Unit 7: Security

7.3. Windows Security Descriptors

Roadmap for Section 7.3.

- Protecting Objects
- Security Descriptors and Access Control Lists
- Auditing and Impersonation
- Privileges

Protecting Objects

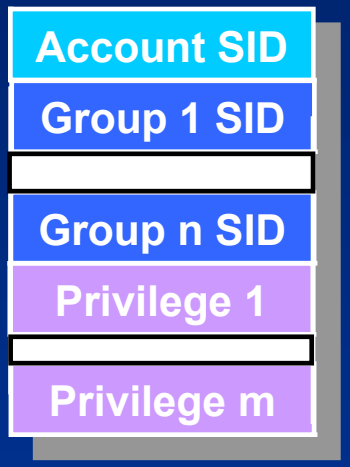
- Access to an object is gated by the Security Reference Monitor (SRM),
  - performs access validation at the time that an object is opened by a process
- Access validation is a security equation that consists of the following components:
  - Desired Access: the type of access that is being requested
    - must be specified up front
    - include all accesses that will be performed on the object as a result of the validation
  - Token: identifies the user that owns the process, as well as the privileges of the user
    - Threads can adopt a special type of token called an “impersonation token” that contains the identify of another account
  - The object’s Security Descriptor
    - contains a Discretionary Access Control List (DACL)
    - describes the types of access to the object users are allowed

Handles and Security

- If the validation succeeds, a handle is created in the process requesting access and through which the process accesses the resource
- Changing security on an object only affects subsequent opens
  - Processes that have existing handles can continue to access objects with the accesses they were granted
  - E.g. changing permissions on a share won't affect currently connected users
- Lab: View process handles and corresponding granted accesses with Process Explorer

Tokens

- The main components of a token are:
  - SID of the user
  - SIDs of groups the user account belongs to
  - Privileges assigned to the user (described in next section)



