INFS 767
Secure Electronic Commerce
Fall 2000

Lecture 4
Secure Attribute Services

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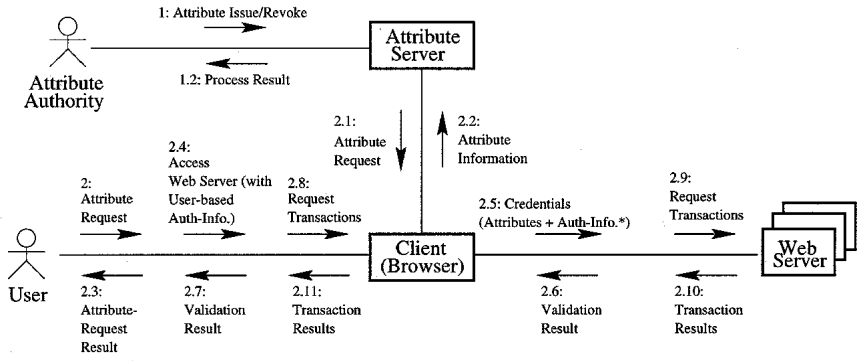
Secure Attribute Services on the Web

- **WWW (World Wide Web)**
  - **widely used for electronic commerce and business**
  - **supports synthesis of technologies**
  - **mostly, Web servers use identity-based access control**
    - **scalability problem**

Background

- **An attribute**
  - **a particular property of an entity**
    - **e.g., role, identity, SSN, clearance, etc.**
- **If attributes are provided securely,**
  - **Web servers can use those attributes**
    - **e.g., authentication, authorization, access control, electronic commerce, etc.**
- **A successful marriage of the Web and secure attribute services is required**

User-Pull Architecture

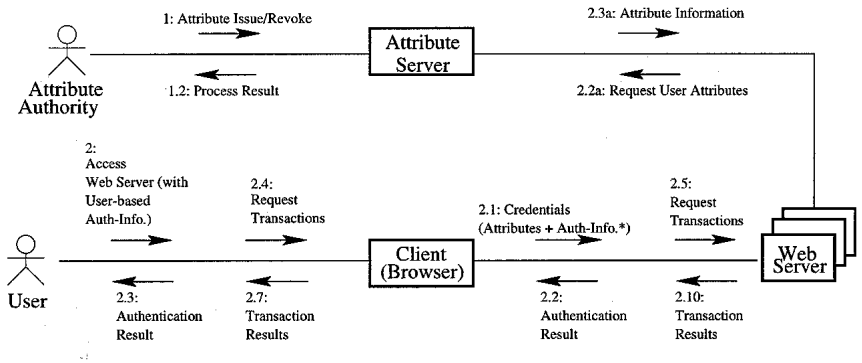


*Authentication Information can be either user-based or host-based.

User-Pull Architecture

- **Each user**
  - **pulls appropriate attributes from the Attribute Server**
  - **presents attributes and authentication information to Web servers**
- **Each Web server**
  - **requires both identification and attributes from users**
- **High performance**
  - **No new connections for attributes**

Server-Pull Architecture



*Authentication Information can be either user-based or host-based.

Related Technologies

- **Cookies**
  - **in widespread current use for maintaining state of HTTP**
  - **becoming standard**
  - **not secure**
- **Public-Key Certificates (X.509)**
  - **support security on the Web based on PKI**
  - **standard**
  - **simply, bind users to keys**
  - **have the ability to be extended**

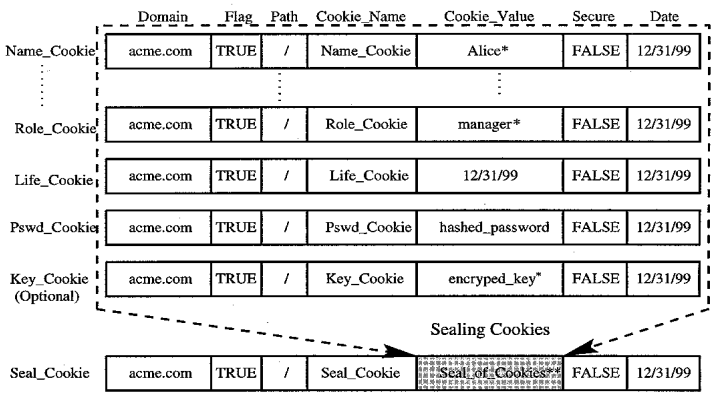
Cookies

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
Cookie 1	acme.com	TRUE	/	Name	Alice	FALSE	12/31/99
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Cookie n	acme.com	TRUE	/	Role	manager	FALSE	12/31/99

