# (Re-thinking) Security Models for Complex Resource Provisioning and Grid based Applications

Yuri Demchenko
System and Network Engineering Group
University of Amsterdam

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# Outline

- Background – security research and practice
- Basic uses cases - Extending edge of security practices and theory
  - Collaborative Virtual Laboratory environment
  - Extending User Controlled Security Domain in Virtualised Workspace Service (VWSS)
  - Pilot Job submission and execution in Computer/Cluster Grids
  - Multidomain Complex Resource Provisioning (CRP)
  - UPVN and Multilevel Secure Networks – Area to investigate
- Two basic security models (TCB and OSI/Internet) and related standards
- Policy Obligations – bridging two fundamental security models

- New/(less) known security mechanisms for building integrated security
  - Combining TCB and OSI security models for managed objects/processes
  - Trusted Computing Platform Architecture (TCPA)
  - Identity Based Cryptography (IBC)

# Security Research and Practice

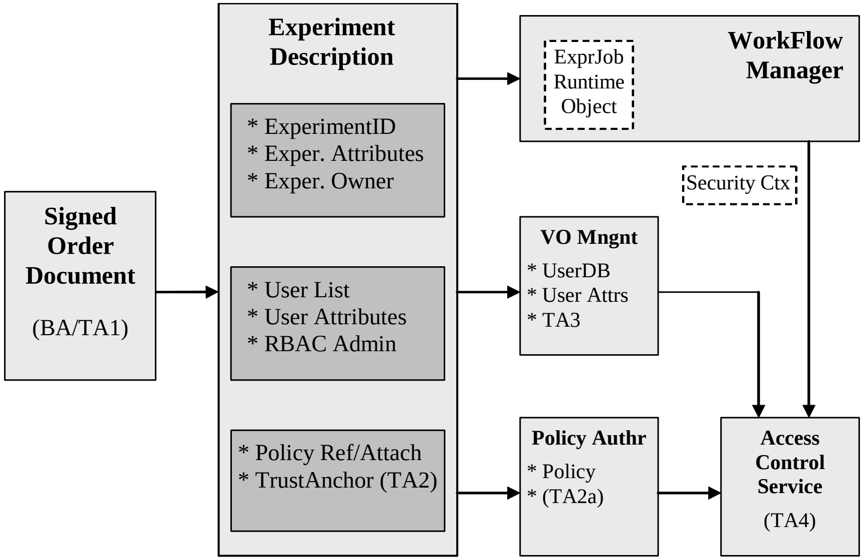
- We all know many basic security concepts and models
  - BUT each research project typically brings new problems that require new approaches
  - Good result if it is resulted in proposing and formalising a new model
    - We can use for further projects and development
- Implementing basic concepts in a specific environment or for specific tasks may require extending and sometimes re-factoring existing models

# What's beyond AuthN/Z services - Application vs Security service view

- Authentication – first/initial step in accessing a system or handling service request
  - Creating process, invoking service or object
  - Retrieving user attributes
  - In general, creating security context for further command/service execution
- Authorisation
  - Applied to user commands/actions, or managed objects
  - Starting/executing process/job/request
  - Creating AuthZ session and AuthZ context
    - Attribute mapping and policy Obligations
- Managing security and AuthZ context
  - User AuthZ session – e.g. web browser cookie
  - Process environment – e.g. Unix processes environment
  - Managed Object property – e.g. job, running code permissions, agents

# Collaborative Virtual Laboratory Environment

- "Micro" actions in remote instrument control, e.g. surface investigation with electronic microscope
  - Method – AuthZ session management
  - Mechanism – AuthZ ticket (similar to cookie in browser)
- Project/experiment and user centric security
  - Method - Binding project/experiment security context to the signed business agreement
  - Mechanism – Business and/or Trust anchor (BA/TA)
- Experiment workflow and dynamic/changing security context
  - E.g. depending on the experiment stages: specimen scanning, data processing, visualisation, report




Experiment Description as a semantic object defining attributes for the workflow/job, user association in a form of VO, access control policy

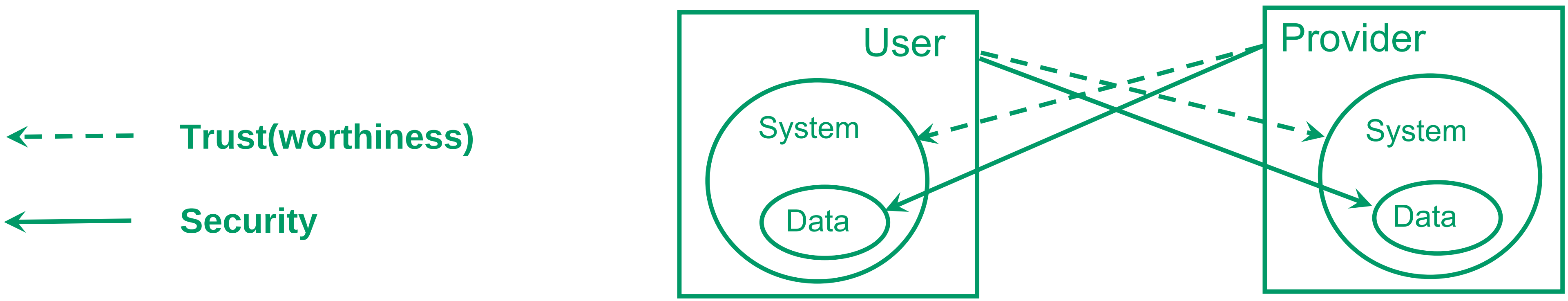
Trust domain based on Business Agreement (BA) or Trust Anchor (TA)

