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Detecting Insider Activity Using Enhanced Directory Virtualization

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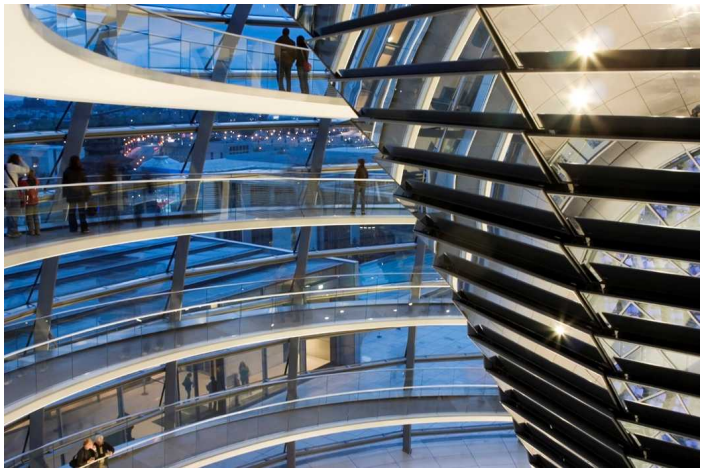
Agenda

- Background on Insider Threats
- Background on Directory Services
  - Directory Virtualization
- Enhancing Directory Virtualization
- Implementation Examples
- Primary Contributions
- Future Work

Insider Threats

- "Insider Threat Study: Illicit Cyber Activity in the Government Sector", a study conducted by U.S. Secret Service and CERT (2008) found:
  - Most of the insiders had authorized access at the time of their malicious activities
  - Access control gaps facilitated most of the insider incidents, including:



- The ability of an insider to use technical methods to override access controls without detection
- System vulnerabilities that allowed technical insiders to use their specialized skills to override access controls without detection

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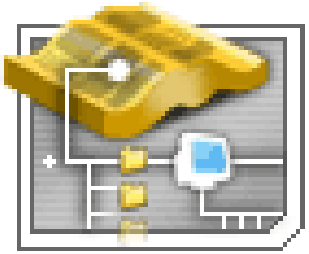

Directory Services

- Localized data store containing information about objects (Users, Computers, Contacts, etc.)
- Provide information to applications
  - Authentication and access control
  - Contact information
  - Group membership
- Popular Directory Services Implementations
  - Windows Server *Active Directory*
  - IBM *Tivoli*
  - *OpenLDAP*
  - Fedora *Directory Server*
  - Sun JAVA System *Directory Server*

