Network Computing and Efficient Algorithms
Topic 2: Distributed Computing Introduction

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Distributed Computing and Distributed System

- **The Rise of Distributed Systems**
    - Computer hardware prices are falling and power increasing.
    - Network connectivity is increasing.
    - It is easy to connect hardware together.

- **Distributed System** - hardware or software components located at networked computers communicate and coordinate their actions only by message passing.
  Distributed System = Distributed hardware + Distributed control + Distributed data

- **Distributed Computing** - a field of computer science that studies distributed systems. Its a kind of science that divides the engineering data which needs a lot of calculation into small pieces, calculates by several computers separately, and unifies the results to get the data conclusion after uploading the calculation results.

Characterizing Distributed Systems

- **Multiple Autonomous Computers**
  - Each consisting of CPUs, local memory, stable storage, I/O paths connecting to the environment
  - Geographically Distributed
- **Interconnections**
  - some I/O paths interconnect computers that talk to each other
- **Shared State**
  - systems cooperate to maintain shared state
  - maintaining global invariants requires correct and coordinated operation of multiple computers.

Parallel and distributed computing

"concurrent computing", "parallel computing", and "distributed computing" have a lot of overlaps.
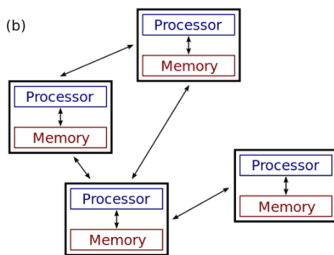

Figure: **a distributed system**
In distributed computing, **each processor has its own private memory (distributed memory).** Information is exchanged by passing messages between the processors
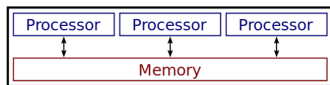

Figure: **a parallel system**
In parallel computing, **all processors may have access to a shared memory** to exchange information between processors.

The History Of Distributed Computing

1960s

- Mainframe IBM System/360
  - Communication is rare
  - Perform large computation/processing
- Study of concurrent process
- ARPANET 1969
  - BBN Technologies
  - Earliest example of Distributed Computing
  - Predecessor of the Internet

The History Of Distributed Computing

1970s

- ARPANET email
  - Pioneer large scale distributed application
  - Most success apps for ARPANET
- Local-area Network - Ethernet
- DCS (Distributed Computing System)
  - Create system that interconnect minicomputers
  - Provide resource sharing, fault tolerant
  - Put in operation at 1973
- Creeper & Reaper - 1971
  - 1st distributed computing programs
  - 1st computer virus

The History Of Distributed Computing

1980s

- Internet, Fidonet, Usenet started to explode
- University & Research Insititude branched out DC as own branch
- Symposium on Principles of Distributed Computing (PODC) 1982 & International Symposium on Distributed Computing (DISC) 1985
- Parallel architectures & message passing interface
- DEC System Research Center - 1988
- 1st distributed computing project

The History Of Distributed Computing

1990s - Present

- Distribute.net - 1997
  - 1st project that use internet to distribute data
  - User download program instead of email
- Advanced in technology
  - Grid architecture
  - Web-Services
  - Cloud computing
- Google optimize search algorithm through DC message passing interface
- SETI@Home
  - Popularized DC
  - Analyze radio signals
  - Prove that DC works
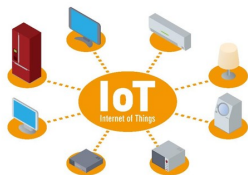
Current Trends Of Distributed Computing

Grid Computing

- **Allow variety of geographically distributed resources to be shared and aggregate**

- **Grid Broker:**
  - Negotiate for access costs
  - Schedule, deploy tasks and collect final results

- **Benefits:**
  - Transparent
  - On-demand access
  - Improved productivity
  - Extra resources to solve problem

- **Example:**
  - Financial Organization - Collaboration for computational power
  - Online Multiplayer Game - Dedicated game server in various country
  - Weather Forecasting - Require high data and computational power

Current Trends Of Distributed Computing

Mobile & Ubiquitous Computing

- **Mobile computing enable:**
  - Use of a computing device even though they are moving around
  - Can continue access the resources in their home such as printers.

- **Known as location-aware/context-aware computing**

- **Ubiquitous computing:**
  - new genre of DC that permeates user's life
  - Enable devices and computers become helpful but invisible force to fulfilled user needs
  - Example: remotely control appliances in home through user smart phone. The appliances will notify the user when job done

Current Trends Of Distributed Computing

Cloud Computing
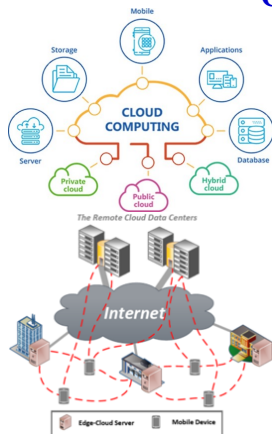
- **A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources**
- **Clustering a set of computers to provide the scale and performance for cloud**
- **Benefits:**
    - Flexible and storage of resources
    - Allow wide range of resource sharing
- **Advantages (for organizations):**
    - Flexible response
    - Reliability
    - Cost reduction
- **A new paradigm: Edge Computing,** which deploys computing resources close to users and data source.