Security Threats to Cookies

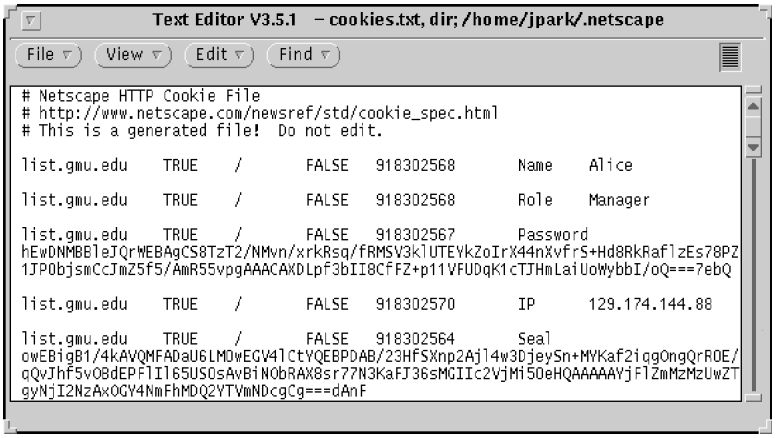
- **Cookies are not secure**
  - **No authentication**
  - **No integrity**
  - **No confidentiality**
- **can be easily attacked by**
  - **Network Security Threats**
  - **End-System Threats**
  - **Cookie Harvesting Threats**

Secure Cookies on the Web

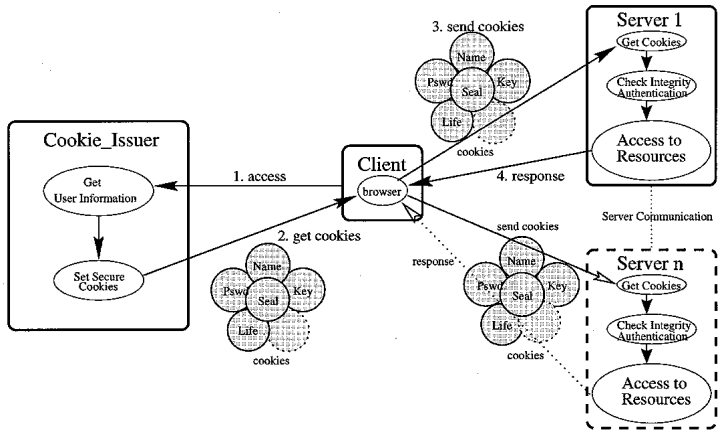


* Sensitive fields can be encrypted in the cookies.
** Seal of Cookies can be either MAC or signed message digest of cookies.
Note: Pswd_Cookie can be replaced with one of the other authentication cookies in Figure 4.1

A Set of Secure Cookies



How to Use Secure Cookies



Pswd_Cookie can be replaced with one of the other authentication cookies in Figure 4.1

Applications of Secure Cookies

- **User Authentication**
- **Electronic Transaction**
- **Eliminating Single-Point Failure**
- **Pay-per-Access**
- **Attribute-based Access Control**

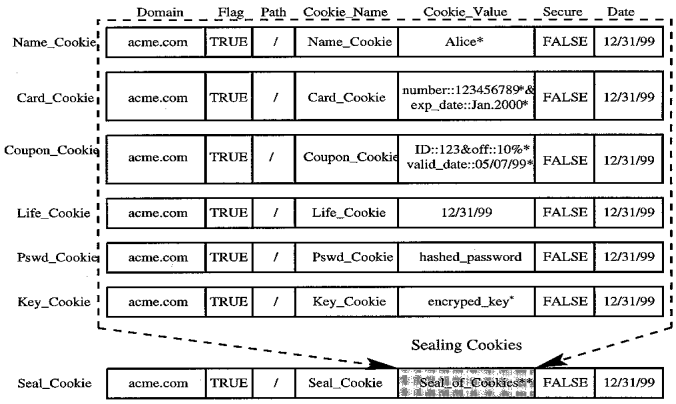
Authentication Cookies

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
IP_Cookie	acme.com	TRUE	/	IP_Cookie	129.174.100.88	FALSE	12/31/99
Pswd_Cookie	acme.com	TRUE	/	Pswd_Cookie	hashed_password	FALSE	12/31/99
KT_Cookie	acme.com	TRUE	/	Kerberos_Ticket	{Alice, K c,s}Ks	FALSE	12/31/99
Sign_Cookie	acme.com	TRUE	/	Sign_Cookie	Signature_of_Alice	FALSE	12/31/99