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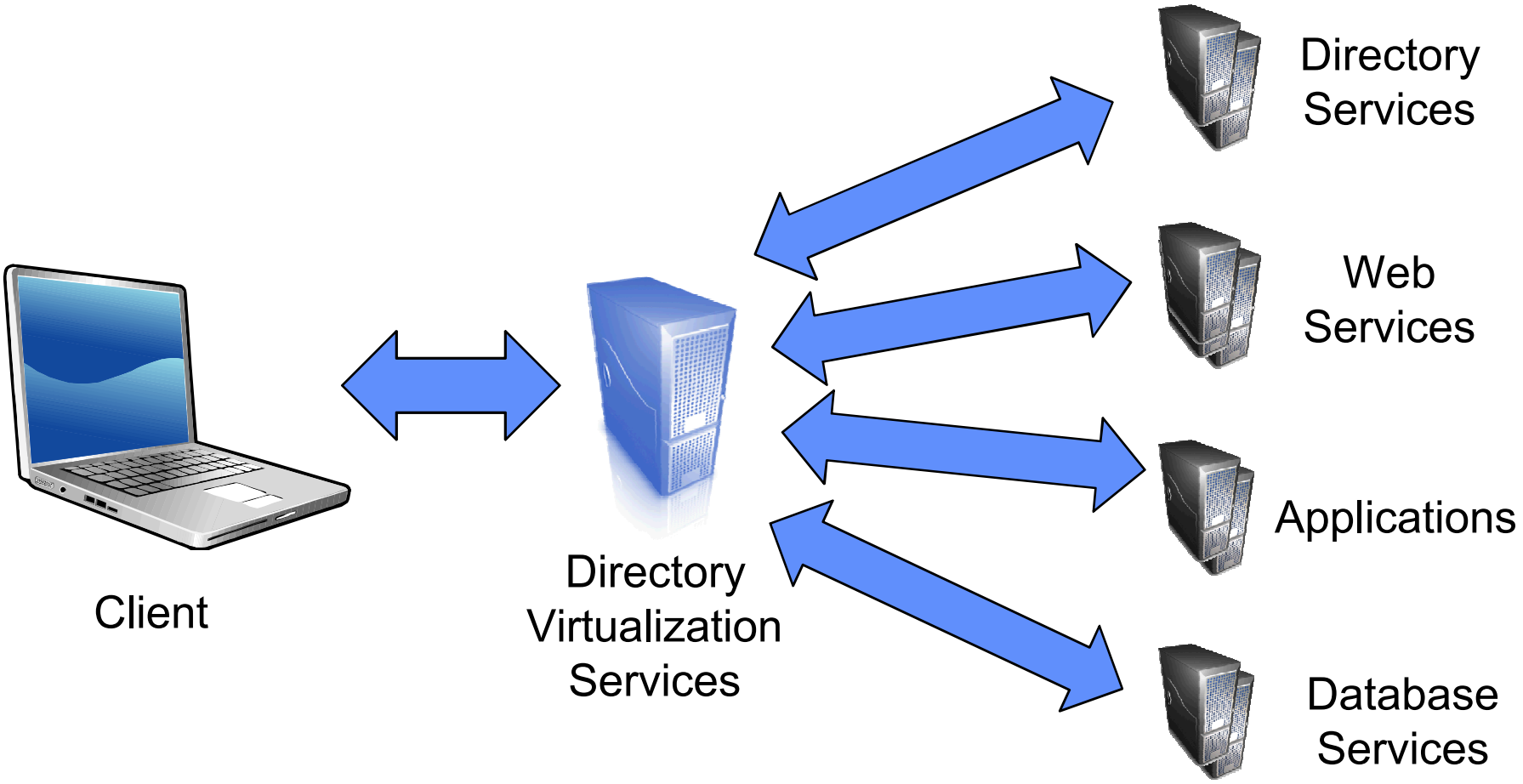
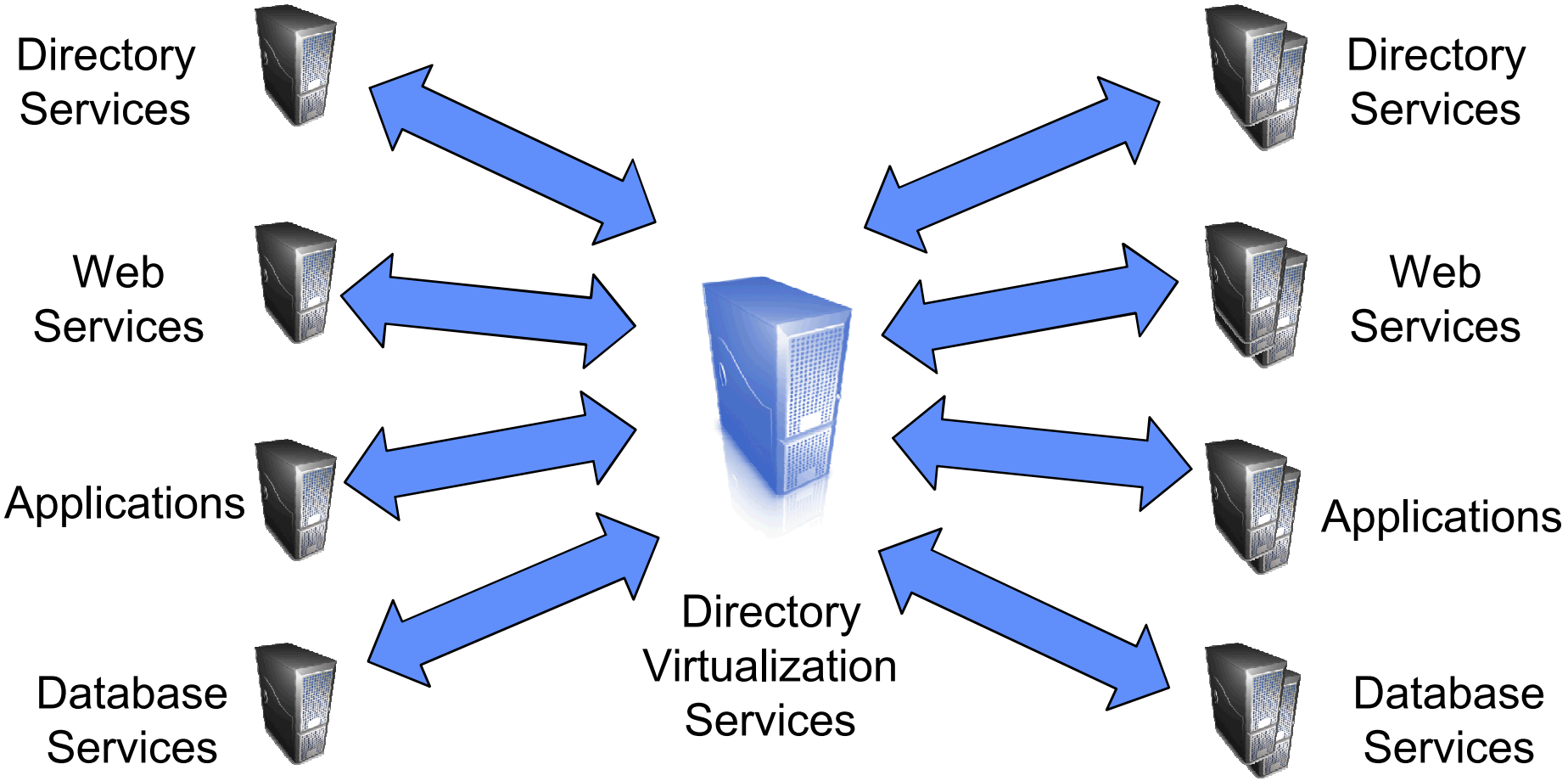
Directory Virtualization



