An Overview of Grid Computing Workshop

Day 1 – August 05, 2004 (Thursday)

Introduction to Grid Computing

By

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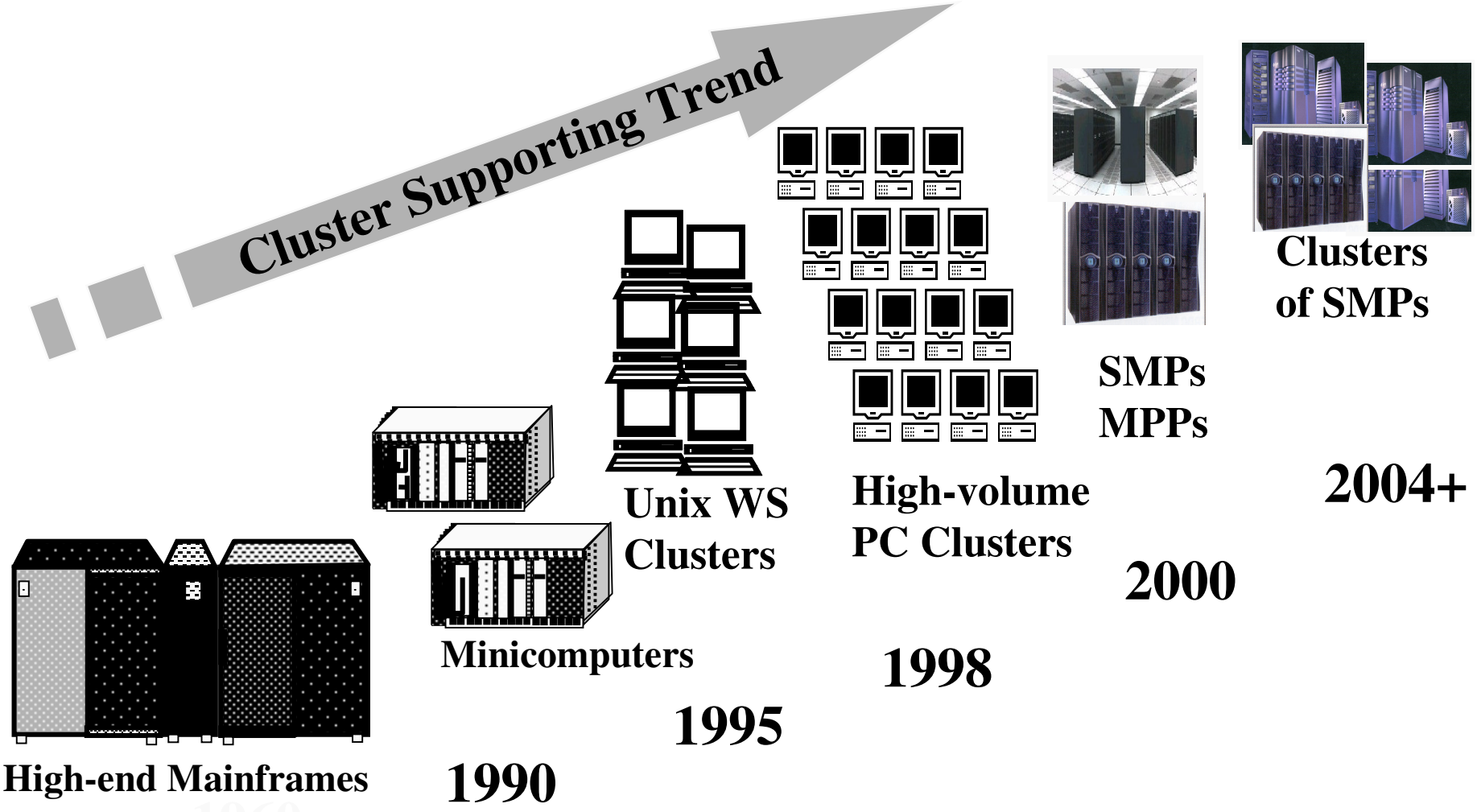
Grid Computing: Introduction

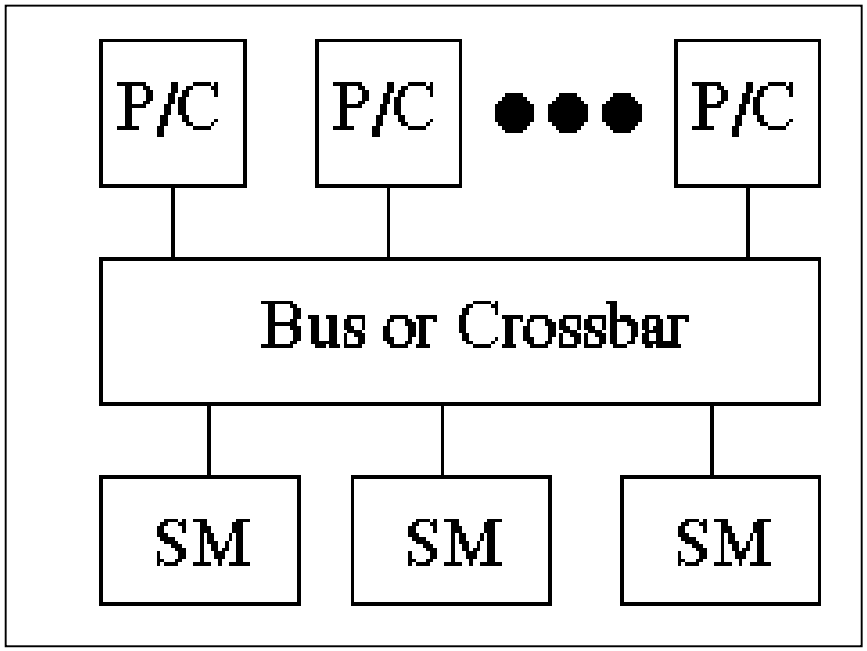
Quick overview of what this Lecture is all about