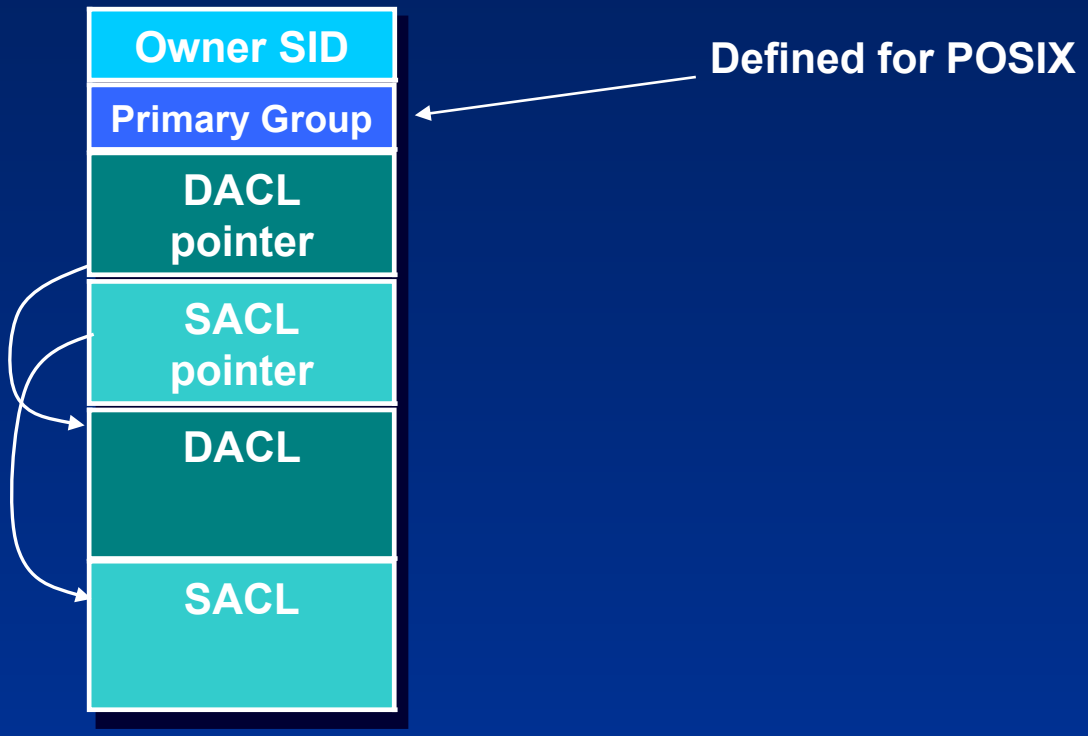
Security Identifiers - SIDs

- Windows uses Security Identifers (SIDs) to identify security principles:
  - Users, Groups of users, Computers, Domains
- SIDs consist of:
  - A revision level e.g. 1
  - An identifier-authority value e.g. 5 (SECURITY_NT_AUTHORITY)
  - One or more subauthority values
- SIDs are generally long enough to be globally statistically unique
- Setup assigns a computer a SID
- Users and groups on the local machine are assigned SIDs that are rooted with the computer SID, with a Relative Identifier (RID) at the end
  - Some local users and groups have pre-defined SIDs (eg. World = S-1-1-0)
  - RIDs start at 1000

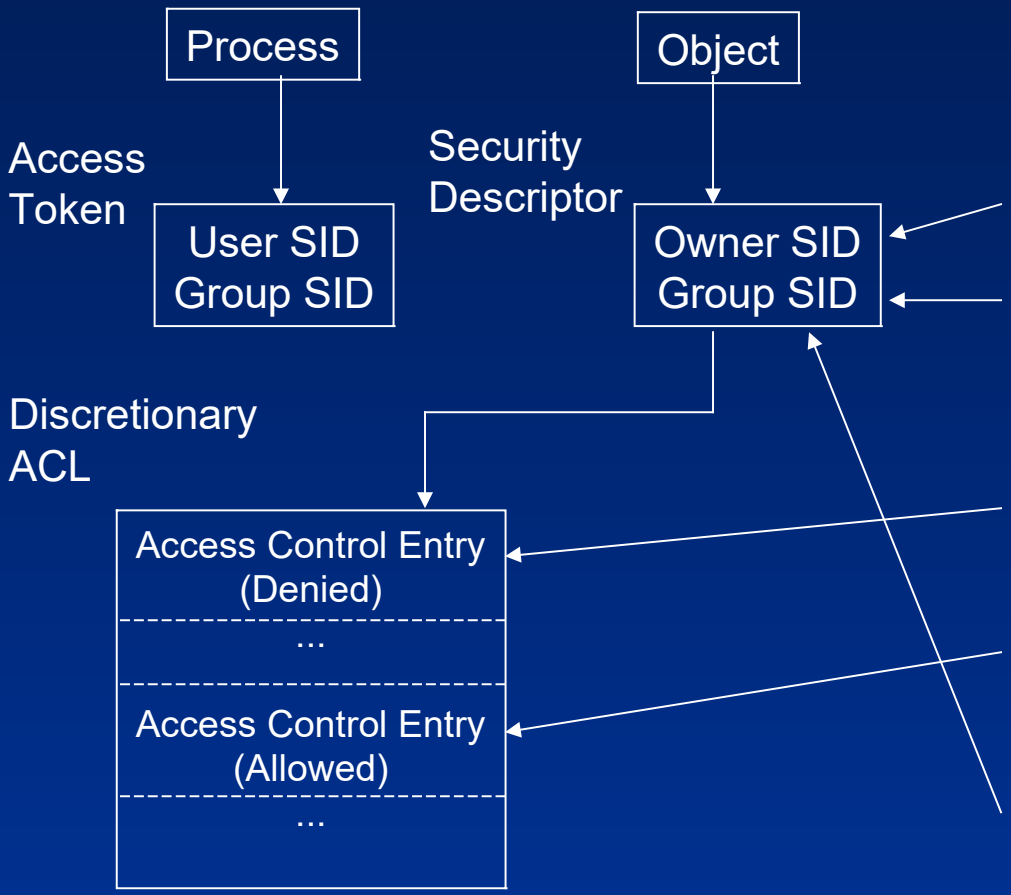
    (RIDs of built-in accounts, like Administrator or Guest, are pre-defined)

Security Descriptors

- Descriptors are associated with objects: e.g. files, registry keys, application-defined
- Descriptors are variable length



