INFS 767
Secure Electronic Commerce
Fall 1999

Lecture 7
Secure Attribute Services

Prof. Ravi Sandhu

AUTHORIZATION, TRUST AND RISK

- **Information security is fundamentally about engineering**
  - **authorization and**
  - **trust**

  so as to
  - **manage risk**

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ENGINEERING AUTHORITY & TRUST 4 LAYERS

What?

Policy
Model
Architecture
Mechanism

How?

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ENGINEERING AUTHORITY & TRUST 4 LAYERS

What? Multilevel Security

No information leakage
Lattices (Bell-LaPadula)
Security kernel
Security labels

How?

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ENGINEERING AUTHORITY & TRUST 4 LAYERS

What? **Role-Based Access Control (RBAC)**

Policy neutral
RBAC96 model
user-pull, server-pull, etc.
certificates, tickets, PACs, etc.

How?

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RBAC

- **Policy neutral yet Policy oriented**
  - **least privilege**
  - **separation of duties**
  - **abstract permissions**
  - **separation of administration and access**
  - **roles are a semantic unit around which to build policy**

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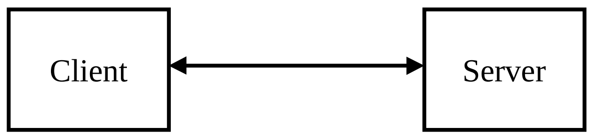
CLASS I SYSTEMS
ENFORCEMENT ARCHITECTURE



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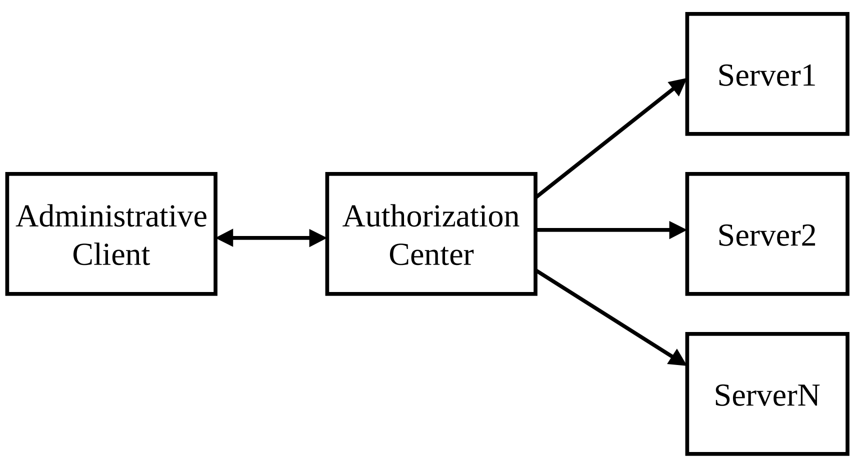
CLASS I SYSTEMS
ADMINISTRATION ARCHITECTURE



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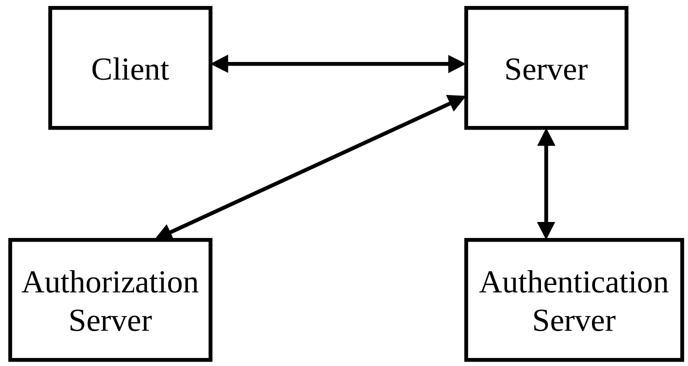
CLASS II SYSTEMS SERVER-PULL