- Introduction
- What is “The Grid” and What is “Globus ?”
- About Globus Toolkit & Grid Applications
- Conclusions and Future Directions
- Some indications where we are heading

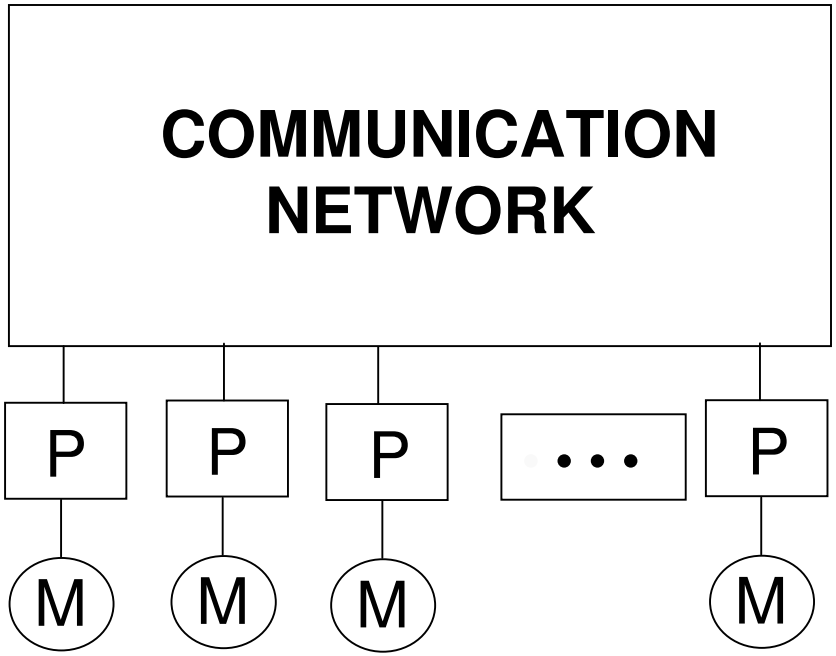
History :Computer for Collective Computing



