Distributed Information Processing

19th Lecture

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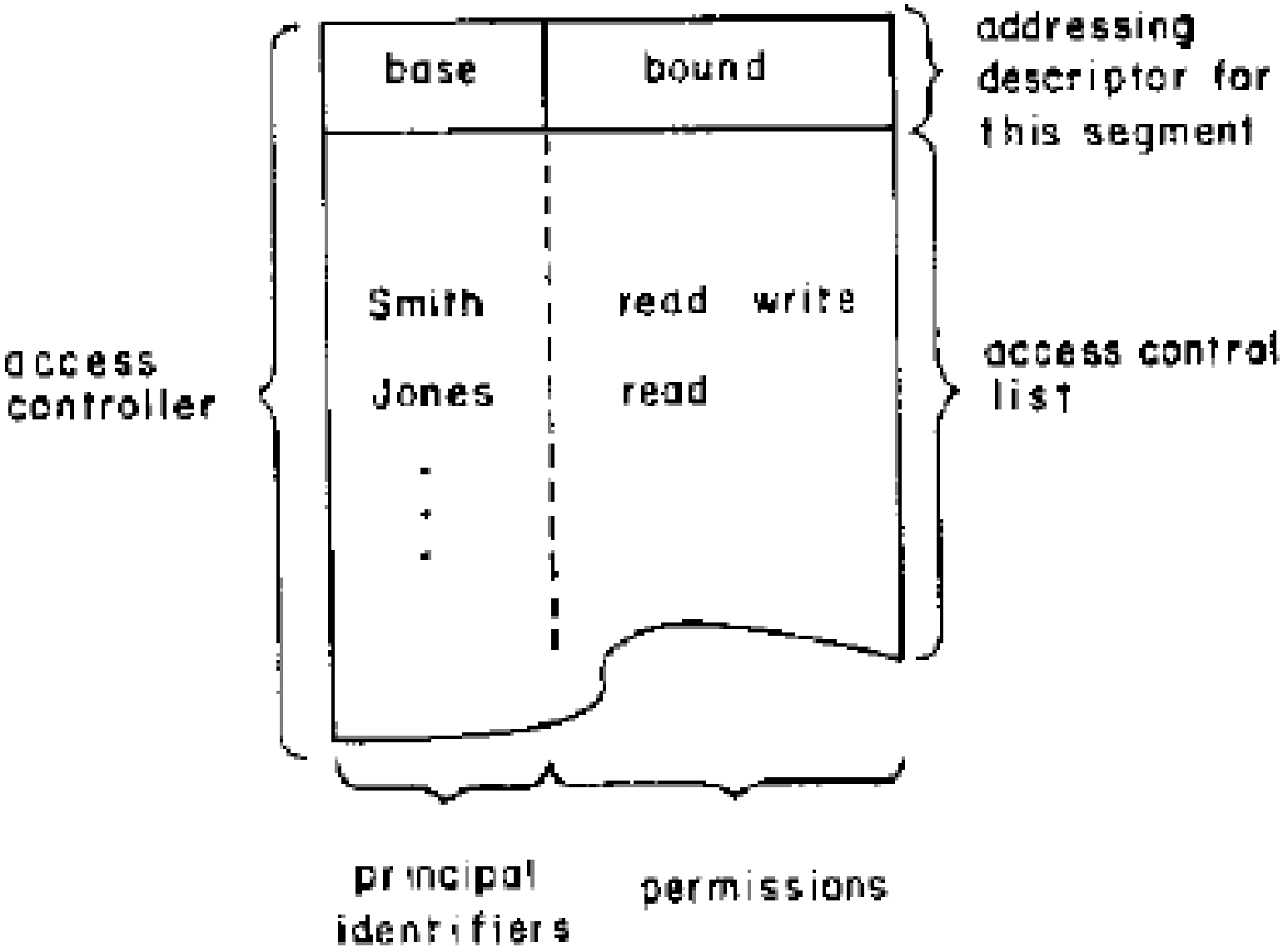
Outline

- Information Protection
  - Information Protection in Computer Systems (Cont'd)
- Q&A