Server-Pull Architecture

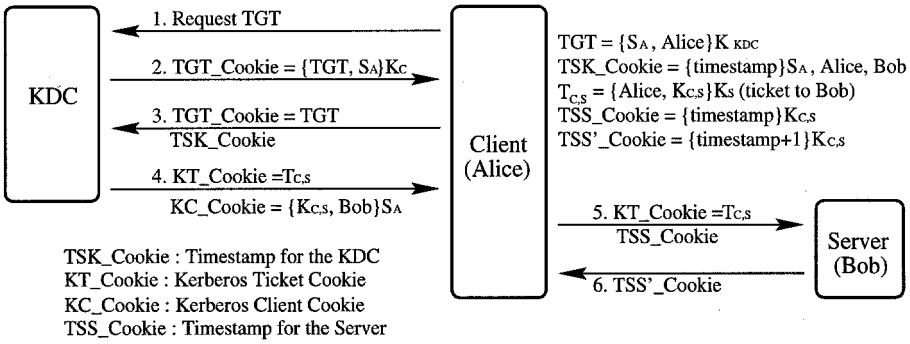
- **Each user**
  - **presents only authentication information to Web servers**
- **Each Web server**
  - **pulls users' attributes from the Attribute Server**
- **Authentication information and attribute do not go together**
- **More convenient for users**
- **Less convenient for Web servers**

Secure Cookies for Electronic Transactions



* Sensitive fields can be encrypted in the cookies.
** Seal of Cookies can be either MAC or signed message digest of cookies.
Note: Pswd_Cookie can be replaced with one of the other authentication cookies in Figure 4.1

Kerberos-Based Authentication by Secure Cookies

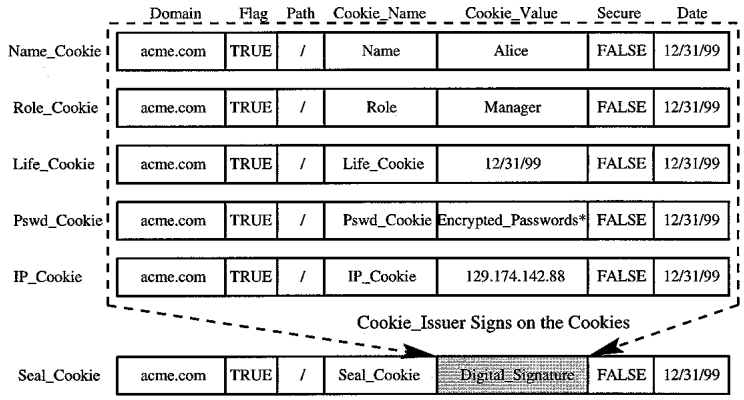


Secure Cookies for Pay-Per-Access

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
Name_Cookie	acme.com	TRUE	/	Name_Cookie	Alice*	FALSE	12/31/99
Ticket_Cookie	acme.com	TRUE	/	Ticket_Cookie	ID::456&Hours::10* valid_date::05/07/99	FALSE	12/31/99
Life_Cookie	acme.com	TRUE	/	Life_Cookie	12/31/99	FALSE	12/31/99
Pswd_Cookie	acme.com	TRUE	/	Pswd_Cookie	hashed_password	FALSE	12/31/99
Key_Cookie	acme.com	TRUE	/	Key_Cookie	encryped_key*	FALSE	12/31/99
				Sealing Cookies			
Seal_Cookie	acme.com	TRUE	/	Seal_Cookie	Seal_of_Cookies**	FALSE	12/31/99

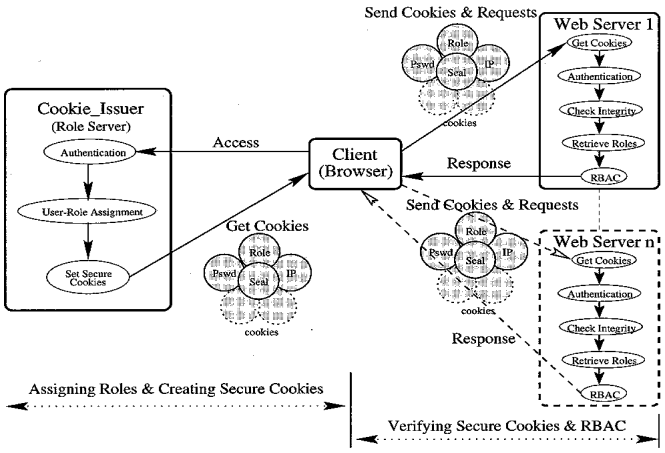
* Sensitive fields can be encrypted in the cookies.
** Seal of Cookies can be either MAC or signed message digest of cookies.
Note: Pswd_Cookie can be replaced with one of the other authentication cookies in Figure 4.1

Secure Cookies for RBAC



* Hash of the passwords is an alternative as the content of the Pswd_Cookie.