General-Purpose Parallel Computers

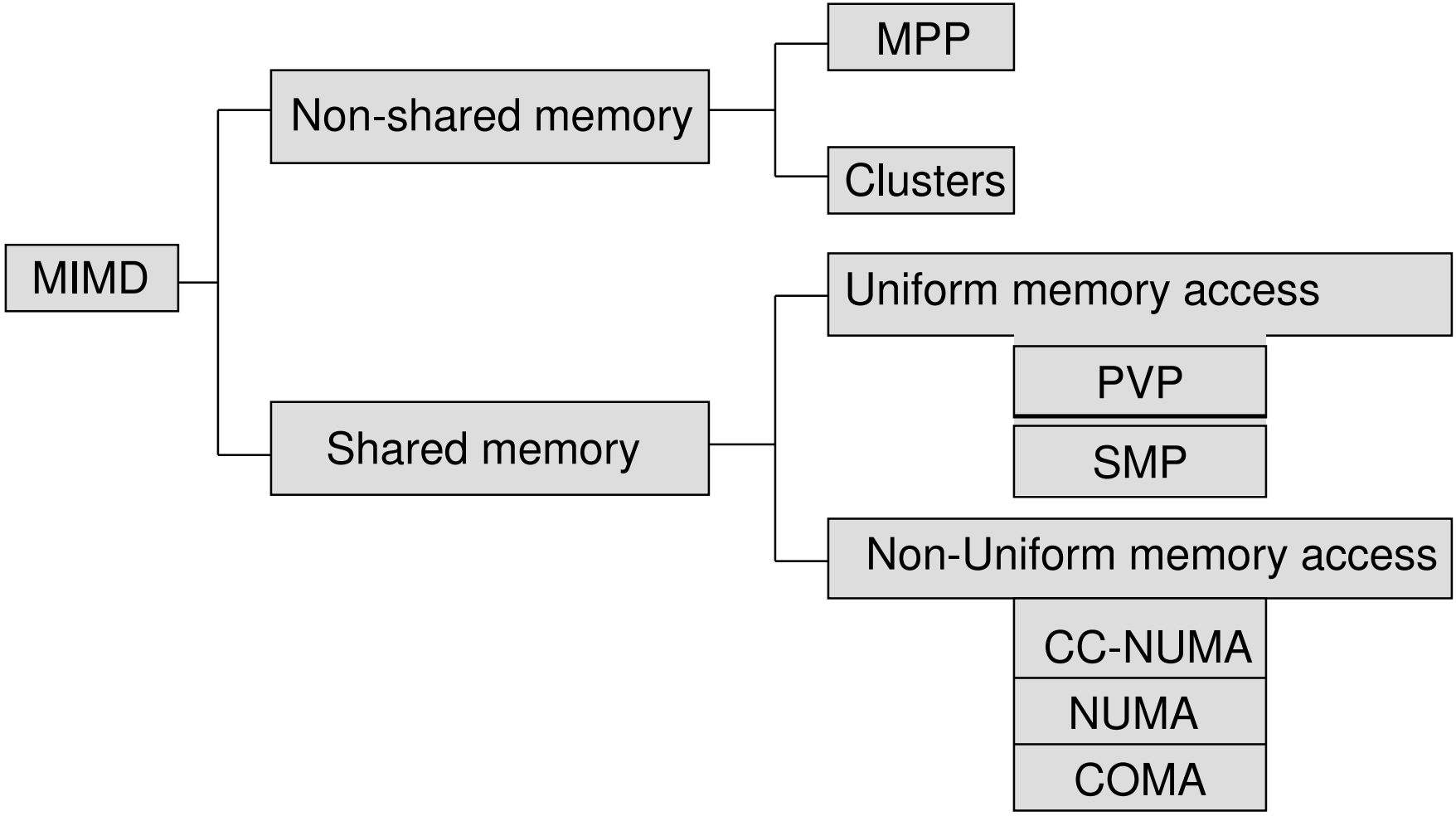


Shared Memory

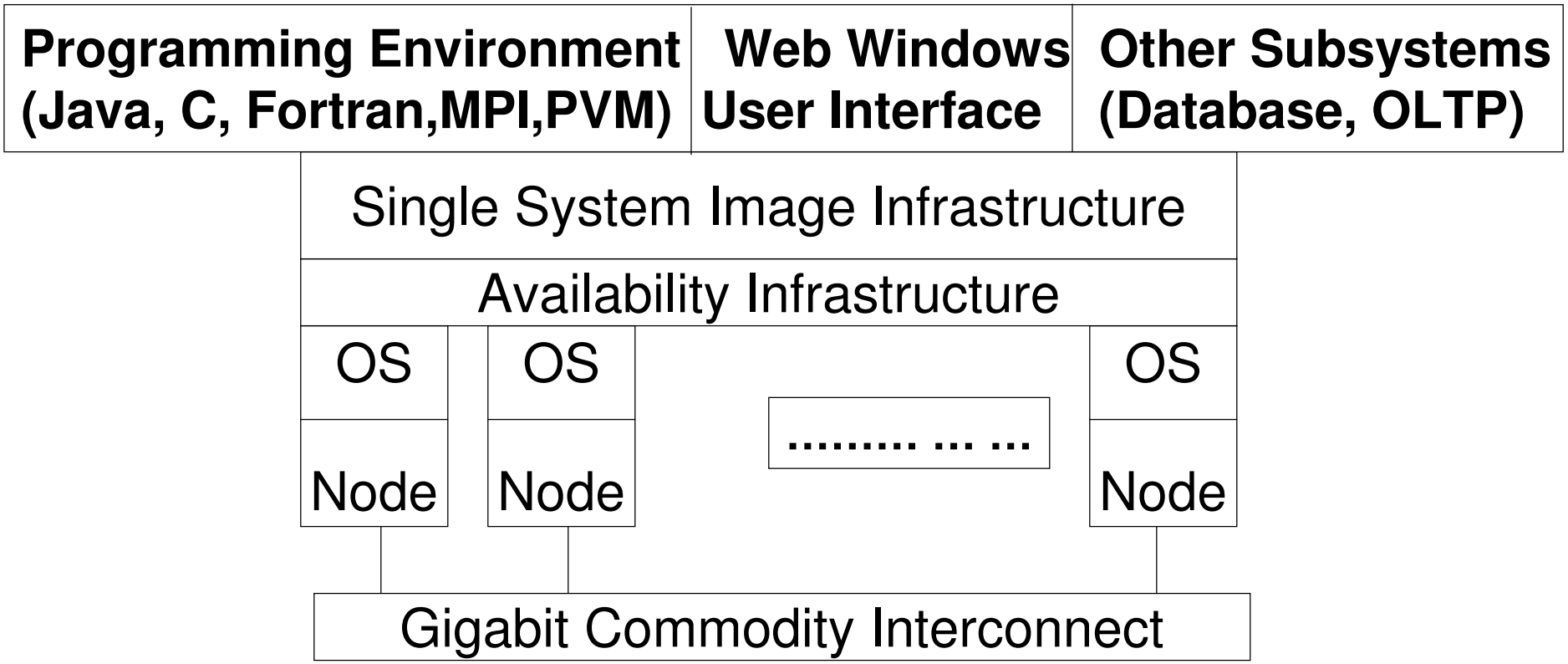


Non-Shared Memory

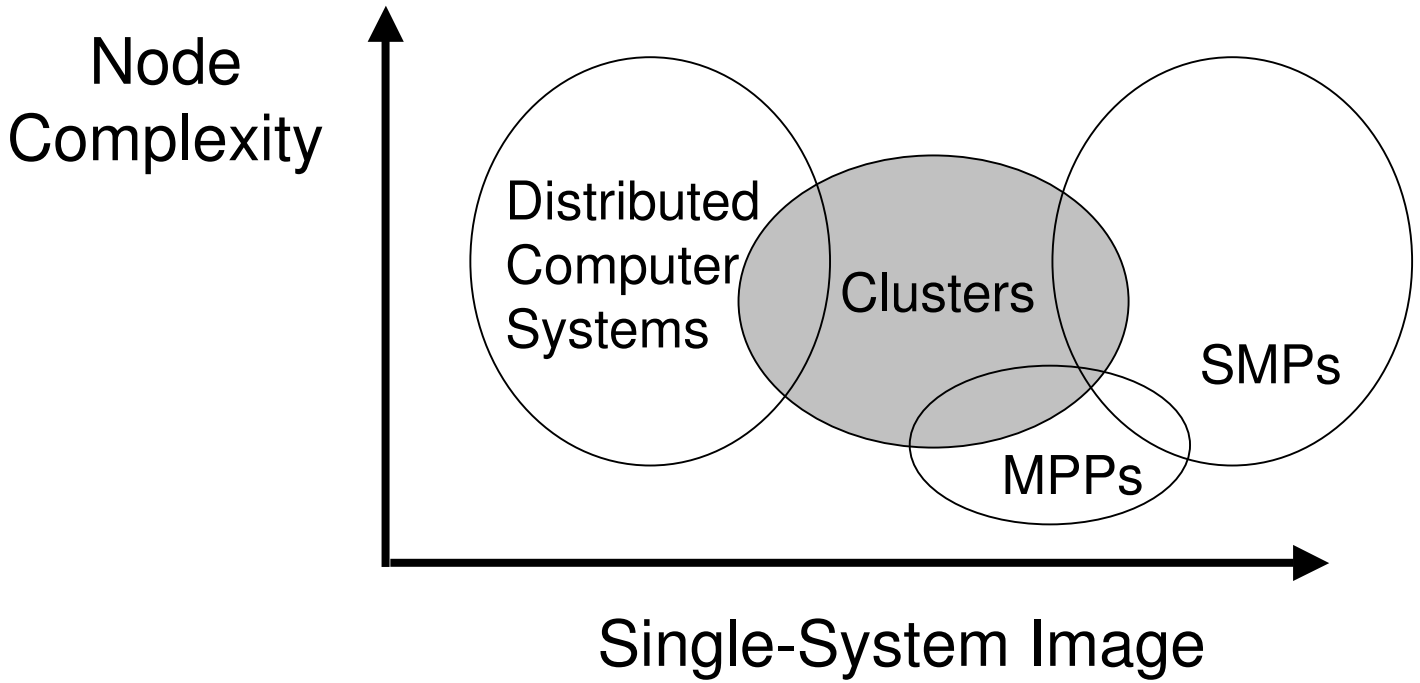