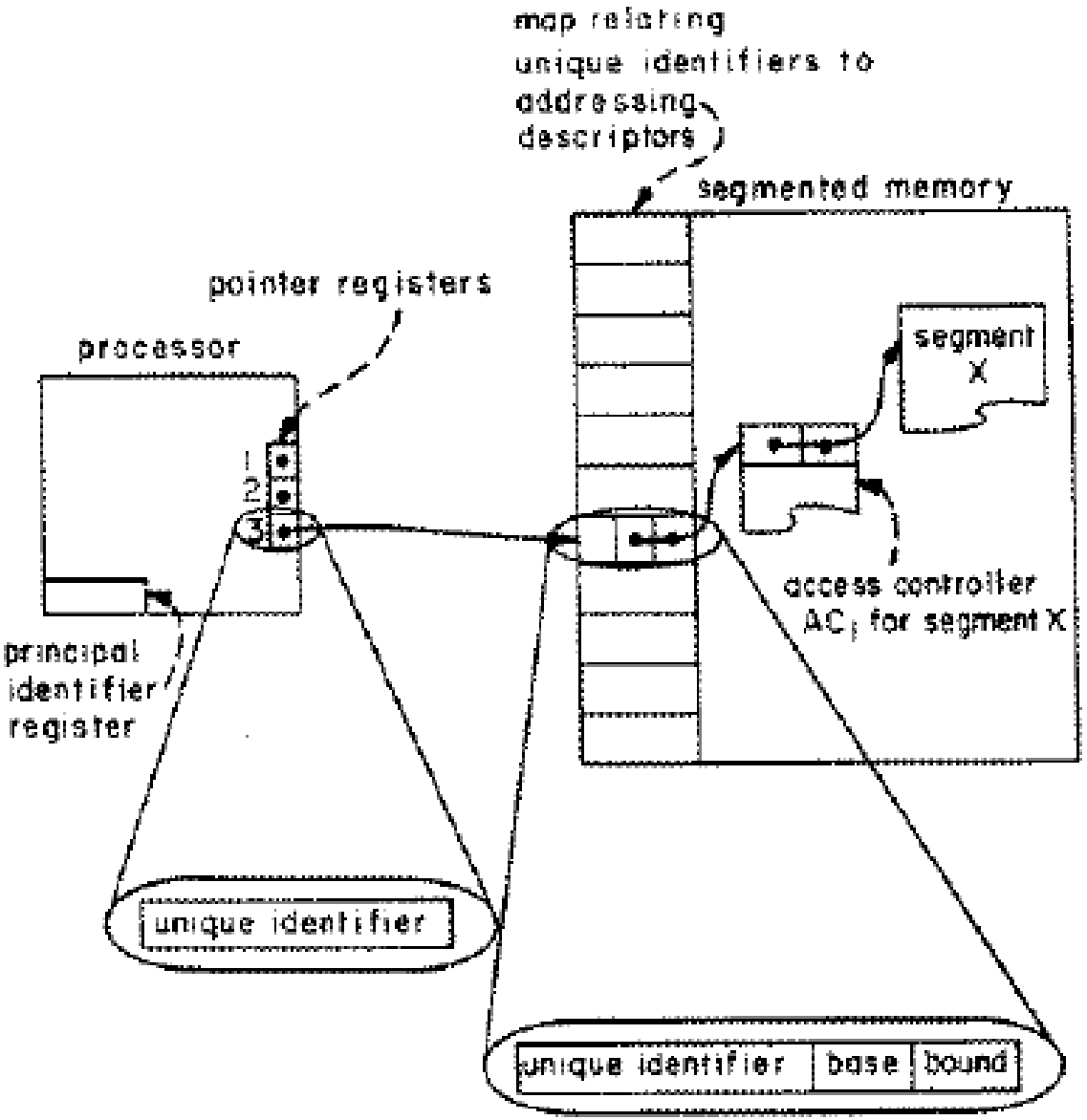
Access Control List System

- Use of an Access Controller
  - Components
    - Addressing descriptor
    - Access control list
  - Characteristics
    - Kind of indirect address
    - Possibly replacing protection descriptors with unprotected pointers
  - Data Reference
    - Using the pointer to address the access controller
    - Searching the access control list
    - Searching the permission bits
    - Generating a reference request if permitted