This approach can use recently standardised WS-Agreement (WSAG) protocol

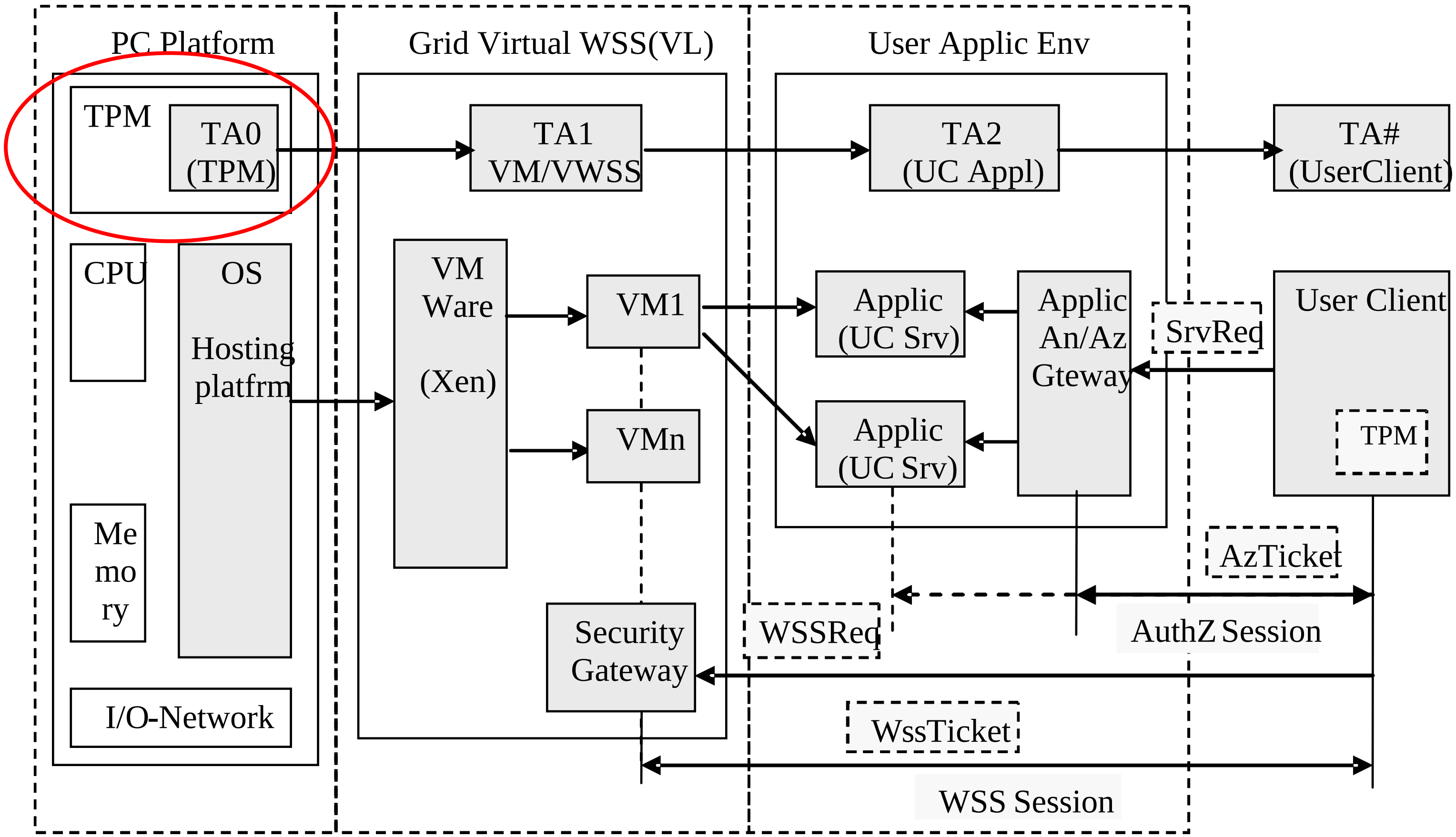
# Extending User Controlled Security Domain in Virtualised Workspace Service (VWSS)

## Different sides of Security and Trust

- Modern paradigm of remote distributed services and digital content providing makes security and trust relations between User and Provider more complex
- User and Service Provider – two actors concerned with own Data/Content security and each other System/Platform trustworthiness
- Two other aspects of security/trust
  - Data stored vs Data accessed/processed
  - System Idle vs Active (running User session)
- Think about real life analogy:
  - *Diplomatic/President's visit*
  - *Combat mission*



# User-controlled Virtual Workspace Service (VWSS-UC) – Proposed 3 layer model



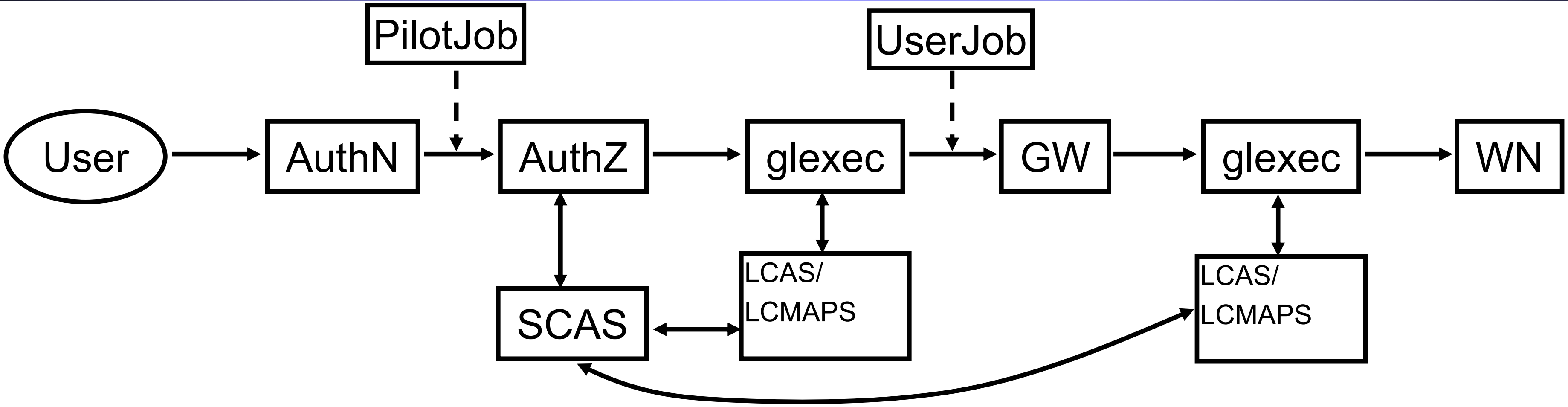

- •Trust Anchors: T0 (TPM) – TA1 (VM/VWSS) – TA2 (Application) – TA# (User)
- •WVSS session and Application AuthZ sessions

# Grid Security Overview – Major concepts/mechanisms

- Grid is for sharing computing resources and unique resources in the distributed heterogeneous environment by means of resource and user virtualisation
  - Grid Security is built around Web Services Security
- Authentication in the Grid is based on PKI and can use different (user) credentials (PKI, SAML, Kerberos tickets, password, etc.)
- Delegation (restricted and full)
  - Job submission in Grid environment requires (credentials) delegation
  - Implemented using X.509 Proxy Certificate (Proxy or PC)
  - Proxy is generated by the user client based on user master PKC or Proxy
  - Limited delegation chain (typically not more than 10)
- Authorisation is based on VO attributes
  - Simple AuthZ session management by using Proxy or Short Lived Creds (CLC) together with CRL
- Trust is an important component of PKI based AuthN and Delegation
  - Trust relations are represented by a certificate chain
  - Typical Proxy Certs chain

    **PKC (DN1, CA) => PC (DN2, (ACa) , PKC) => PPC (DN2, (ACb) , PC) => …**
  - International Grid Trust Federation GridPMA – http://www.gridpma.org/

# Use Case for “*gLExec on the WN*” – Pilot Job




Use case that doesn’t fit typical policy based access control in Grids

- Make pilot job subject to normal site policies for jobs

VO submits a pilot job to the batch system

- the VO ‘pilot job’ submitter is responsible for the pilot behavior
  - *this might be a specific role in the VO, or a locally registered ‘special’ user at each site*
- Pilot job obtains the true user job, and presents the user credentials and the job (executable name) to the site (gLExec) to request a decision on a cooperative basis

Preventing ‘back-manipulation’ of the pilot job

- make sure user workload cannot manipulate the pilot
- project sensitive data in the pilot environment (proxy!)
- by changing uid for target workload away from the pilot