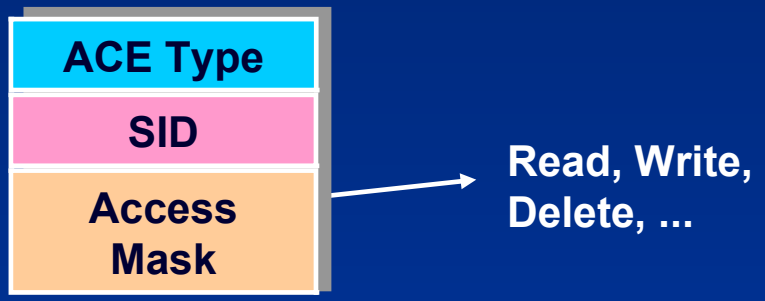
Constructing a Security Descriptor



1) InitializeSecurityDescriptor()
2) SetSecurityDescriptorOwner()
3) SetSecurityDescriptorGroup()
4) InitializeAcl()
5) AddAccessDeniedAce()
...
6) AddAccessAllowedAce()
...
7) SetSecurityDescriptorDacl()

Discretionary Access Control Lists (DACLs)

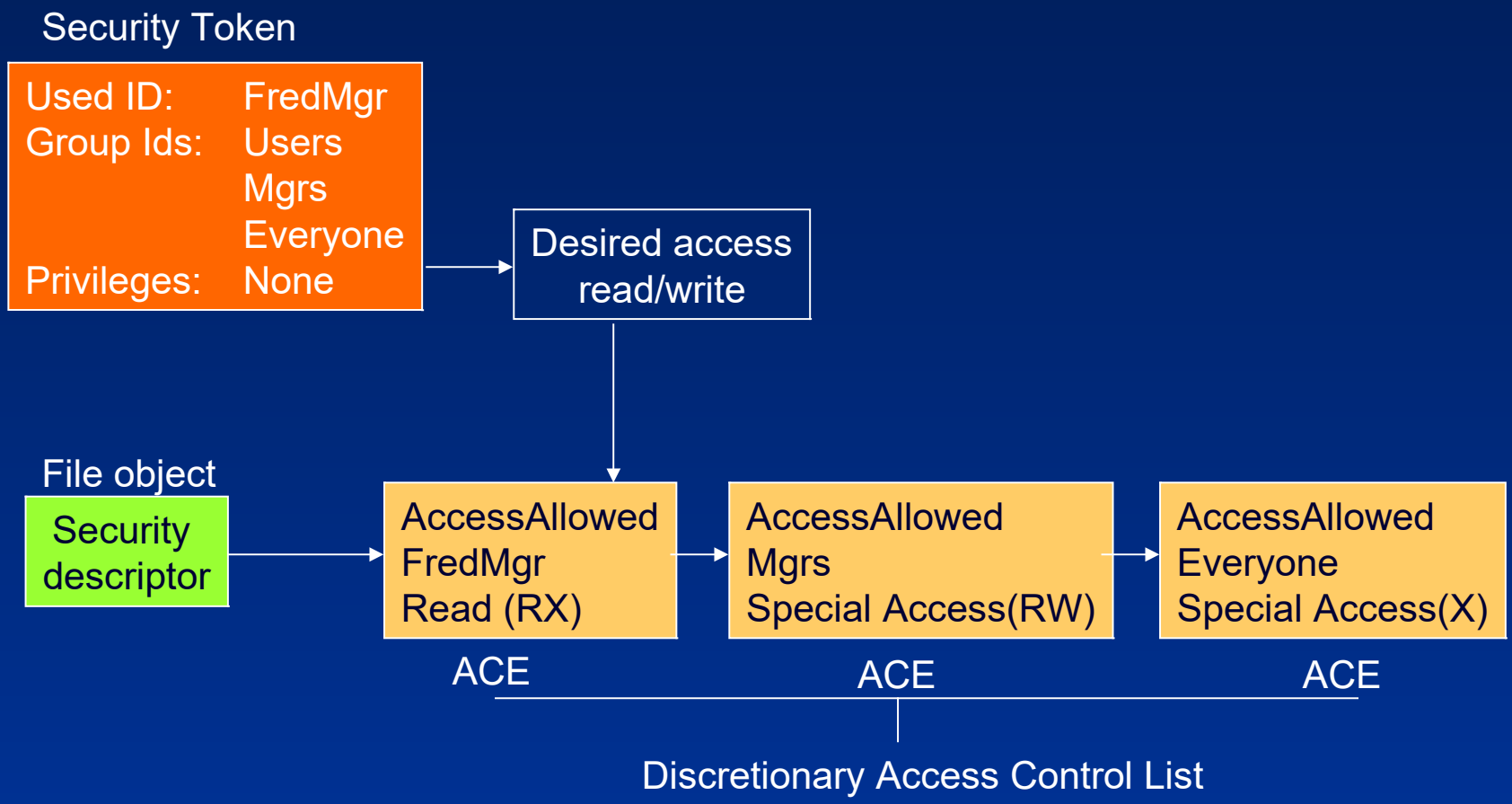
- DACLs consist of zero or more Access Control Entries
  - A security descriptor with no DACL allows all access
  - A security descriptor with an empty (0-entry) DACL denies everybody all access
- An ACE is either “allow” or “deny”



