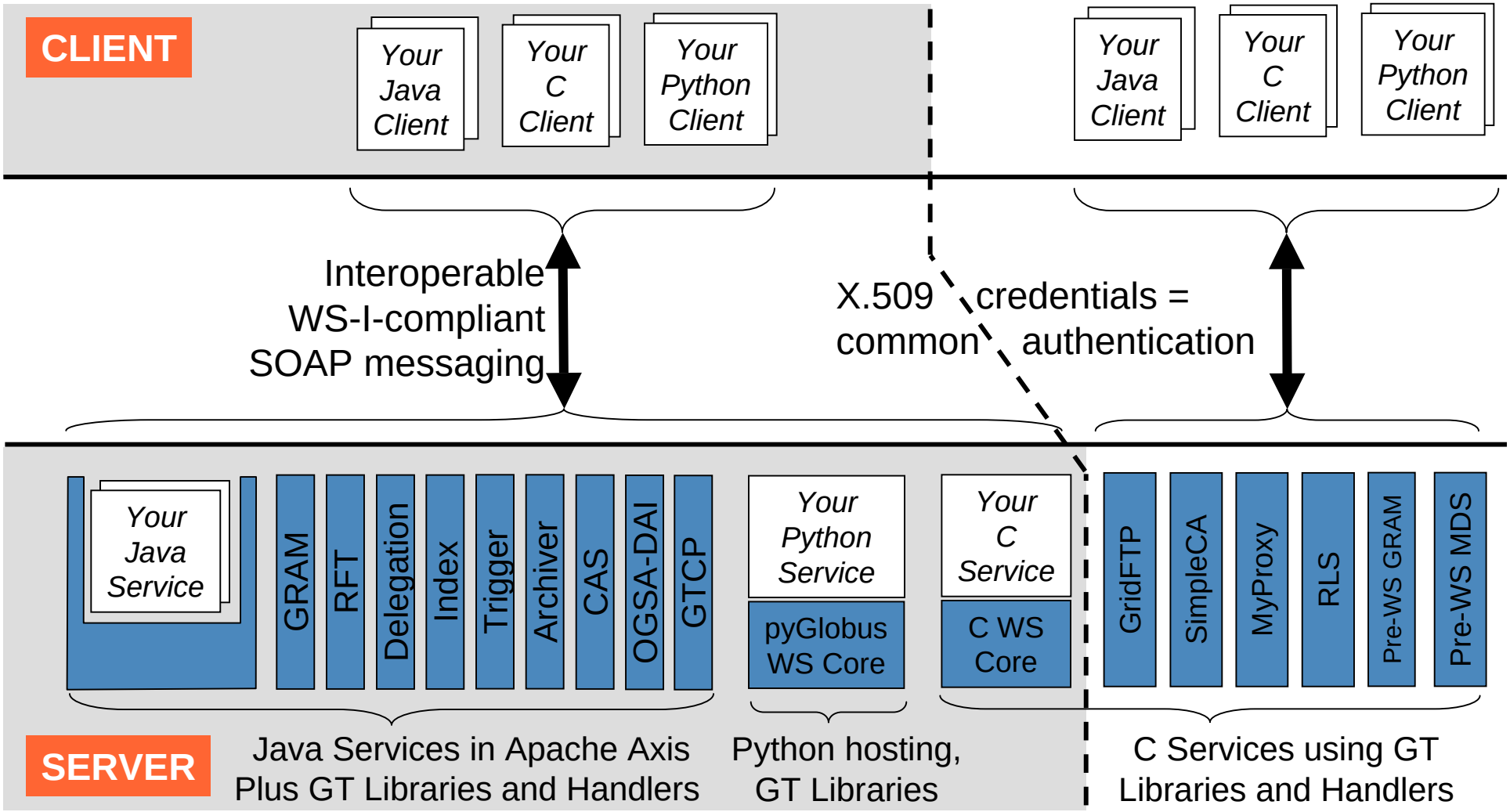
GT4 Components



Our Goals for GT4

- Usability, reliability, scalability, …
  - Web service components have quality equal or superior to pre-WS components
  - Documentation at acceptable quality level
- Consistency with latest standards (WS-*, WSRF, WS-N, etc.) and Apache platform
  - WS-I Basic Profile compliant
  - WS-I Basic Security Profile compliant
- New components, platforms, languages
  - And links to larger Globus ecosystem

GT4 Common Runtime

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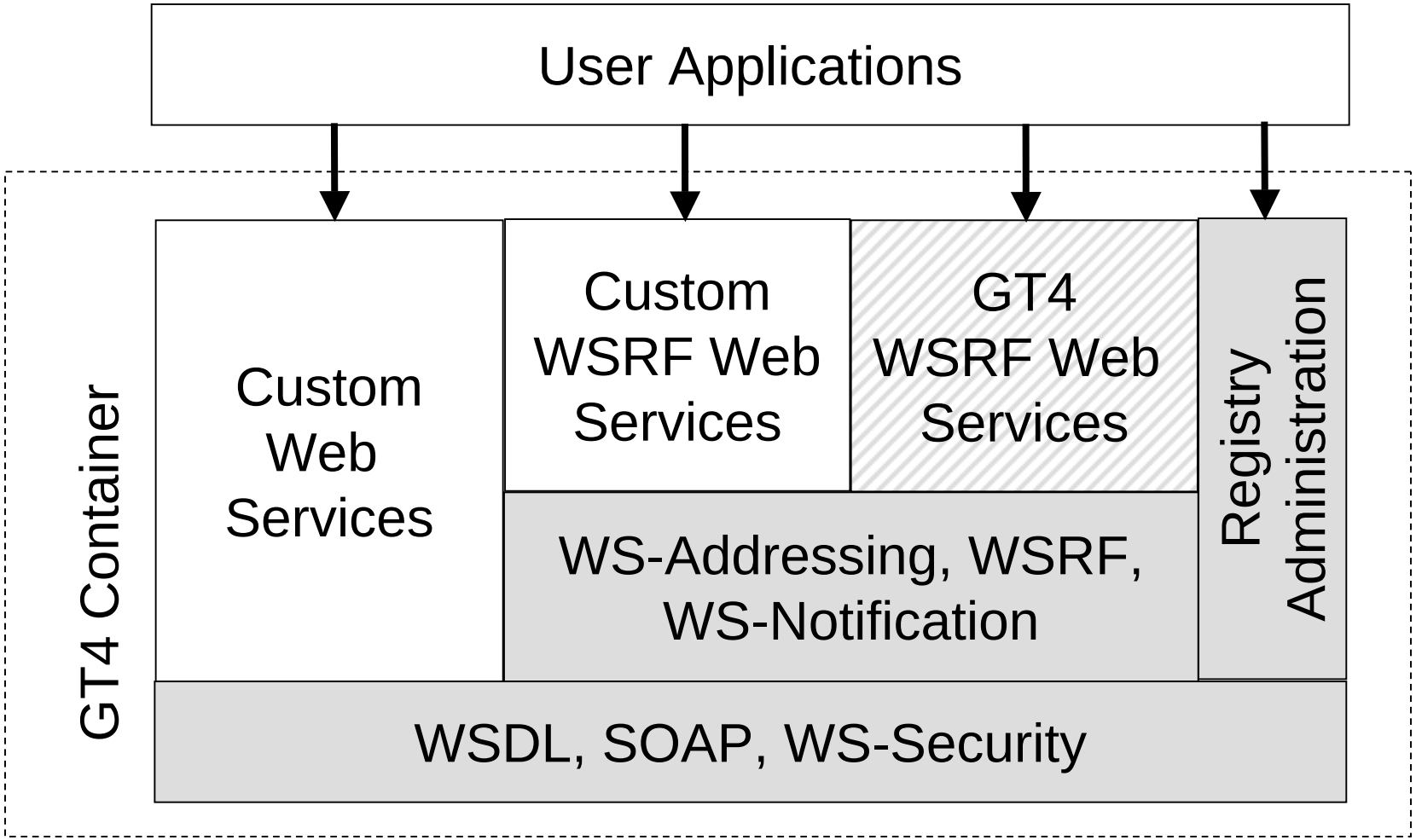
GT4 Web Services Core



GT4 Web Services Core

- Supports both GT (GRAM, RFT, Delegation, etc.) & user-developed services
- Redesign to enhance scalability, modularity, performance, usability
- Leverages existing WS standards
  - WS-I Basic Profile: WSDL, SOAP, etc.
  - WS-Security, WS-Addressing
- Adds support for emerging WS standards
  - WS-Resource Framework, WS-Notification
- Java, Python, & C hosting environments
  - Java is standard Apache

WSRF & WS-Notification

- **Naming and bindings** (basis for virtualization)
  - Every resource can be uniquely referenced, and has one or more associated services for interacting with it
- **Lifecycle** (basis for fault resilient state mgmt)
  - Resources created by services following factory pattern
  - Resources destroyed immediately or scheduled
- **Information model** (basis for monitoring, discovery)
  - Resource properties associated with resources
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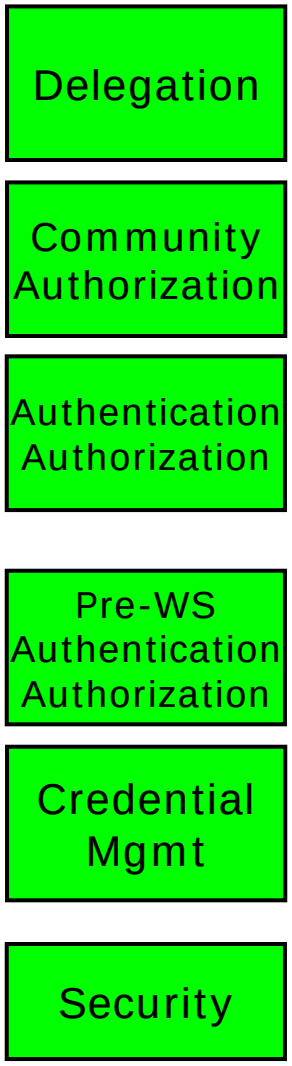
  - Group membership rules & membership management
- **Base Fault type**

GT4 Security



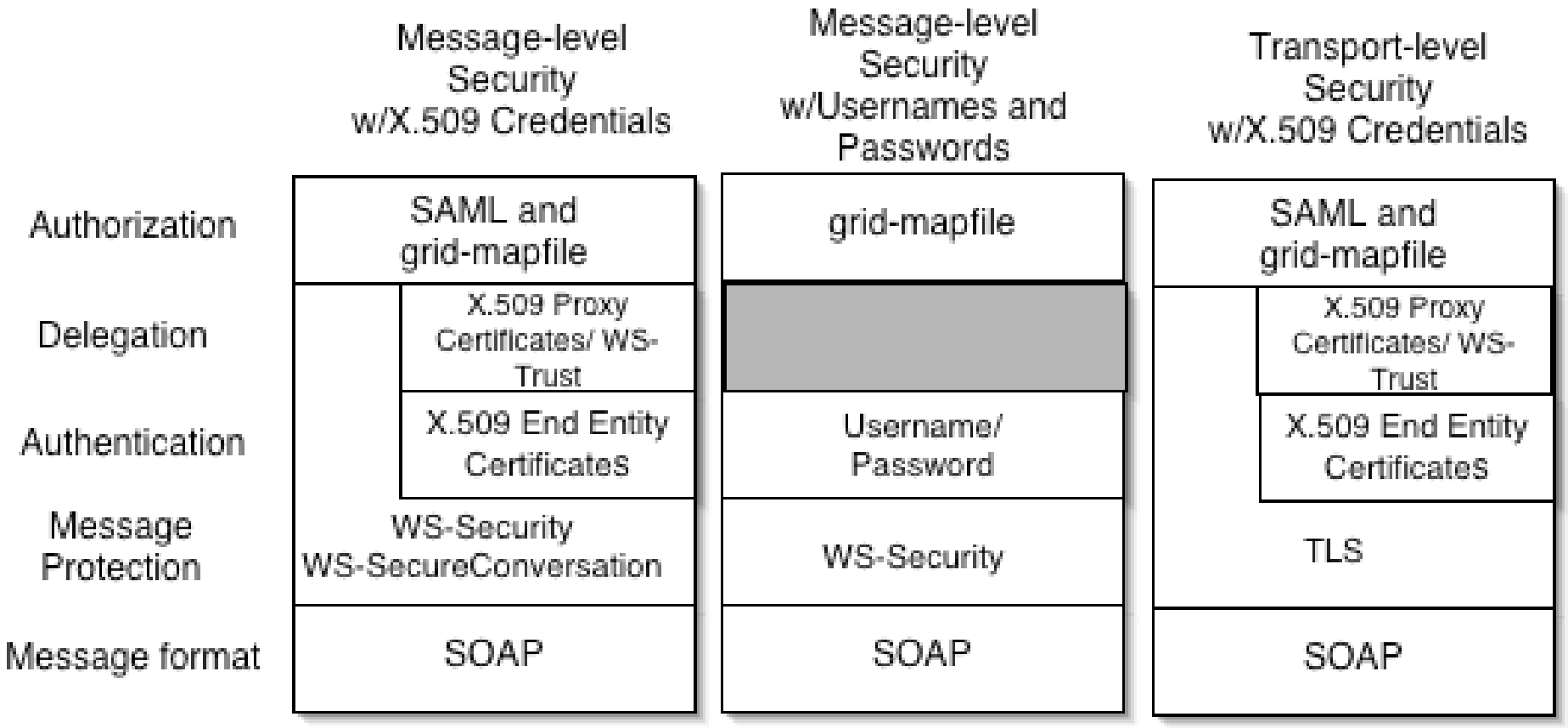
Globus Security

- Control access to shared services
  - Address autonomous management, e.g., different policy in different work-groups
- Support multi-user collaborations
  - Federate through mutually trusted services
  - Local policy authorities rule
- Allow users and application communities to set up dynamic trust domains
  - Personal/VO collection of resources working together based on trust of user/VO