# Obligations in Access Control and Management

Obligations in access control and policy based management

- Obligated policy decision
- Provisional policy decision

Access control in Grid and Policy Obligations

- Account mapping
- Quota assignment
- Environment setup/configuration

General Complex Resource provisioning

- Fixed, Time-flexible, Malleable/”Elastic” Scheduling
- Usable Resource

Other/general

- Accounting, Logging, Delegation

# Policy enforcement mechanisms and Obligations

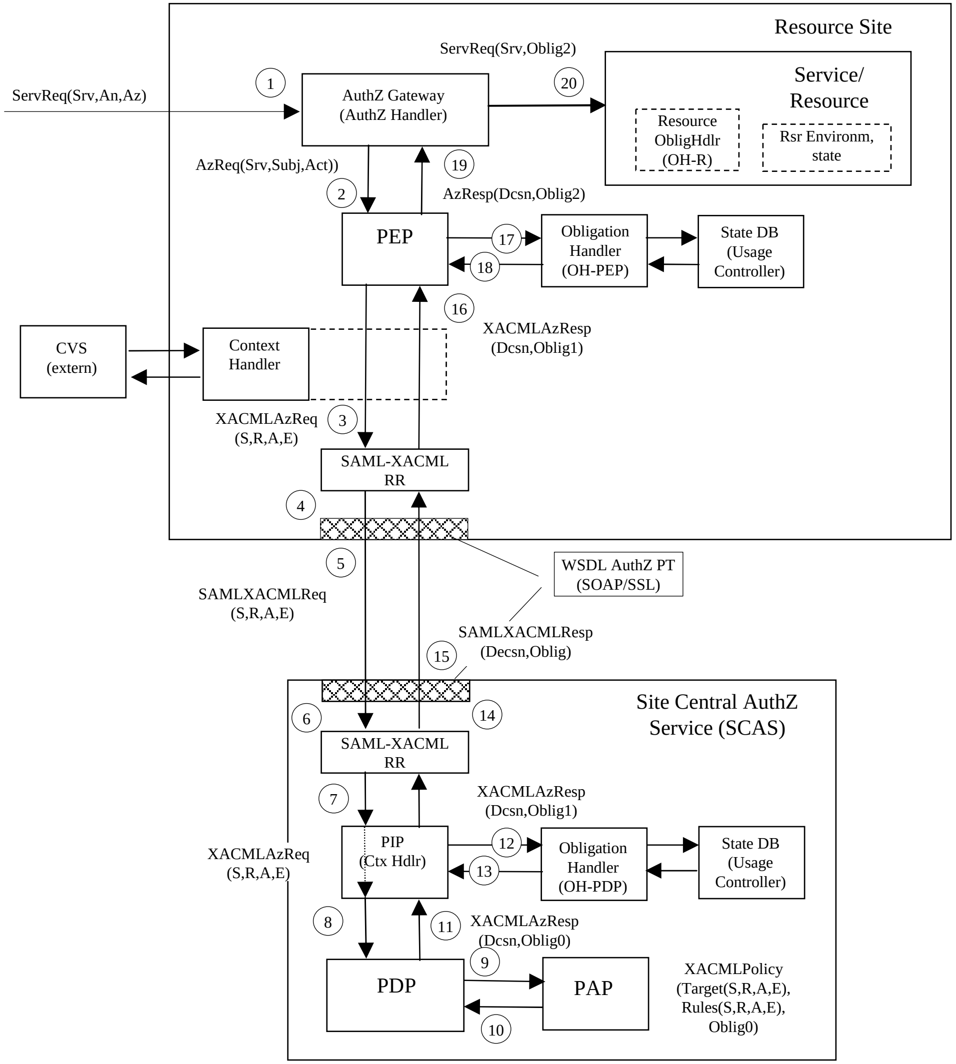
Policy Obligation is one of the policy enforcement mechanisms

- ***Obligations*** are a set of operations that must be performed by the ***PEP*** in conjunction with an ***authorization decision*** [XACML2.0]

Obligations enforcement scenarios

- Obligations are enforced by PEP at the time of receiving obligated AuthZ decision from PDP
- Obligations are enforced at later time when the requestor accesses the resource or service
  - Require use of AuthZ assertions/tickets/(restricted proxy?)
- Obligations are enforced before or after the resource or service accessed/delivered/consumed
  - Not discussed in current study/document – refer to OGSA AUTHZ-WG discussions

# Proposed Obligations Handling Reference Model




## Generic AuthZ service model

PEP – Policy Enforcement Point

PDP – Policy Decision Point

PAP – Policy Authority Point

OH – Obligation Handler

CtxHandler – Context Handler

(S, R, A, E) – components of the AuthZ request
(Subject, Resource, Action, Environment)

# Obligations Handling Stages

Obligation0 = tObligation => Obligation1 ("OK?", (Attributes1 v Environments1))
=> Obligation2 ("OK?", (Attributes2 v Environments2))
=> Obligation3 (Attributes3 v Environments3)

Obligation0 – (stateless or template)

**Obligations are returned by the PDP in a form as they are written in the policy. These obligations can be also considered as a kind of templates or instructions, tObligation.**

Obligation1 and Obligation 2

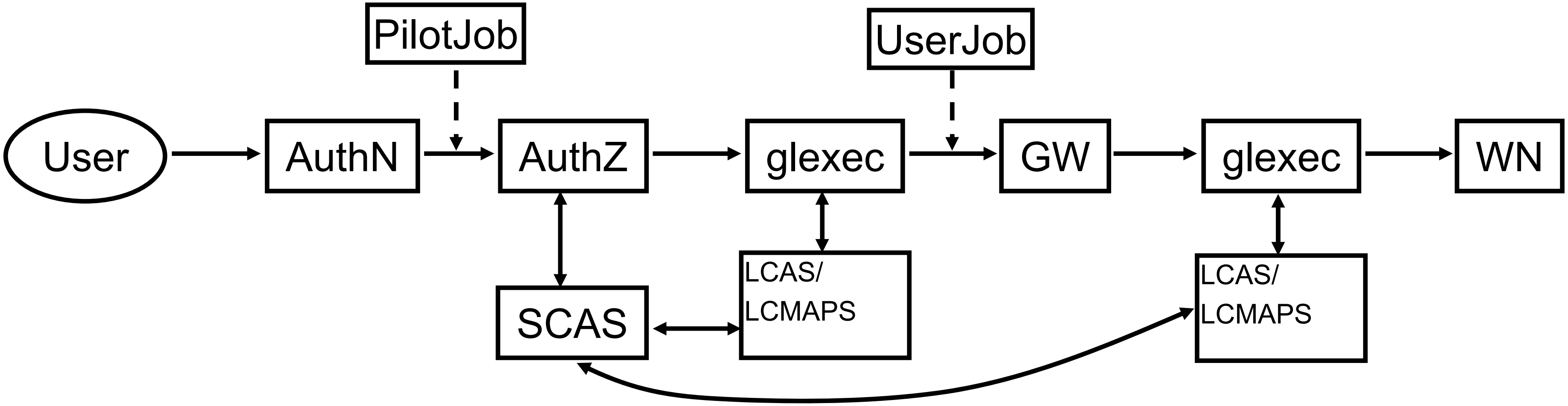
**Obligations have been handled by Obligation handler at the SCAS/PDP side or at the PEP side, depending on implementation. Templates or instructions of the Obligation0 are replaced with the real attributes in Obligation1/2, e.g. in a form of "name-value" pair.**

- The result of Obligations processing/enforcement is returned in a form of modified AuthzResponce (Obligation1) or global Resource environment changes
- Obligation handler should return notification about fulfilled obligated actions, e.g. in a form of Boolean value "False" or "True", which will be taken into account by PEP or other processing module to finally permit or deny service request by PEP.
- Note. Obligation1 handling at the SCAS or PDP side allows stateful PDP/SCAS.