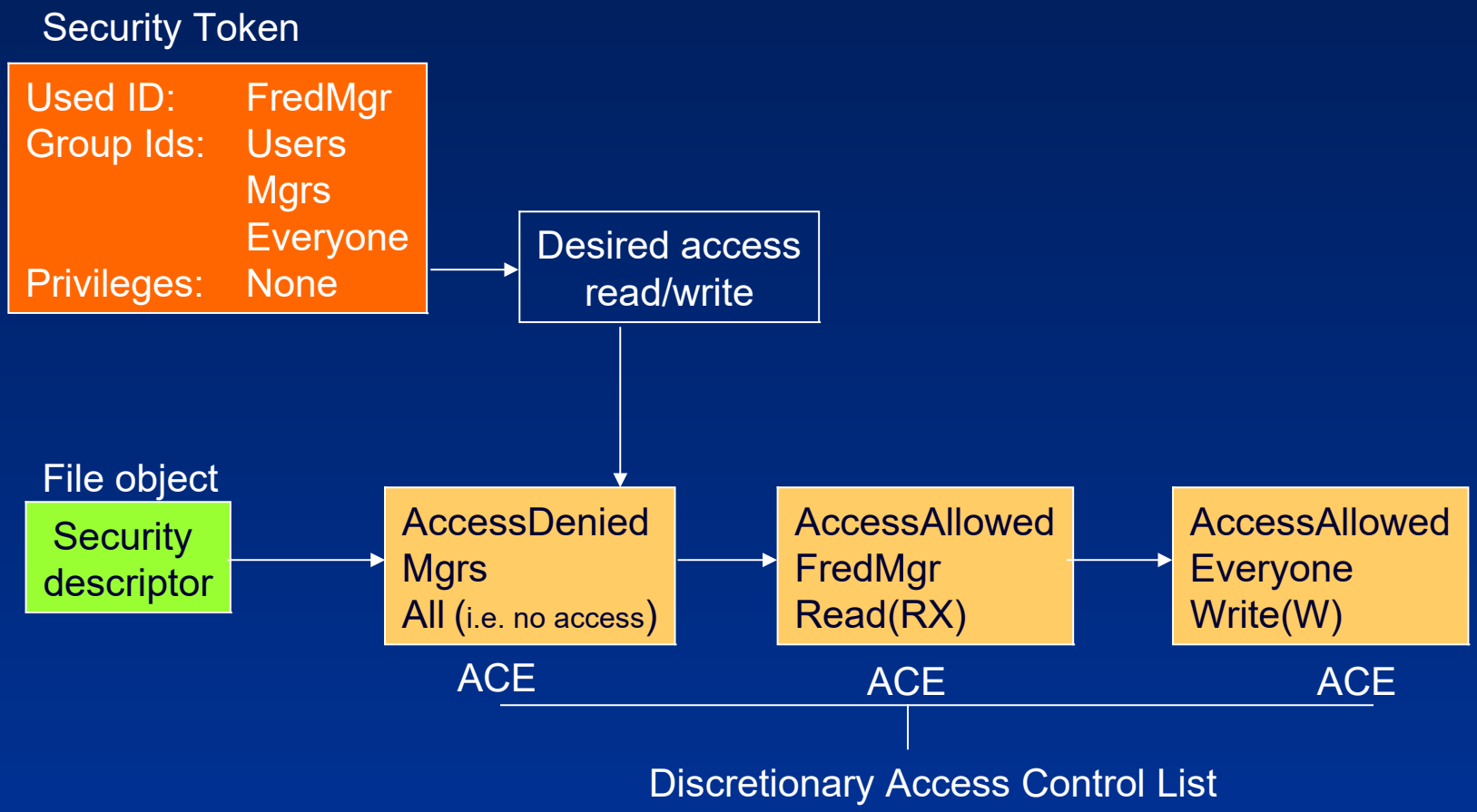
Access Check

- ACEs in the DACL are examined in order
  - Does the ACE have a SID matching a SID in the token?
  - If so, do any of the access bits match any remaining desired accesses?
  - If so, what type of ACE is it?
    - Deny: return ACCESS_DENIED
    - Allow: grant the specified accesses and if there are no remaining accesses to grant, return ACCESS_ALLOWED