Access Controller Model



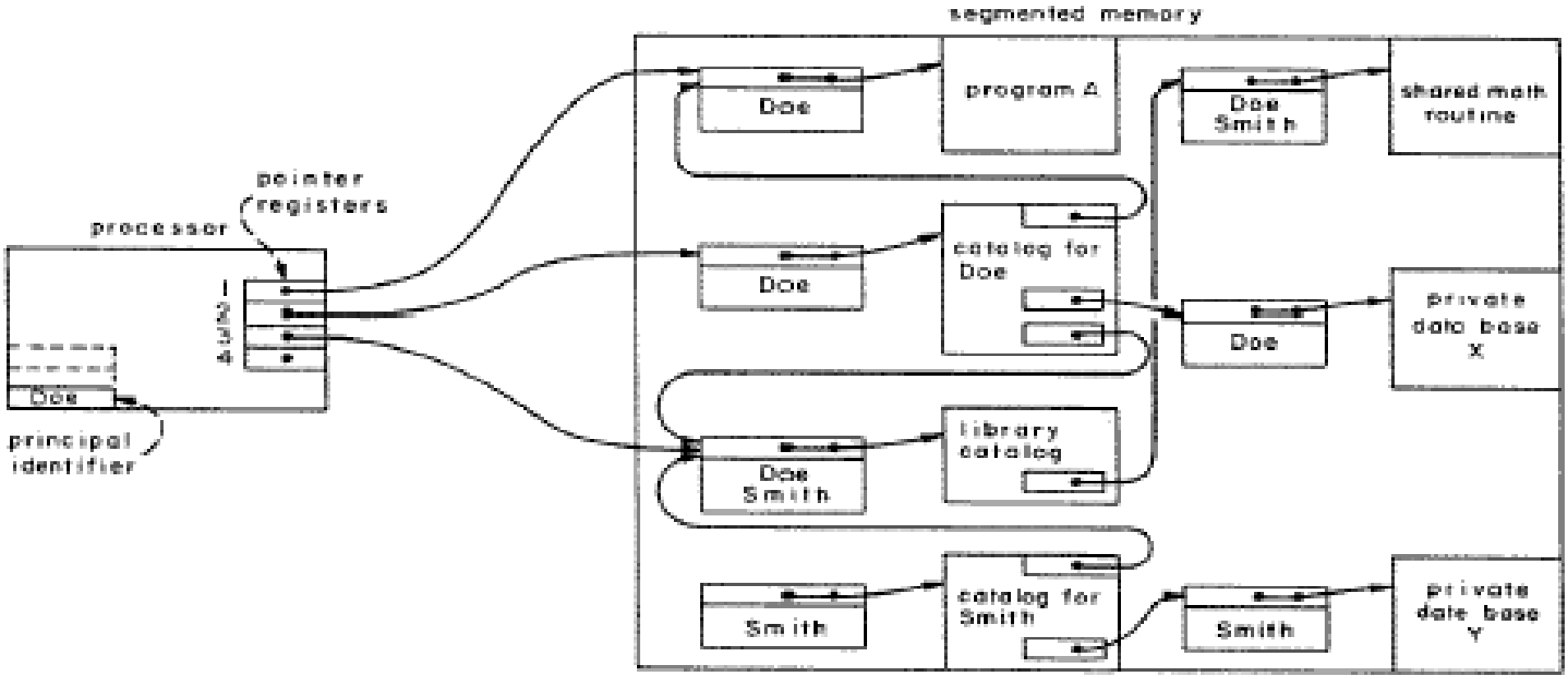
Revised Separating Organization



Differences with Capability Systems

- Using the Pointer via the Access Controller
  - Preventing Unauthorized Access
- Using the Access Control List
  - Authorizing Possibly on Every Access
- Updating the Access Control List
  - Making Access Revocation Manageable
- Examining the Access Control List
  - Figuring Out Authorized Users
- Using Different Access Control Lists
  - Differing Based on the Purposes