Architectural Models MIMD Machines



Cluster System Architecture

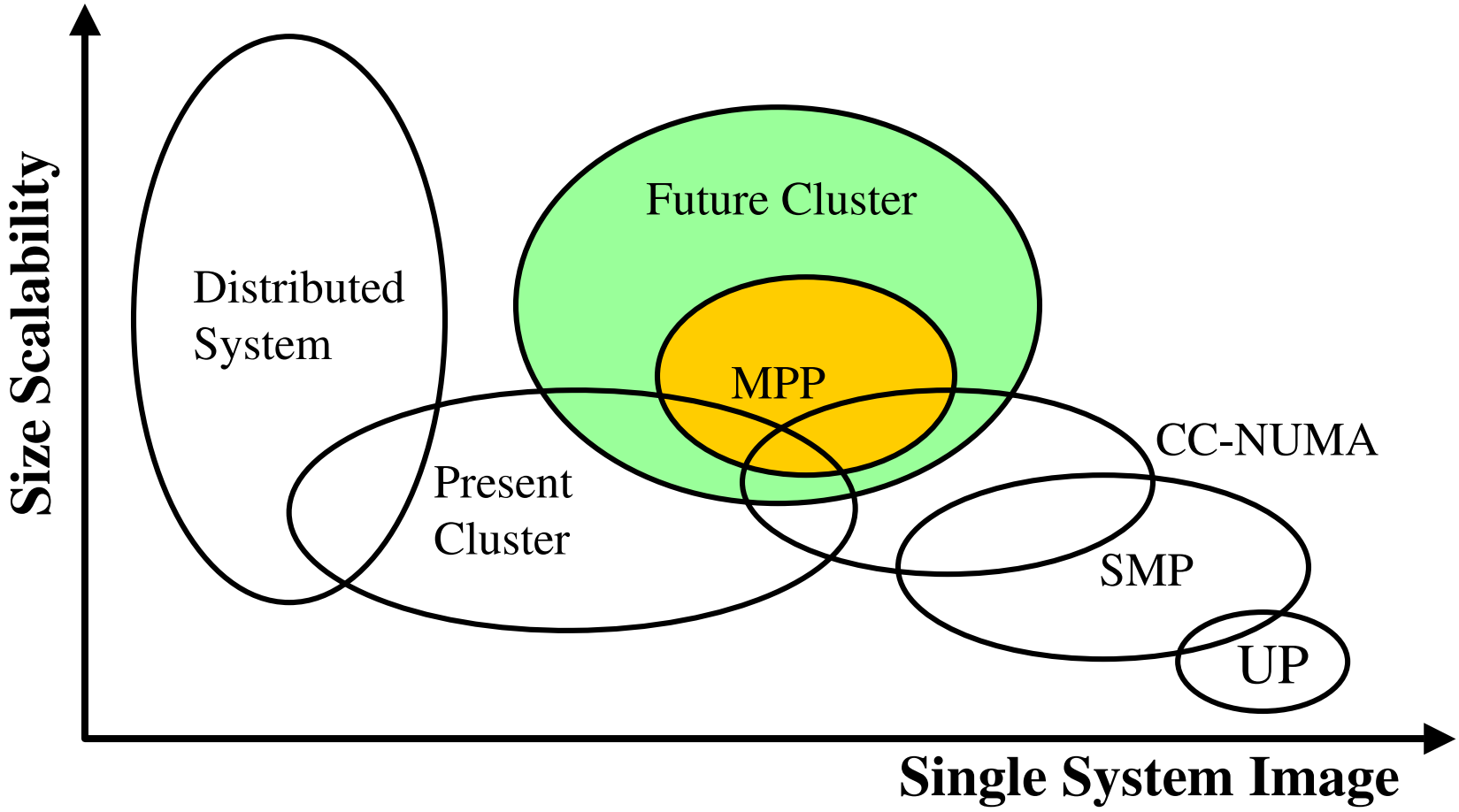


Better Performance on Cluster

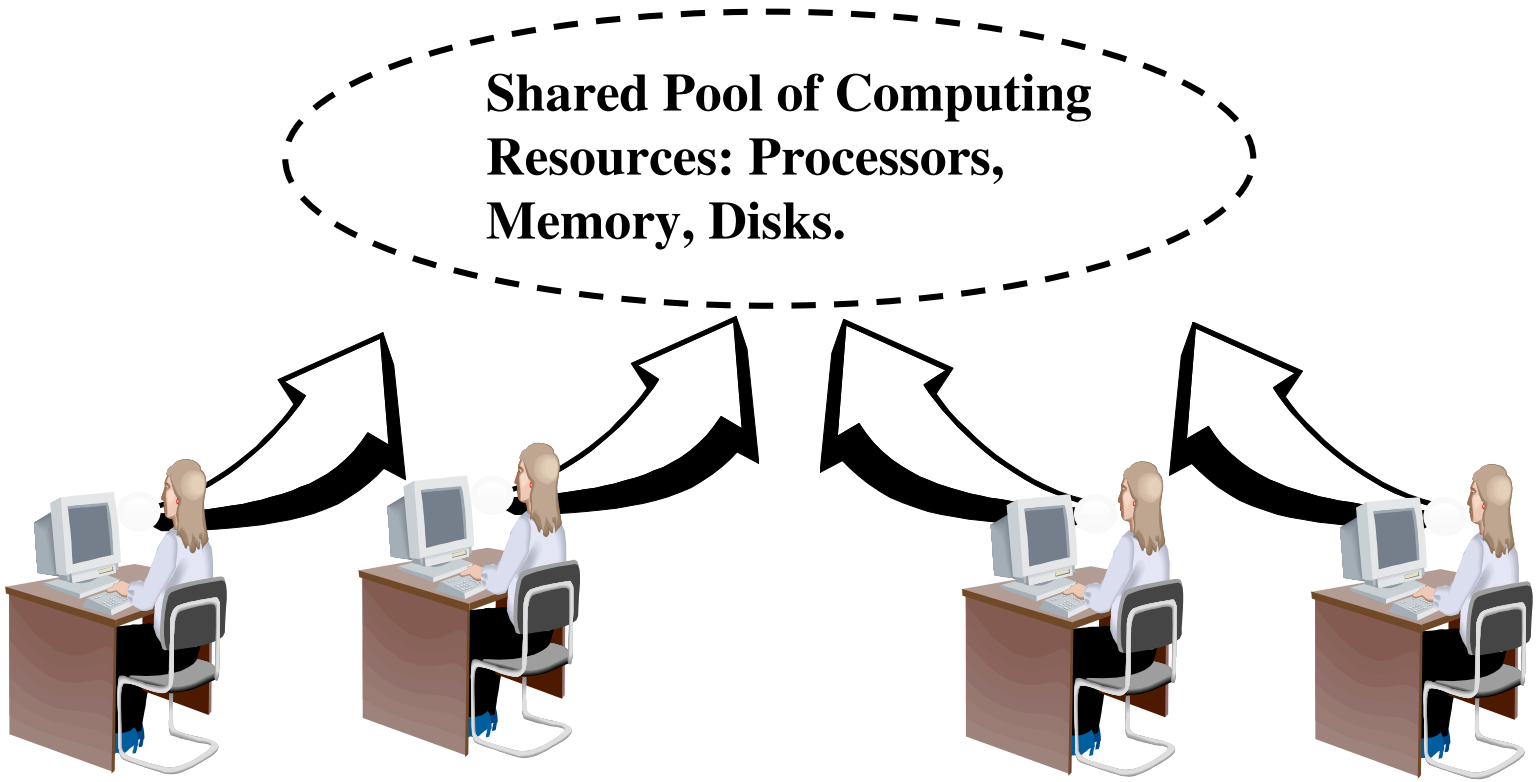