  - If we get to the end of the DACL and there are remaining desired accesses, return ACCESS_DENIED
- The Security Reference Monitor (SRM) implements an *explicit allow* model
  - Exposed to apps through Windows API AccessCheck(), AccessCheckByType(), TrusteeAccessToObject())

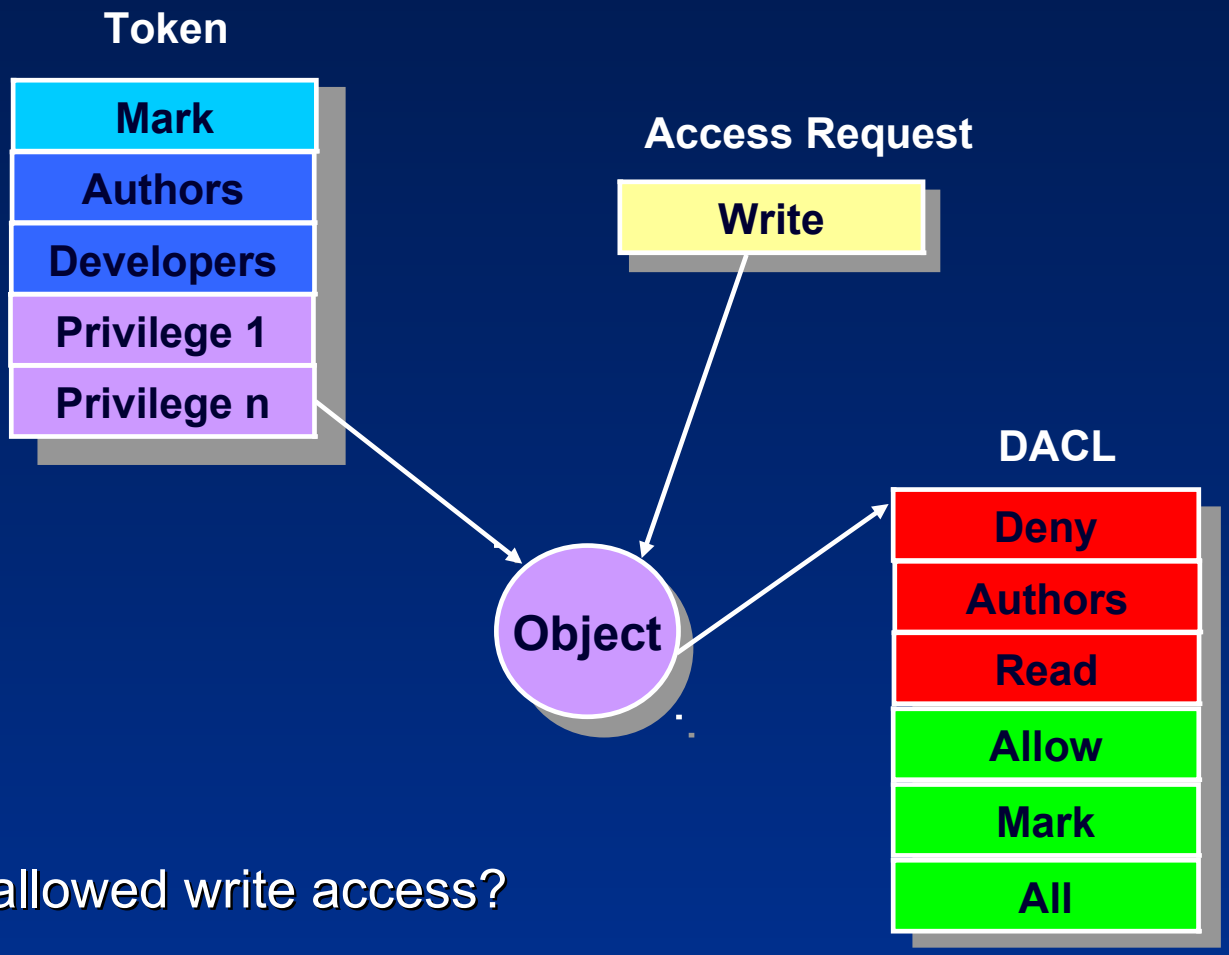
Example: Access granted



Example: Access denied



Access Check Quiz



Is Mark allowed write access?