Directory Virtualization and Synchronization



Attacks on Directory Services

- Create a new user
  - Allows insider to impersonate another account, rather than using her own
- Change group membership
  - Modify ACL to gain unauthorized access to protected resources
- Reset user password
  - Allows insider to masquerade as an existing user
  - Used to circumvent processes that monitor for unauthorized account creation

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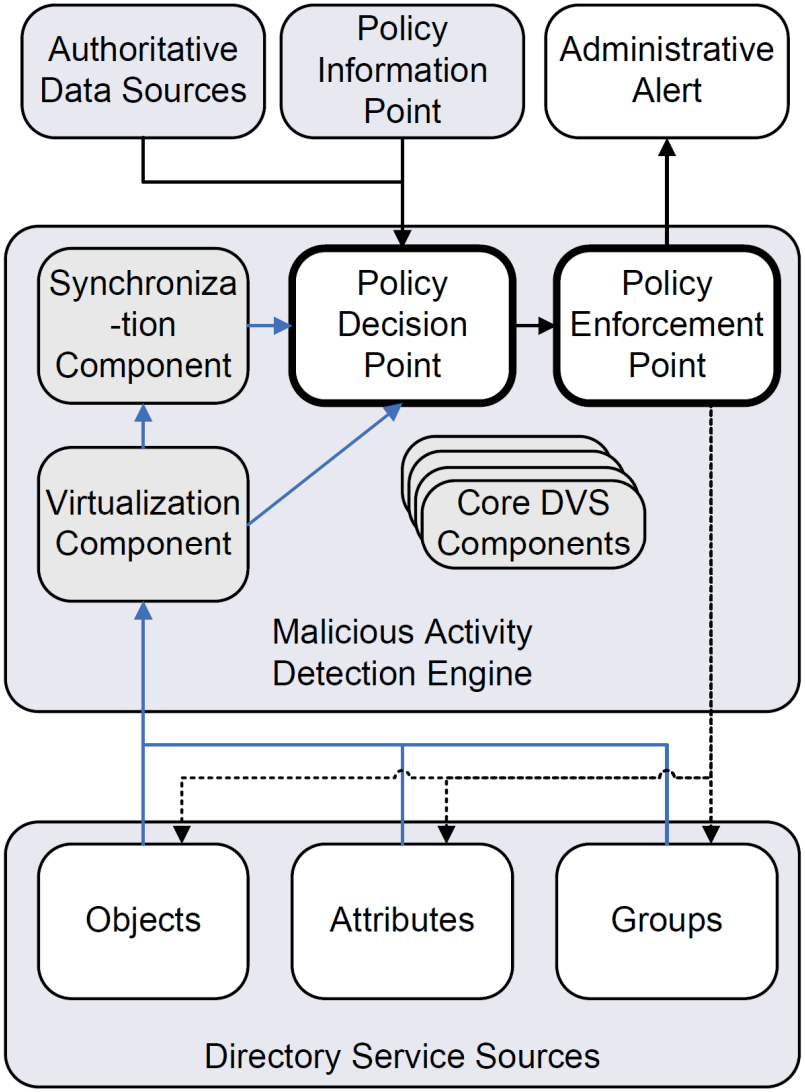
Enhancing Directory Virtualization