System with Access Control Lists



Protection Groups

- Definition
  - Principals Used by More Than One User
    - Members Permitted to Access the Segment
- Motivation
  - Possibly Very Long List
  - Frequently Changing List
- Simple Method
  - Extending the "Principal Holding" Register
    - One for a personal principal ID
    - Another for each protection group

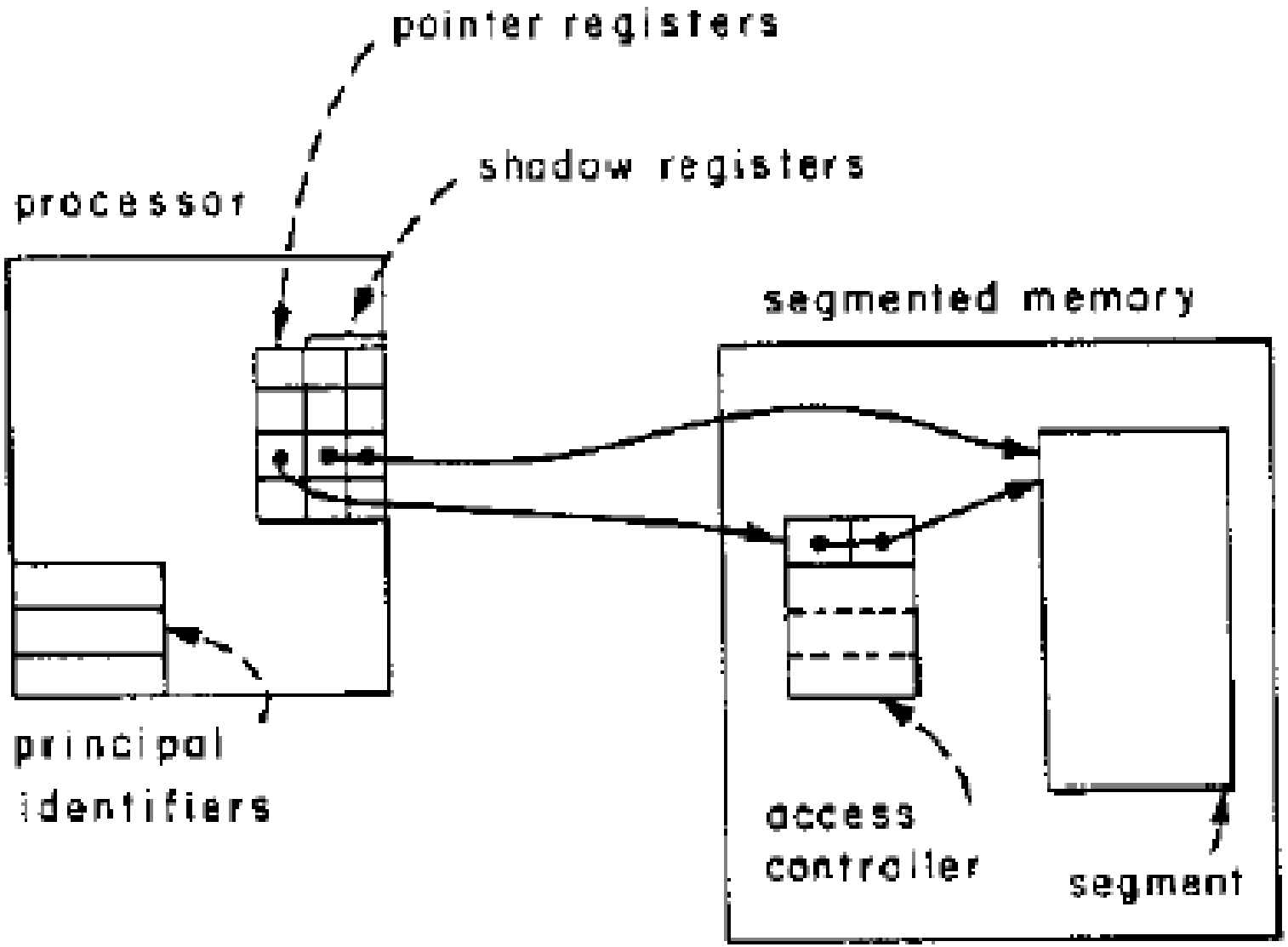
Protection Group List Must Be Controlled Systematically