GT4 Security

- Public-key-based authentication
- Extensible authorization framework based on Web services standards
  - SAML-based authorization callout
    - As specified in GGF OGSA-Authz WG
  - Integrated policy decision engine
    - XACML policy language, per-operation policies, pluggable
- Credential management service
  - MyProxy (One time password support)
- Community Authorization Service
- Standalone Delegation Service

GT4's Use of Security Standards



Supported, but slow

Supported, but insecure

Fastest, so default

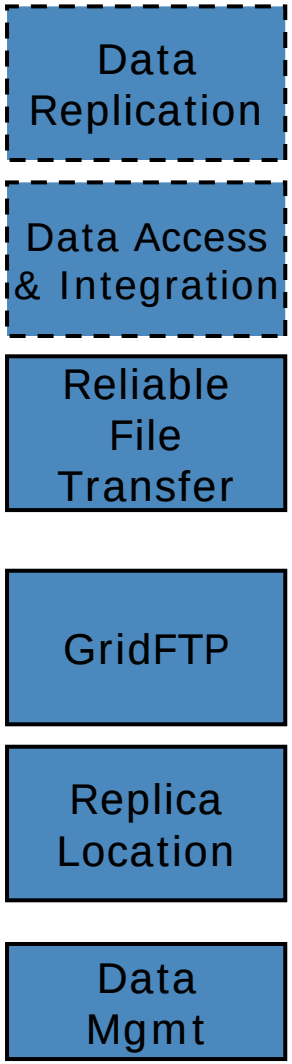
GT-XACML Integration

- eXtensible Access Control Markup Language
  - OASIS standard, open source implementations
- XACML: sophisticated policy language
- Globus Toolkit ships with XACML runtime
  - Included in every client and server built on GT
  - Turned-on through configuration
- ... that can be called transparently from runtime and/or explicitly from application ...
- ... and we use the XACML-"model" for our Authz Processing Framework

Other Security Services Include …

- MyProxy
  - Simplified credential management
  - Web portal integration
  - Single-sign-on support
- KCA & kx.509
  - Bridging into/out-of Kerberos domains
- SimpleCA
  - Online credential generation
- PERMIS
  - Authorization service callout

GT4 Data Management

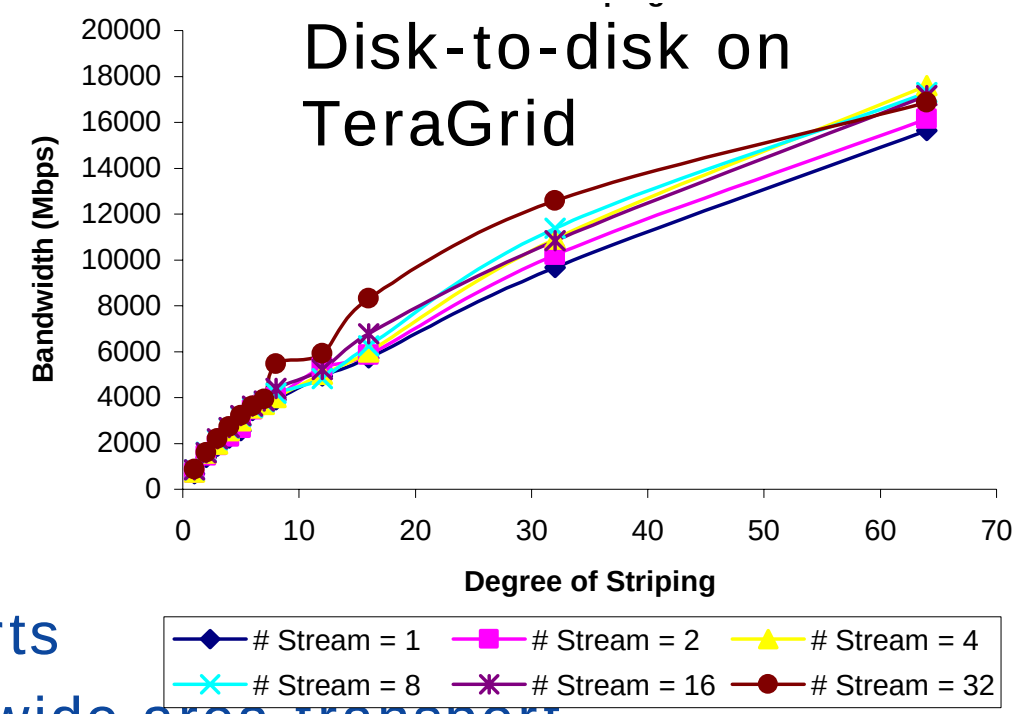


GT4 Data Management

- **Stage / move** large data to/from nodes
  - GridFTP, Reliable File Transfer (RFT)
  - Alone, and integrated with GRAM
- **Locate** data of interest
  - Replica Location Service (RLS)
- **Replicate** data for performance/reliability
  - Distributed Replication Service (DRS)
- Provide **access** to diverse data sources
  - File systems, parallel file systems, hierarchical storage: GridFTP
  - Databases: OGSA DAI

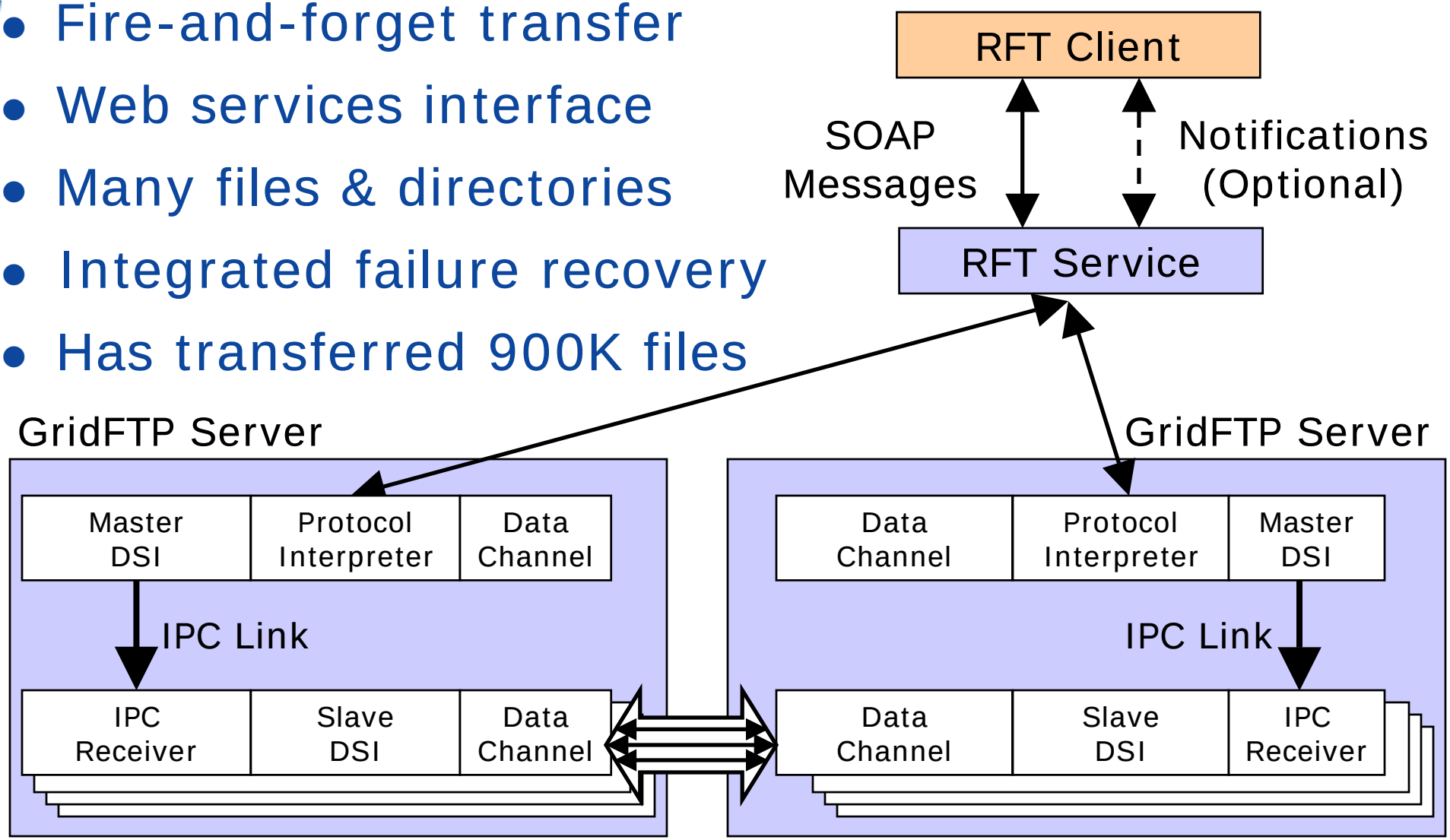
GridFTP in GT4

- 100% Globus code
  - No licensing issues
  - Stable, extensible
- IPv6 Support
- XIO for different transports
- Striping → multi-Gb/sec wide area transport
  - 27 Gbit/s on 30 Gbit/s link
- Pluggable
  - Front-end: e.g., future WS control channel
  - Back-end: e.g., HPSS, cluster file systems
  - Transfer: e.g., UDP, NetBLT transport



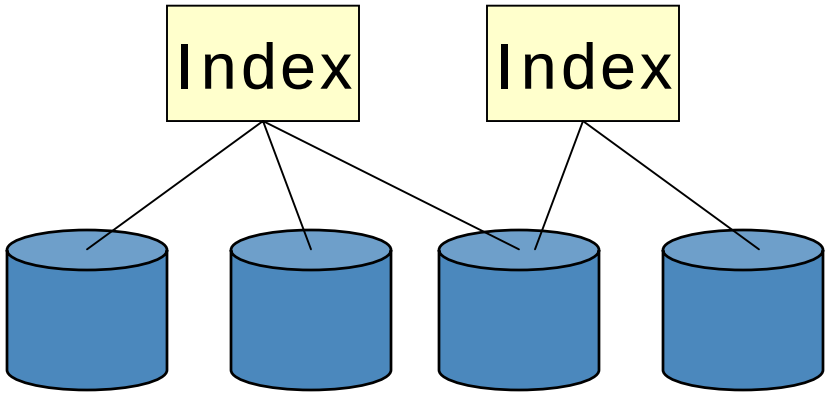
Reliable File Transfer: Third Party Transfer

- Fire-and-forget transfer
- Web services interface
- Many files & directories
- Integrated failure recovery
- Has transferred 900K files

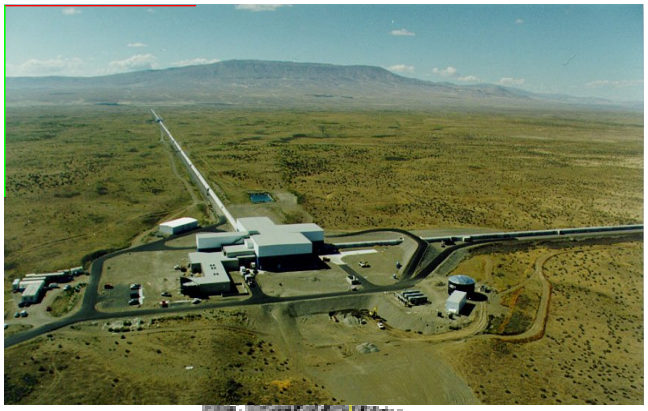


Replica Location Service

- Identify location of files via logical to physical name map
- Distributed indexing of names, fault tolerant update protocols
- GT4 version scalable & stable
- Managing ~40 million files across ~10 sites

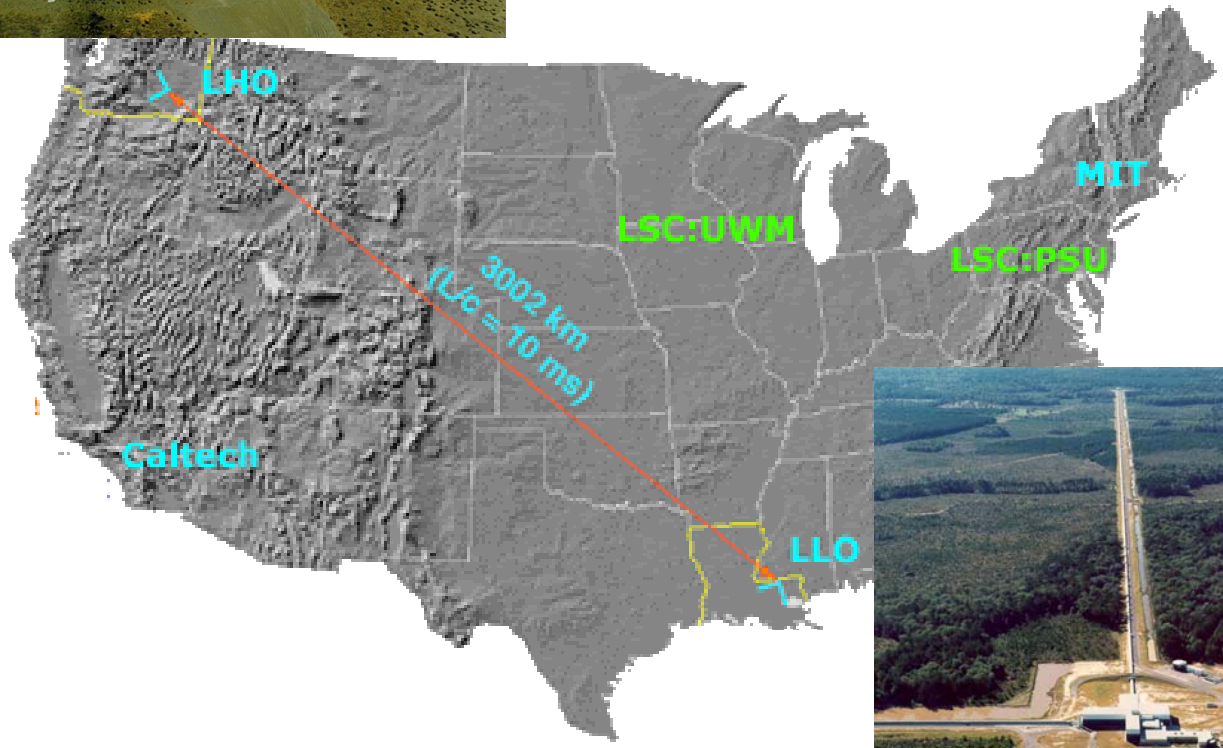


Local DB	Update send (secs)	Bloom filter (secs)	Bloom filter (bits)
10K	<1	2	1 M
1 M	2	24	10 M
5 M	7	175	50 M



