Evolution of Distributed Computing
Scalable Computing over Internet

Kai Hwang, Geoffery C. Fox and Jack J. Dongarra, “Distributed and Cloud Computing: Clusters, Grids, Clouds and the Future of Internet”, First Edition, Morgan Kaufman Publisher, an Imprint of Elsevier, 2012

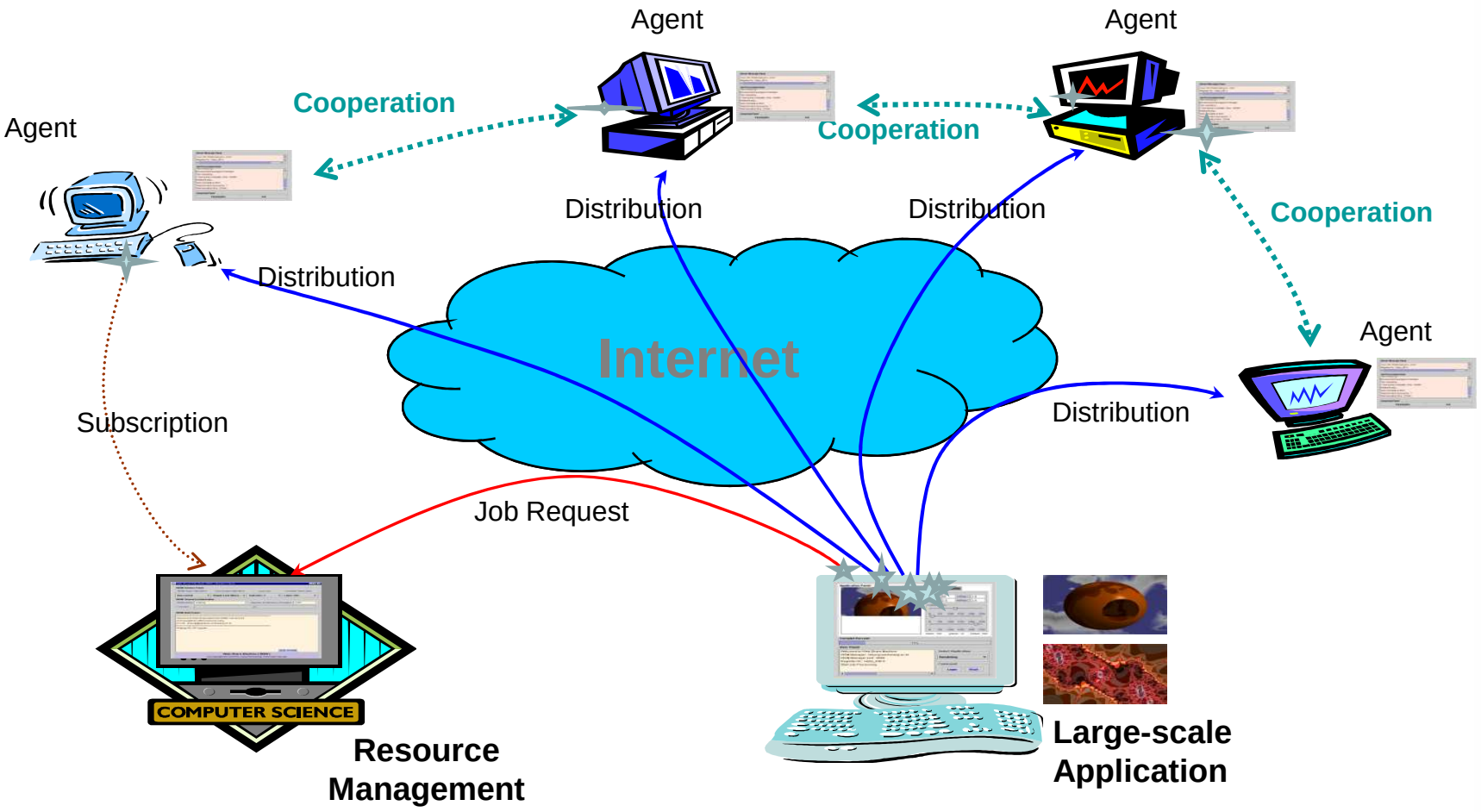
Centralized vs Distributed Systems

S.No	Centralized System	Distributed System
1	One system with non autonomous parts	Multiple autonomous components
2	System shared by users all the time	Components shared by users
3	All resources accessible	Resources may not be accessible
4	Software runs in a single process	Software can run in concurrent processes on different processors
5	Single physical location	Multiple physical locations
6	Single point of control (and management)	Multiple points of control
7	Single point of failure	Multiple points of failure
8		No global time
9		No shared memory