Problems & Solutions

- Several Memory References
  - Shadow Capability Register for Each Pointer Register
    - Loaded with a capability consisting of copies of the addressing descriptor and protection bits
      - Whenever a pointer register is first loaded
    - Not affected by changing an access control list (a minor change in revocability properties)

Clearing Shadow Registers and Triggering Their Reloading

Shadow Capability Registers



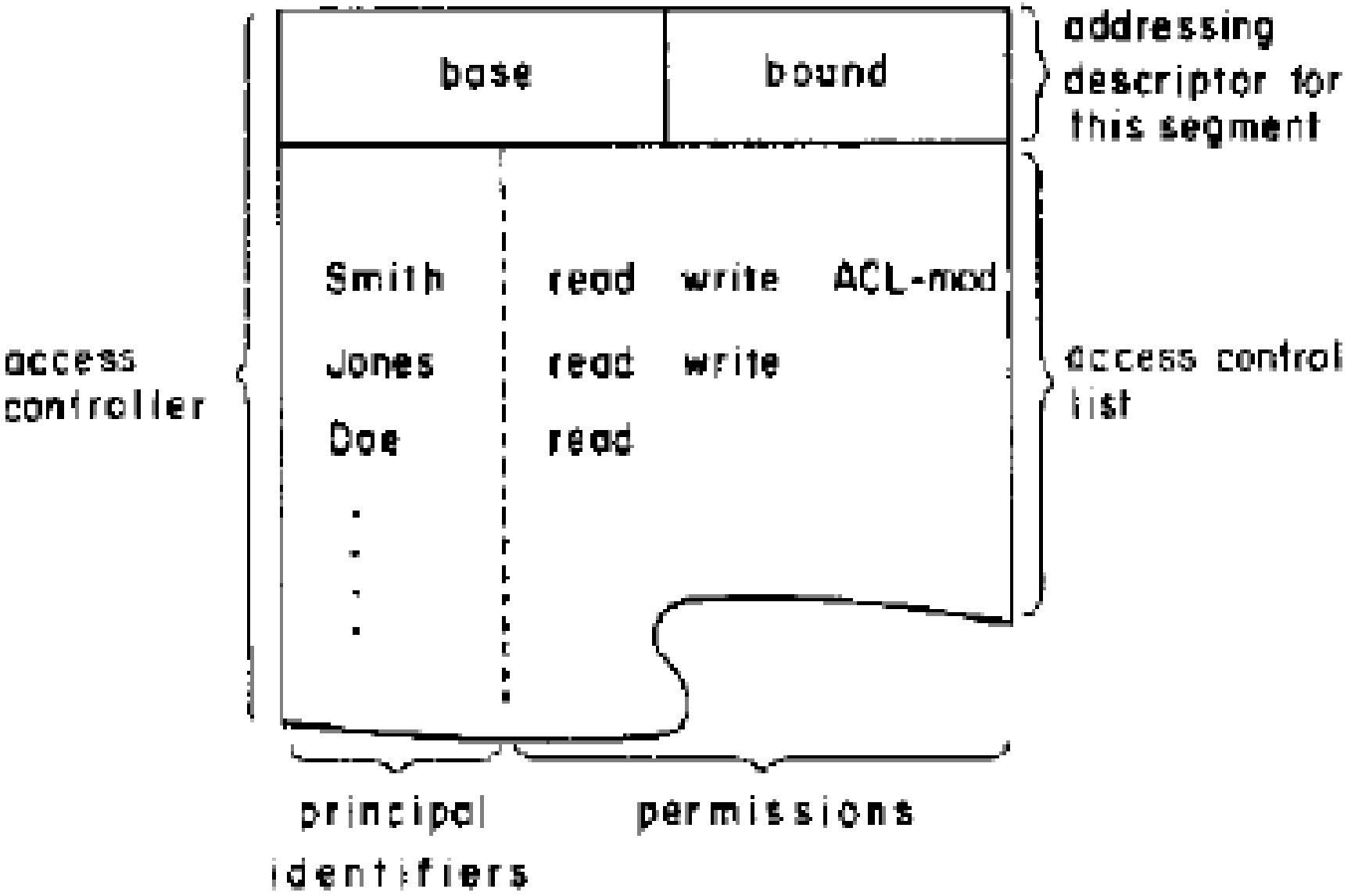
Problems & Solutions (Cont'd)