- Malicious Activity Detection Engine (MADE)
  - Builds on core components
    - Virtualization
    - Synchronization
  - Adds Policy Components
    - Policy Decision Point (PDP)
    - Policy Information Point (PIP)
    - Policy Enforcement Point (PEP)

Architecture



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Policy Decision Point

- Detects events
- Obtains policy information from PIP
- Makes determination on activity detected
- Coordinates response using PEP

Modeling the Problem

- **Boolean function describing an account and its relationships with other data sources**

$$s_i \equiv s_j\left(a_1, a_2, \ldots, a_j\right)$$

- $s_j\left(a_1, a_2, \ldots, a_j\right) = 1$ **implies** $a_1 = 1, a_2 = 1, \ldots, a_j = 1$
- **Disjunctive conditions can be included in separate conjunctive states**

Function Conditions

- Variety of possibilities
  - Value (or presence) of a specific attribute on an account
  - Membership of an account in a particular group
  - Relationship between two objects and their attributes
  - Etc.

Example

- **Unauthorized account creation**
  - **Policy:** $s_{new\_acct}(a_X, a_Y, a_Z)$
  - a_X : **presence of account in data source X**
  - a_Y : **"active" status of the account in data source Y**
  - a_Z : **presence of specific training records for the account owner in data source Z**

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Implementation: Hypothetical Organization

- DVS implemented with Microsoft Visual Studio
- Directory Services
  - Microsoft Active Directory
  - Sun Java System Directory Server
- Database Services
  - Microsoft SQL
- PIP integrated into DVS
  - Could have been Windows Server Group Policy, etc.
- Tests
  - 15000 user objects
  - 4 domain controllers, 1 SQL database

Implementation: Creating Unauthorized User Accounts

- Insider creates new user to access unauthorized resource
- Policy to prevent such action:

$$s_{auth\_acct}\left(a_{auth\_acct}\right)$$

- Virtualization service monitors directory service for changes, passes events to synchronization service
- Sync service reports new account to PDP
- PDP requests information from auth_acct,
- Applies information to policy retrieved from PIP
- Because $s_{auth\_acct}\left(a_{auth\_acct}\right)=0$, PDP notifies PEP of actions to take, based on information from PIP
- PEP takes appropriate action
  - disable account
  - notify admin

Implementation: Creating Unauthorized User Accounts

- **Test**
  - Use administrative controls to create a new account in directory service
- **Performance**
  - Unauthorized account disabled by MADE within 1 sec of detection

Implementation: Changing Group Membership

- Object attributes often used to make access control decisions
  - Group membership, clearance level, citizenship, organizational status, management level, etc.

Implementation: Changing Group Membership

- **Policy:**

$$s_{group\_membership}\left(a_{auth\_admn}, a_{mbr\_org}, a_{grp\_size}\right)$$

- a_{auth_admn} : **Account is listed as valid domain administrator in** *auth_admin*
- a_{mbr_org} : **Account owner is part of specified organization in a separate data source**
- a_{grp_size} : **Three or less accounts can exist in domain administrators group at any one time**

