File-System

Directories in Linux

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Directories

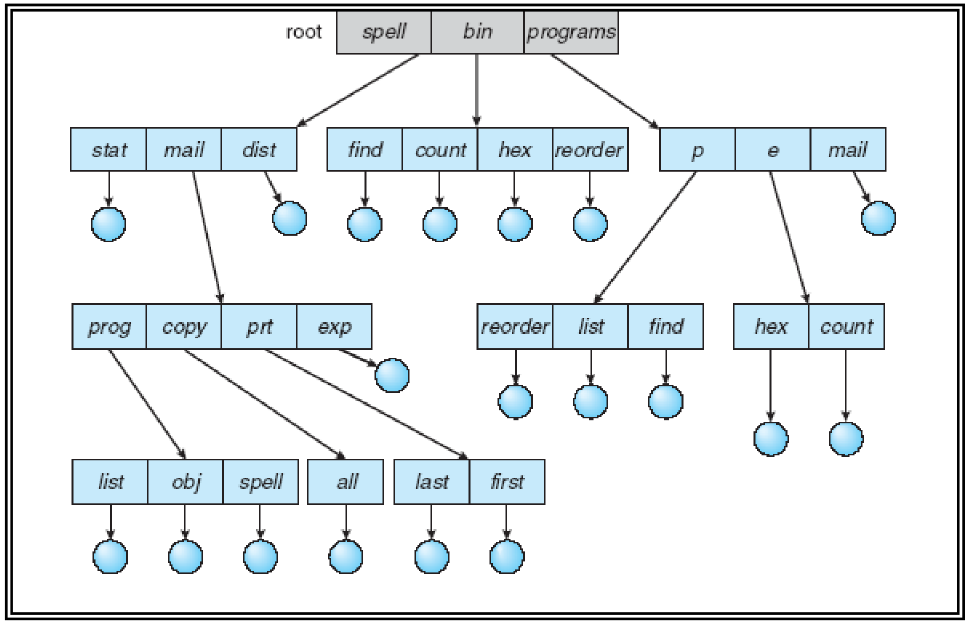
- Modern file systems are structured by means of special files: the directories
  - A directory is the node of a tree, or the vertex of a graph that includes some information about the (regular) files that it contains.
  - Directories and files are stored in the mass memory
- Operations that can be performed on directories are similar to the ones applied to files
  - Creation, deletion, listing, rename, visit, search, etc.

Structure

- Structuring a file systems by means of directories has several advantages:
  - Efficiency
    - Searching a file
  - Naming
    - Simplicity for a user to identify his files
      - The same name can be assigned to different files
  - Grouping (organization)
    - Grouping to the programs and data according to their characteristics
      - Editors, compilers, documents, etc.

Directory tree

- Directories and files are organized as a tree
  - Every node/vertex of the tree can include other nodes/vertex of the tree



Tree directories

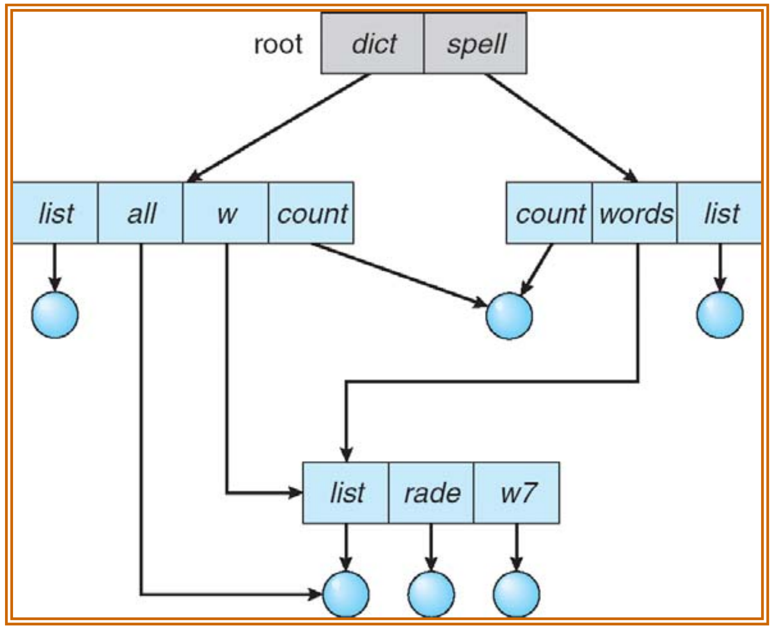
- Tree directories imply:
  - Current work directory, change of directory, absolute and relative path name, etc.
- Performance
  - Efficiency
    - Efficient search
  - Naming
    - With absolute path or relative to the current working directory
  - Grouping
    - Flexible

Acyclic graph directories

- A tree file system does not allow **sharing**
- It is often useful to refer to the same object in the file system with different filenames
  - Same user refers to an object with different pathnames
  - Different users want to share objects
  - It is worth noting that duplication of the object is not a solution because of
    - Increase of file system occupation
    - Possible information incoherence in one or more copies

Acyclic graph directories

- Tree file systems can be generalized organizing them as acyclic graphs.



Acyclic graph directories

- Performance
  - Similar to tree directories, but with possibility of sharing
- Method
  - A directory entry can be share by means of the creation of la **link**
    - A link is a reference (pointer) to another pre-existing entry

Acyclic graph directories

- More complex filesystem management due to links
  - File system visit
    - If the entry is a link, follow the indirect link to reach the pointed-to entry
    - Many absolute paths, and different filenames may correspond to the same entry
      - File system analysis (statistics, e.g., how many files with extension "**`.c`**" exist?) are more complex

Acyclic graph directories

- Removing an entry)
  - Immediate deletion of the data
    - Some dangling links may remain
    - Attempt accessing data through a link could return a missing file error
  - Remove the data when the last link is removed
    - Avoids dangling links
    - Need to manage multiple links
      - Keeping the list of all link is expensive (variable length list)
      - Removing all links is expensive (need to search)
      - Search is more expensive
    - It is more effective to store a link counter associated to the data (for the hard links in UNIX the counter is stored in a field of the inode)

Acyclic graph directories

- Creating a new link to a directory could cause the generation of a cycle in the file system
  - Managing a cyclic graph is more complex
    - Search and visit has to avoid infinite recursion
  - The simplest strategy avoid visiting the links
  - Cycles can be avoided if the creation of a link to a directory is forbidden