- Allocation and Search of an Access Control List
  - Constraining All Access Control Lists to Contain a Certain Number of Entries
    - E.g., three entries on each access list
      - User
      - Group
      - Universal Group

Authority to Change Access Control Lists

- Self Control
  - Including Permission to Modify the Access Control List
    - Allowing the creator to adjust the list
  - Not Permitting Graceful Changes of Authority

Self Control Scheme

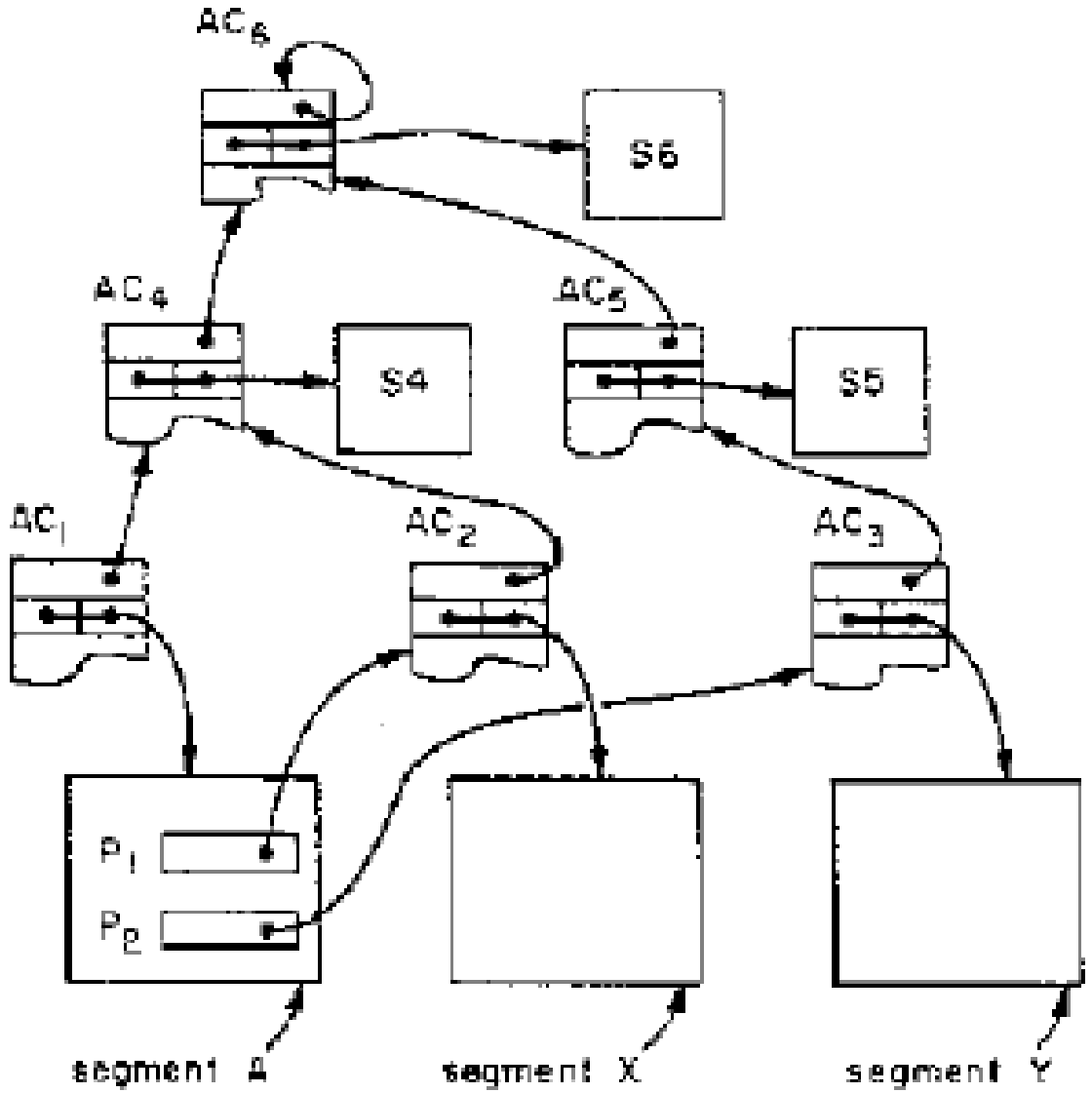


Authority to Change Access Control Lists (Cont'd)

- Hierarchical Control
  - Including Permission to Modify the Lists of Lower Level Access Controllers
    - Allowing a node to change lists further down the hierarchy
  - Permitting Access to Anything in the Entire Subtree
    - Giving too much power to high-level nodes, leading to concentration of authority and possible (unchecked) abuse of higher level authority

Higher Level Checking and Taking Actions Based on the Prescript Field: e.g., Logging the ID and Delaying the Change

Hierarchical Control Scheme



Discretionary and Nondiscretionary Controls

- Discretionary Control
  - Creator's Authorization of Access to What Is Created
    - Against the principle of least privilege
- Nondiscretionary Control
  - Authorization Limited by "Employees"