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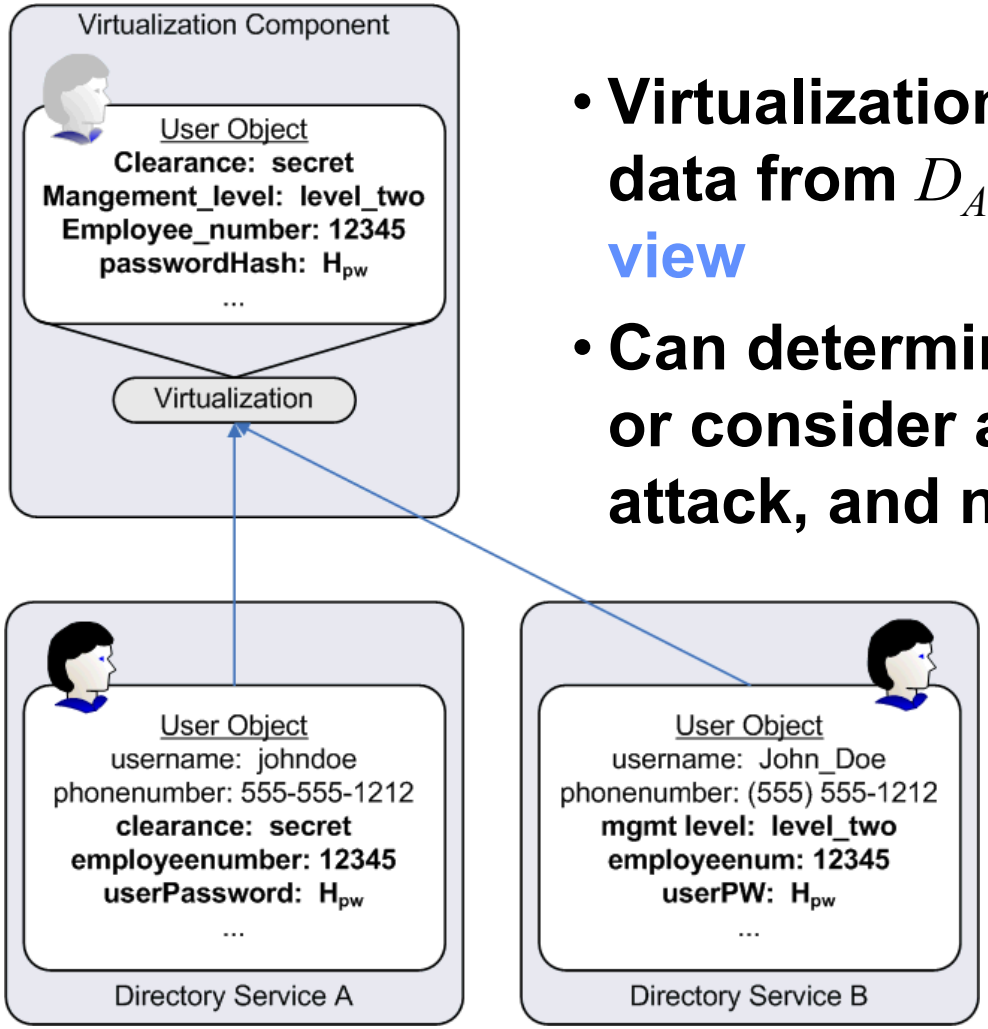
Implementation: Changing Group Membership

- **Attack: Adding an unauthorized account to *Domain Administrators* group**
- **Detection similar to previous example**
- a_{auth_admin} **and** a_{mbr_org} **are determined to be false**
- a_{grp_size} **may also be exceeded**
- **PEP notified to take appropriate action**
- **Interesting to note that policy decision used information from the directory service itself**
  - **Group size**
- **Performance and results similar to previous case**

Implementation: Using Cross-Directory Relationships

- Two different directory services
- Users required to have matching accounts in both directories
  - Directory D_A contains mandatory clearance level information
  - Directory D_B contains mandatory management level information
- Administrators are not allowed to administer both directories simultaneously

Implementation: Using Cross-Directory Relationships



- **Virtualization component combines data from D_A and D_B to form a single view**
- **Can determine authoritative source, or consider a discrepancy a potential attack, and notify PDP**

