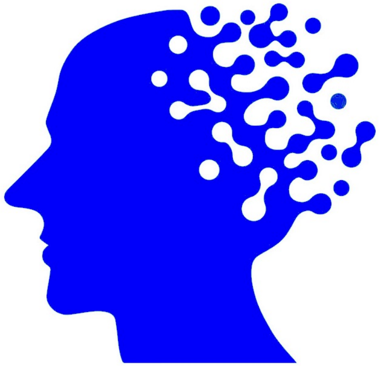
Spring 2023



Distributed Computing

- Basic Primitive Operations

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> Distributed Computing?

- How will you design a Distributed Algorithm?

- Learn to Solve using Distributed Algorithms

Overview

> About this Lecture

What do we learn today?

- This covers a model of distributed computations that every algorithm designer needs to know

  - **Challenges and Goals**
  - **A model of distributed executions**

with an application to

  - **Distributed Sorting on a line network**

Let us explore these topics → → →

Today's Focus

Recap: Distributed Systems

A Distributed System:

- A collection of independent systems that appears to its users as a single coherent system
- A system in which hardware and software components of networked computers communicate and coordinate their activity only by passing messages
- A computing platform built with many computers that:
  - Operate concurrently
  - Are physically distributed (have their own failure modes)
  - Are linked by a network
  - Have independent clocks

Recap: Characteristics

- Concurrent execution of processes:
  - Non-determinism, Race Conditions, Synchronization, Deadlocks, and so on
- No global clock
  - Coordination is done by message exchange
  - No Single Global notion of the correct time
- No global state
  - No Process has a knowledge of the current global state of the system
- Units may fail independently
  - Network Faults may isolate computers that are still running
  - System Failures may not be immediately known

Challenges and Goals of Distributed Systems

Challenges / Goals of DS

What are the challenges / goals of distributed systems?

- → Heterogeneity
- → Openness
- → Security
- → Scalability
- → Failure Handling
- → Concurrency
- → Transparency

Heterogeneity

Heterogeneity (= the property of consisting of different parts) applies to:

- Networks, Computers, Operating Systems, Languages, and so on
- Data types, such as integers, may be represented differently
- Application program interfaces may differ

Middleware: a software layer that provides a programming abstraction to mask the heterogeneity of the underlying platforms (networks, languages, H/W, ...)

- E.g. Java RMI

Openness

Each system is open to interaction with other systems

→Key software interfaces are made publicly available.

→E.g. Web services to support interoperable machine to machine interaction over a network

Properties:

- Once something is published, cannot be taken back
- No central arbiter of truth - different subsystems have their own
- Unbounded non-determinism: The amount of delay in servicing a request can become unbounded, still guaranteeing - requests will eventually be serviced

Security

Three aspects:

- ➔ Confidentiality (Protection against disclosure to unauthorised individuals)
- ➔ Integration (protection against alteration or corruption)
- ➔ Availability (protection against interference with the means to access the resources)

Encryption Techniques (Cryptography) answer some of the challenges:

- ➔ Denial of Service (DoS) Attacks: A service is bombarded by a large number of pointless requests

Scalability

When a system is said to be scalable?

If the system remains effective, without disproportional performance loss, when there is an increase in the number of resources, the number of users, or the amount of input data

- ➔ Factors: load, geographical distribution, number of different organizations and so on

Challenges:

- ➔ Control the cost of physical resources & performance loss
- ➔ Prevent software resources running out
- ➔ Avoid performance bottlenecks: use caching, replication

Fault-Tolerance

Some Components may fail while others continue executing

We need to:

- ➔ Detect failures: use checksums to detect corrupted data
- ➔ Mask failures: retransmit a message when it failed to arrive
- ➔ Tolerate failures: do not keep trying to contact a web server if there is no response
- ➔ Recover from failures: make sure that the state of permanent data can be recovered
- ➔ Build redundancy: Data may be replicated to ensure continuing access

Concurrency

- Several clients may attempt to access a shared resource at the same time
- Requires proper synchronisation to make sure that data remains consistent

- Lot more to learn about this in DC … !!

Transparency

Any distributed system appears and functions as a normal centralized system … e.g, DeepBLUE system (30 nodes system)

- ➔ Access transparency: resources are accessed in a single, uniform way
- ➔ Location transparency: users should not be aware of where a resource is physically located
- ➔ Concurrency transparency: multiple users may compete for and share a single resource: this should not be apparent to them
- ➔ Replication transparency: even if a resource is replicated, it should appear to the user as a single resource (without knowledge of the replicas)
- ➔ Failure transparency: always try to hide any faults
- ➔ And more: mobility, performance, scaling, persistence, security, etc

Applications

- Mobile Systems
- Sensor networks
- Pervasive Computing
  - Smart workplace
  - Intelligent Home
- Peer-to-peer computing
- Distributed Agents
- Distributed Data Mining
- Grid Computing
- Security aspects in Distributed Systems

Summary

Focused on exploring the following:

- Goals and Challenges of DS
  - Fundamental aspects while building distributed applications
- A Model of Distributed Computations
  - Primitives of Distributed Communications
    - Message Passing is the main focus
  - Properties of distributed Computations
  - Events and their ordering
    - How to handle Causal Precedence ?
    - Lamport's Logical Clocks ?
    - Many more to come up … stay tuned in !!

Penalties

- Every Student is expected to strictly follow a fair Academic Code of Conduct to avoid penalties

- Penalties is heavy for those who involve in:
  - Copy and Pasting the code
  - Plagiarism (copied from your neighbor or friend - in this case, both will get "0" marks for that specific take home assignments)
  - If the candidate is unable to explain his own solution, it would be considered as a "copied case"!!
  - Any other unfair means of completing the assignments

Help among Yourselves?

- **Perspective Students** (having CGPA above 8.5 and above)
- **Promising Students** (having CGPA above 6.5 and less than 8.5)
- **Needy Students** (having CGPA less than 6.5)
  - Can the above group help these students? (Your work will also be rewarded)
- You may grow a culture of **collaborative learning** by helping the needy students

How to reach me?

- Please leave me an email:

  rajendra [DOT] prasath [AT] iiits [DOT] in

- Visit my homepage @
  - https://www.iiits.ac.in/people/regular-faculty/dr-rajendra-prasath/

(OR)

  - http://rajendra.2power3.com

Assistance

- You may post your questions to me at any time
- You may meet me in person on available time or with an appointment
- You may ask for one-to-one meeting

Best Approach

- You may leave me an email any time
  (email is the best way to reach me faster)

Questions

It's Your Time

Contact Information

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