File System Interface

File Attributes: properties that files tend to have:

- **Name**: symbolic file-name, in human-readable form.
- **Identifier:** unique identifier identifying filewithin file-system.
- **Type:** Types of file (directory, data, etc.)
- **Location:** Physical location (e.g., HDD, SSD, etc.)
- **Size:** Current, maximum file-size.
- **Protection:** Access control information
- **Time, Data, User ID:** Data for usage monitoring, security etc.

Links:

- A single file can have *multiple* names.
- **Hardlink:** Refernce to a file whose refernce count is maintained.
    - Deleting file, and accessing *hardlink* will *not* lead to error.
    - Deleted-file memory is *not* de-allocated unless all *hardlinks* are removed.
- **Symlink:** Reference to a file whose reference count is *not* maintained.
    - Deleting file, and accessing *symlink* will lead to error.

File Operations:

- Commonly supported file-operations.
- Many resemble *memory operations* since file-system is a *memory-mapping* of physical data.
- Operations resemble operations on *nodes* of a *tree*

- Operations:
    - **Create:** Creating a new file, allocating memory, putting in proper directory.
    - **Read:** Requires file-name/identifier to see where next file-block should be put in main-memory (using a *pointer*).
    - **Write:** Requires file-name/identifier to see where the write happens within file (using a *pointer*)
    - **Delete:** Find the file, de-allocate space, remove it from directory listing.
    - **Repositiong Access:** Read, Write pointer might be the same; it may be 'moved around' or repositioned.
    - **Truncating:** Deleting the file contents, maintain meta-data.

File Opening

- Each process maintains *Open-File* table
- *Open-File* table contains reference to elements in *Global Open-File table*
- *Global Open-File table* keeps track of reference count
    - File memory cannot be de-allocated (even after *deletion*) unless refernce count is zero
    - Reference count *incremented* when file is *opened* by a process
    - Reference count decreased when file is *closed,* or process *ends*

File Deletion

- Simply *removes* file-entry from directory-listing.
- Modern OSes will move file to *special location* (*i.e.* recycle bin etc.)
- File-memory may not be de-allocate unless *Hardlinks* are removed.

Directories:

- Special files storing mapping of directory-entry *identifiers* to *file-names.*
- Support some common operations:
  - **Search:** Searching for a file/entry within directory.
  - **Add File:** Storing new files into directory.
  - **Remove File:** Removing files from the directory
  - **List Entries:** Return a list of directory-entries.
  - **Rename File:** Rename a file-name given the *identifier.*
  - **Navigate Sub/Parent Directories:** Allow accessing children-directories, parent-directories.

File-Permissions: Control various types of file access.

- **UNIX Style:**
  - Permissions represented using 10 bits in form: `d rwx rwx rwx`
  - **1st Bit:** represents whether file is a *directory*
  - **2nd to 4th Bits:** Read, Write, Execute permissions for *Owner.*
  - **5th to 7th Bits:** Read, Write, Execute permissions for *Group.*
  - **8th to 10th Bits:** Read, Write, Execute permissions for *Everyone.*
  - *e.g.* `-rwx-r-----` means:
    - File is *not* a directory
    - *Owner* has read, write, and execute permissions
    - *Group* has read permission
    - *Everyone* else has *no* permissions.
  - Last *9 bits* can be represented in **Octal**:
    - Put *r = 4, w = 2, x = 1* and sum to get octal representation of each 3-bit group.
- **Access Control Lists:**
  - Tuples of <*user_name, permission*>
  - **Default Deny:** Requires explicit allowing to allow accessing.
  - **Default Allow:** Requires explicit denying to prevent access.
  - **Inheritnce:**
    - Files in a directory *inherit* the parent's list
    - Files *moved into* the directory maintain their *original* list.
      - *Explicit* change to current directory's list required.

.