yes

ACE Ordering

- The order of ACEs is important!
  - Low-level security APIs allow the creation of DACLs with ACEs in any order
  - All security editor interfaces and higher-level APIs order ACEs with denies before allows
- Example:

Access Special Cases

- An object's owner can always open an object with WRITE_DACL and READ_DACL permission
- An account with "take ownership" privilege can claim ownership of any object
- An account with backup privilege can open any file for reading
- An account with restore privilege can open any file for write access

Object-specific ACEs

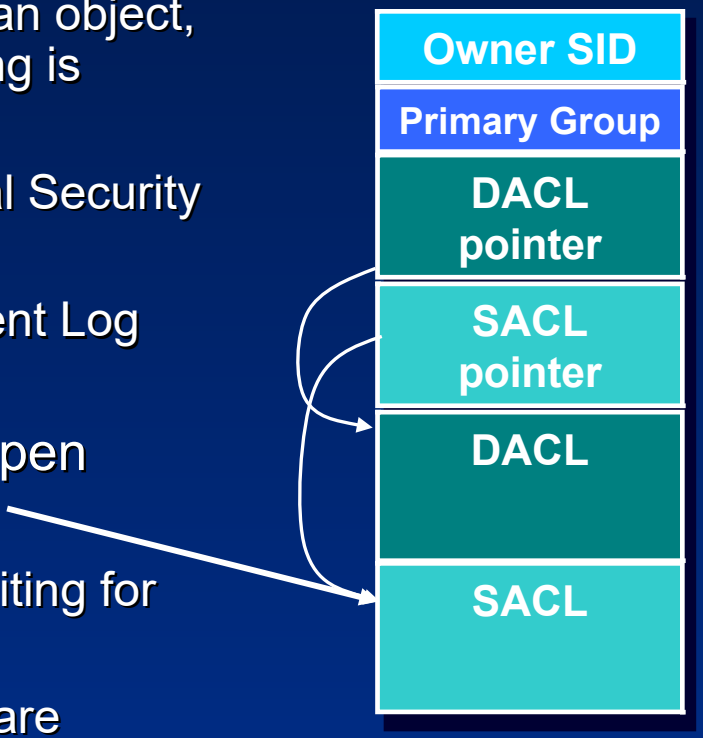
- Object-specific ACEs can be applied to Directory Services (DS) objects
  - They are just like ACES, but have two GUID fields
- The GUIDs allow the ACE to:
  - Control access to a property sheet or set on the object
  - Specify the type of child object that can inherit the ACE
  - Specify the type of child object for which the ACE grants or denies creation rights

Controllable Inheritance

- In NT 4.0, objects only inherit ACEs from a parent container (e.g. Registry key or directory) when they are created
  - No distinction made between inherited and non-inherited ACES
  - No prevention of inheritance
- In Windows 2000 and higher inheritance is controllable
  - SetNamedSecurityInfoEx and SetSecurityInfoEx
  - Will apply new inheritable ACEs to all child objects (subkeys, files)
  - Directly applied ACEs take precedence over inherited ACEs