RBAC on the Web by Secure Cookies



X.509 Certificate

- **Digitally signed by a certificate authority**
  - **to confirm the information in the certificate belongs to the holder of the corresponding private key**
- **Contents**
  - **version, serial number, subject, validity period, issuer, optional fields (v2)**
  - **subject's public key and algorithm info.**
  - **extension fields (v3)**
  - **digital signature of CA**
- **Binding users to keys**
- **Certificate Revocation List (CRL)**

X.509 Certificate

Certificate Content:

```
Certificate:
    Data:
        Version: v3 (0x2)
        Serial Number: 5 (0x5)
        Signature Algorithm: PKCS #1 MD5 With RSA Encryption
        Issuer: CN=data.list.gmu.edu, OU=LIST, O=GMU, C=US
        Validity:
            Not Before: Tue Feb 09 03:10:38 1999
            Not  After: Wed Feb 09 03:10:38 2000
        Subject: CN=admin.list.gmu.edu, OU=LIST, O=GMU, C=US
        Subject Public Key Info:
            Algorithm: PKCS #1 RSA Encryption
            Public Key:
                Modulus:
                    00:bc:d7:fc:4f:29:a4:29:a5:21:be:69:47:4d:55:db:37:50:
                    18:2b:6e:3e:b0:85:3e:0f:86:0f:be:58:2b:c9:d3:dc:bc:03:
                    bc:86:44:c4:f4:18:94:51:96:c6:f9:c5:db:b0:9d:88:5b:53:
                    b7:08:2f:86:64:cb:c2:7b:60:36:87
                Public Exponent: 65537 (0x10001)
        Extensions:
            Identifier: Certificate Type
                Critical: no
                Certified Usage:
                    SSL Client
            Identifier: Authority Key Identifier
                Critical: no
                Key Identifier:
                    a5:d7:08:bc:ff:07:bd:5a:d4:8d:d4:68:53:07:4b:af:81:90:
                    f0:4d
    Signature:
        Algorithm: PKCS #1 MD5 With RSA Encryption
        Signature:
            11:ca:b1:94:14:fb:67:a2:ad:90:f1:ee:88:24:a8:d3:fd:5c:75:34:fc:
            c1:68:23:e6:12:19:3a:5c:45:62:af:51:a0:2f:44:96:f8:2e:1f:75:9a:
            4b:9c:ed:2a:45:2e:db:c8:9c:56:1a:e1:75:0a:8e:bf:f8:44:b8:84:31:
            d8
```

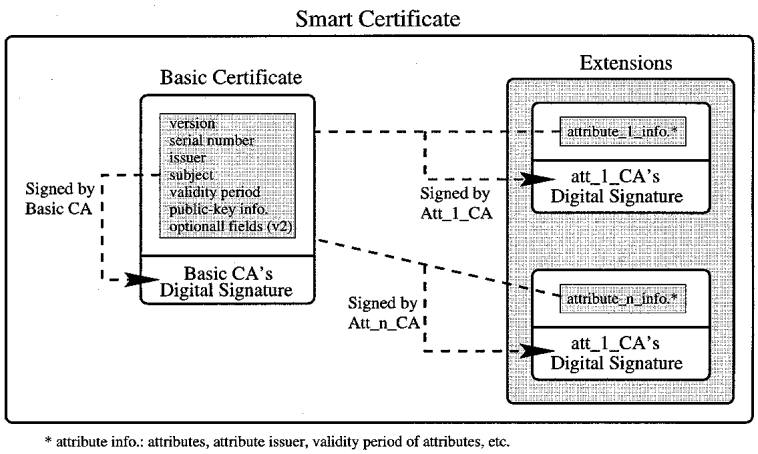
Smart Certificates

- **Short-Lived Lifetime**
  - **More secure**
    - **typical validity period for X.509 is months (years)**
    - **users may leave copies of the corresponding keys behind**
    - **the longer-lived certificates have a higher probability of being attacked**
  - **No Certificate Revocation List (CRL)**
    - **simple and less expensive PKI**

Smart Certificates

- **Containing Attributes Securely**
  - **Web servers can use secure attributes for their purposes**
  - **Each authority has independent control on the corresponding information**
    - **basic certificate (containing identity information)**
    - **each attribute can be added, changed, revoked, or re-issued by the appropriate authority**
      - e.g., role, credit card number, clearance, etc.
  - **Short-lived certificate can remove CRLs**

Separate CAs in a Certificate



Smart Certificates

- **Postdated Certificates**
  - **The certificate becomes valid at some time in the future**
  - **possible to make a smart certificate valid for a set of duration**
  - **supports convenience**
- **Confidentiality**
  - **Sensitive information can be**
    - **encrypted in smart certificates**
      - e.g. passwords, credit card numbers, etc.