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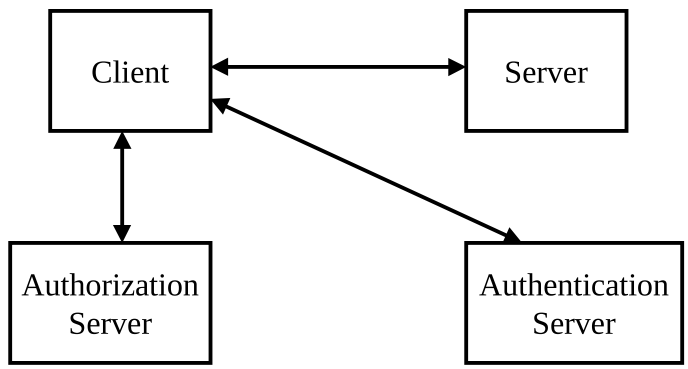
CLASS II SYSTEMS USER-PULL



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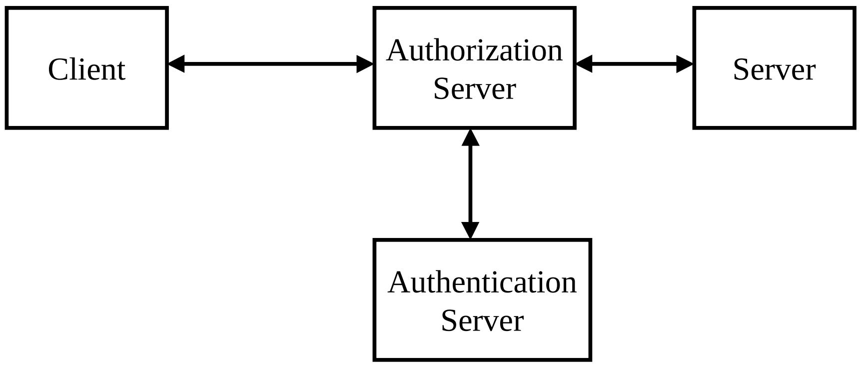
CLASS II SYSTEMS THREE-TIER



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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**

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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

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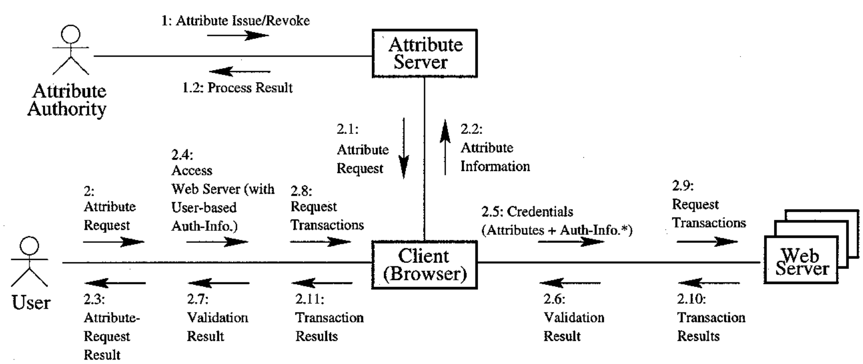
User-Pull Model



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

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User-Pull Model

- **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**

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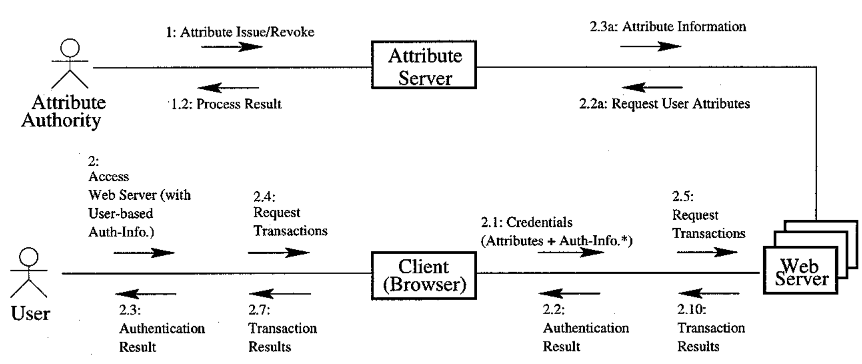
Server-Pull Model