Obligation3

**Final stage when an Obligation actually takes effect (Obligations "termination"). This is done by the Resource itself or by services managed/controlled by the Resource.**

# Obligations and Pilot Job use case



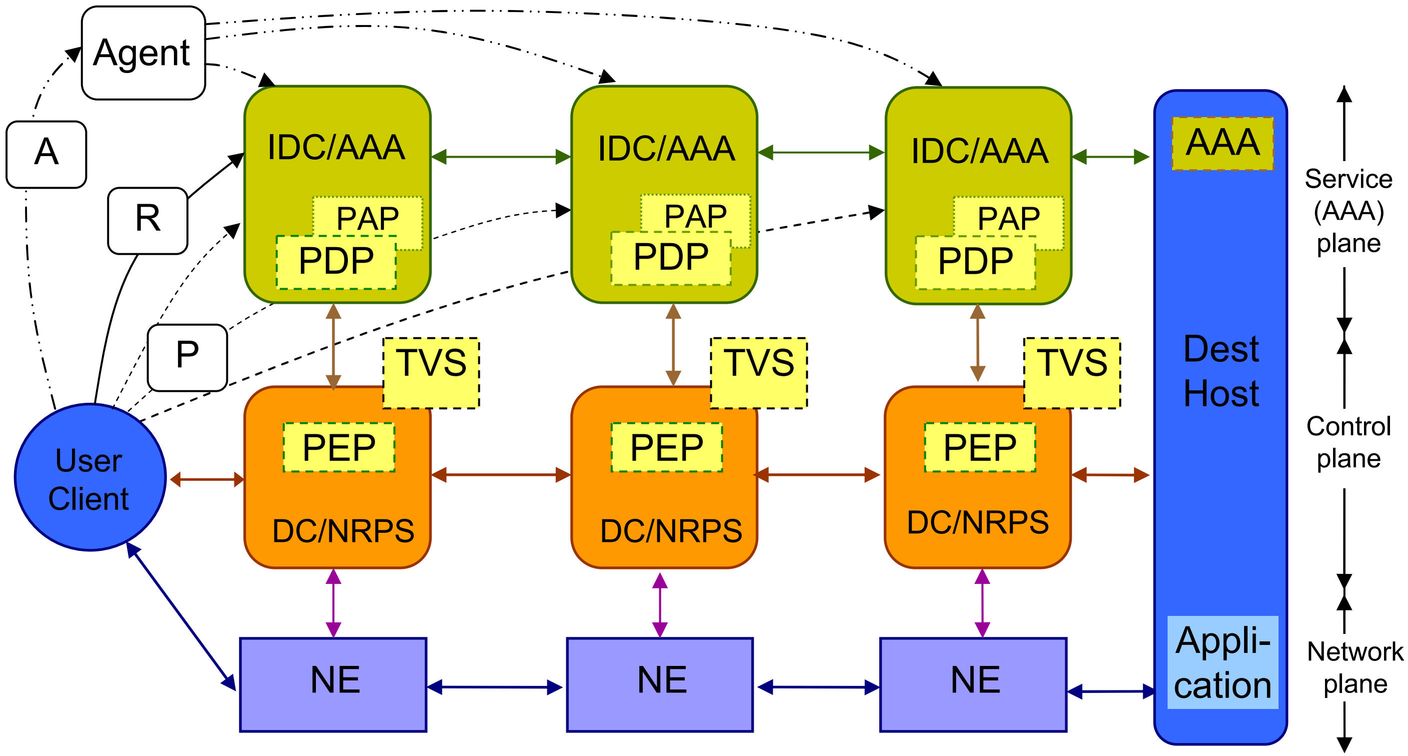

Introducing SCAS as external AuthZ service called from protected environment changes simple security model

- AuthN-AuthZ-glexec flow needs analysis
- Behind each (SCAS) policy should be clear operational model

SCAS is verified to be compatible with the XACML policy and PDP

- XACML uses pluggable security service model (i.e. called from major Service)
- glexec is a kind of gateway/border device

# Multidomain Network/Complex Resource Provisioning




Provisioning sequences

- Agent (A)
- Polling (P)
- Relay (R)

Token based policy enforcement

GRI – Global Reservation ID

AuthZ tickets for multidomain context mngnt

NRPS – Network Resource Provisioning System

DC – Domain Controller

IDC – Interdomain Controller

AAA – AuthN, AuthZ, Accounting Server

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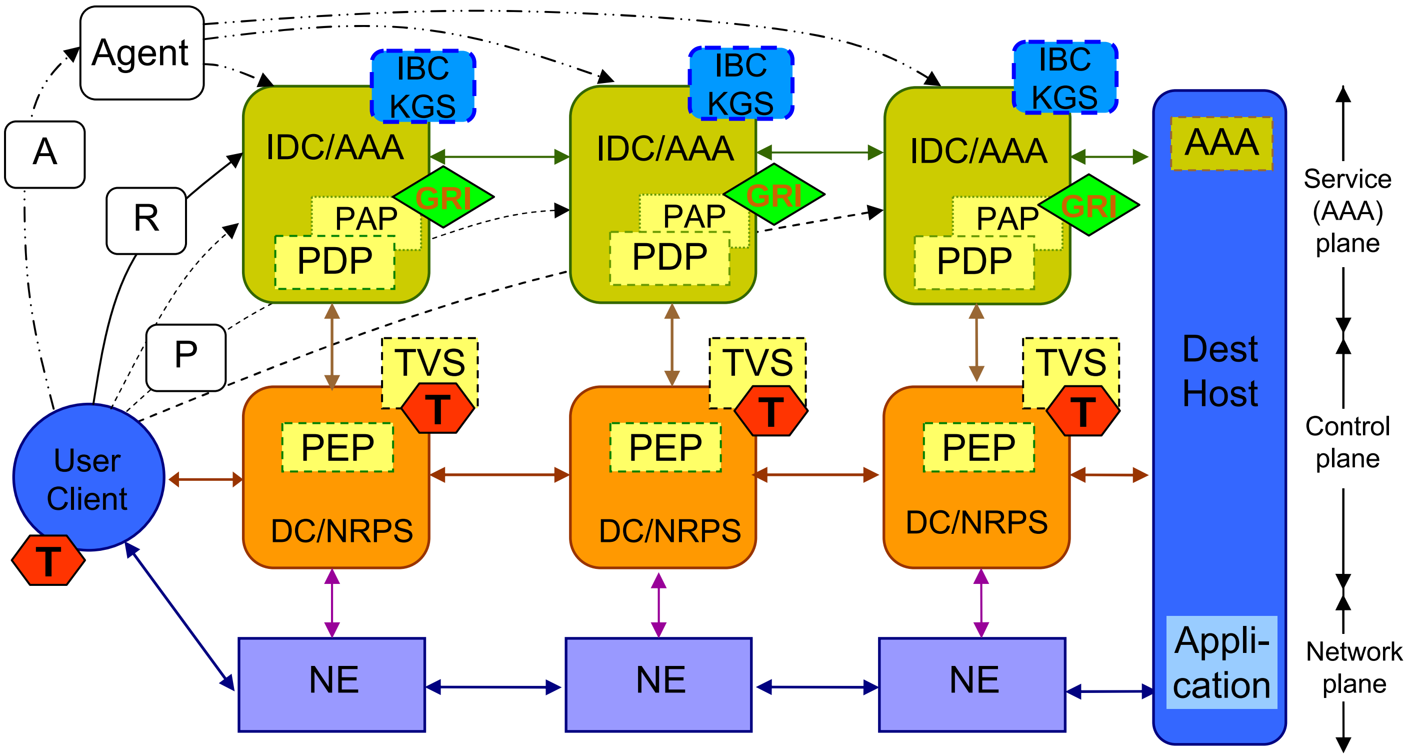
# Multidomain Network Resource Provisioning (NRP)