A Smart Certificate

Certificate Content:

```
Certificate:
    Data:
        Version: v3 (0x2)
        Serial Number: 26 (0x1a)
        Signature Algorithm: PKCS #1 MD5 With RSA Encryption
        Issuer: CN=data.list.gmu.edu, OU=LIST, O=GMU, C=US
        Validity:
            Not Before: Sun May 02 17:25:31 1999
            Not After: Mon May 03 01:25:31 1999
        Subject: CN=Alice List, UID=alice, OU=LIST, O=GMU, C=US
        Subject Public Key Info:
            Algorithm: PKCS #1 RSA Encryption
            Public Key:
                Modulus:
                    00:9d:31:41:cf:45:d3:25:10:41:b3:ca:23:f6:09:91:ad:3d:
                    2d:c0:62:e1:ff:24:43:fe:39:90:c0:13:03:11:b5:77:ec:79:
                    17:b8:63:be:aa:36:4e:29:08:9b:76:64:b7:97:94:19:06:a7:
                    7a:b2:8b:31:f3:b5:72:3f:04:8f:17
                Public Exponent: 65537 (0x10001)
        Extensions:
            Identifier: Certificate Type
                Critical: no
                Certified Usage:
                    SSL Client
                    Secure E-mail
            Identifier: role
                Critical: no
                Value: hEwDNMBB1eJQrWEBAgCS8TsT2/NMvn/zrkRsq/fRMSV3klUTEYkZoI
            Identifier: Authority Key Identifier
                Critical: no
                Key Identifier:
                    a5:d7:08:bc:ff:07:bd:5a:d4:8d:d4:60:53:07:4b:af:81:90:
                    f0:4d
    Signature:
        Algorithm: PKCS #1 MD5 With RSA Encryption
        Signature:
            c7:39:f7:b8:59:19:52:1c:fc:08:7c:11:f6:6e:5a:07:5b:55:80:a5:d8:
            65:a4:40:dc:06:5e:e4:ff:96:ad:71:9b:21:7a:4b:be:50:48:c2:f1:a6:
            7c:16:12:61:c7:bf:57:07:6d:c5:f4:f0:c2:e1:62:27:f6:d6:ae:09:77:
            46
```


Applications of Smart Certificates

- **On-Duty Control**
- **Compatible with X.509**
- **User Authentication**
- **Electronic Transaction**
- **Eliminating Single-Point Failure**
- **Pay-per-Access**
- **Attribute-based Access Control**

Injecting RBAC to Secure a Web-based Workflow System

Gail-Joon Ahn and Ravi Sandhu
George Mason University

Myong Kang and Joon Park
Naval Research Laboratory

WORKFLOW MANAGEMENT SYSTEMS

- **Control and coordinate processes that may be processed by different processing entities**
- **Received much attention**
- **Marriage with Web technology**
- **Minimal security services**

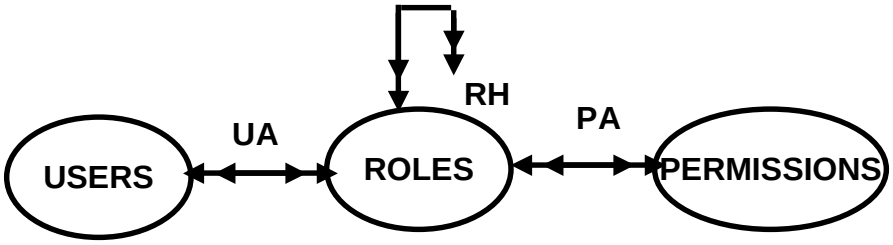
OBJECTIVE

- **Inject role-based access control (RBAC) into an existing web-based workflow system**

WHY RBAC?

- **A mechanism which allows and promotes an organization-specific access control policy based on roles**
- **Has become widely accepted as the proven technology**