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

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Server-Pull Model

- 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

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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

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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

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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

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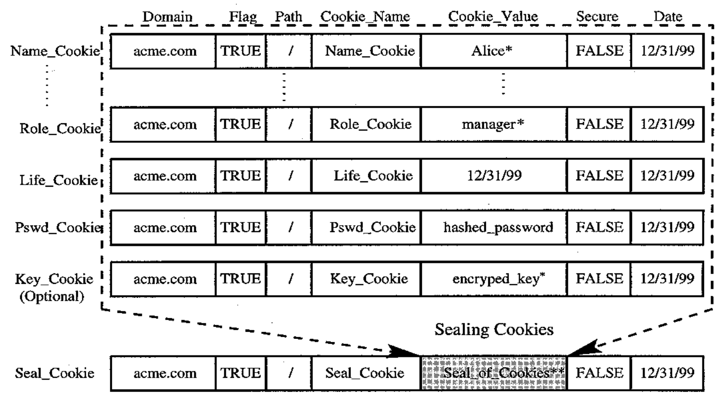
Secure Cookies on the Web



* 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

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A Set of Secure Cookies

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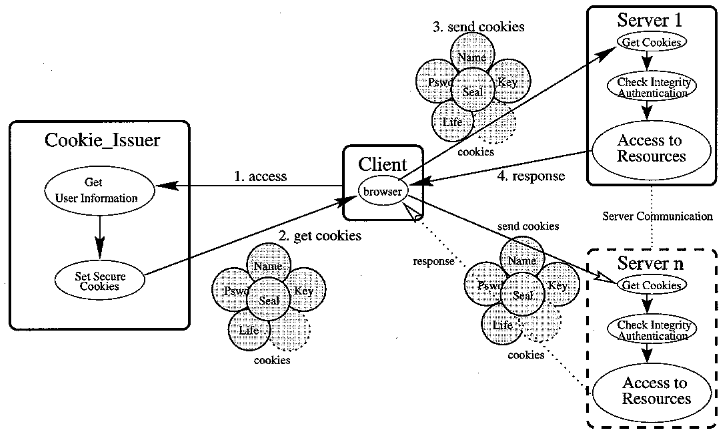
How to Use Secure Cookies



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

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Applications of Secure Cookies

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

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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

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Secure Cookies for Electronic Transactions

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
Name_Cookie	acme.com	TRUE	/	Name_Cookie	Alice*	FALSE	12/31/99
Card_Cookie	acme.com	TRUE	/	Card_Cookie	number::123456789*& exp_date::Jan.2000*	FALSE	12/31/99
Coupon_Cookie	acme.com	TRUE	/	Coupon_Cookie	ID::123&off::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

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
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

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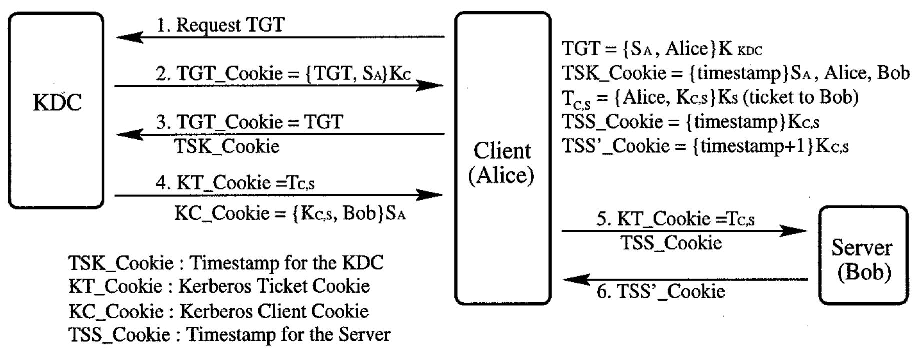
Kerberos-Based Authentication by Secure Cookies