Reliable Wide Area Data Replication

LIGO Gravitational Wave Observatory



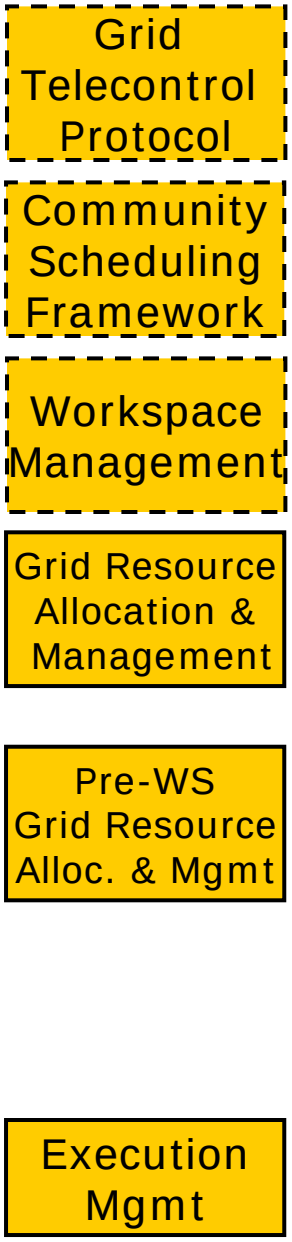
Replicating >1 Terabyte/day to 8 sites

>30 million replicas so far

MTBF = 1 month

www.globus.org/solutions

GT4 Execution Management



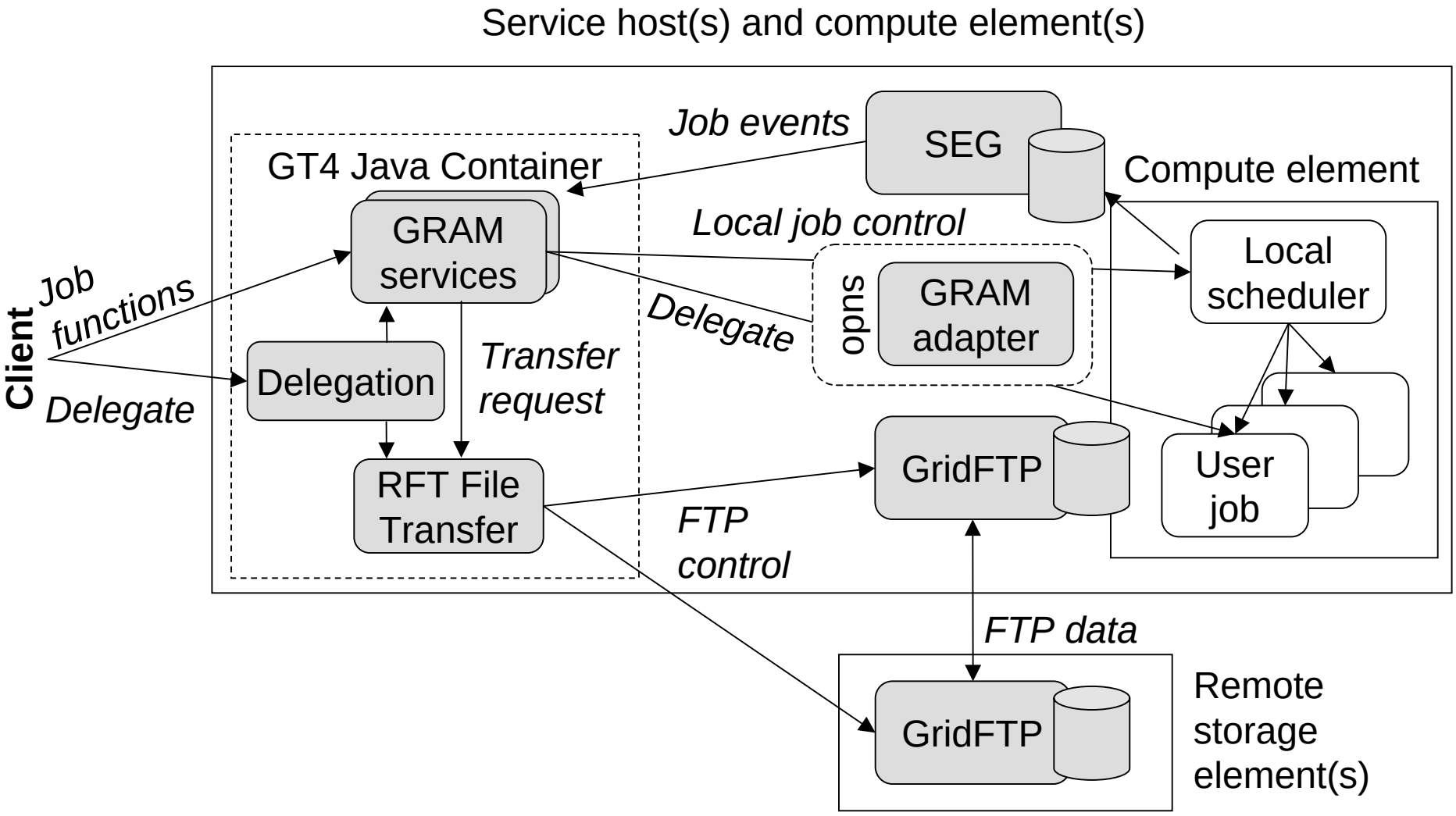
Execution Management (GRAM)

- Common WS interface to schedulers
  - Unix, Condor, LSF, PBS, SGE, ...
- More generally: interface for process execution management
  - Lay down execution environment
  - Stage data
  - Monitor & manage lifecycle
  - Kill it, clean up
- A basis for application-driven provisioning

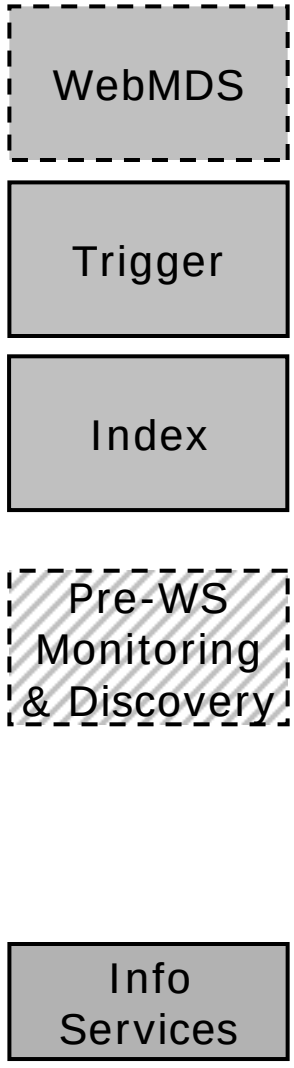
GT4 WS GRAM

- 2nd-generation WS implementation optimized for performance, flexibility, stability, scalability
- Streamlined critical path
  - Use only what you need
- Flexible credential management
  - Credential cache & delegation service
- GridFTP & RFT used for data operations
  - Data staging & streaming output

GT4 WS GRAM Architecture



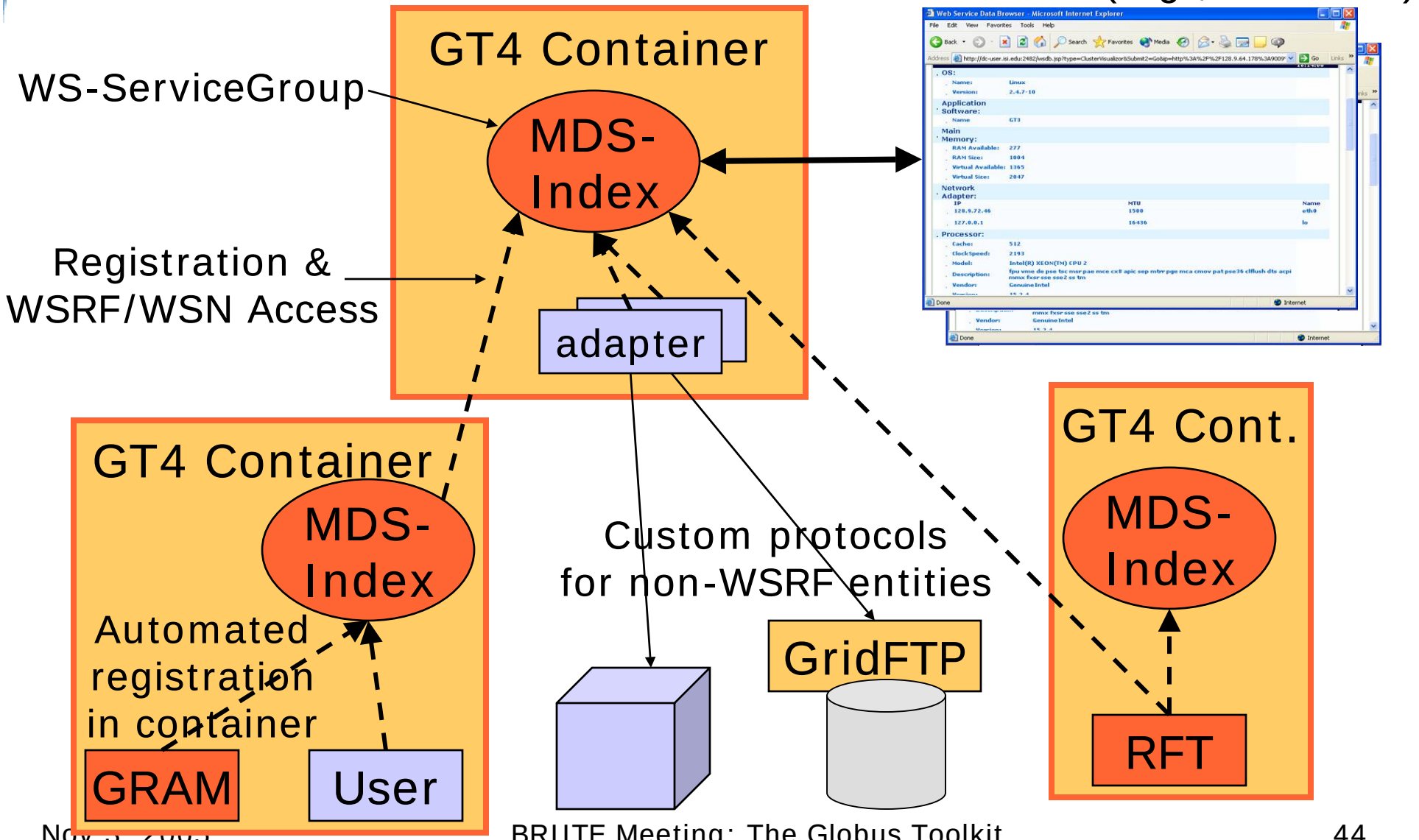
GT4 Information Services

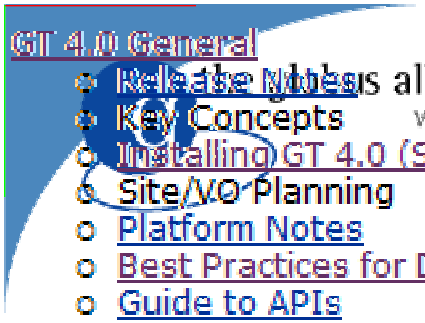


Monitoring and Discovery

- "Every service should be monitorable and discoverable using common mechanisms"
  - WSRF/WSN provides those mechanisms
- A common aggregator framework for collecting information from services, thus:
  - MDS-Index: Xpath queries, with caching
  - MDS-Trigger: perform action on condition
  - (MDS-Archiver: Xpath on historical data)
- Deep integration with Globus containers & services: every GT4 service is discoverable
  - GRAM, RFT, GridFTP, CAS, ...

GT4 Monitoring & Discovery





- GT 4.0 General
  - Release Notes
  - Key Concepts
  - Installing GT 4.0 (System Administrator's Guide)
  - Site/VO Planning
  - Platform Notes
  - Best Practices for Developing with GT 4.0
  - Guide to APIs
  - Coding Guidelines
  - Migration Guide
    - From GT2 to GT4
    - From GT3 to GT4
  - Samples
  - Command Line Clients Guide
  - GUI Guide
  - Resource Properties Guide
  - Overview and Status of Current GT Performance Studies
  - Release Version Scheme
- GT 4.0 Common Runtime Components
  - Common Runtime Components: Key Concepts
  - Java WS Core
  - C WS Core
  - XIO
  - C Common Libraries
- GT 4.0 Security (GSI)
  - Security: Glossary
  - Security: Key Concepts
  - WS A&A
    - Community Authorization Service (CAS)
    - Delegation Service
    - Authorization Framework
    - Message/Transport-level Security
  - Credential Management
    - MyProxy
    - SimpleCA
  - Utilities
    - GSI-OpenSSH
    - Pre-WS Authentication & Authorization

GT4 Documentation is Extensive!