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# OSI/Internet Security vs TCB Security - Two basic security concepts

## Open Systems and Internet

**Open Systems Interconnection (OSI) Security Architecture**

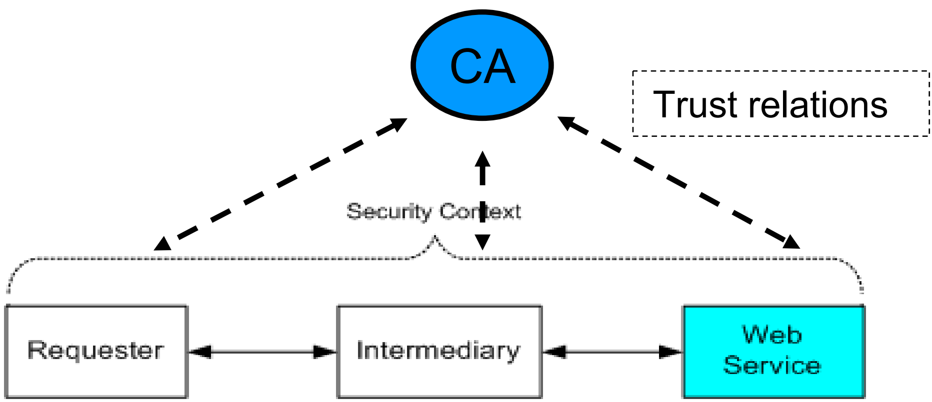
- ISO7498-2/X.800

**Independently managed interconnected system**

**Trust established mutually or via 3rd party**

**PKI and PKI based AuthN and key exchange**

**Concept of the Security Context**



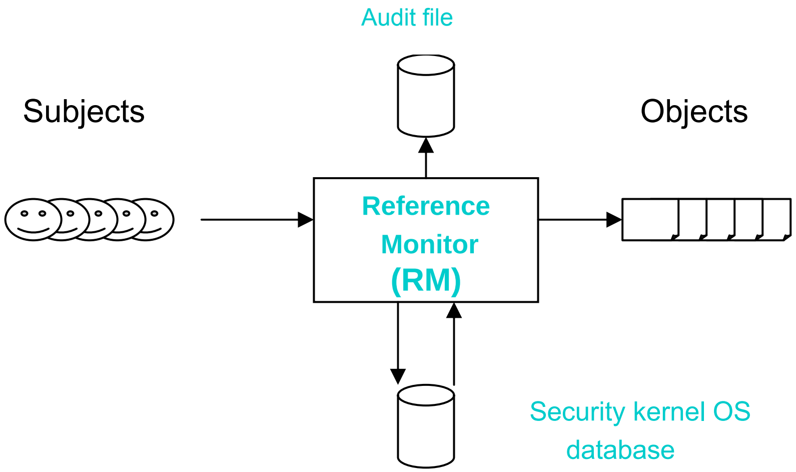

## Trusted Computing Base (TCB)

Reference Monitor (RM) by J.P.Anderson “Computer Security Planning Study” (1972)

Models Bell-LaPadula and Biba

Certification criteria TCSEC/Common Criteria (1984)

- A1, B1, B2, B3, C1, C2, D



# ISO7498-2/X.800 Security –
# Layers vs Services vs Mechanisms

| Service / Mechanism -> | Encipherment | Digital signature | Access control | Data integrity | Authentication exchange | Traffic padding | Routing control | Notarization |
|---|---|---|---|---|---|---|---|---|
| Authentication, Peer entity | Y | Y | | | Y | | | |
| Authentication, Data origin | Y | Y | | | | | | |
| Access control service | Y | | Y | | | | | |
| Connection confidentiality | Y | | | | | | Y | |
| Connectionless confidentiality | Y | | | | | | Y | |
| Selective field confidentiality | Y | | | | | | | |
| Traffic flow confidentiality | Y | | | | | Y | Y | |
| Connection Integrity with recovery | Y | | | Y | | | | |
| Connection integrity without recovery | Y | | | Y | | | | |
| Selective field connection integrity | Y | | | Y | | | | |
| Connectionless integrity | Y | Y | | Y | | | | |
| Selective field connectionless integrity | Y | Y | | Y | | | | |
| Non-repudiation. Origin | | Y | | Y | | | | Y |
| Non-repudiation. Delivery | | Y | | Y | | | | Y |

| Service | Layer | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7* |
| Peer entity authentication | | | Y | Y | | | Y |
| Data origin authentication | | | Y | Y | | | Y |
| Access control service | | | Y | Y | | | Y |
| Connection confidentiality | Y | Y | Y | Y | | Y | Y |
| Connectionless confidentiality | | Y | Y | Y | | Y | Y |
| Selective field confidentiality | | | | | | Y | Y |
| Traffic flow confidentiality | Y | | Y | | | | Y |
| Connection Integrity with recovery | | | | Y | | | Y |
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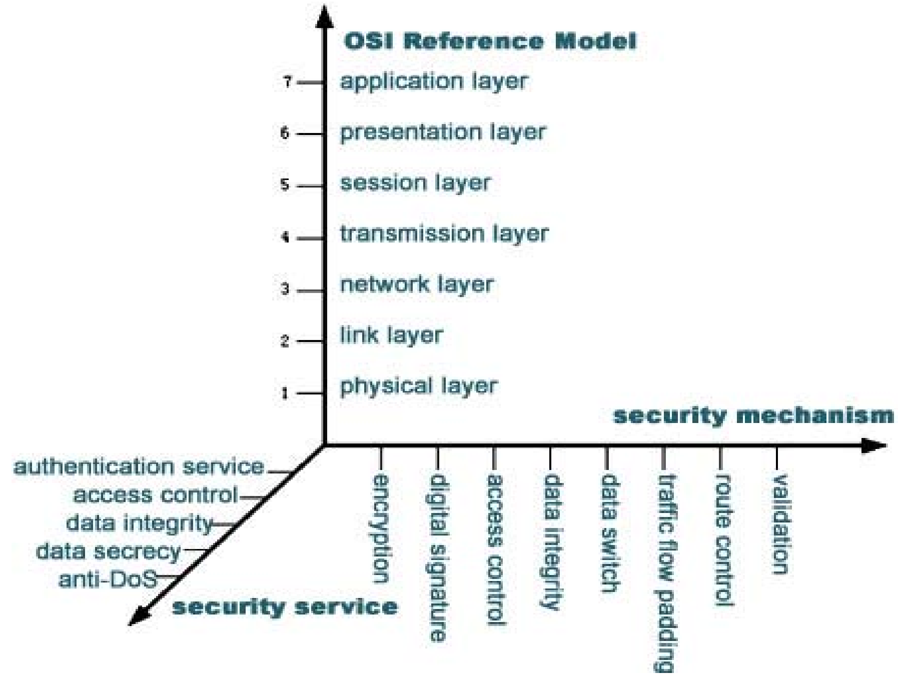
| Selective field connection integrity | | | | | | | Y |
| Connectionless integrity | | | Y | Y | | | Y |
| Selective field connectionless integrity | | | | | | | Y |
| Non-repudiation Origin | | | | | | | Y |
| Non-repudiation. Delivery | | | | | | | Y |




**Similar model should be proposed for WS SOAP based security services and mechanisms**

**Layers model for above Application layer are uncertain**

# From OSI/Internet to SOA/WSA Security Model

X.800 Security Architecture for Open Systems Interconnection for CCITT applications. ITU-T (CCITT) Recommendation, 1991