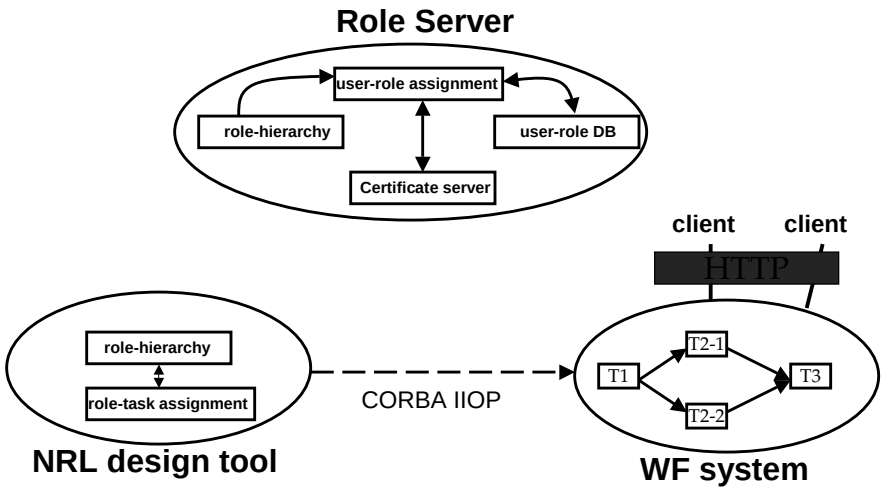
SIMPLIFIED RBAC MODEL



ROLE-BASED SECURE WORKFLOW SYSTEM

- **Workflow Design Tool**
- **Workflow (WF) System**
- **Role Server**

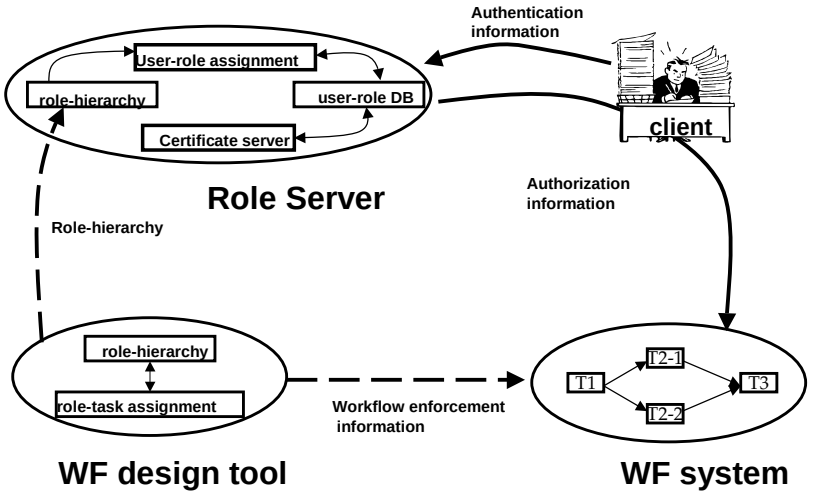
BASIC COMPONENTS



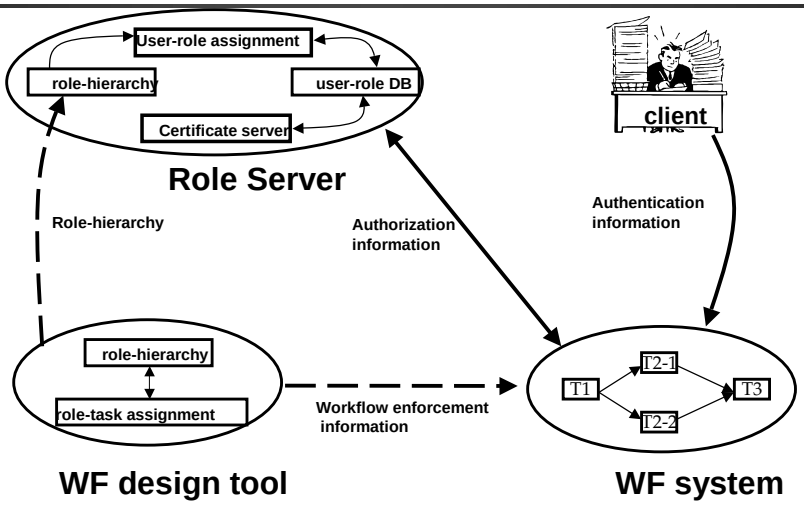
ARCHITECTURES

- **USER-PULL STYLE**
- **SERVER-PULL STYLE**

USER-PULL STYLE



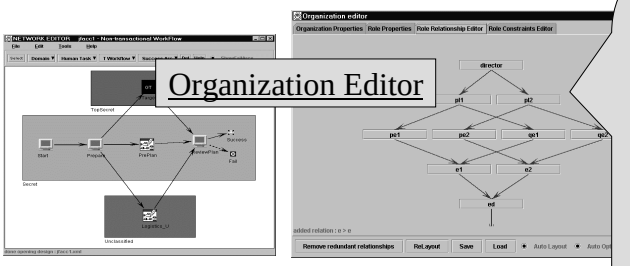
SERVER-PULL STYLE



NRL (Naval Research Lab.) DESIGN TOOL

- **design workflow model**
- **create role and role hierarchies**
- **assign role to task**
- **exporting role hierarchies to role server**