Distributed Computing

- A distributed system is one in which hardware or software components located at **networked computers** communicate and coordinate their actions only by **message passing.**

Distributed Computing



Motivation for Distributed Computing

- Inherently distributed applications
- Performance/cost
- Resource sharing
- Flexibility and extensibility
- Availability and fault tolerance
- Scalability
- Network connectivity is increasing.
- Combination of cheap processors often more cost-effective than one expensive fast system.
- Potential increase of reliability.

Evolution of Distributed Computing

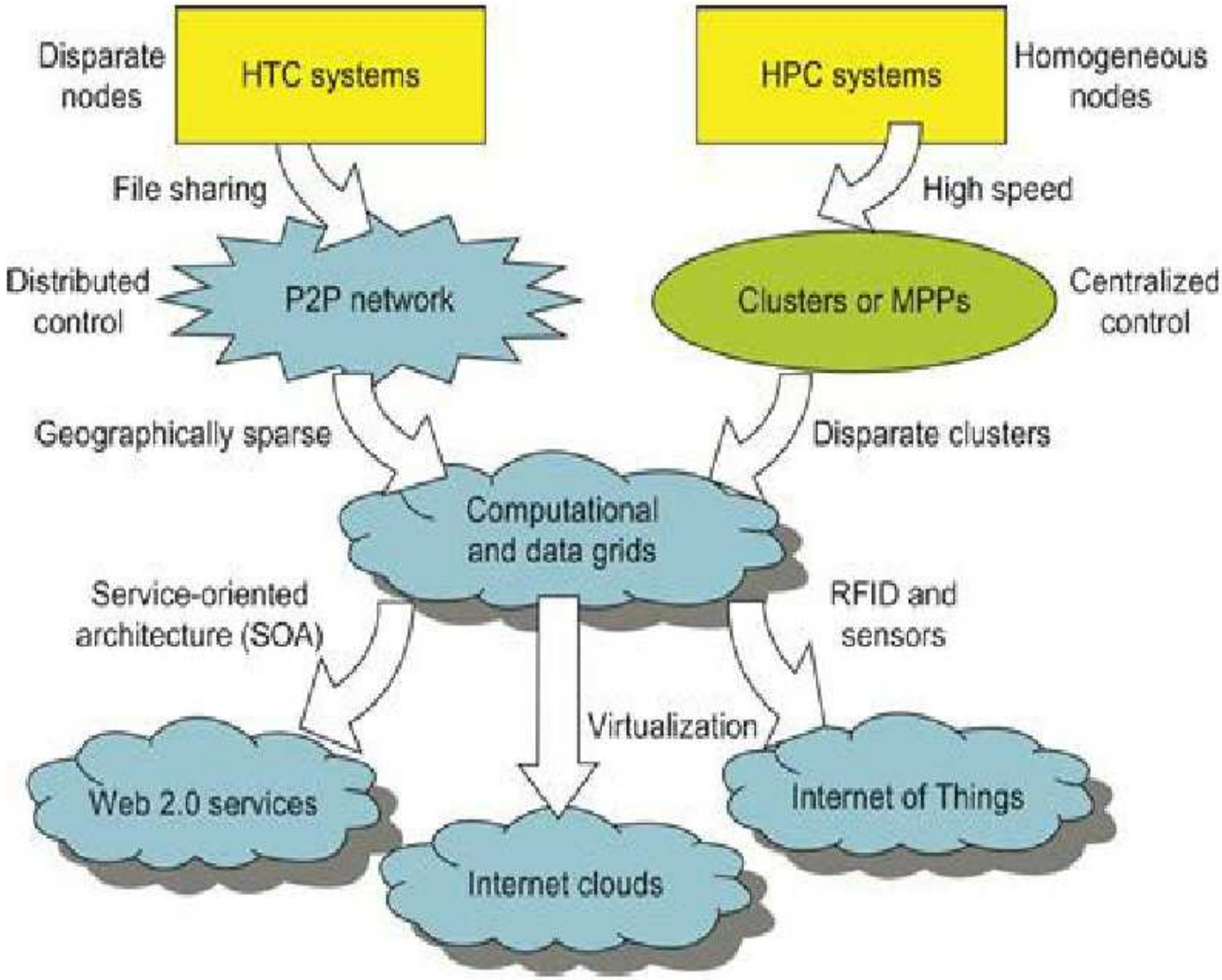
- **1960**
  centralized Mainframe — happy system manager
  centralized control — sad users
  single point of failure
- **1970**
  localized Minicomputers
  localized control
- **1980**
  de-centralized PC's — sad system manager
  user control — happy users
- **1985**
  networked PC's on LAN and WAN
  client server
- **1990**
  distributed Systems — happy system manager
  distributed management — happy users
  distributed applications
  middleware. virtual computing
- **2000**
  internet computing, grid,
  web services,
  cluster and cloud computing
- **2010**
  Mobile, ubiquitous and pervasive computing

