Networking through Linux

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Outline

- Some network related data structures
- Networking in Linux

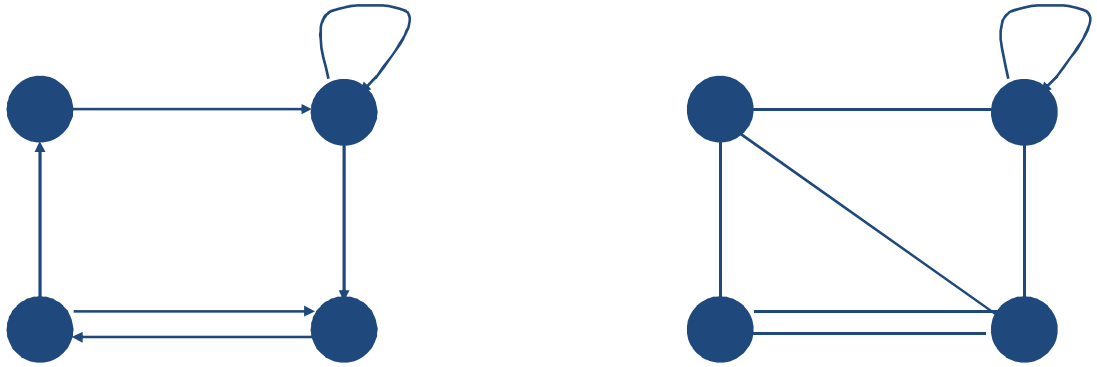
What is a graph?

What is a tree?

Graphs

A graph *G* is a pair of two sets *(V, E)*

V = a finite set of vertices in *G.*
E = a binary relation on *V*, or
an unordered pair of vertices.



What is the degree of vertex 4?

Are all vertices reachable from a given vertex?

What is a multi-graph?

What is a hyper-graph?

Trees

Let *G* = (*V, E*) be an undirected graph. Any one of the following statements define a tree.

- *G* is a tree.
- Any two vertices in *G* are connected by a simple path.
- *G* is connected, but if any edge is removed from *E*, the resulting graph is disconnected.
- *G* is connected, and |E| = |V| - 1.
- *G* is acyclic, and |E| = |V| - 1.
- *G* is acyclic but if any edge is added to *E*, the resulting graph contains a cycle.

Binary trees

Binary tree *T* is a structured tree defined on a finite set of nodes that either:

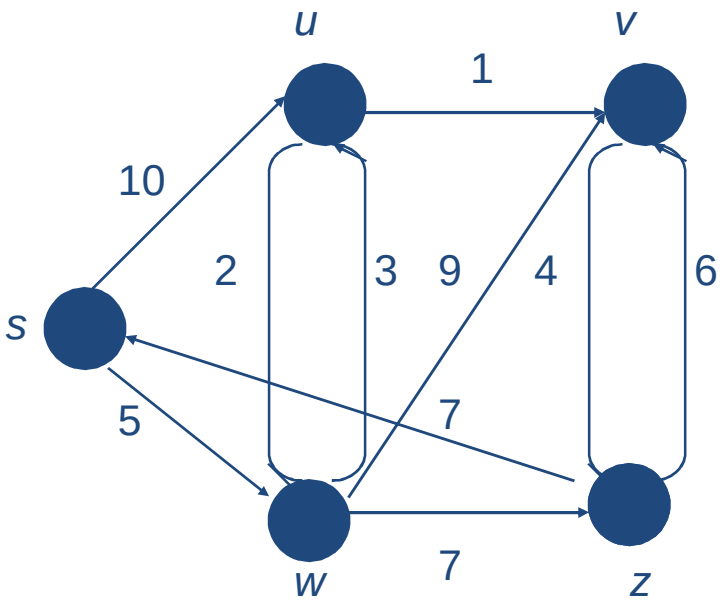
- contains no nodes, or
- is comprised of three disjoint sets of nodes: a root node, a binary tree called its left sub-tree, and a binary tree called its right subtree.

Examples?

What is Binary search?