- GT 4.0 Data Management
  - Data Management: Key Concepts
  - RFT
  - GridFTP
  - RLS
- GT 4.0 Information Services
  - Information Services: Key Concepts
  - WS MDS (MDS4)
    - Aggregator Framework
    - Index Service
    - Trigger Service
    - WebMDS (Tech Preview)
  - Pre-WS MDS (MDS2)
- GT 4.0 Execution Management
  - Execution Management: Key Concepts
  - WS GRAM (GRAM4)
  - WS Rendezvous
  - Pre-WS GRAM (GRAM2)

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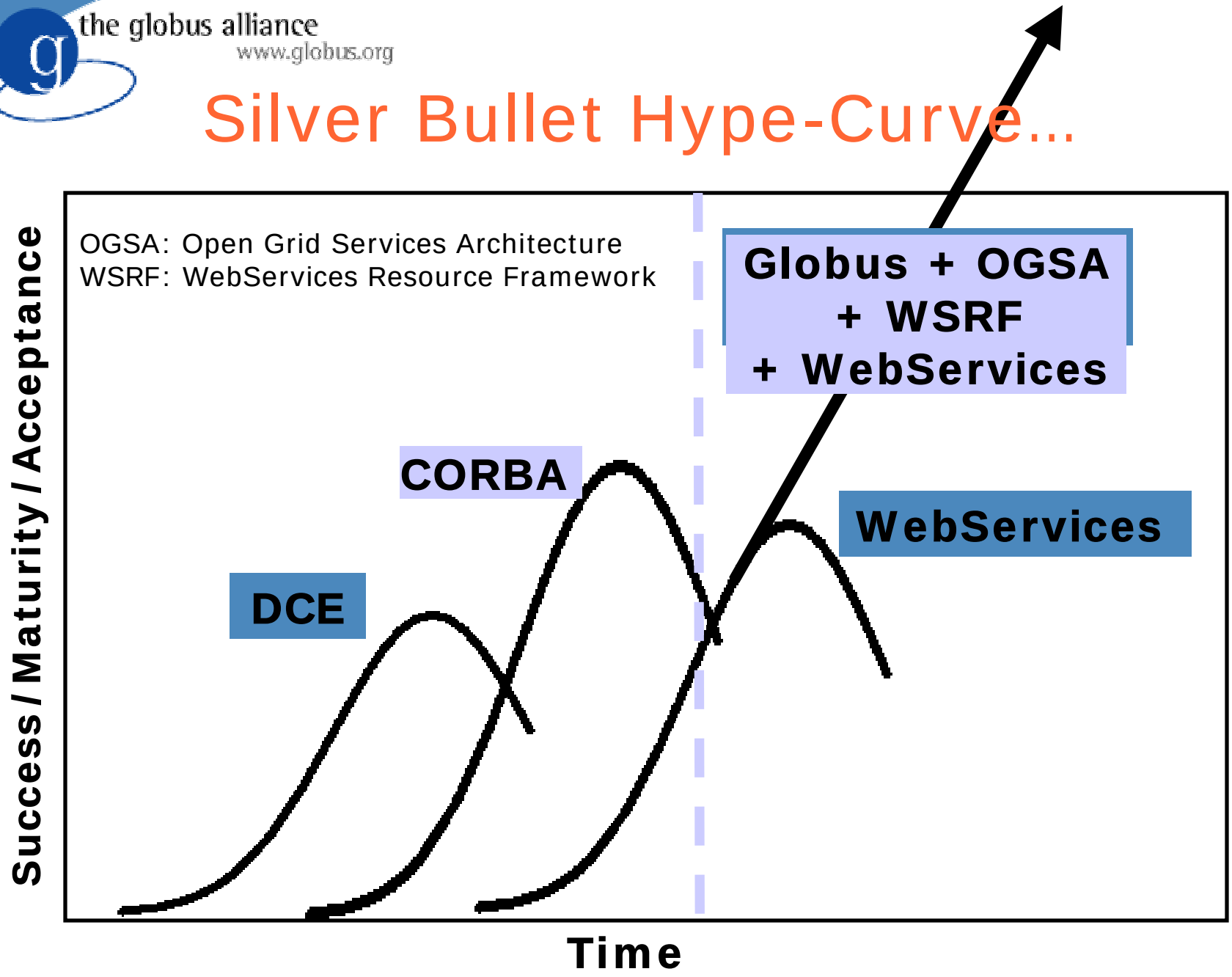
Working with GT4

- Download and use the software, and provide feedback
  - Join **gt4friends@globus.org** mail list
- Review, critique, add to documentation
  - Globus Doc Project: **http://gdp.globus.org**
- Tell us about your GT4-related tool, service, or application
  - Email **info@globus.org**

Silver Bullet Hype-Curve…



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Outline

- Globus Alliance
- Grids
- Globus Toolkit Introduction

- Virtual Organizations
- GT's BIG Security "Issue"

- Questions & Discussion

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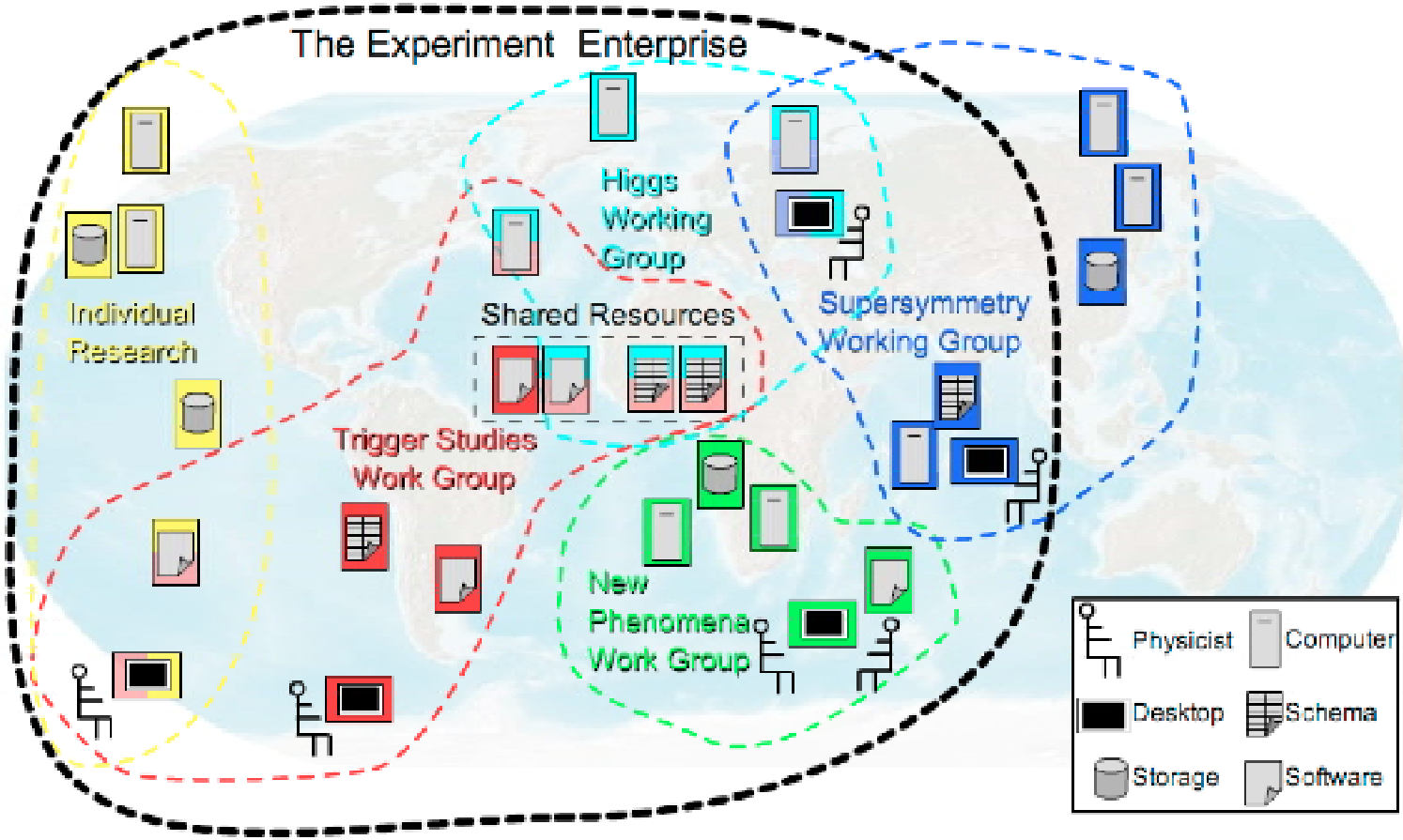
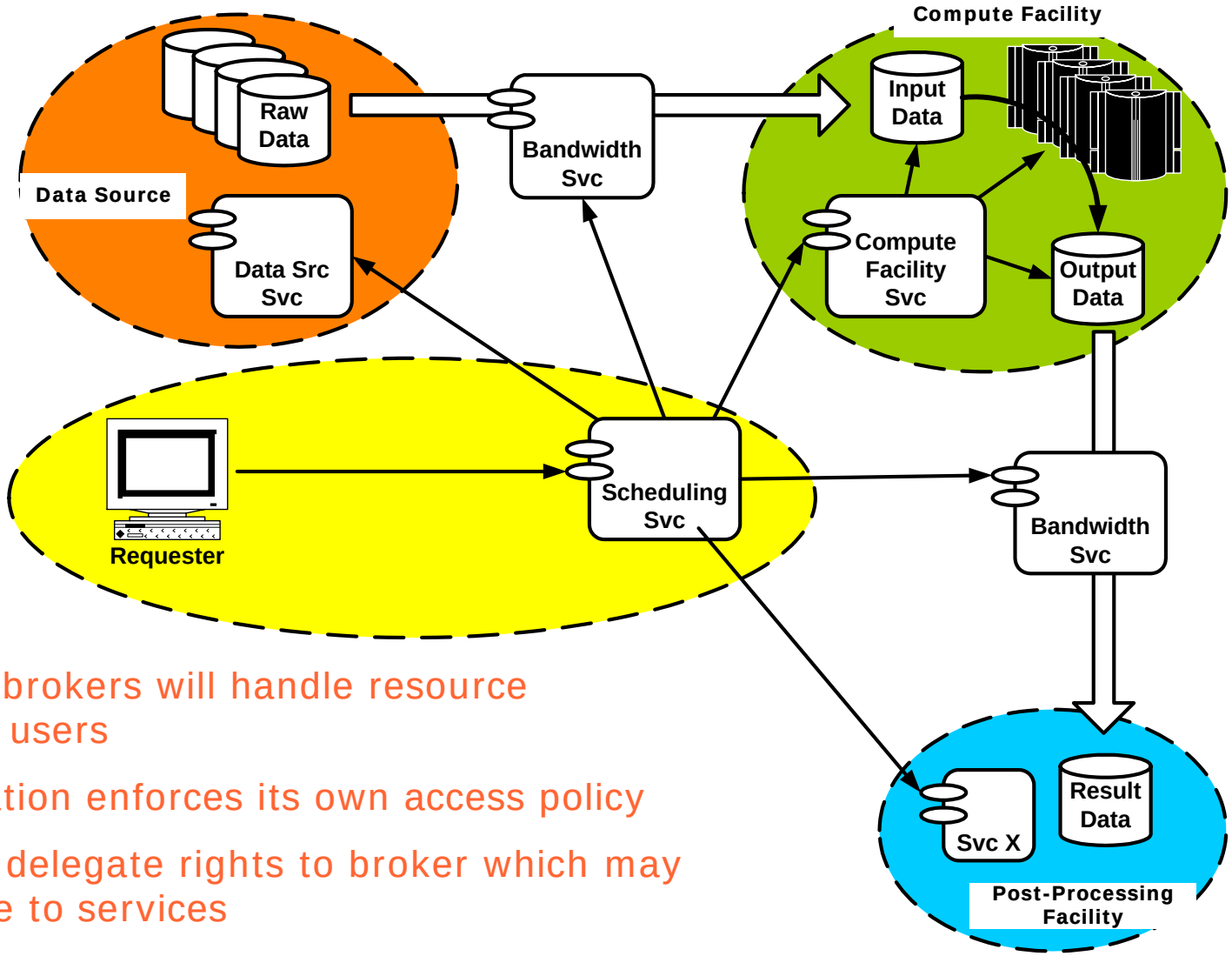
Objective:
Enable Cross-Organizational Collaboration



Security of Grid Brokering Services



- It is expected brokers will handle resource coordination for users
- Each Organization enforces its own access policy
- User needs to delegate rights to broker which may need to delegate to services
- QoS/QoP Negotiation and multi-level delegation