    - Similar to Isolated Compartments and Sensitivity Levels

Confinement: No Sharing with Other Domains

Protecting Objects

- Operations On Objects, Working Out Permissions for These Objects
  - Type Field Added to a Capability
    - Special instructions requiring different operand capabilities
    - Interpretation of the permission bits different for types
    - Extended "create" operation to permit type specification

      Examples of Type Extension in Capability System: Any Data Structure Including Queues, I/O Streams Attached to Terminals, Printers, and the Like
  - Type Field Placed in the Access Controller

Typical Protected Objects

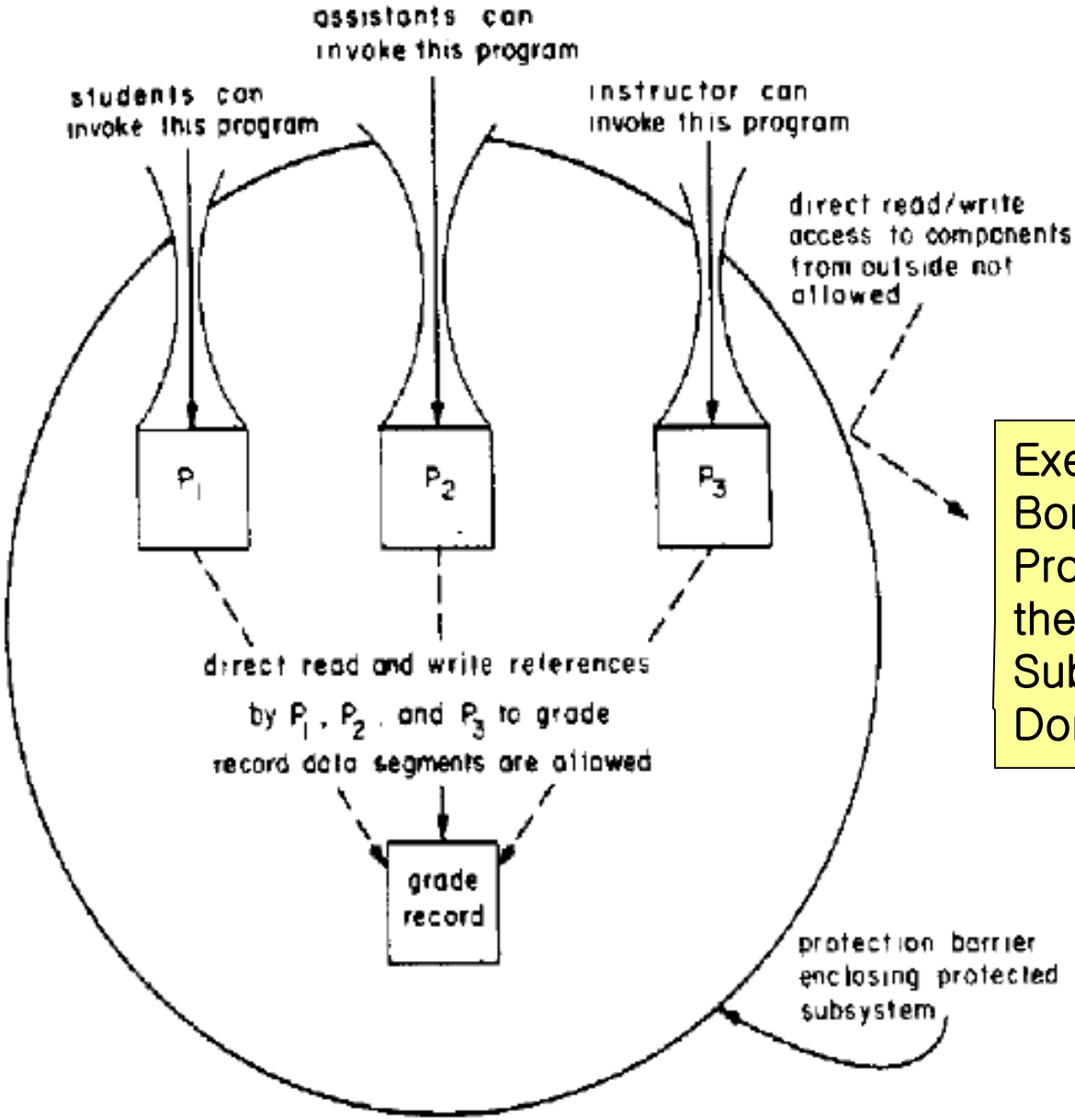
Object	Typical Separately Permittable Operations
Data segment	READ data from the segment WRITE data into the segment Use any capability found in the segment Write a capability into the segment
Access controller	Read access control list Modify names appearing on an access control list Modify permissions in access control list entries Destroy objects protected by this access controller
FIFO message queue	Enqueue a message Dequeue a message Examine queue contents without dequeueing
Input/Output	READ data WRITE data Issue device-control commands
Remove recording medium (e.g. magnetic tape reel)	READ data WRITE over data WRITE data in new area