- ISO 7498-2:1989 Information processing systems -- Open Systems Interconnection -- Basic Reference Model -- Part 2: Security Architecture

Web Services Security Roadmap (2002)

- http://www.ibm.com/developerworks/library/specification/ws-secmap/

OGSA Security Model Components (2002-2006)

- GFD.80 - OGSA version 1.5, Section 3.7 Security Services
- Re-states Web Services Security roadmap

**WS-Security stds specify using SOAP header for security related issues**

- Considered as orthogonal to major service

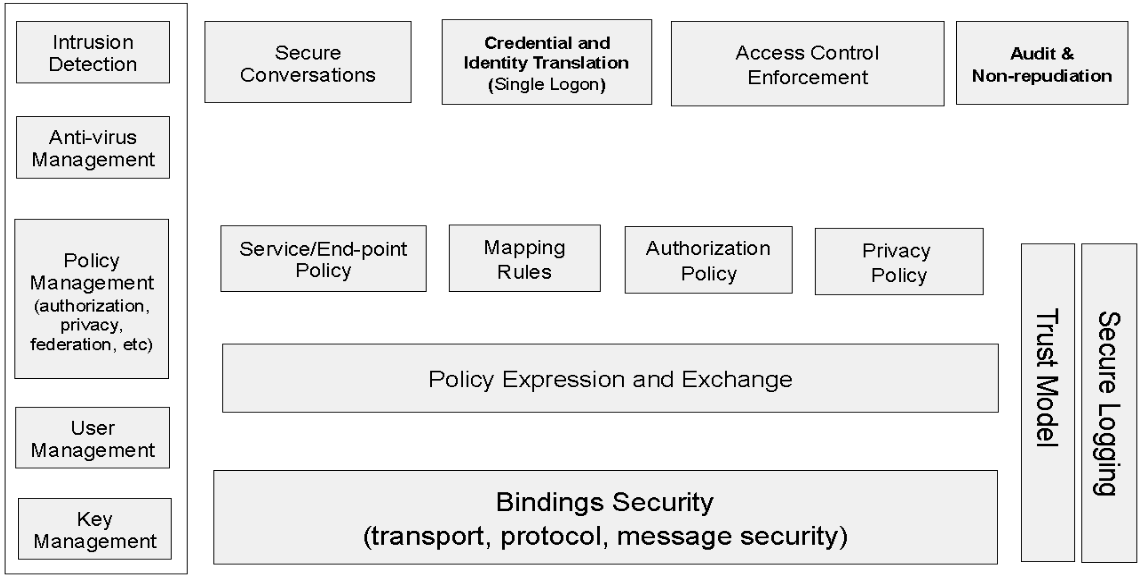
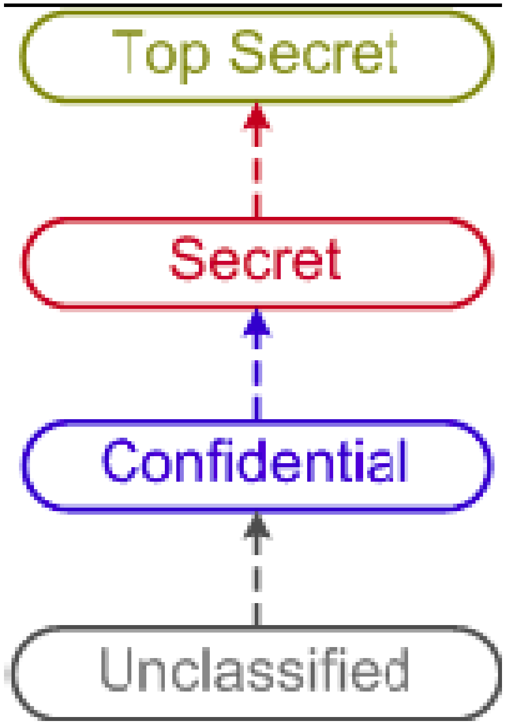


Figure 2: Components of Grid Security Model

# Multilevel Security (MLS)




Originated from Defense community, three classification levels are defined

*Clearance level*

- indicates the level of trust given to a person with a security clearance, or a computer that processes classified information, or an area that has been physically secured for storing classified information.
- Clearance level indicates the highest level of classified information to be stored or handled by the person, device, or location.

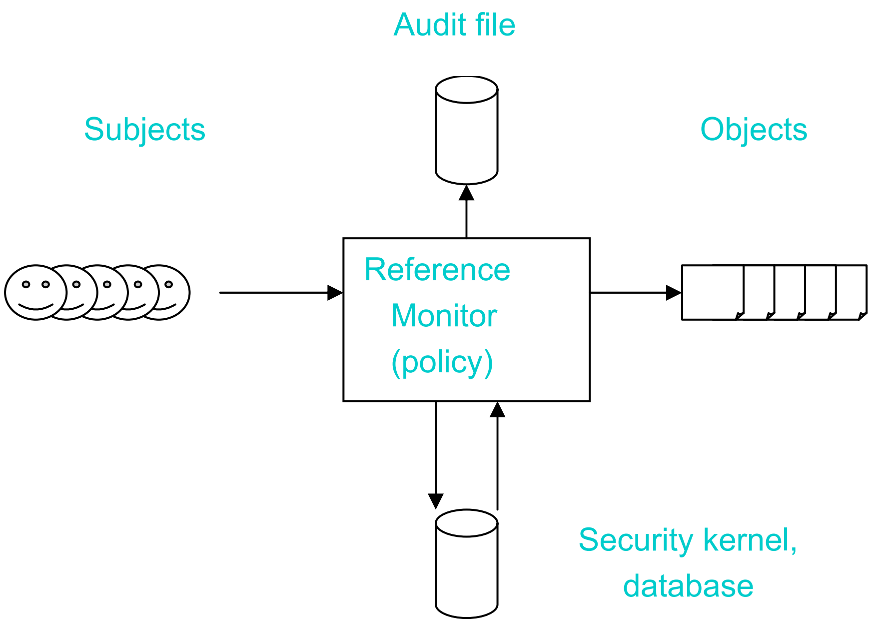
*Classification level*

- indicates the level of sensitivity associated with some information, like that in a document or a computer file. The level is supposed to indicate the degree of damage the country could suffer if the information is disclosed to an enemy.

*Security level*

- generic term for either a clearance level or a classification level.

# Reference Monitor (RM) Concept




**Proposed by J.P. Anderson in the report "Computer Security Planning Study" (1972)**

**RM property provides a basis for Multi-Level Security (MLS)**

- **Complete mediation:** The security rules are enforced on every access, not just, for example, when a file is opened.
- **Isolation:** The reference monitor and databases must be protected from unauthorized modification.
- **Verifiability:** The reference monitor's correctness must be provable. That is, it must be possible to *demonstrate mathematically* that the reference monitor enforces the security rules and provides complete mediation and isolation.