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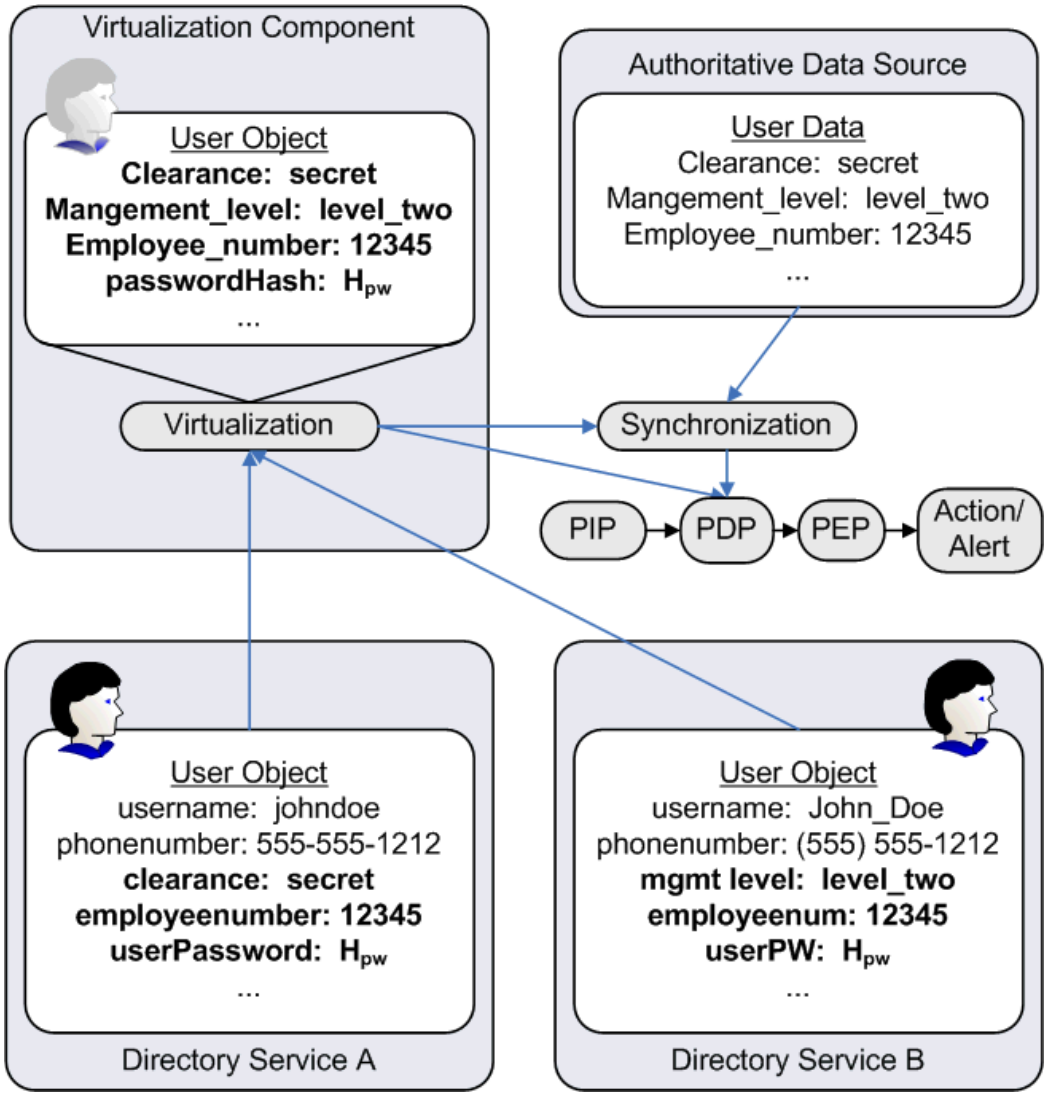
Implementation:
Using Cross-Directory Relationships



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Implementation: Using Cross-Directory Relationships

- **Policy:**

$$s_{auth\_acct}\left(a_{clearance}, a_{mgmt\_level}, a_{pwd\_match}\right)$$

- $a_{clearance}$: **presence of correct clearance level**
- a_{mgmt_level} : **presence of correct management level**
- a_{pwd_match} : **synchronization of passwords between domains**

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Implementation: Using Cross-Directory Relationships

- **Attack: Insider changes a user password in D_A in order to impersonate that account**