Scalable Computing over Internet

Scalable Computing Over Internet

- Instead of using a centralized computer to solve computational problems, a parallel and distributed computing system uses multiple computers to solve large-scale problems over the Internet.
- **High-performance computing (HPC)** applications are no longer optimal for measuring system performance.
- The emergence of computing clouds instead demands **High-throughput computing (HTC)** systems built with parallel and distributed computing technologies.
- We have to upgrade data centers using fast servers, storage systems, and high bandwidth networks.

The Platform Evolution



HPC: High-Performance Computing

HTC: High-Throughput Computing

P2P: Peer to Peer

MPP: Massively Parallel Processors

Computing Paradigm Distinctions

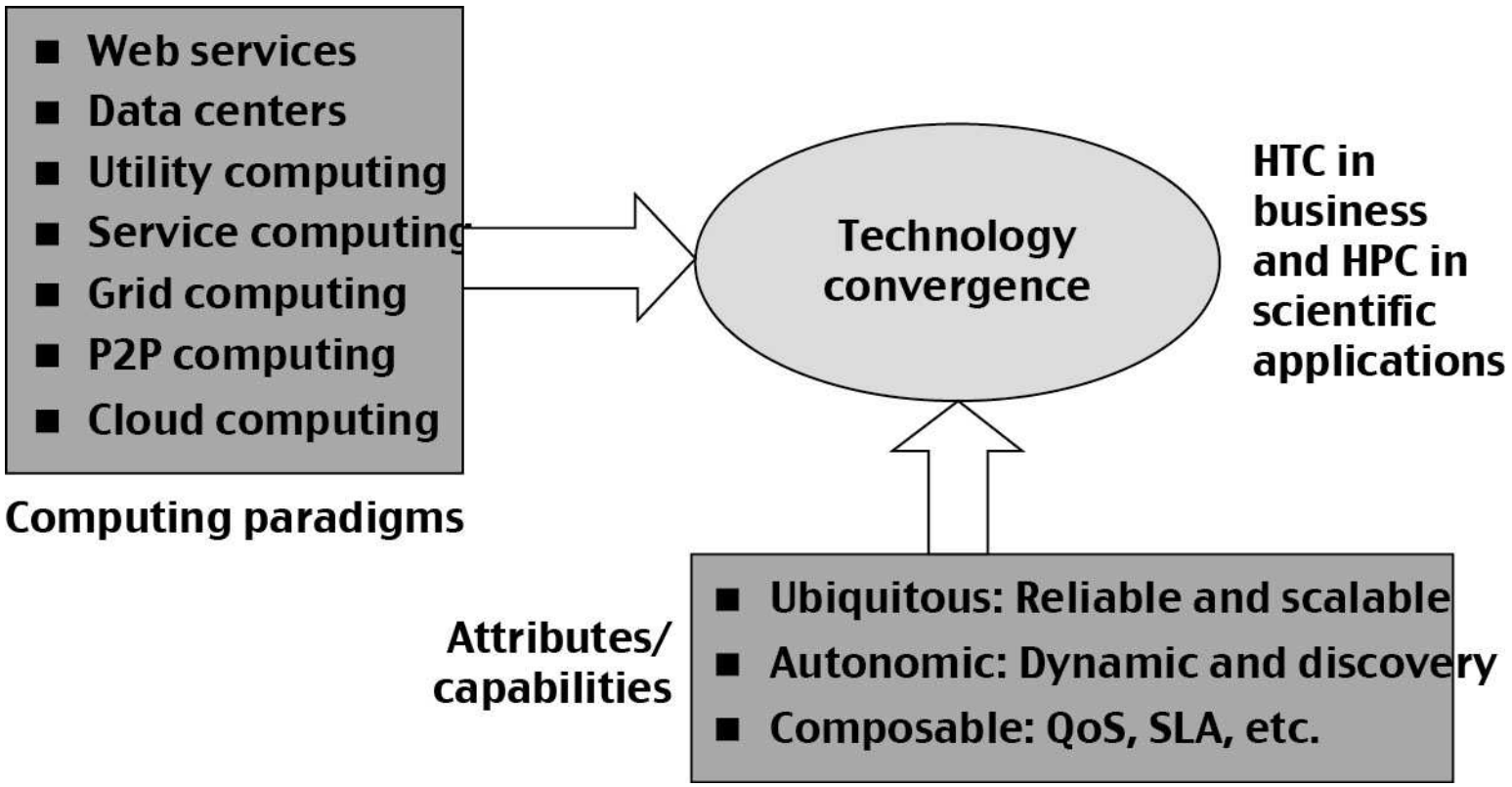
- **Centralized Computing**
  - All computer resources are centralized in one physical system.
- **Parallel Computing**
  - Task runs in multiple processors concurrently. All processors are either tightly coupled with central shared memory or loosely coupled with distributed memory
- **Distributed Computing**
  - A distributed system consists of multiple autonomous computers, each with its own private memory, communicating over a network.
- **Cloud Computing**
  - An Internet cloud of resources that may be either centralized or decentralized. The cloud applies to parallel or distributed computing or both. Clouds may be built from physical or virtualized resources.

Applications of High-Performance and High-Throughput Systems

Table 1.1 Applications of High-Performance and High-Throughput Systems

Domain	Specific Applications
Science and engineering	Scientific simulations, genomic analysis, etc.
	Earthquake prediction, global warming, weather forecasting, etc.