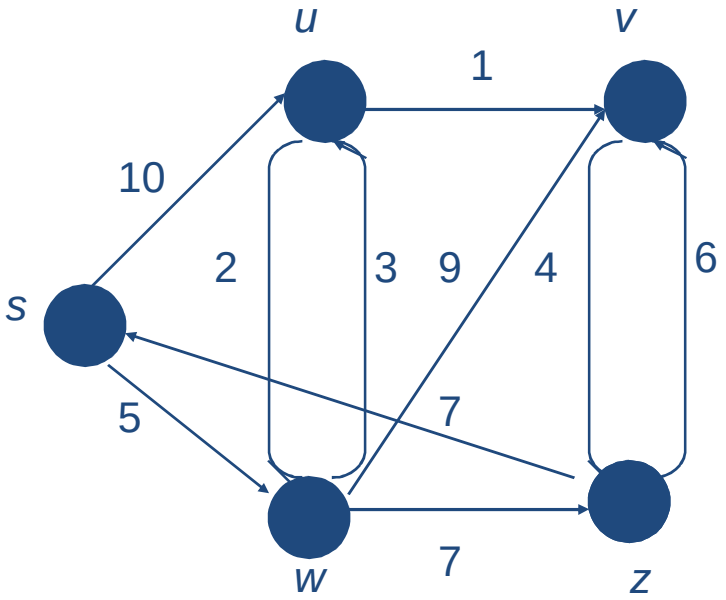
Shortest Path: Dijsktra's algorithm

• Solves the single-source shortest-path problem on a weighted, directed graph G = (V, E) where all edge weights are non-negative.



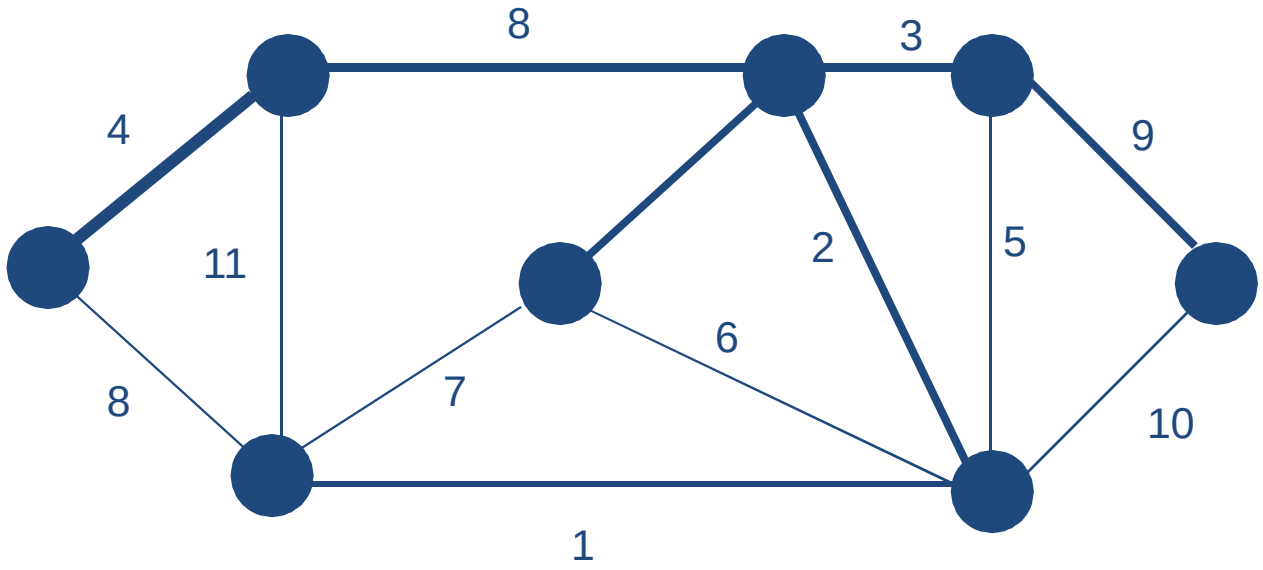
Find shortest-path from *s* to *v*

Shortest Path



1. Data structure: d[v] for v in V, a variable D.
2. Initialize d[v] to infinity.
3. Find immediate successors of *s*, and set d[] for all successors.
4. Select the successor of minimum d[] value.
5. Continue the same for the next set of successors, until you reach *v.*

Minimum Spanning Tree



UNIX volume structure

- Boot block: contains code required to boot the operating system
- Superblock: Contains attributes and information about the file system, such as partition size and inode table size
- Inode table: The collection of inodes for each file
- Data blocks: Storage space available for data files and subdirectories

File allocation

- File allocation done on a block basis
- Allocation is dynamic
- An indexed method is used to keep track of each file, with part of index stored in the inode
- Inode includes 39 bytes of address information organized as thirteen 3-byte addresses or pointers
- First 10 addresses points to the first 10 data blocks of the file
- what if the file is longer than 10 blocks?

File allocation

- Eleventh address in the inode points to a block on disk that contains the next portion of the index (1st level of indirection)

- If the file is longer, twelfth address points to a double indirect block. This block contains a list of addresses of additional single indirect blocks. Each of the single indirect blocks, in turn, contains points, contains pointers to file blocks.

- if the file is still longer?