**RM concept is a basis for TCB certification**

# Multi-Level Security Models

Bell–LaPadula (BLP) model

- No write down
- No read up

Focus – Confidentiality

- Mandatory Access Control

Applicability – Data

*Known flaw – not protected against insider "worm" virus*

Biba model

- No write up
- No read down

Focus – Integrity

Applicability – (Open) Data and Control/Mngnt

TCSEC Common Criteria

- A1 – B3 + formally/mathematically verified design
- B1-B3 – Multilevel security, Formal security model, Mandatory AC
- C1-C2 – Discretionary access control model, auditable user activity
- D – minimal protection
- Currently replaced by ISO 15408 Evaluation Assurance Level (EAL)

# TCSEC/ISO Common Criteria

TCSEC Certification Criteria

- A1 – B3 + formally/mathematically verified design
- B3 – Clear security model and layered design, Security functions tamperproof, Auditing mandatory
- B2 – Least-privilege access control model, Certifiable security design implementation, *Covert channels analysis*
- B1 – Labelled security protection, MAC-BLP + DAC
- C2 – Discretionary access control model, auditable user activity
- D – minimal protection

Currently replaced by ISO 15408 Evaluation Assurance Level (EAL)

- EAL1: Functionally Tested
- EAL2: Structurally Tested
- EAL3: Methodically Tested and Checked
- EAL4: Methodically Designed, Tested and Reviewed
- EAL5: Semiformally Designed and Tested
- EAL6: Semiformally Verified Design and Tested
- EAL7: Formally Verified Design and Tested

EAL1-4 – commercial systems, EAL5-7 - special systems (EAL4 circa C2)

- Windows NT (EAL4+) and many routing and Unix systems certified for EAL4

# Clark – Wilson Integrity Policy

Criteria for achieving data integrity (primary target for reliable business operation)

- Authentication of all user accessing system
- Audit – all modifications should be logged
- Well-formed transactions
- Separation of duties

**Enforcement Rules**

E1 (Enforcement of Validity) - Only certified TPs can operate on CDIs

***E2 (Enforcement of Separation of Duty) - Users must only access CDIs through TPs for which they are authorized*.**

E3 (User Identity) - The system must authenticate the identity of each user attempting to execute a TP

E4 (Initiation) - Only administrator can specify TP authorizations

**Certification Rules**

C1 (IVP Certification) - The system will have an IVP for validating the integrity of any CDI.

C2 (Validity) - The application of a TP to any CDI must maintain the integrity of that CDI. CDIs must be certified to ensure that they result in a valid CDI

C3 - A CDI can only be changed by a TP. TPs must be certified to ensure they implement the principles of separation of duties & least privilege

C4 (Journal Certification) - TPs must be certified to ensure that their actions are logged

C5 - TPs which act on UDIs must be certified to ensure that they result in a valid CDI

TP – transformational procedure; IVP – integrity verification procedure; CDI – constrained data Item; UDI - unconstrained data Item

# Security technologies for building integrated security

- Combining TCB and OSI security models for managed objects/processes
  - Security context management with AuthZ tickets/assertions
  - Adding security context/attributes to managed objects
    - Revisiting COPS (Common Open Policy Service) protocol
- Trusted Computing Platform Architecture (TCPA)
- Identity Based Cryptography (IBC)

# TCG Trusted Computing Platform

Promoted by the Trusted Computing Group (TCG)

- Basis for building and managing controlled secure environment for running applications and processing (protected) content
  - https://www.trustedcomputinggroup.org/home
- Standards for trusted network, client, server and mobile agent
- TMP software stack (TSS) defines API's for remote access, Identity Mngnt, PKI, Secure e-mail, file/folder encryption, etc.

TCG components

- **Trusted Platform Module (TPM)**
- "Curtained memory" in the CPU
- Security kernel in the OS and security kernel in each application
- Back-end infrastructure of online security servers maintained by hardware and software vendors

Trusted Network Connect (TNC) – to enforce security policies before and after endpoints or clients connect to multi-vendor environment

# Trusted Platform Module (TPM)

Chip built-in into the computer system or a smartcard chip

- Can be considered as a platform tied "root-of-trust" and used for trusted platform registration and integrity assurance

Provides a number of hardware-based cryptographic functions

- **Asymmetric key functions** for on-chip key pair generation using hardware random key generation; private key signatures; public key encryption and private key decryption
- An **Endorsement key** that can be used by a platform owner to establish that identity keys were generated in a TPM, without disclosing its identity
- **Direct Anonymous Attestation (DAA)** that securely communicates information about the static or dynamic platform configuration, which is internally stored in TPM in the form of hashed values (based on Zero-knowledge cryptography)
- Monotonic counter and the tick counter to enable **transaction timing and sequencing**
- Protection of communication between two TPM's
- Secure key/data backup to another TPM

# PKI vs Identity Based Cryptography (IBC)

Uses publicly known remote entity's identity as a public key to send encrypted message or initiate security session

- Initially proposed by Shamir in 1984 as an alternative to PKI
  - Shamir is one of the RSA inventors in 1977 (Rivest, Shamir, Adleman)
- Identity can be email, domain name, IP address
- Allows conditional private key generation

Requires infrastructure different from PKI but domain based (doesn't require trusted 3rd party outside of domain)

- Private key generation service (KGS)
  - Generates private key to registered/authenticated users/entities
- Exchange inter-domain trust management problem to intra-domain trust

# Identity Based Cryptography (IBC)

## Available implementations

Voltage Identity-Based Encryption (C based)

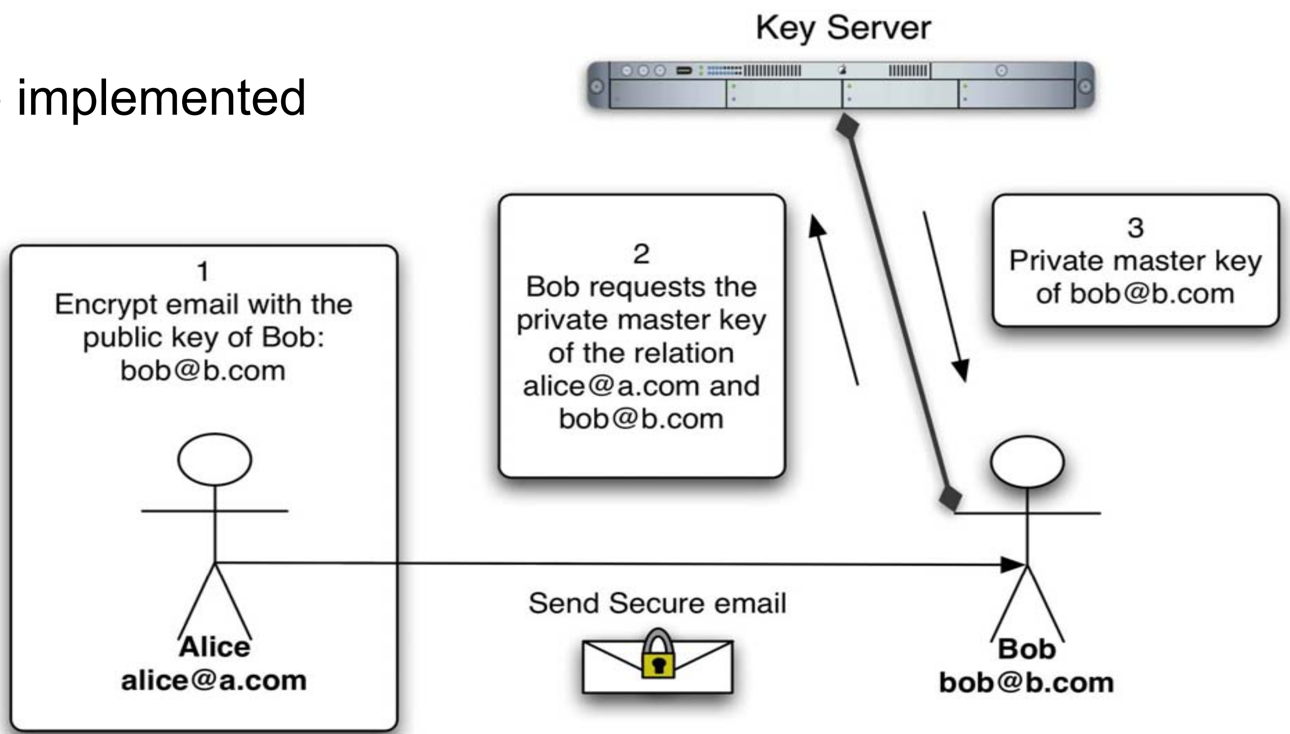
- Used in Microsoft Exchange Server

Eyebee by Univ Ireland (Java)