Overlapped design space of clusters, MPPs, SMPs, and distributed computer systems

Scalability Vs. Single System Image



Enterprise Cluster Systems

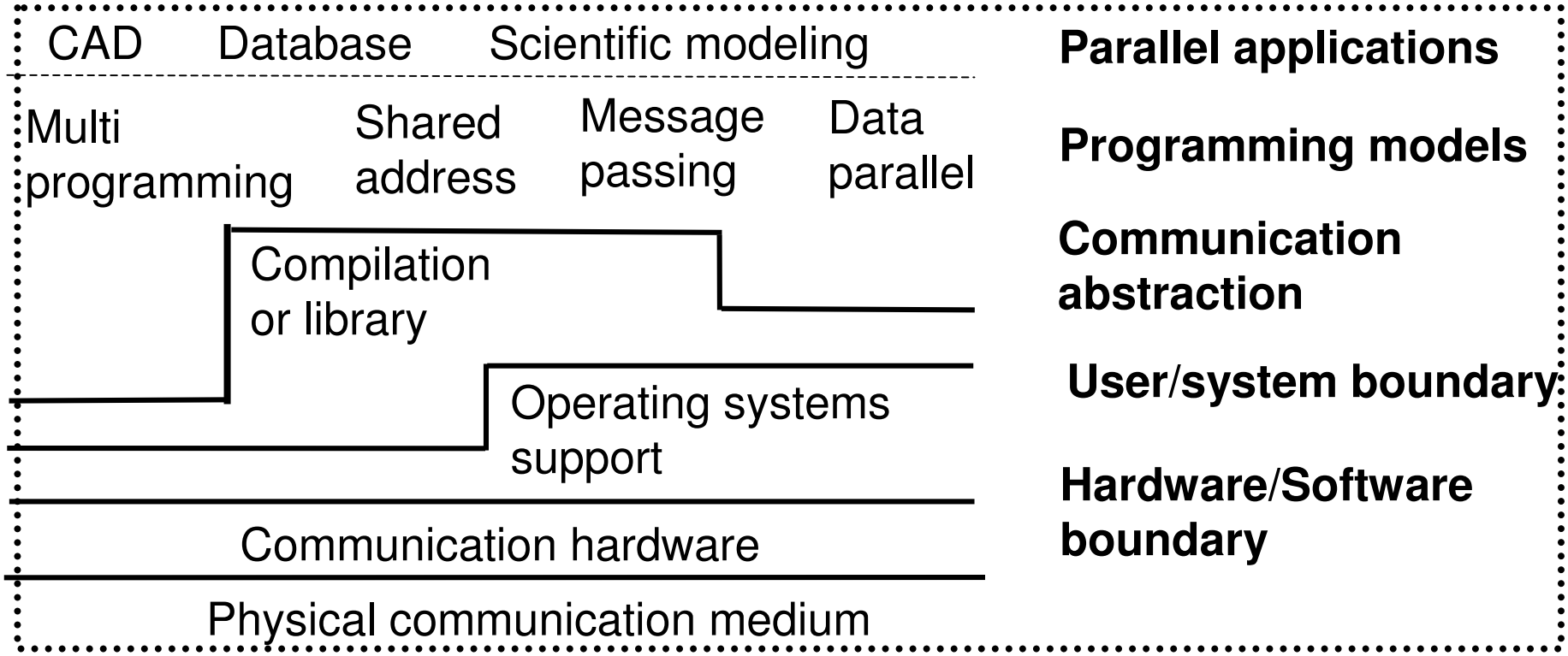


Guarantee at least one workstation to many individuals (when active)

Deliver large % of collective resources to few individuals at any one time.