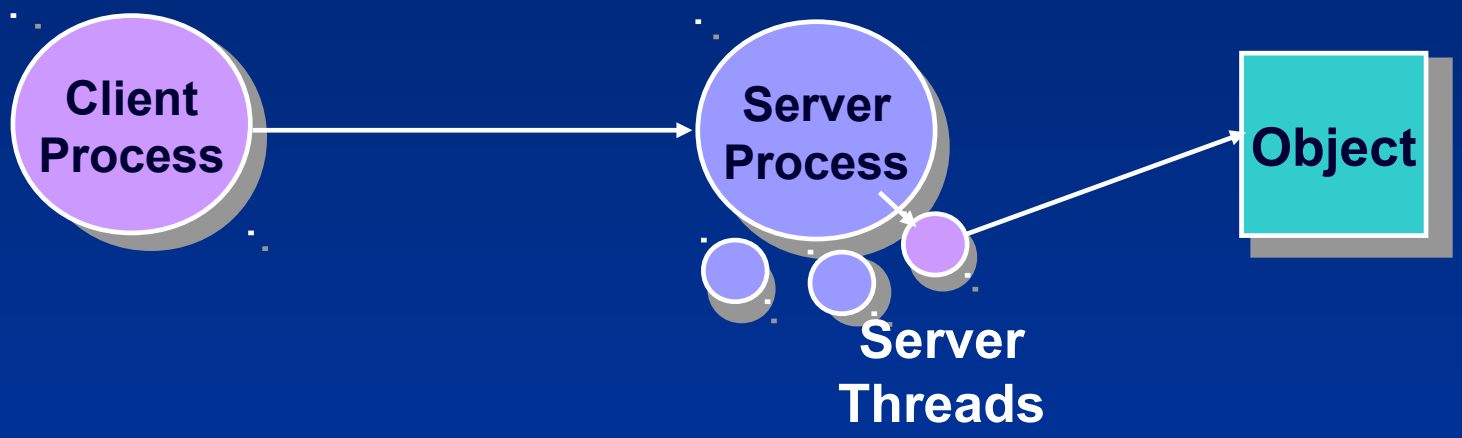
Auditing

- Provides for monitoring of accesses to objects
  - Even if you specify auditing information for an object, it won't result in audit records unless Auditing is enabled
  - An administrator can enable it with the Local Security Policy Editor (secpol.msc)
  - The security log can be viewed with the Event Log Viewer
- Like for DACLs, SACL check is made on open after access check
  - Audit check is performed only if system auditing for access check result is on
  - Only ACEs that match access check result are processed
  - Test is similar to DACL test, but a record is written if there is any match
- Demo: Explorer file auditing settings

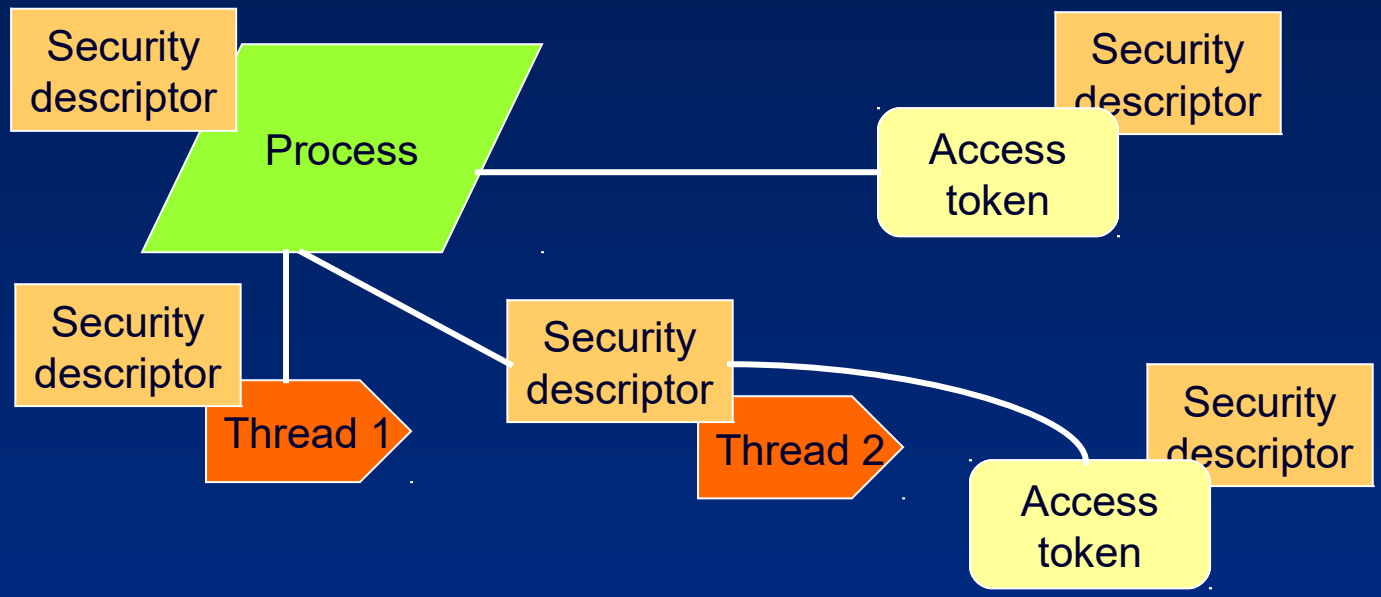


Impersonation

- Lets an application adopt the security profile of another user
  - Used by server applications
  - Impersonation is implemented at the thread level
    - The process token is the “primary token” and is always accessible
    - Each thread can be impersonating a different client
- Can impersonate with a number of client/server networking APIs – named pipes, RPC, DCOM