Extending the Range of Protected Objects by Using the Type Field Containing the Additional Unique ID

Protected Objects and Domains

- Protected Subsystems
  - Definition
    - Collection of encapsulated program and data segments
      - Preventing other programs from reading/writing them
      - Preventing other programs from disrupting the intended operations
      - Allowing other programs to call the programs by calling the designated entry points
  - Motivation
    - Limitations of using objects independently controlled such as reading, writing, or executing as programs
      - Not being able to define a new type dynamically
      - Danger presented by executing a borrowed program

Illustration: A Protected Subsystem



Executing the Borrowed Program Outside the Protected Subsystem Domain

Implementation of Protected Subsystems

- Associating Multiple Domains with a Single Computation (with Asynchronous Activities)
  - Use of a Separate Virtual Processor
    - One with its own domain
    - Another for each protected subsystem
- Using a Single Virtual Processor
  - Association of multiple domains with a single virtual processor

Changing Domains: Changing Principal IDs in ACL Systems, and Changing the Set of Capabilities of the New Domain in Capability Systems; e.g., Including the ENTER Permission Possibly with the Domain ID

Other Considerations

- Domain Switching
  - (Restricted) Role of the Supervisor
    - Having only the Enter capability leading to a authentication program
  - Using the Seal Capability (with a Seal in the Type Field)
    - Accessing internal data (Separation of Privilege)
  - Distinction between Dynamic and Static Data
    - Using multiple virtual processors
  - Passing of Arguments
    - Controlling specially the argument indicating how to return

Other Considerations (Cont'd)

- Precise Model of Protection Goals
  - Isolation vs Sharing
- Verifying the Implementation
  - Establishing the Correctness Formally
- Providing Need-Specification Interface
- Providing System S/W with Constraints
  - Establishing a Set of Protected Functions
- Making Protection Not Affected by Failure
- Constraining After-Release Use
- Communicating Keys to Authorized Users