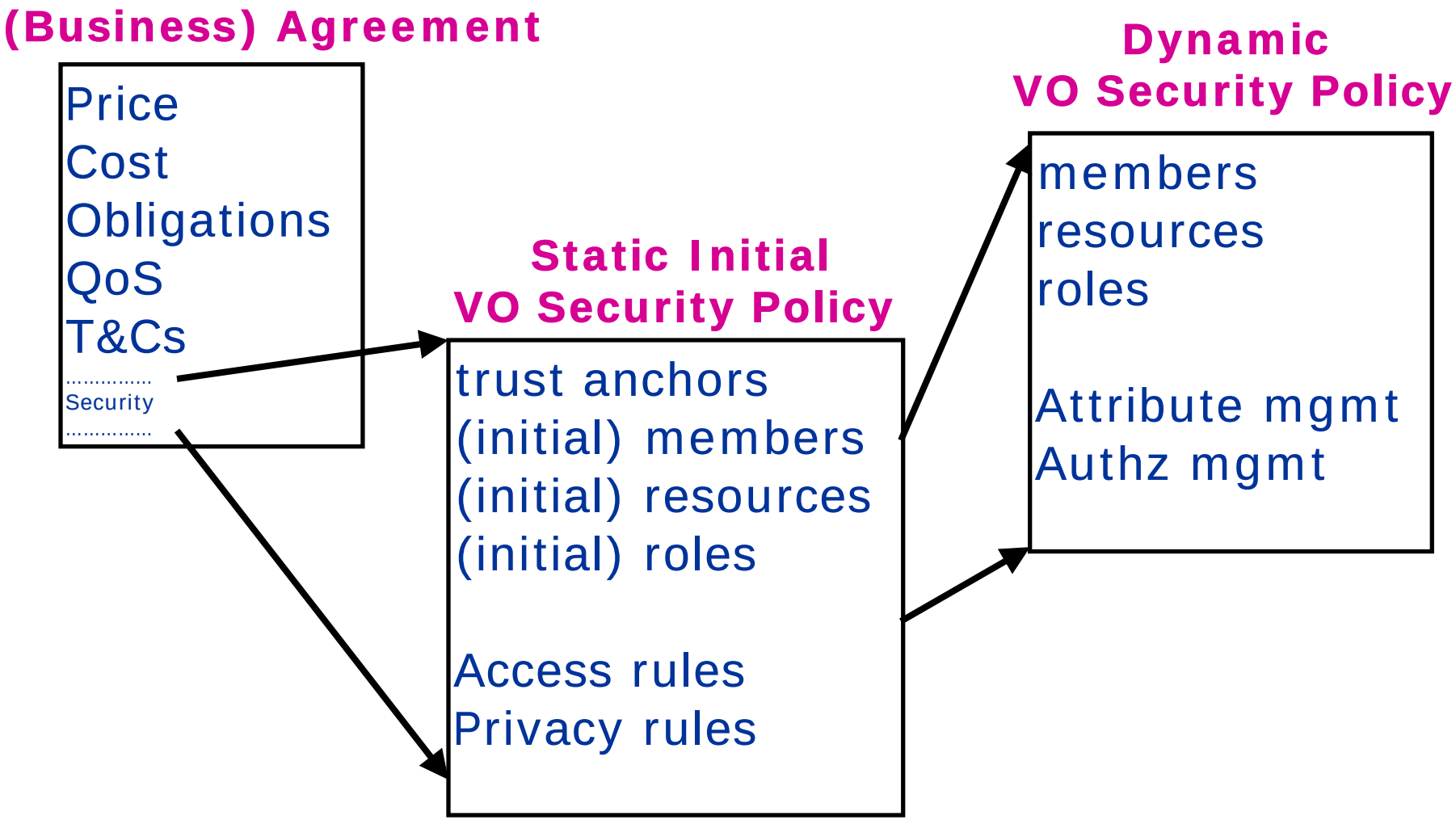
Security Objective: Forceful Enforcement (?)

Security Services Objectives

- It's all about "Policy"
  - (Virtual) Organization's Security Policy
  - Security Services facilitate the enforcement
- Security Policy to facilitate "Business Objectives"
  - Related to higher level "agreement"
- Security Policy often delicate balance
  - More security ⇔ Higher costs
  - Less security ⇔ Higher exposure to loss
  - Risk versus Rewards
  - Legislation sometimes mandates minimum security

Security: Risk versus Reward

Agreement ⇔ VO Security Policy



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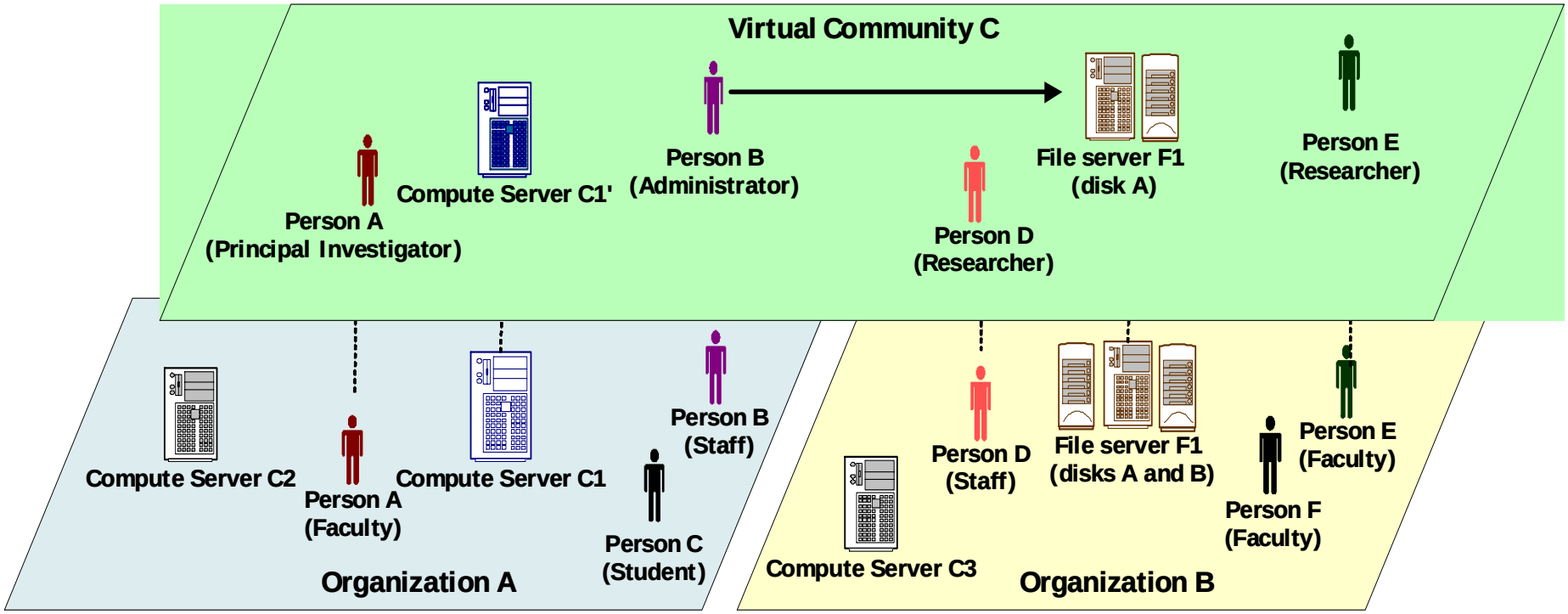
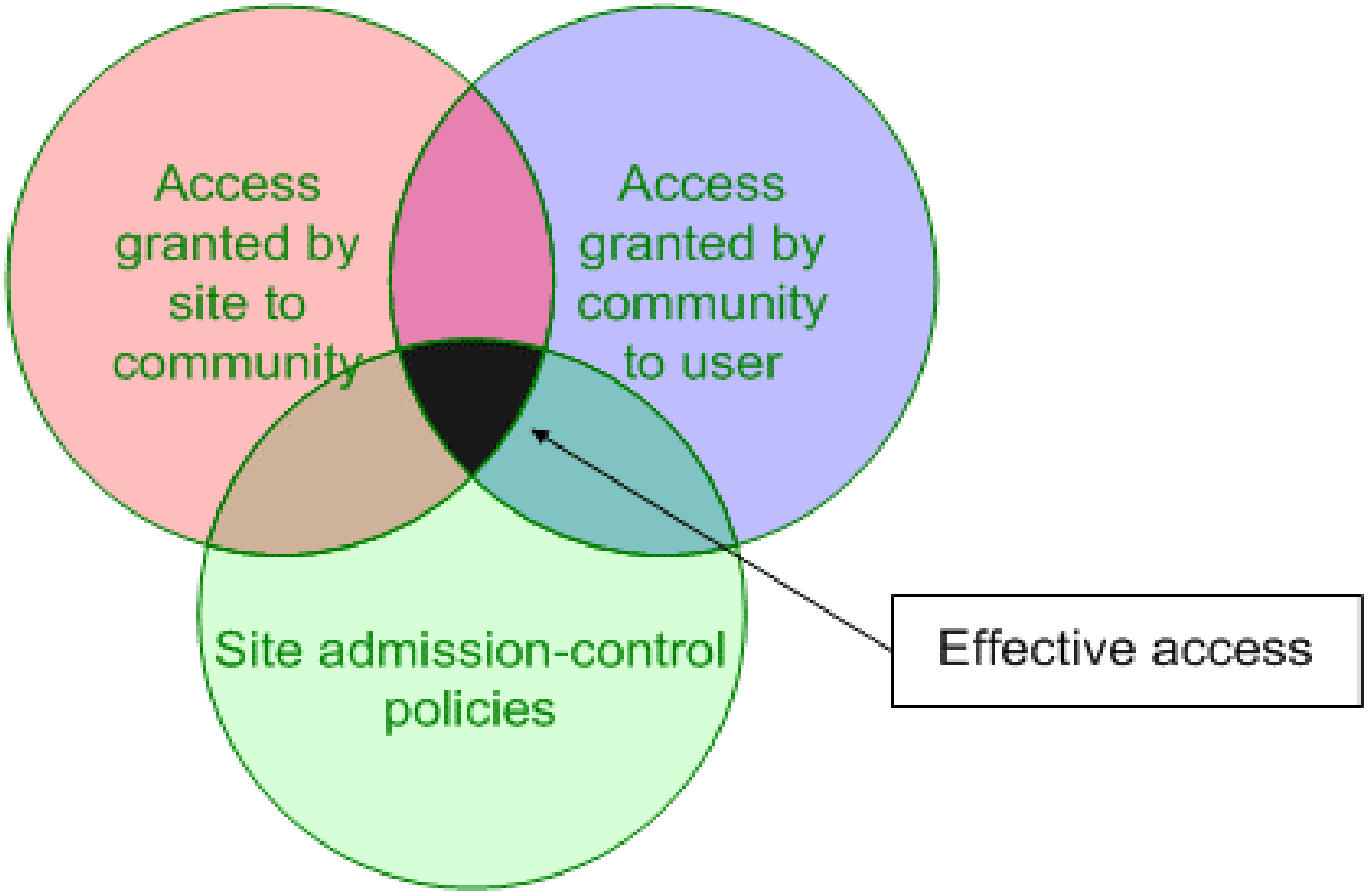
Virtual Organization (VO) Concept



- VO for each application/workload/collaboration
- Carve out and configure resources for a particular use and set of users

Effective Policy Governing Access Within A Collaboration



Why Grid Security is Hard...(1)

- Resources being used may be valuable & the problems being solved sensitive
  - Both users and resources need policy enforcement
- Dynamic formation and management of Virtual Organizations (VOs)
  - Large, dynamic, unpredictable…
- VO Resources and Users are often located in distinct administrative domains
  - Can't assume cross-organizational trust agreements
  - Different mechanisms & credentials
    - X.509 vs Kerberos, SSL vs GSSAPI, X.509 vs. X.509 (different domains),
    - X.509 attribute certs vs SAML assertions

Why Grid Security is Hard...(2)

- Interactions are not just client/server, but service-to-service on behalf of the user
  - Requires delegation of rights by user to service
  - Services may be dynamically instantiated
- Standardization of interfaces to allow for discovery, negotiation and use of resources/services
- Implementation must be broadly available & applicable
  - Standard, well-tested, well-understood protocols; integrated with wide variety of tools
- Policy from sites, VO, users need to be combined
  - Varying formats
- Want to hide as much as possible from applications!