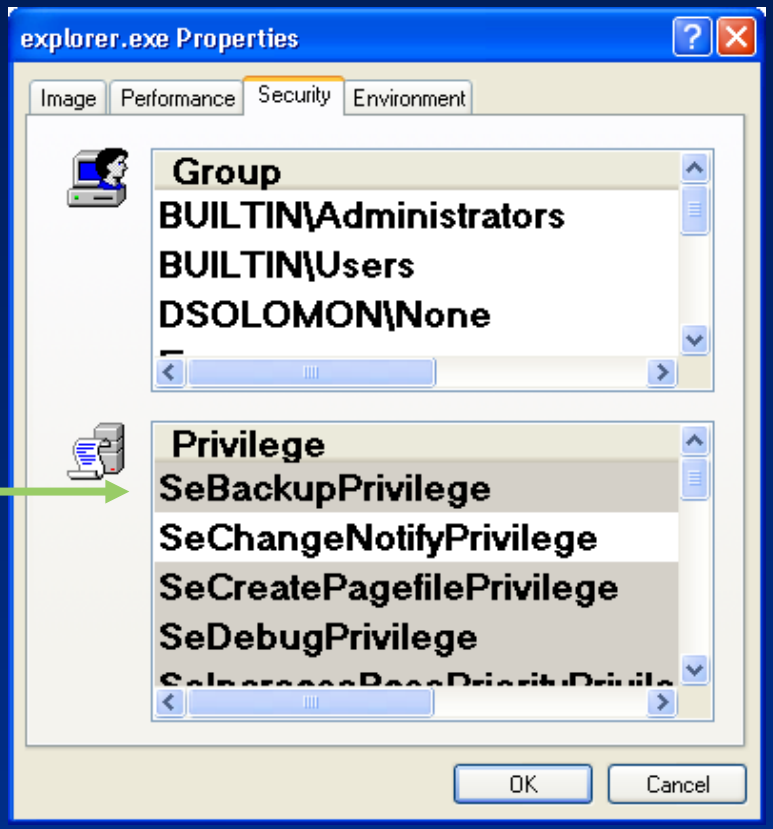
Process and Thread Security Structures



- Process/thread/access token objects have security descriptors
- Thread 2 has an impersonation token
- Thread 1 defaults to process access token

Privileges

- Specify which system actions a process (or thread) can perform
- Privileges are associated with groups and user accounts
  - There are sets of pre-defined privileges associated with built-in groups (e.g. System, Administrators)
- Examples include:
  - Backup/Restore
  - Shutdown
  - Debug
  - Take ownership
- Privileges are disabled by default and must be programmatically turned on with a system call



Powerful Privileges

- There are several privileges that gives an account that has them full control of a computer:
  - Debug: can open any process, including System processes to
    - Inject code
    - Modify code
    - Read sensitive data
  - Take Ownership: can access any object on the system
    - Replace system files
    - Change security
  - Restore: can replace any file
  - Load Driver
    - Drivers bypass all security
  - Create Token
    - Can spoof any user (locally)
    - Requires use of undocumented Windows API
  - Trusted Computer Base (Act as Part of Operating System)
    - Can create a new logon session with arbitrary SIDs in the token

Further Reading

- Pavel Yosifovich, Alex Ionescu, et al., “Windows Internals”, 7th Edition, Microsoft Press, 2017.
  - Chapter 6 – Security (from pp. 837)
    - Security descriptors and access control (from pp. 899)
    - Account rights and privileges (from pp. 924)

- Johnson M. Hart, “*Win32 System Programming: A Windows® 2000 Application Developer's Guide*”, 2nd Edition, Addison-Wesley, 2000.
  - Chapter 5, Securing Win32 objects (from pp. 111)