Business, education, services industry, and health care	Telecommunication, content delivery, e-commerce, etc.
	Banking, stock exchanges, transaction processing, etc.
	Air traffic control, electric power grids, distance education, etc.
	Health care, hospital automation, telemedicine, etc.
Internet and web services, and government applications	Internet search, data centers, decision-making systems, etc.
	Traffic monitoring, worm containment, cyber security, etc.
	Digital government, online tax return processing, social networking, etc.
Mission-critical applications	Military command and control, intelligent systems, crisis management, etc.

Technology Convergence toward HPC for Science and HTC for Business: *Utility Computing*



Internet of Things

- RFID, GPS and Sensors triggered development of IoT
- In the IoT era, all objects and devices are instrumented, interconnected, and interacted with each other intelligently.
- This communication can be made between people and things or among the things themselves.
- Three communication patterns co-exist:
  - H2H (human-to-human),
  - H2T (human-to-thing), and
  - T2T (thing-to-thing).
- Things include machines such as PCs and mobile phones. The idea here is to connect things (including human and machine objects) at any time and any place intelligently with low cost.

Cyber-Physical System

- A cyber-physical system (CPS) is the result of interaction between computational processes and the physical world.
- A CPS merges the "3C" technologies of computation, communication, and control.
- The IoT emphasizes various networking connections among physical objects.
- CPS emphasizes exploration of virtual reality (VR) applications in the physical world.

Summary

- Centralized vs. Distributed Systems
- Evolution of Distributed Systems
- HPC & HTC
- Grid and Cloud
- IoT
- Cyber-Physical System