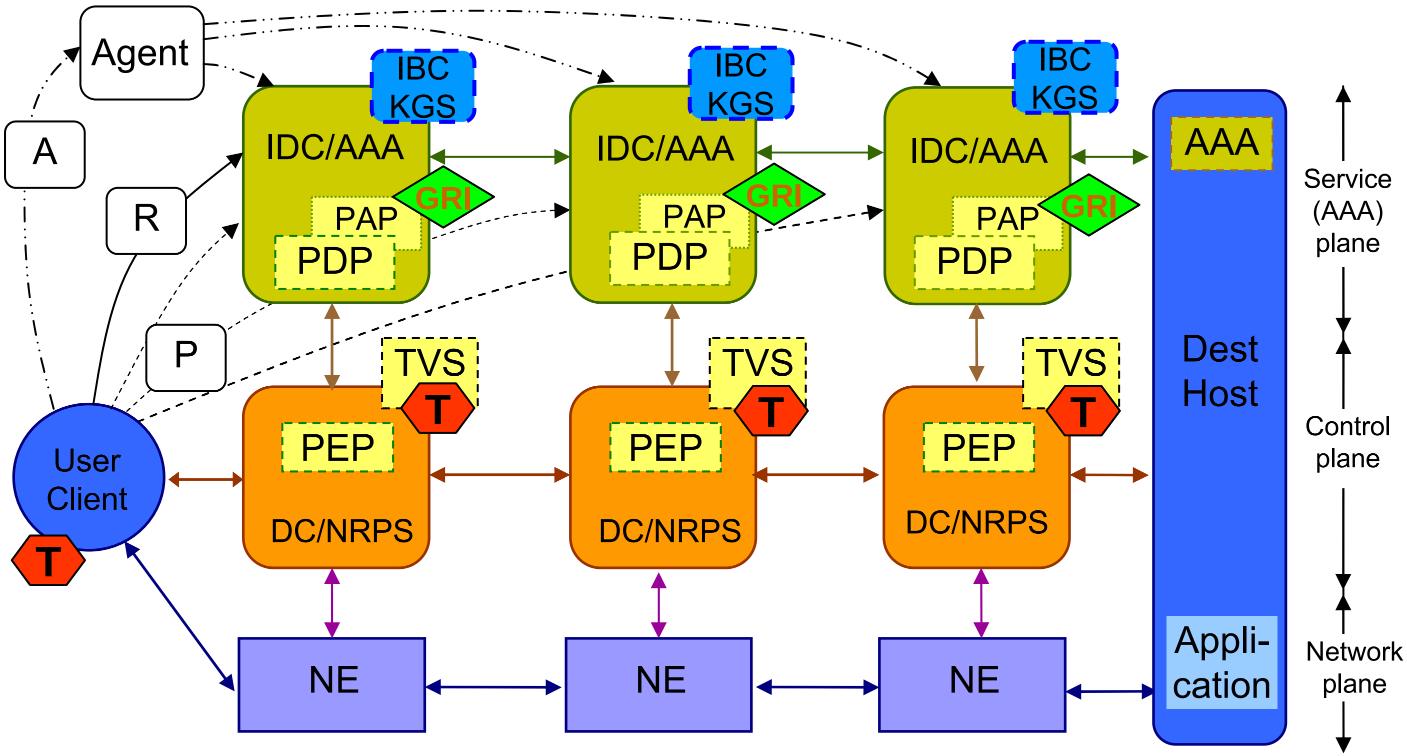
- Tested by us and will be implemented in IDC

Strong motivation for privacy concerned applications

- E.g. patient-doctor communication



# Multidomain Network Resource Provisioning (NRP)

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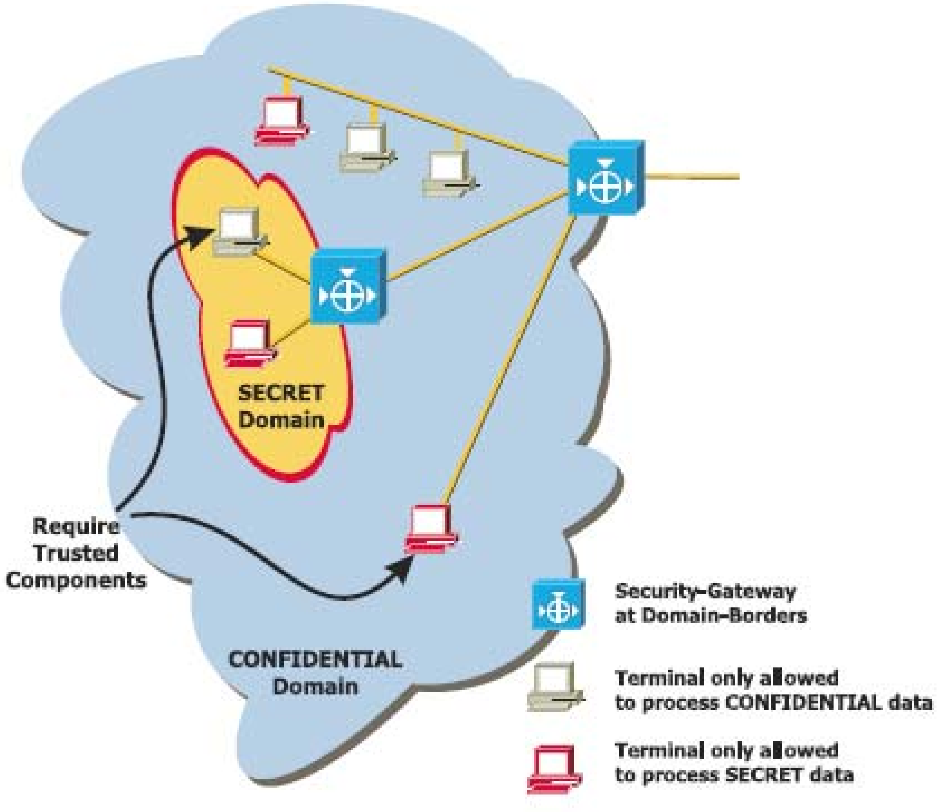
# Integrated Networks and MLS




The paper provides a use case for TBN to support Multi-Level Security (MLS) as a concept associated with MAC (Mandatory Access Control: user clearance must match document classification)

- MLS network must ensure dataflow (between applications) binding to the security levels
- Suggests implementation using TCPA, FPGA

Paper (from military domain) by A. Alkassar, C. Stueble

“Security Framework for Integrated Networks”

http://krypt.cs.uni-sb.de/download/papers/AlSt_03.pdf

# Questions and Discussion

# Additional materials

# XACML Policy format

- Policy target is defined for the triad Subject-Resource-Action and may include Environment
- Policy may contain Obligation element that defines actions to be taken by PEP on Policy decision by PDP