CS 419: Computer Security

Recitation: Project 1 Discussion

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Deadline: February 13, 2022

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Background: OS access control

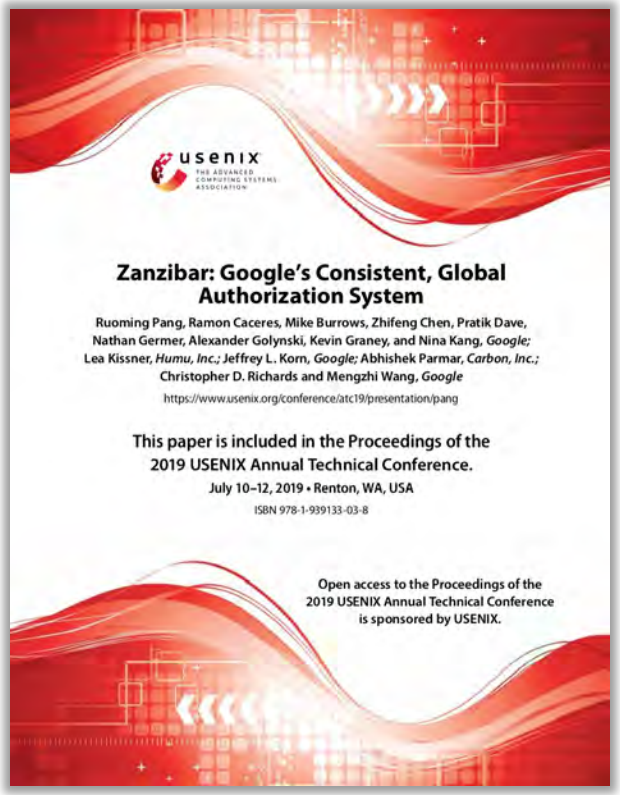
- **Operating systems have traditionally been responsible for enforcing access permissions**
- **Example: access control lists (ACL)**
  - An access control list stores access permissions as part of the metadata of the file (metadata also includes the owner, size, create/modification/access times, etc.)
- **Operating system checks whether a user (subject) is allowed to access a file (object) when the user's process opens a file**
  - Example: if you don't have read access to a file and try to open the file for reading, the *open* system call will fail (return -1)

Background: OS-based Access Control Problems

- **But this does not work for applications that manage their own users, like network services**
  - You may have an account on eBay but you don't have an account on any of eBay's computer systems
  - How does the service know what you should be allowed to do?
  - How do you log in?
- **It also does not work for application-aware operations**
  - An operating system controls *read*/*write*/*append*/*execute* permissions for files but does not know the meaning of the data
  - The operating system doesn't understand or manage application-specific actions
    - Are you allowed to delete an employee from a database?
    - Do you have rights to stream video content from a video server?

Background: What can be done?

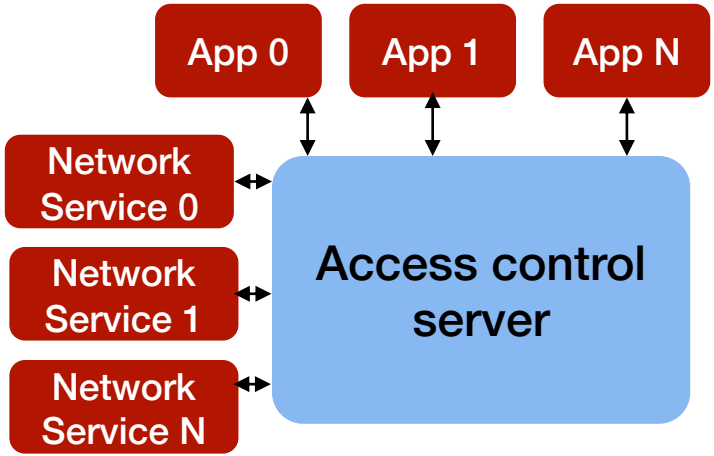
- **Applications end up managing their own authentication & access control**
  - Authentication for users that access services
  - Access control to decide who is allowed what access to an object
  - This risks introducing extra vulnerabilities: programmers can make implementation mistakes
- **In 2019, Google introduced Zanzibar**
  - A consistent authorization system for Google services world-wide
  - Applications can now use a single system to manage permissions



