

Distributed System: Structures

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Update: April 20, 2020

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1 Motivations

- distributed system is a collection of loosely coupled processors interconnected by a communication network
- processors are also known as nodes, computers, machines, hosts
- site is the location of the processor
- reasons
 - resource sharing (e.g. Google File System)
 - computation speed-up (load sharing, e.g. Map-Reduce, Spark)
 - reliability (fault tolerance, e.g. Raft, paxos)
 - communication (message passing)

2 Tightly / Loosely?

- tightly: two CPU share the same memory
 - a.k.a. coherent shared memory
 - easy to program
 - hard to scale
- loosely: one CPU uses its local memory
 - a.k.a. distributed memory
 - hard to program
 - easy to scale

3 Basic Performance Metrics

- workload (W) = number of ops required to complete the program
- T_p = execution time using P processors
- speed = W / T_p
- speedup (S) = T_1 / T_p
- efficiency = S / P
- general agreement: speed up = serial time / parallel time

4 Types of Distributed Operating Systems

- note the difference between "distributed system" and "distributed operating system"
- network operating systems
 - access to resource is done by remote access
- distributed operating systems
 - more advanced
 - appear to user as a single machine, user not aware that there're multiple machines
 - data migration
 - computation migration
 - process migration
 - e.g. LegoOS

5 Network Structure

5.1 Local-Area Network

- fast, Gbps or faster nowadays
- broadcast is fast and cheap
- usually workstations + 1/2 mainframe

5.1.1 Bus Topology

- stations send information on bus (linear medium)
- data are broadcast
- need to regulate transmission
 - avoid collision: overlap signal become garbage
 - avoid starvation: transmit in small blocks
- in fact, we do not use such topology in modern network, usually we connect each computer to a switch

5.1.2 Ring Topology

- not commonly used in LAN too
- repeaters joined by point-to-point links in closed loop
- like daisy chain

5.1.3 Star Topology

- each station connected directly to central node
- most of us use this topology

5.2 Wide-Area Network

- p2p connection over long-haul lines
- communication processor (router) inside communication subsystem

5.2.1 Network Topology

- installation cost
- communication cost
- reliability
- fully-connected, partially-connected, tree-structured, star, ring

5.2.2 Communication Structure

- naming and name resolution
 - name system
 - message with process id
 - identify by hostname, identifier
 - DNS
 - OSI 7-layer model
 - different naming system in different layer
- routing strategies
 - fixed routing
 - virtual circuit
 - dynamic routing
- connection strategies
 - circuit switching
 - message switching
 - packet switching
- contention
 - CSMA/CD
 - carrier sense with multiple access (CSMA)

- collision detection (CD)
- token passing
- message slots
- TCP congestion control

5.2.3 Communication Protocol

- physical layer (electric details, bit stream)
- data-link layer (handle frames, e.g. PPPoE, Ethernet)
- network layer (packets, IP, IPsec, ICMP)
- transport layer (TCP, UDP)
- session layer
- presentation layer (SSL, TLS)
- application layer (HTTP, FTP)

5.2.4 Failure Detection

- detecting hardware failure is difficult