Cluster Computing

Critical layers of abstraction lie between the application program and actual hardware



Requirements for Applications

- Parallel I/O (Seismic Data Processing)
- Optimized Scientific Computing libraries
- Low latency and High bandwidth networks
- Scalability of a parallel system
- Numerical Algorithms : Dense Matrix Algorithms; Solving linear system of equations; Solving Sparse system of equations; Fast Fourier Transformations
- Non-Numerical Algorithms :Graph Algorithms;Sorting algorithms; Search algorithms for discrete Optimization; Dynamic Programming

Grid Computing: Introduction

- What is “the Grid ?”
- It is an infrastructure that enables the integrated collaborative use of high-end computers, networks, databases and scientific instruments owned and managed by multiple organizations
- Grid applications often involve large amounts of data and /or computing and often require secure resources sharing across organizational boundaries
- Can not be handled easily by today’s Internet Technology and web infrastructure

Towards a new generation of applications Grid aware applications

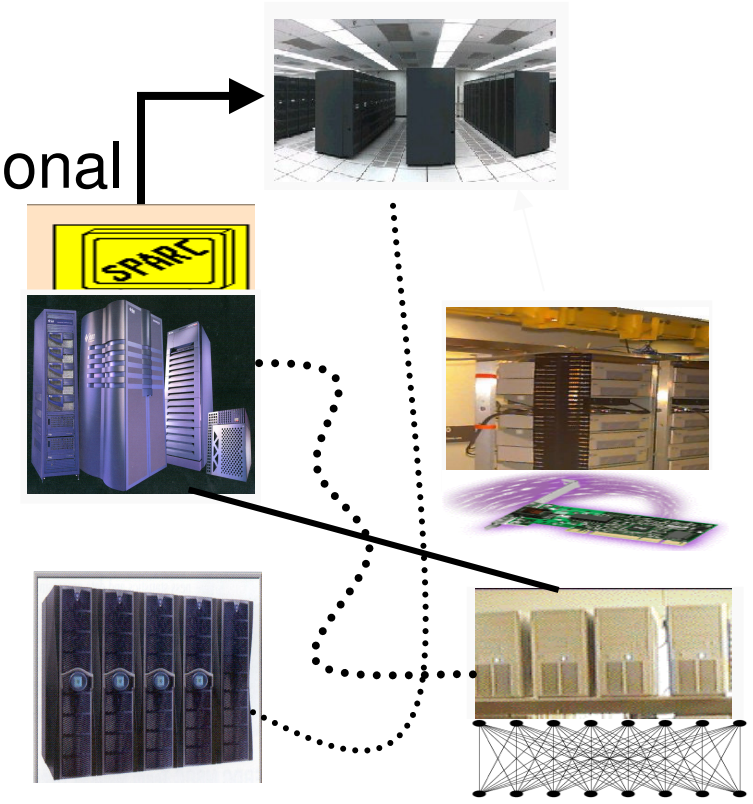
Simple Grid

Grid Computing differs from conventional distributed computing in its focus on

Innovative Applications

Grid aware applications also called as Multi-disciplinary Applications or Meta Applications

These make use of coupled computational resources that are not available at a **SINGLE SITE**



2000 : Early Definitions of Grid

- *Grid is a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed "autonomous" resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements.*

1998 : Early Definitions of Grid

- Back in 1998, Carl Kesselman and Foster attempted a definition in the book “
- **The Grid: Blueprint for a New Computing infrastructure**.”

We wrote:

- *A computational grid is a hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities.*

1969 : Early Definitions of Grid

- Of course, in writing these words we were not the first to talk about on-demand access to computing, data, and services.
- For example, in 1969 Len Kleinrock suggested presciently, if prematurely:
- ***We will probably see the spread of 'computer utilities', which, like present electric and telephone utilities, will service individual homes and offices across the country."***

Grid Computing: Introduction

- Flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resource
  - From "The Anatomy of the Grid: Enabling Scalable Virtual Organizations"
- Enable communities ("virtual organizations") to share geographically distributed resources as they pursue common goals -- assuming the absence of…
  - central location
  - central control
  - omniscience
  - existing trust relationships.

Ref [1],[2],[3]

Why should I care about this Grid Stuff?

- Example : New applications enabled by Grid environments
  - Smart Instruments (Advanced Scientific Instructions- Electron Microscope, Partial Accelerators, wind tunnels couple with remote supercomputers, users, and databases to enable interactive sessions, Collaborations)
  - Teraflop desktops (Chemical Modeling, Symbolic algebra, Transfer computationally intensive operations to more capable remote resources)
  - Parameter Studies (Rapid,large scale parametric studies, in which a single problem is run many times in order to explore a multi-dimensional parameter space.)

Why should I care about this Grid Stuff?

- Example : New applications enabled by Grid environments
  - Collaborative Engineering (High Bandwidth access to shared virtual spaces that support interactive manipulation of shared datasets and steering of sophisticated simulations, Collaborative design of complex Systems (Tele-immersion, Disaster Management)
  - Distributed Supercomputing (Ultra-large virtual supercomputers constructed to solve problems too large to fit on any single computer)

What is Globus ?