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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
Seal_Cookie	acme.com	TRUE	/	Seal_Cookie	Seal_of_Cookies**	FALSE	12/31/99

Sealing Cookies

* 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

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Secure Cookies for RBAC

	Domain	Flag	Path	Cookie_Name	Cookie_Value	Secure	Date
Name_Cookie	acme.com	TRUE	/	Name	Alice	FALSE	12/31/99
Role_Cookie	acme.com	TRUE	/	Role	Manager	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	Encrypted_Passwords*	FALSE	12/31/99
IP_Cookie	acme.com	TRUE	/	IP_Cookie	129.174.142.88	FALSE	12/31/99

Cookie_Issuer Signs on the Cookies

Seal_Cookie	acme.com	TRUE	/	Seal_Cookie	Digital_Signature	FALSE	12/31/99

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

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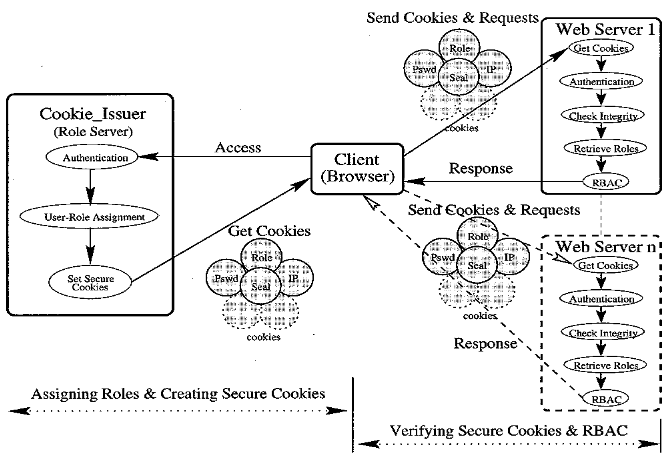
RBAC on the Web by Secure Cookies



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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)**

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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:b8:9d: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:d4:68:53:87:4b: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
```

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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

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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

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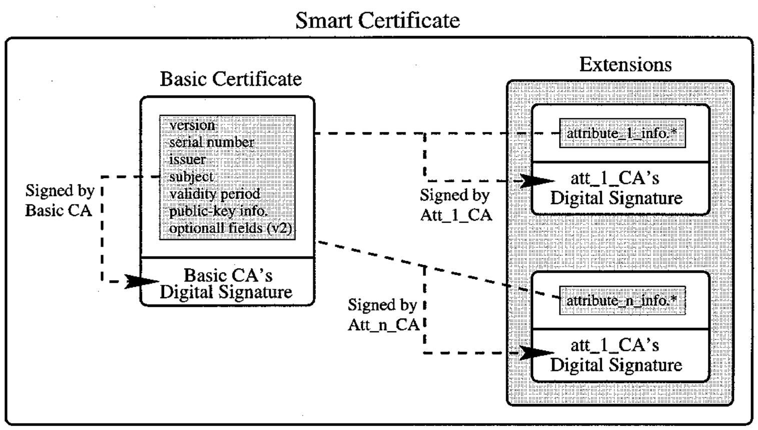
Separate CAs in a Certificate



* attribute info.: attributes, attribute issuer, validity period of attributes, etc.

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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.

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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: hEwDNMBBleJQrWEBAgCS8TzT2/NMvn/xrkRsq/fRMSV3klUTEYkZoI
            Identifier: Authority Key Identifier
                Critical: no
                Key Identifier:
                    a5:d7:08:bc:ff:07:bd:5a:d4:8d:d4:68:53:87:4b: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:f8:c2:e1:62:27:f6:d6:ae:09:77:
            46
```

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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

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