Project goals

The goal of this project is to build an authentication & access control service that any program can use so programmers will not have to write their own for each new application

- **Ideally, this would be a network service that could be shared among anyone who wants to use it**
- **For simplicity, we will write the service as one program**
  - It can easily be wrapped as a network service
- **All data will be persistent**
  - It will not be lost whenever a program is run



What the program does: (1)

Authentication

Manage users and passwords

- Check if a password matches a user account

What the program does: (2)

Access control

- *Manage access permissions*
- Define arbitrary operations on objects
  - They don't have to be only read/write/execute
  - They can be anything the service needs: *view*, *destroy*, *invert*, *hide*, …
- Access control is similar to the **type enforcement model**
  - Each **user** can be assigned one or more labels – called a **domain** ⇒ *user groups*
  - Each **object** can be assigned one or more labels – called a **type** ⇒ *object groups*
  - **Access control matrix** of domains and types: each cell contains access rights
- Access control answers the question:
  can domain D perform operation X on type T?

Domains	Types: Employee_data	Types: Videos	Types: Audio
Admin	read, write	read	read
Editor	read	download, write, delete	listen, delete
User		stream	stream

Your program

- **You will write a program named `auth`**
  - (either one that compiles to `auth` or one named `auth.class` or `auth.py`)
- **It is NOT interactive: all parameters are specified on the command line**

```
auth command sub-command arguments …
```

- **Output is text and will usually be one line that one of:**

```
Success
Error: error_text
```

- **Otherwise, the output is a list of items – one per line**
- **Don't be creative with output!**

Authentication

- **Create (user, password) data**
  - The command
    ```
    auth AddUser alice monkey
    ```
  - Will add a user named `alice` with a password `monkey`
    ```
    Success
    ```
- **Authenticate a password**
  - Check if the password belongs to user alice:
    ```
    $ auth Authenticate alice monkey
    Success
    $ auth Authenticate alice password
    Error: bad password
    ```

See the assignment writeup for details on error conditions

Implementation advice

Since the program exits after each command,
you will need to store the data in a file (or multiple files)

There are many, many ways to do this

- Multiple individual files in a directory structure
  - Example: `accounts/alice` will store the password for `alice`
- A single file with a user & password on each line (e.g., a comma-separated list):
  - Example: The file accounts can contain
    ```
    alice,monkey
    bob,password123
    ```
- Store one or more data structures in a serial format
  - Python pickle serialization, Python PyYAML, Java Serializable, Google Protobufs
- **Keep it simple!** (no encryption or hashing needed!)!
  - You can use an external library (e.g., to parse CSV data) but make sure it's included in your submission or it is available on the iLab systems
  - If any tools need to be compiled or built, include the build in a makefile or some make script

Domains

- **A domain is a grouping of subjects (users)**
  - A user may belong to multiple domains
  - You can think of a domain as an attribute of a user (they're often called labels)
  - Domains make access control management easier because the administrator does not have to think of individual users, just categories of users
- **Two commands manage domains:**

```
$ auth SetDomain alice admin
Success
```

  - Adds `alice` to the domain `admin`

```
$ auth DomainInfo admin
alice
```

  - Shows all the users in that domain – may be none
  - If there is no such domain then there are no users in it so list nothing

Domains – Implementation advice

- **You need to store a list of 0 or more domains**
- **Each domain will contain 1 or more users**
- **You don't need to delete domains or users in your implementation!**
- **As with user names, you may pick any storage structure that works for you**
- **One really simple implementation is to create a file per domain**
  - Example: the file `domains/admin` can contain a list of users, one per line

Types

- **A type is a grouping of objects (e.g., files or application-specific items)**
  - An object may have multiple types associated with it
  - As with domains, you can think of a type as an attribute of an object
- **Like domains, types make access control management easier because the administrator does not have to think of individual objects, just categories**
- **Two commands:**

```
$ auth SetType mulan.mp4 videos
Success
```

  - Adds `mulan.mp4` to the domain `videos`

```
$ auth TypeInfo videos
mulan.mp4
```

  - Shows all the objects in the given type – there may be none (empty list)
  - If there is no such type then there are no objects in it so list nothing