NRL DESIGN TOOL (Cont'd)



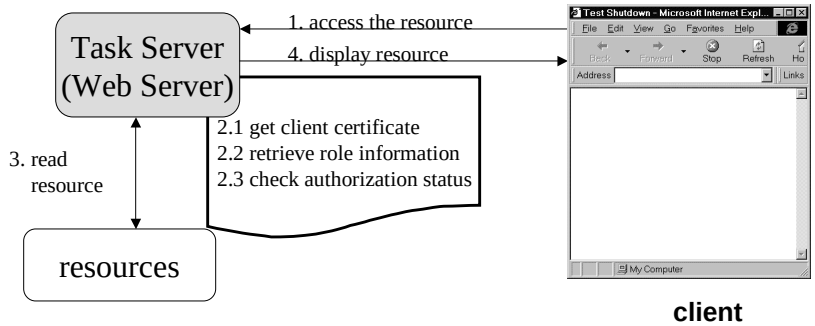
Platform: Windows NT, JDK1.2

```
<?xml version="1.0"?>
<!--URA     Revision: 1
   Mon Dec 07 15:59:28 EDT 1999-->
<!DOCTYPE Organization SYSTEM
  "../dtd/Organization.dtd">
<Organization id="Organization_URA">
<Name>URA</Name>
<Description></Description>
<Role id="director">
<Name>director</Name>
<Description></Description>
<Privileges></Privileges>
<LowRoleList>
 <RoleReference>
                <Link idref = "pl1"/>
 </RoleReference>
 <RoleReference>
                <Link idref = "pl2"/>
 </RoleReference>
</LowRoleList>
<HighRoleList>
</HighRoleList>
</Role>
<RoleReference>
```

WORKFLOW SYSTEM

- **each task server is web server**
- **user should present client authentication certificate**
- **user's privilege is authorized by content of certificate (specially client's role information)**

ROLE AUTHORIZATION ON WORKFLOW SYSTEM



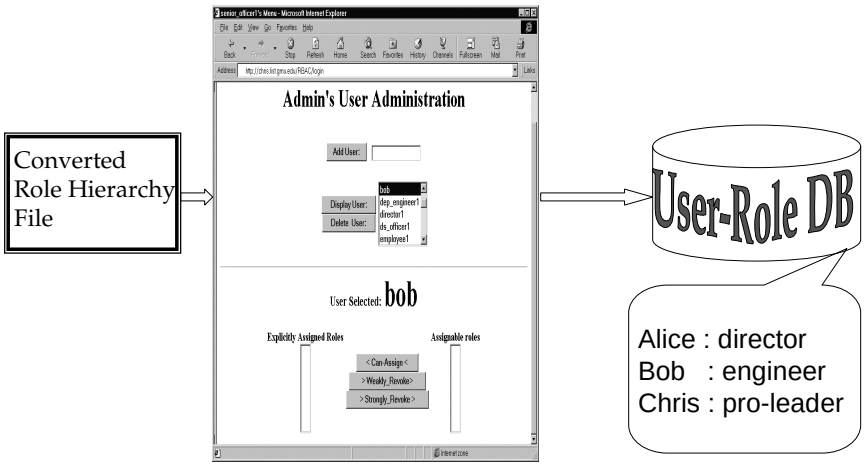
ROLE SERVER

- **User Role Assignment**
- **Certificate Server**

USER ROLE ASSIGNMENT

- **maintain role hierarchies and user database**
- **assign users to roles**
- **generate user-role database**

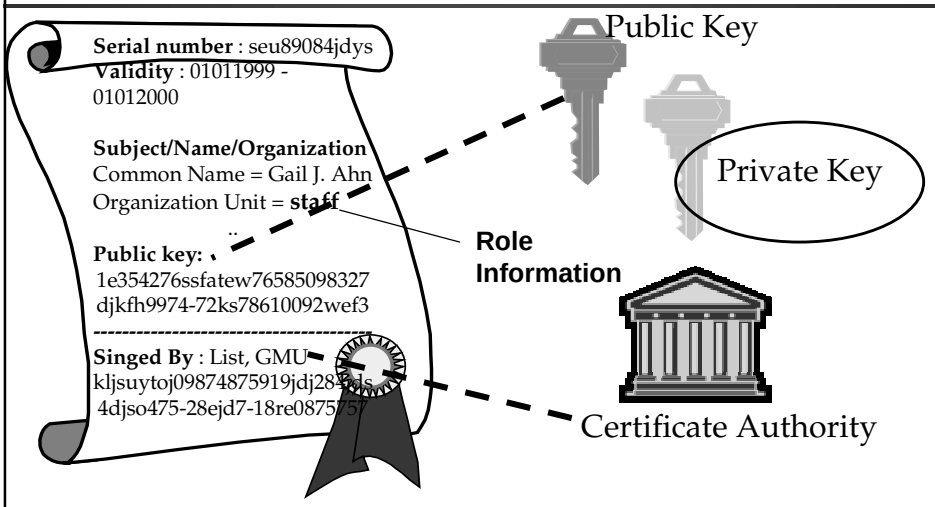
USER ROLE ASSIGNMENT (Cont'd)