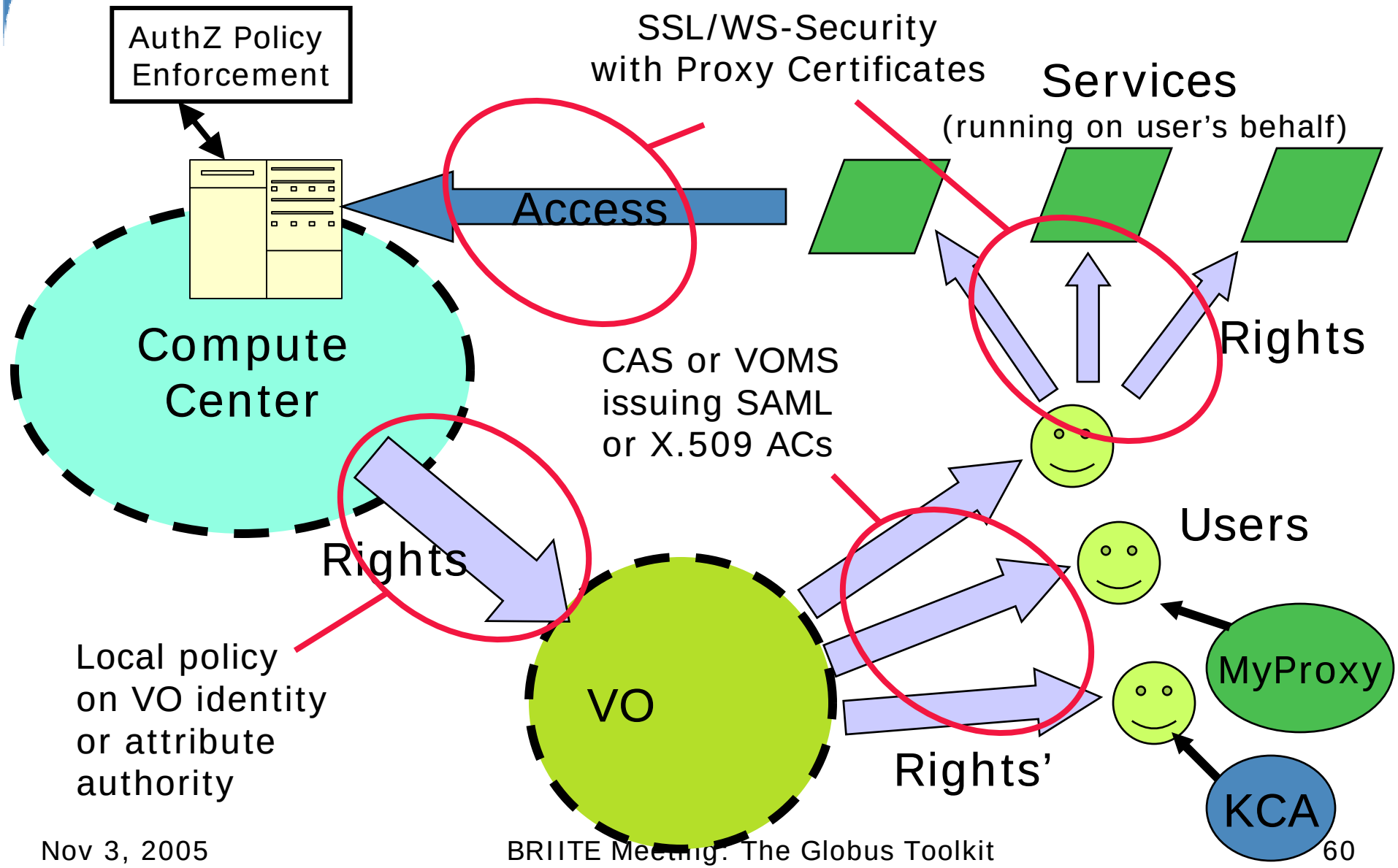
The Grid Trust solution

- Instead of setting up trust relationships at the organizational level

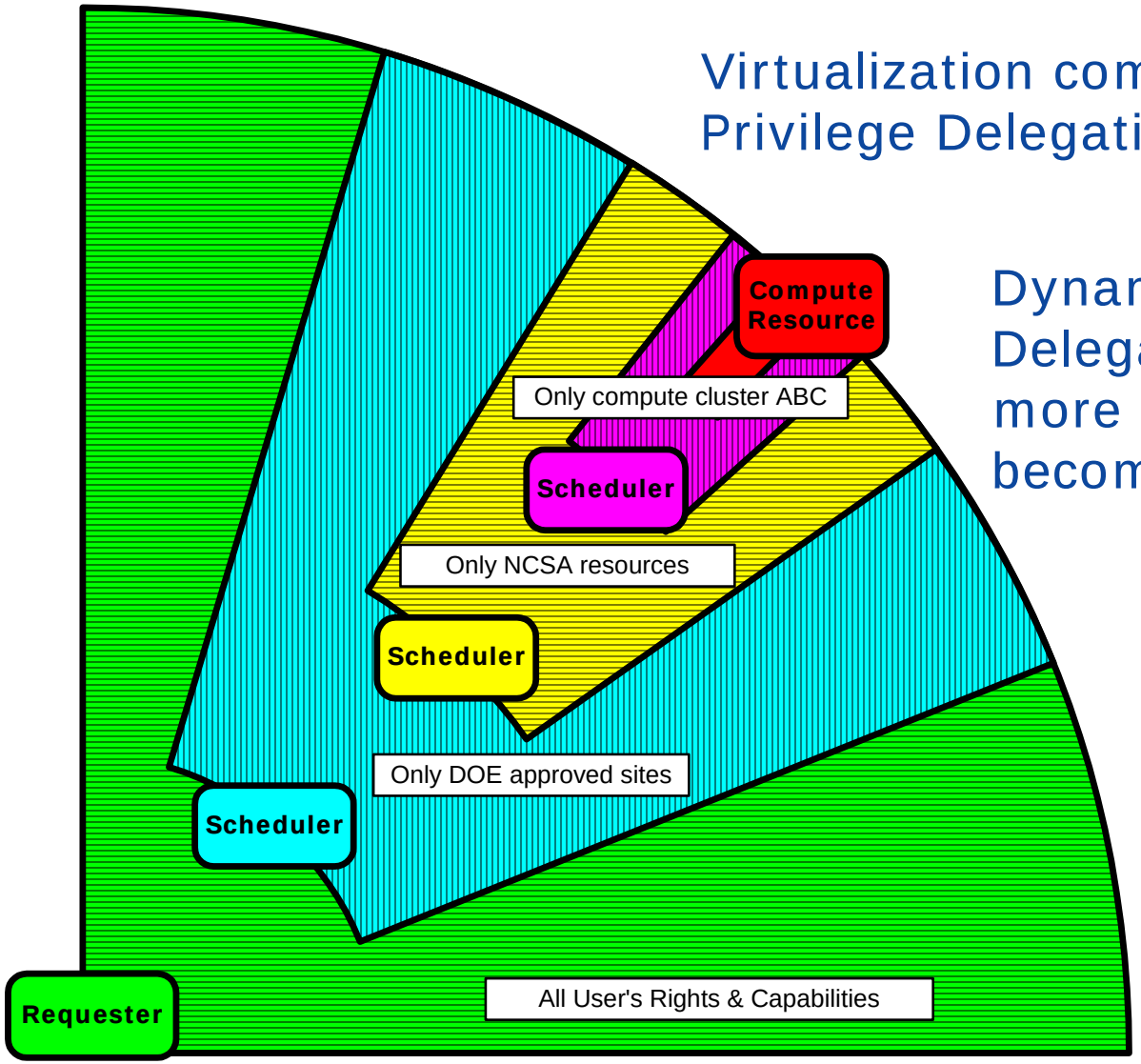
  (lots of overhead, possible legalities - expensive!)

  => set up trust at the user/resource level
- Virtual Organizations (VOs) for multi-user collaborations
  - Federate through mutually trusted services
  - Local policy authorities rule
- Users able to set up dynamic trust domains
  - Personal collection of resources working together based on trust of user

GT4 Security



Propagation of Requester's Rights through Job Scheduling and Submission Process



Virtualization complicates Least Privilege Delegation of Rights

Dynamically limit the Delegated Rights more as Job specifics become clear

Trust parties downstream to limit rights for you… or let them come back with job specifics such that you can limit them

Grid Security must address…

- Trust between resources without organization support
- Bridging differences between mechanisms
  - Authentication, assertions, policy…
- Allow for controlled sharing of resources
  - Delegation from site to VO
- Allow for coordination of shared resources
  - Delegation from VO to users, users to resources
- …all with dynamic, distributed user communities and least privilege.

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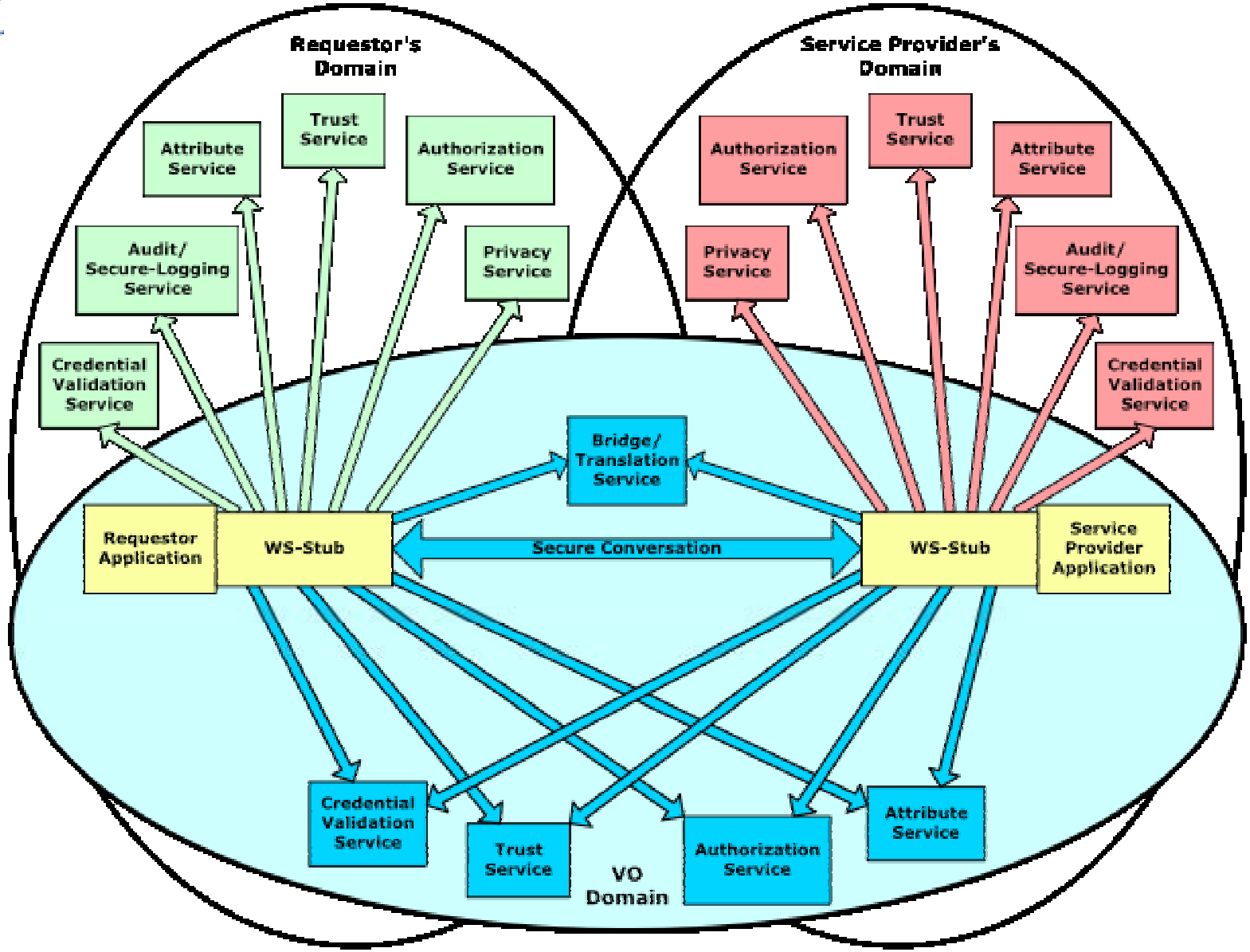
Security Services with VO



GT's GGF's Authorization Call-Out Support

- GGF's OGSA-Authz WG:
  "Use of SAML for OGSA Authorization"
  - Authorization service specification
  - Extends SAML spec for use in WS-Grid
  - Recently standardized by GGF
- Conformant call-out integrated in GT
  - Transparently called through configuration
- Permis interoperability
  - Ready for GT4!
- Futures…
  - SAML2.0 compliance … XACML2.0-SAML2.0 profile

GT-XACML Integration

- eXtensible Access Control Markup Language (XACML)
  - OASIS standard
  - Open source implementations
- XACML: sophisticated policy language
- Globus Toolkit ships with XACML runtime
  - Integrated in every client and server build on GT
  - Turned-on through configuration
- ...can be called transparently from runtime and/or explicitly from application...
- ...and we're using the XACML-"model" for our Authz Processing Framework...

GT's Assertion Processing "Problem"

- VOMS/Permis/X509/Shibboleth/SAML/Kerberos identity/attribute assertions
- XACML/SAML/CAS/XCAP/Permis/ProxyCert authorization assertions
- Assertions can be pushed by client, pulled from service, or locally available
- Policy decision engines can be local and/or remote
- Delegation of Rights is required "feature" implemented through many different means

GT-runtime has to mix and match all policy information and decisions in a consistent manner…

Delegation of Rights Complexity

Bob

Can I have glass of lemonade?

Ivan

Delegation of Rights Complexity

Ivan's policy:
I don't know any Bob…(?)
I do know John, Mary, Carol, Olivia, …

Bob

Can I have glass of lemonade?

Ivan

Delegation of Rights Complexity

Bob

Ivan's policy:
I don't know any Bob…(?)
I do know John, Mary, Carol, Olivia, …

Can I have glass of lemonade?

Ivan

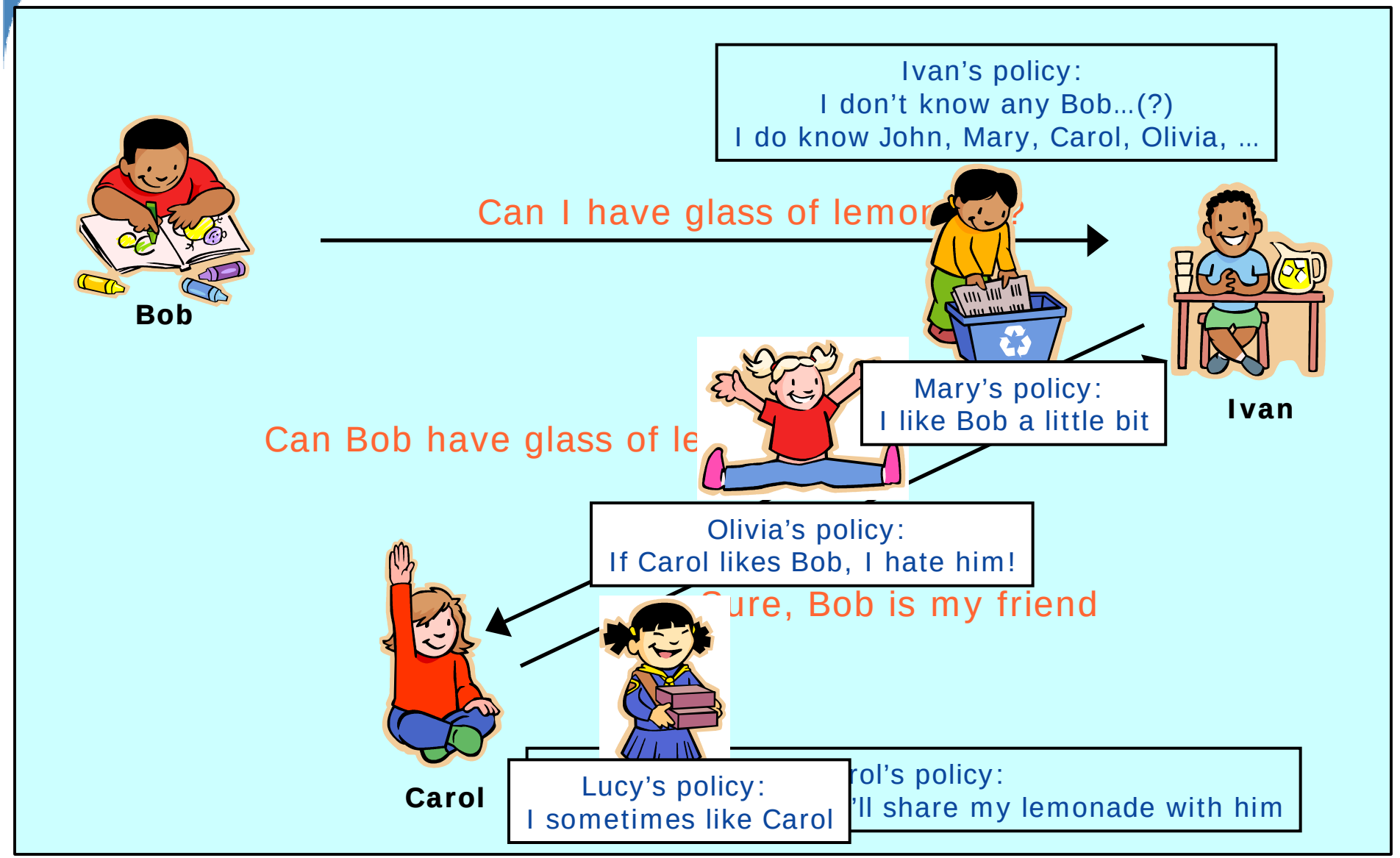
Can Bob have glass of lemonade?