File capacity

- Direct — 10 blocks
- Single indirect — 256 blocks
- Double indirect — 256 x 256 blocks
- Triple indirect — 256 x 256 x 256 blocks

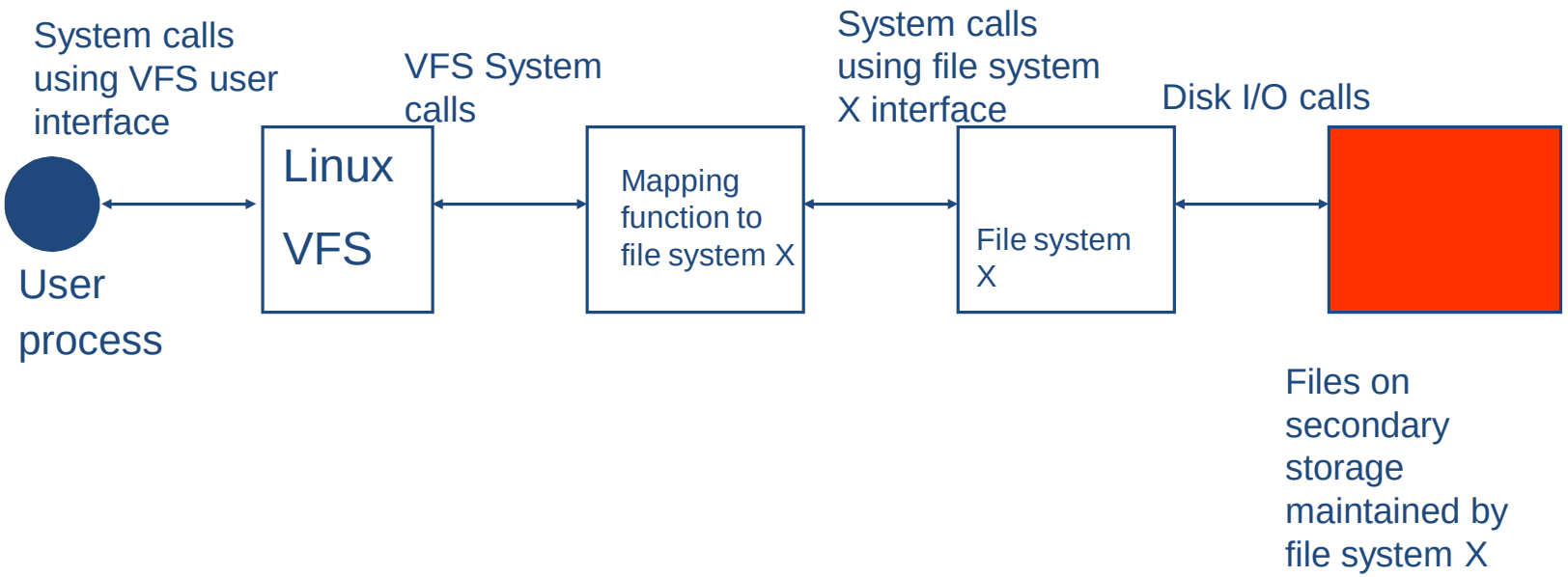
- Maximum file size = 16 G (block size = 1 k)

Advantages of this file system?

1. The inode is of fixed size and relatively small and hence may be kept in main memory for longer time.
2. Smaller files may be accessed may be accessed with little or no indirection, reducing processing and disk access time.
3. Theoretical maximum size of a file is large enough.

Linux Virtual File System

- Linux includes a versatile and powerful handling facility, designed to support a wide variety of file management systems and file structures
- VFS presents a single, uniform file system interface to user processes.
- VFS defines a common fileodel that is capable of representing any file system's general feature and behaviour



Client-Server computing

Sockets

- a socket is an endpoint in a communication
- concept of sockets and socket programming developed in 1980s in Unix
- a socket enables communication between a client and server process
- may be either connection-oriented or connectionless
- a client socket in one computer uses an address to call a server socket on another computer.
- computers with server sockets keep a UDP or TCP port open, ready for unscheduled calls.
- client determines the socket identification of the desired server by finding it in a DNS database. Once a connection is made, the server switches the dialogue to different port. Why?
- TELNET and rlogin make use of sockets.

Sockets

- Sockets can be constructed from within a program.
- Port value identifies the respective applications of the two TCP entities.
- Port value + IP address forms a socket (unique in the Internet).
- An application might have multiple socket addresses, one for each port into the application.
- socket() call returns an integer result that identifies this socket.

Socket connection

- server side of a connection setup requires two steps
  - a server application issues a listen(), indicating the given socket is ready to accept incoming connections.
  - Each incoming connection is placed in this queue until a matching accept() is issued by the server side. accept() call removes one entry from the queue.
  - if there is a waiting call, then accept() returns a new *fd* for the connection.
  - This creates a new socket which has the port number and IP address of the remote party, the IP address of this system, and a new port number.
  - A new socket with a new port number is assigned to allow the local application to create new requests. An application may thus have a multiple connections active at any time.
  - client application issues a connect() that specifies both local socket and a remote socket.

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