- **Performance similar to previous examples**
  - **Detection and enforcement within one second of detection**

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Primary Contributions

- Monitoring for unauthorized changes is not new
- Adding policy engine in this form is somewhat novel
- Real contribution is the ability to monitor multiple systems simultaneously, and present a consolidated systems view of key data and relationships.
- Insider may be able to modify individual components, but is less likely to be able to modify all monitored components simultaneously

Primary Contributions

- DVS present a lightweight footprint
  - Many DVS may be distributed across the network
  - Makes disabling or defeating them more difficult
- DVS exist outside normal directory services
  - Enhances the chances of detecting a savvy insider
  - Basically a covert channel for directory services

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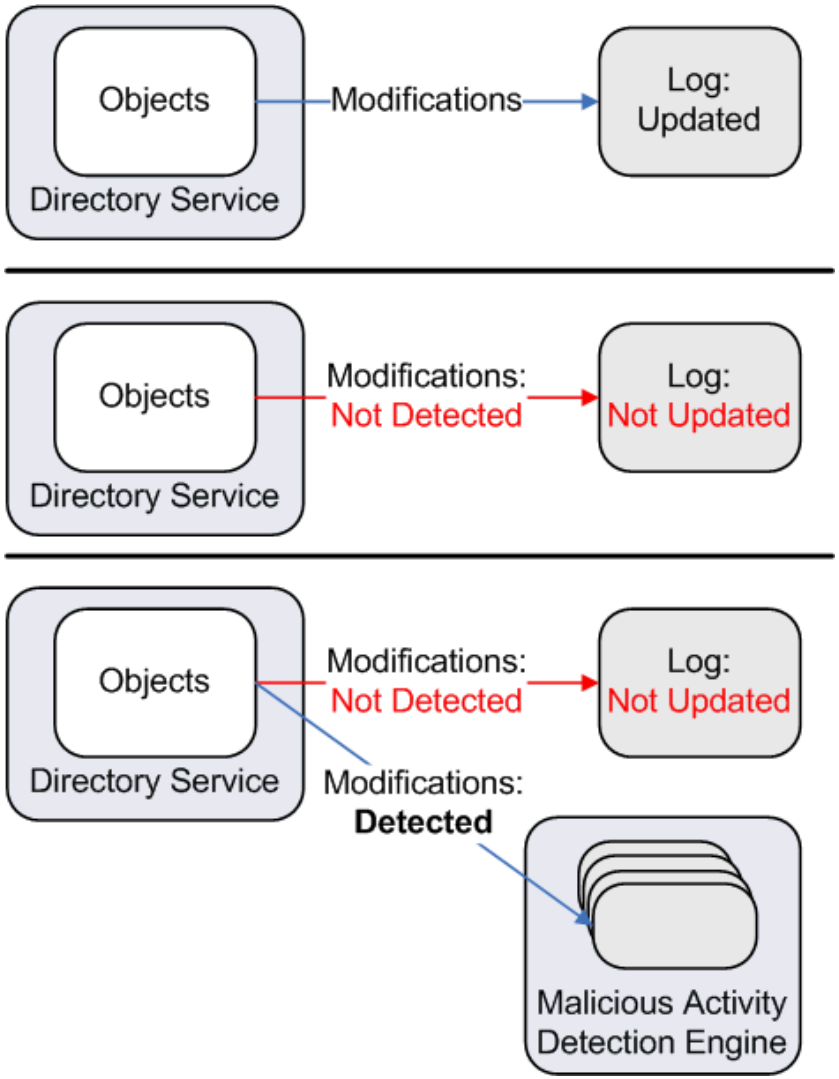
Covert Channel



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Attacks on MADE

- Administrator with control of authoritative data sources
  - Separation of duties
  - Careful monitoring and auditing
- Administrator access to DVS
  - Disable monitoring
  - Makes key changes to specific repositories simultaneously
- Administrator access to administrative applications
  - Makes unauthorized changes appear legitimate
- Administrative access or attacks on PIP or PEP

Future Work

- Additional performance testing under real-world scenarios and in production environments
- Apply MADE to other access control models
- Deployment of many lightweight DVS
- Enhanced interaction with PIP
  - What other systems can be used as PIP
  - How to prevent PIP compromise

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Questions

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