Sure, Bob is my friend

Carol

Carol's policy:
Bob is my friend and I'll share my lemonade with him

Delegation of Rights Complexity



Delegation of Rights Complexity

Bill's policy:
Lemonade is bad for you

Ivan's poli
I don't know any Bob...(?)
I do know John, Mary, Carol, Olivia, ...

Bob

Can I have glass of lemon

Ivan

Jogger's policy:
I'd like a glass too

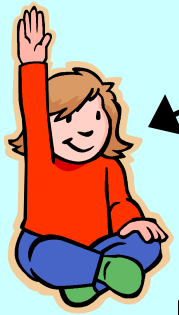
Can Bob have glass of le

Mary's policy:
I like Bob a little bit

John's policy:
I don't like girls

Olivia's policy:
If Carol likes Bob, I hate him!

ure, Bob is my friend



Carol

Ann's policy:
I like Ivan very much!

Lucy's policy:
I sometimes like Carol

rol's policy:
'll share my lemonade with him

Delegation of Rights Complexity

Frosty's policy:
Only share lemonade with ice

Bill's policy:
Lemonade is bad for you

Aunt's policy:
Sharing is good

Ivan's poli
I don't know any Bob...(?)
I do know John, Mary, Carol, Olivia, ...

Bob

Laura's policy:
Share if he pays!

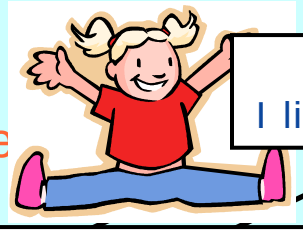
Can Bob have glass of lemonade?

Ivan

Jogger's policy:
I'd like a glass too

Mary's policy:
I like Bob a little bit

Can Bob have glass of le

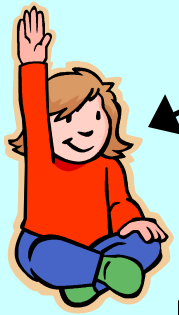


John's policy:
I don't like girls

Olivia's policy:
If Carol likes Bob, I hate him!

Sure, Bob is my friend

Ann's policy:
I like Ivan very much!



Carol

Lucy's policy:
I sometimes like Carol

rol's policy:
'll share my lemonade with him

Delegation of Rights Complexity

Neighbor's policy:
Let's party!

Aunt's policy:
Sharing is good

Frosty's policy:
Only share lemonade with ice

Bill's policy:
Lemonade is bad for you

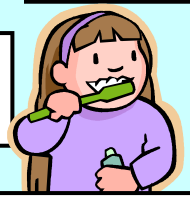
Ivan's poli
I don't know any Bob...(?)
I do know John, Mary, Carol, Olivia, ...

Laura's policy:
Share if he pays!

Can I ... glass of lemon?

Bob

Jogger's policy:
I'd like a glass too



Mary's policy:
I like Bob a little bit

Iva

Can B... ...of l...

Rita's policy:
No lemonade after eight

John's policy:
I don't like girls

Olivia's policy:
If Carol likes Bob, I hate him!

Accountant's policy:
Only if he signs here

Sure, Bob is my fri...

Emma's policy:
Only on his birthday

Ann's policy:
I like Ivan very much!

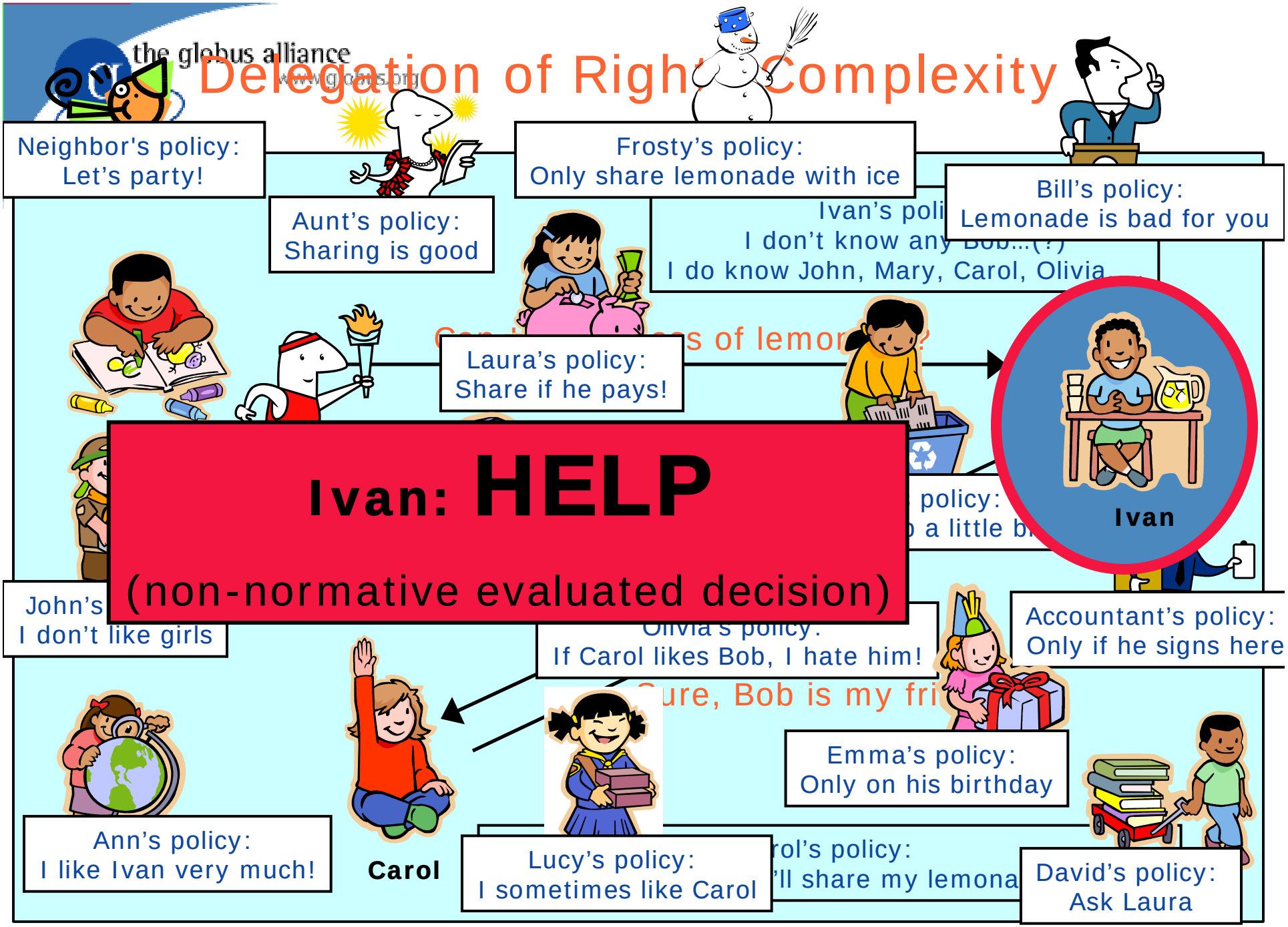
Carol

Lucy's policy:
I sometimes like Carol

...rol's policy:
...'ll share my lemona...

David's policy:
Ask Laura

Delegation of Rights Complexity



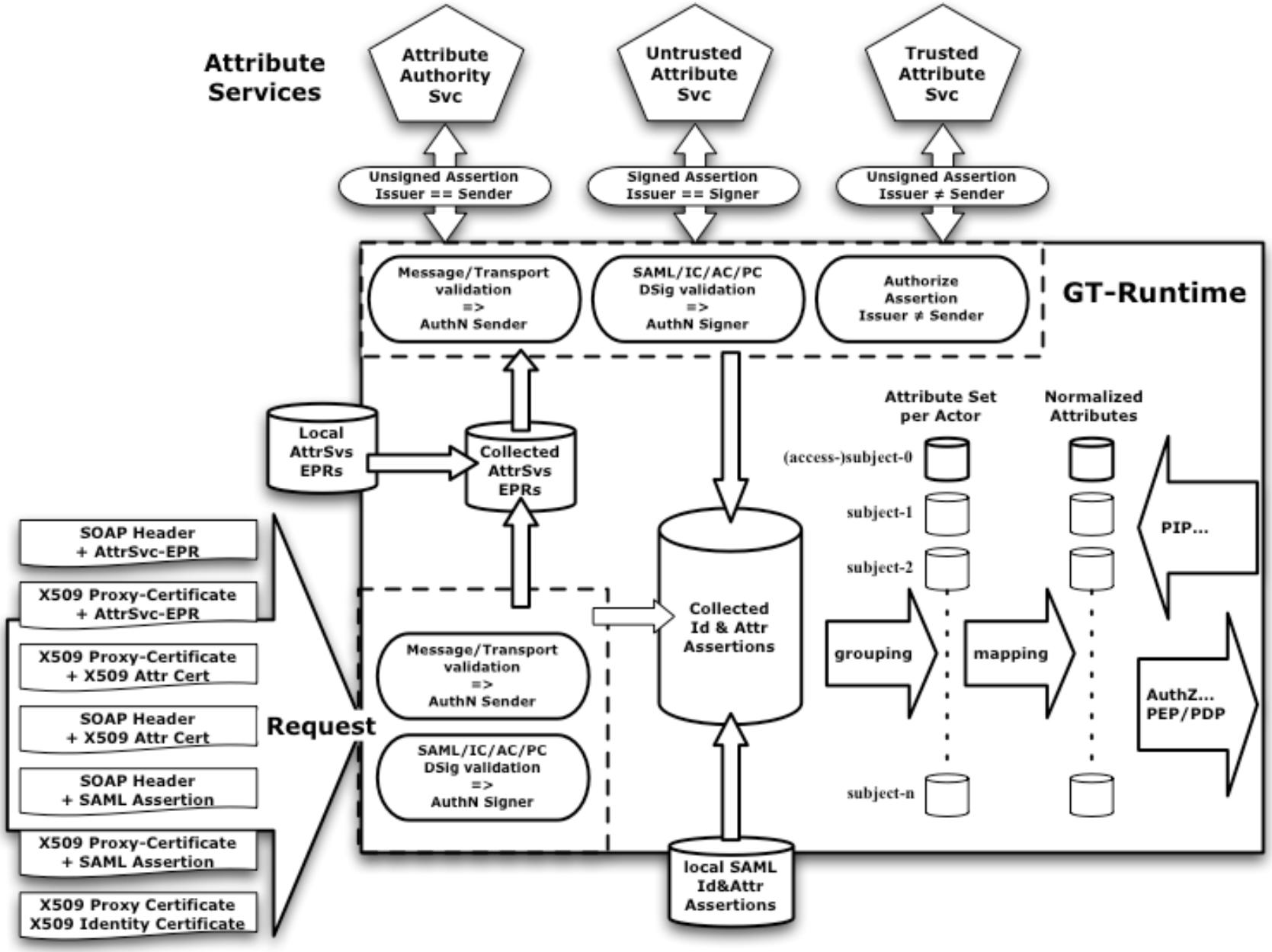
What are the Grid/P2P issues with "distributed authorization"? (1)

- Many different parties want to express their opinion about each other's access rights
  - Anybody can say anything about anyone else
- Expressed in many different languages
  - Enforcement of single policy language impossible/not-desirable
- Some parties can be asked about their opinion
  - Expose themselves as an AuthZ-oracle (PDP)
- Other parties send their opinion as statements
  - Authenticated policy/decision statements/assertions expressed in their favorite language

What are the Grid/P2P issues with "distributed authorization"? (2)

- Some of that advise is from parties you've never met before
  - So they must be empowered by those you do know…
- Some advise does not apply, is mal-formed, malicious, fake, erroneous, ….
  - …often you do not know that by looking at them…
- Different parties will use different names for the same subject
  - Need identity federation for mapping
- Different parties will use different groups/roles in their policy expressions
  - Only the group/role that is actually used in a relevant policy expression is of interest…