Types – Implementation advice

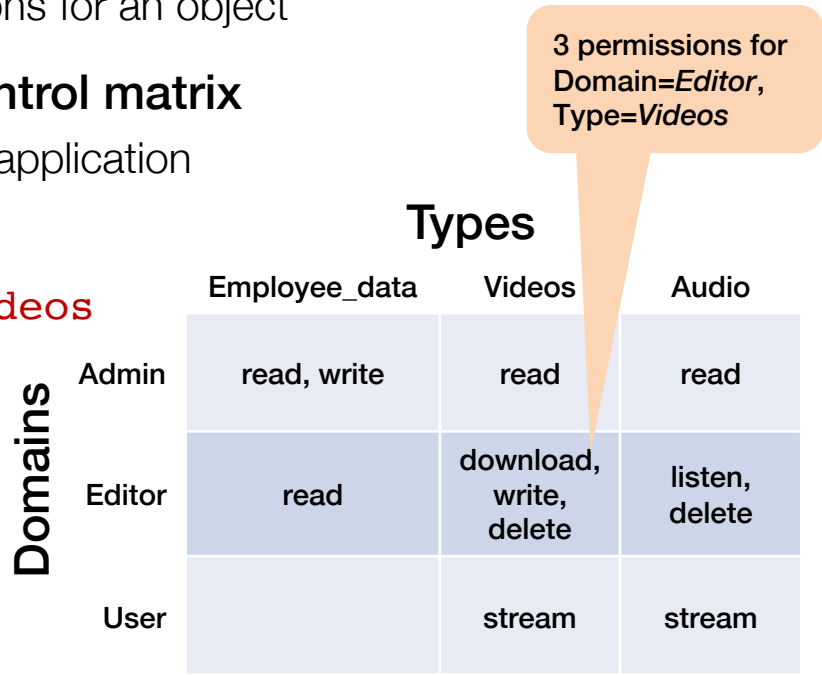
- **The implementation of types is *exactly* the same as domains!**

Access

- **The core of the service is:**
  - Add a permission for a domain to an object
  - Deciding whether a user has specific permissions for an object
- **Access control is (logically) an access control matrix**
  - Permissions can be ANY string – it's up to the application
- **Example**

```
$ auth AddAccess download Editor Videos
Success
```

  - Adds `download` permission for the set of objects in `Videos` to the domain `Editor`



Access checking

- **Example**

```
$ auth CanAccess download alice mulan.mp4
Success
```

  - Tests if the operation "`download`" is permitted for user "`alice`" on the object "`mulan.mp4`"
  - This means there must exist some ***domain*** that `alice` is a member of that has a "`download`" operation for some ***type*** of which `mulan.mp4` is a member

Domains \ Types	Employee_data	Videos	Audio
Admin	read, write	read	read
Editor	read	download, write, delete	listen, delete
User		stream	stream

Access checking

- **We can check if a user has access on an object by iterating over domains and types:**

```
for d in domains(user)
    for t in types(object)
        if access[d][t] contains operation
            return true
return false
```

Types

Domains	Employee_data	Videos	Audio
Admin	read, write	read	read
Editor	read	download, write, delete	listen, delete
User		stream	stream

Access implementation

- **You will need to think about how to store the access matrix**
  - Spend some time thinking so your coding will be simple!
- **A two-dimensional structure is simple if you store the matrix as a serialized object (e.g., JSON, Java serialization, etc.)**
- **If you want to use files, you can create a directory hierarchy where each** `domain_name/type_name` **file contains a list of allowable operations for that (*domain*, *type*)**

Incremental development

- **This program can be developed incrementally!**
- **Start with user authentication: get that to work**
- **Then implement domains (adding, listing)**
- **Test thoroughly!**
  - You should be able to handle hundreds of users and domains
  - Test for null users and null domains
- **Copy your domains code to handle types**
- **Only then … add access (AddAccess, CanAccess)**

Partial credit

- **You will get no credit if nothing works … even if you wrote a lot of code**
  - That's why incremental development & testing is important!
- **Credit**
  - Authentication: 25%
  - Domains & Types: 25%
  - Access management: 50%
- **You will lose points for**
  - Not conforming to the interface
    - We do not have time to figure out how to run your program!
  - Not providing clear instructions on how to compile and run your program
    - We will not have time to figure this out – test by having a friend follow your instructions
  - Not working in a different environment (e.g., using full pathnames)
  - Not handling errors (including checking # of parameters)

The End