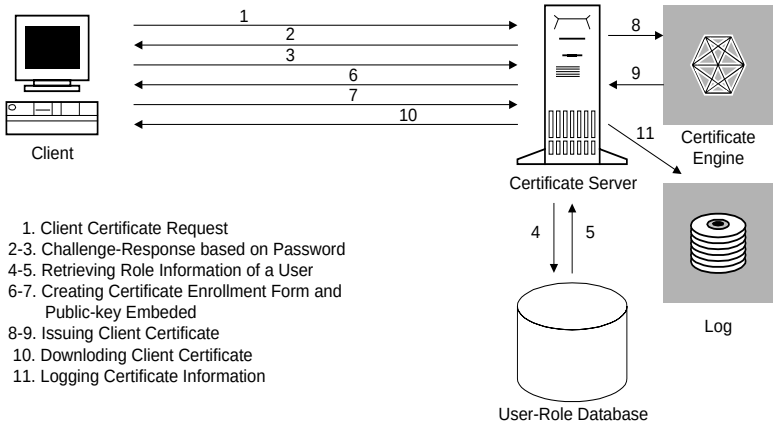
CERTIFICATE SERVER

- **authenticate client**
- **retrieve client's role information from user-role database**
- **issue certificate with client's role information**

X.509 CERTIFICATE

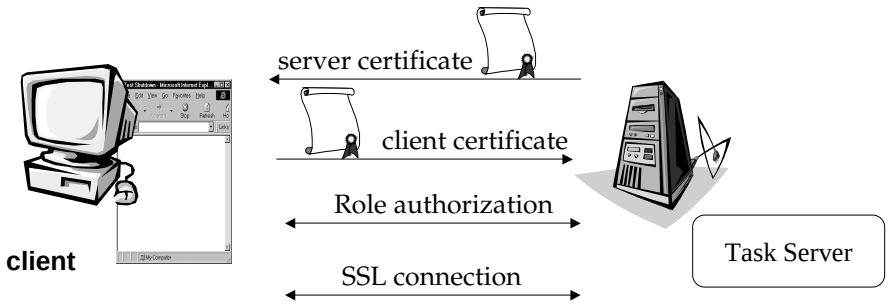


CERTIFICATE ISSUE

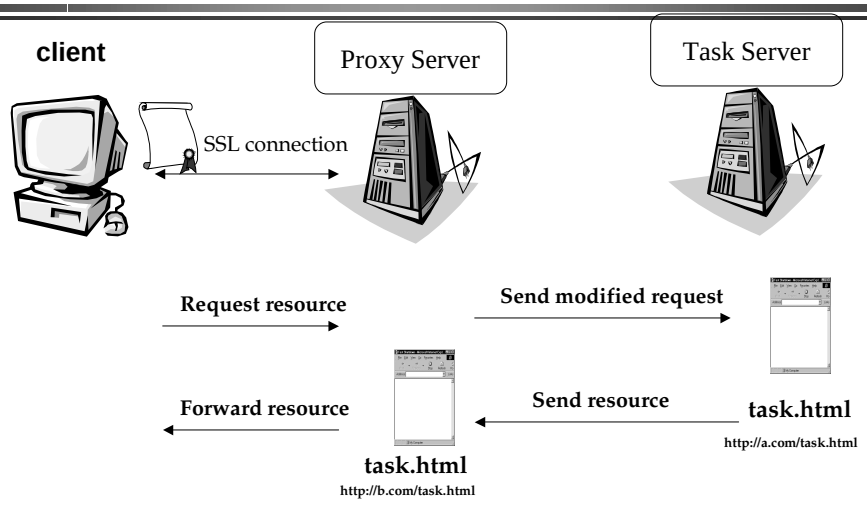


1. Client Certificate Request
2-3. Challenge-Response based on Password
4-5. Retrieving Role Information of a User
6-7. Creating Certificate Enrollment Form and Public-key Embeded
8-9. Issuing Client Certificate
10. Downloding Client Certificate
11. Logging Certificate Information

CERTIFICATE AUTHORIZATION OVER SSL



REVERSE PROXYING
(MINIMAL CHANGES IN SERVER SIDE)



FINAL SCENARIO