Attribute Collection Framework



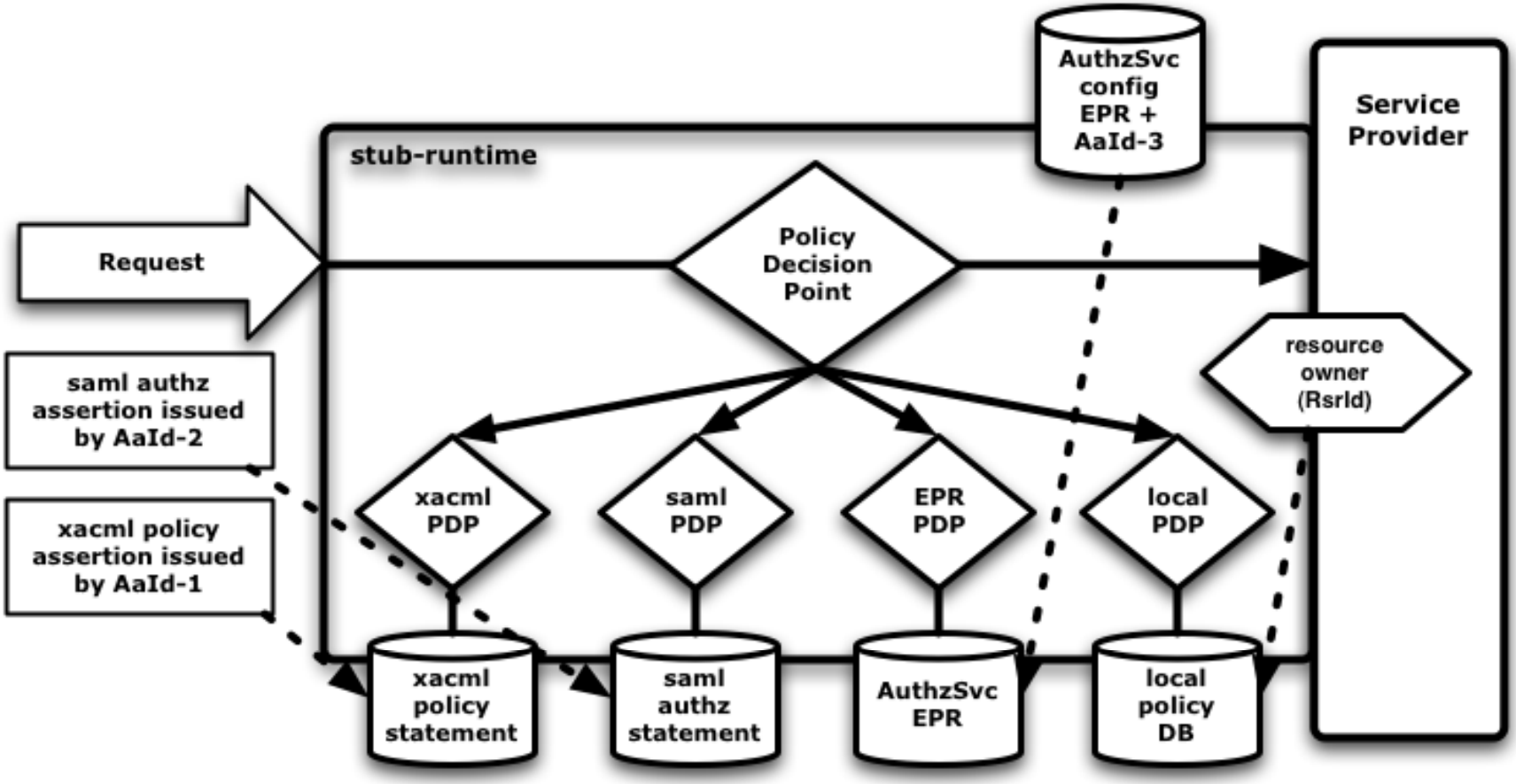
GT's Authorization Processing Model (1)

- Use of a Policy Decision Point (PDP) abstraction that conceptually resembles the one defined for XACML.
  - Normalized request context and decision format
  - Modeled PDP as black box authorization decision oracle
- After validation, map all attribute assertions to XACML Request Context Attribute format
- Create mechanism-specific PDP instances for each authorization assertion and call-out service
- The end result is a set of PDP instances where the different mechanisms are abstracted behind the common PDP interface.

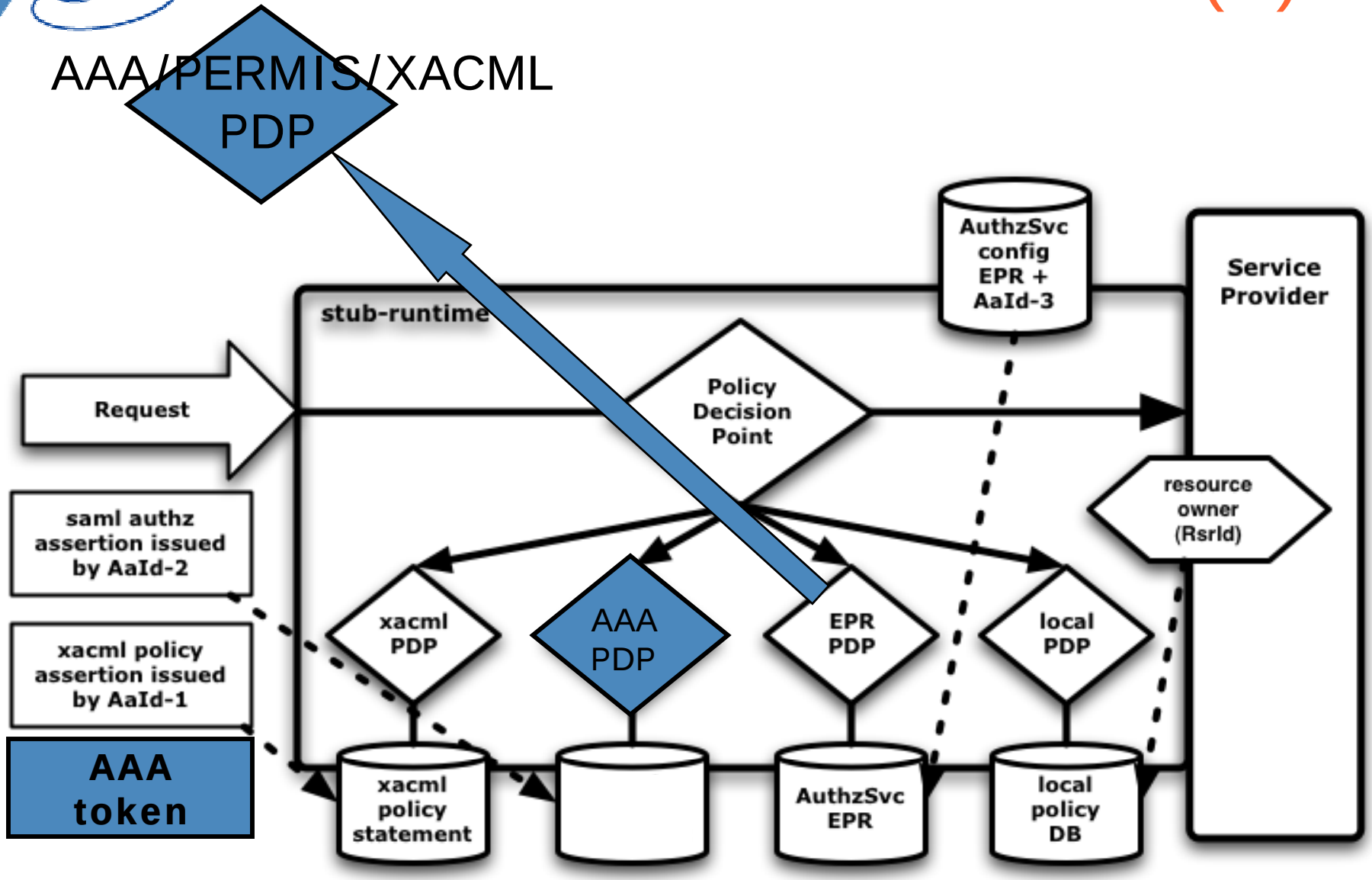
GT's Authorization Processing Model (2)

- The Master-PDP orchestrates the querying of each applicable PDP instance for authorization decisions.
- Pre-defined combination rules determine how the different results from the PDP instances are to be combined to yield a single decision.
- The Master-PDP is to find delegation decision chains by asking the individual PDP instances whether the issuer has delegated administrative rights to other subjects.
- the Master-PDP can determine authorization decisions based on delegated rights without explicit support from the native policy language evaluators.

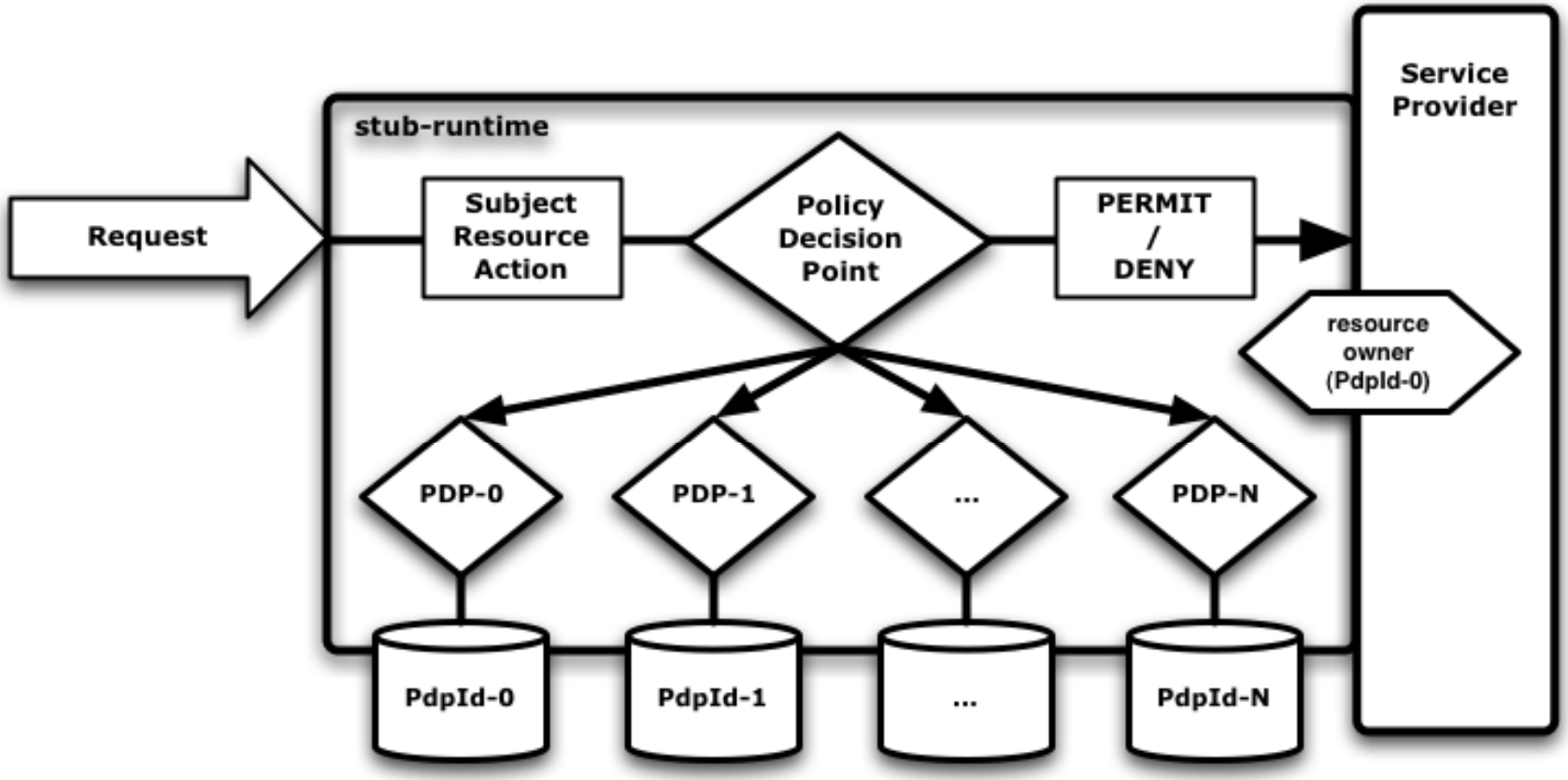
GT Authorization Framework (1)



GT Authorization Framework (2)



GT Authorization Framework (3)



GT Authorization Framework (3)

- Master-PDP accessed all mechanism-specific PDPs through same Authz Query Interface
  - SAML-XACML-2 profile
- Master PDP acts like XACML “Combinator”
  - “Permit-Overrides” rules
    - Negative permissions are evil…
- Delegation-chains found through exhaustive search
  - …with optimization to evaluate cheap decisions first…
- “Blacklist-PDPs” are consulted separately
  - Statically configured, call-out only PDPs
  - Deny-Overrides only for the blacklist-PDPs…
    - Pragmatic compromise to keep admin simple

Big Picture & Conclusion

- GT4 is security buzzword compliant!
  - …probably the most full-featured-security ws-toolkit…
- WebServices technologies provide low-level plumbing
  - following all relevant standards
- Portals growing as a user interface
  - Clients use http-browsers,
    … but portals will use WS-protocols!
  - PURSE, ESG, GridSite, LEAD Portal, …
- New Deployment Paradigms (GridLogon, VMs)
  - Driven by inability to protect…
- Authorization still the big focus
  - “unification framework” needed to support different mechanisms and formats => GT4.2
  - Required for fine-grained VO-policy

http://www.mcs.anl.gov/~franks/presentations/GT-BRIITE-Nov3-2005.ppt


Q?