- Globus is a research and development project focused on enabling the application of Grid concepts to Scientific and Engineering Computing
  - Started in 1996
  - Build Grid Applications by Groups around the world.
  - Research targets technical challenges (Resource management, data management and access, application development environments, information services, and security)
  - Resulted Globus Toolkit

What is in the Globus Toolkit?

- It is “BAG”of services – a set of useful components that can be used either independently or together to develop useful grid applications and programming tools
- The Globus Resource Allocation Manager (GRAM)
  - The Grid Security Infrastructure (GSI)
  - The Metcomputing Directory Service (MDS)
  - Global Access to Secondary Storage (GASS)
  - The Heartbeat Monitor (HMD)
  - Nexus and Globus_IO
  - Application Programming Interface (API)

Application Programmer Interface (API)?

- For each component, API written in C prog language is provided for use by software developers
  - Command line tools are provided
  - Java Classes are provided
  - Make use of Globus server running on Computing resources
- Globus developed High level components (resource brokers, resource co-allocators) and services
- Large number of individuals, organization have developed higher level series, application frameworks, Applications using Globus Toolkit, and Condor-G
- Use Globus Tool-kit

Isn't it a lot of work to use Globus in my application?

Some applications can run with no modification at all by linking with a grid-enabled version of an appropriate programming library

- Example :Astrophysics Simulation : (Cray T3E: Germany/California - using GRID enabled)
- Distributed Interactive Simulation- Developed at Caltech to incorporate Globus capabilities
- Performance issues of Inter-continental Computing Projects (Flow Simulation – URANUS)

Isn't it a lot of work to use Globus in my application?

- Combining TWO / MORE MPPs –1026 nodes
- Two Cray T3E's - Simulation across ATLANTIC
  - Pittsburgh Super Computing Center,USA
  - University of Stuttgart,Germany
- Latency Bound Application
- Flow Simulation
- Using PAC-X MPI for Communication

What Success have you had to date?

- **Application Framework Developers**
  - Using Global services to build software frameworks that facilitate the development and execution of specific types of applications
- **Application developers**
  - Use Globus services to construct innovative Grid based applications, either directly or via Grid-enabled tools
- **Grid builders**
  - Using Globus services to construct production Grid Computing environments Grid based applications, either directly or via Grid-enabled tools. Grid builders are using Globus services to create production Grid computing environments.

What Success have you had to date?

- The Globus project started in 1996 and we have had significant success every year.
- International Collaborations; NASA's Information Power Grid, European DataGrid Project
- Distributed interactive simulation application used Globus services to couple 13 supercomputers at 10 sites – to achieve a record setting 100,00 vehicle simulation
- Other projects …..

So have you solved the problems?

- Overcoming barriers to Grid Computing
- We can not say that we have a fully functional Grid
- Automatic techniques for negotiation of resource usage,policy and accounting in large-scale grid environment
- High Performance communication and protocols

Who is Using the Globus Toolkit?

- CAVERNSoft – frame work for tele-immersive applications
- Univ of Illinois at Chicago – Electronic Visualization Lab
- Univ Wisconsin Condor (High throughput computing
- Sandiego Supercomp Centre (HotPage Grid Page Portals)
- Indiana University (Linear system analyzer)
- Argone National Lab /North Illinois Univ- (Globus MPI)
- Univ of Stuttgart, Germany (PACX-MPI)
- Monash University (Nimrod /G)
- Syracuse University (WebFlow)
- Los Alamos National Lab (Parallel Appln workspace
- Univ of Virginia- Legion

Don't JAVA and JINI solve all these problems?

- Doesn't help us to run programs on different types of supercomputers
- Doesn't discover the policy elements that apply at a particular site
- Doesn't achieve single sign-on authentication
- Doesn't perform High speed transfer across wide area networks.

Doesn't CORBA solve all these problems

- The common Object Request Broker Architecture (CORBA) defines a standard interface Definition Language (IDL) for inter-language interoperability
- Doesn't address the challenges that arise in Grid Environments such as specialized devices and high performance required by many grid applications.
- CORBA /Globus interfaces – research in Commercial database applications
- Java/Globus interface research in progress

Issues in Grid Computing :Globus/Legion

- Resource sharing
  - Computers, storage, sensors, networks, …
  - Sharing always conditional: issues of trust, policy, negotiation, payment, …
- Coordinated problem solving
  - Beyond client-server: distributed data analysis, computation, collaboration, …
- Dynamic, multi-institutional virtual orgs
  - Community overlays on classic org structures
  - Large or small, static or dynamic
- Globus focus on low-level services and Legion focus on high-level services

Grid Computing :One view of Requirements

- Identity & authentication
- Authorization & policy
- Resource discovery
- Resource characterization
- Resource allocation
- (Co-)reservation, workflow
- Distributed algorithms
- Remote data access
- High-speed data transfer
- Performance guarantees
- Monitoring
- Adaptation
- Intrusion detection
- Resource management
- Accounting & payment
- Fault management
- System evolution
- Etc.
- Etc.

…

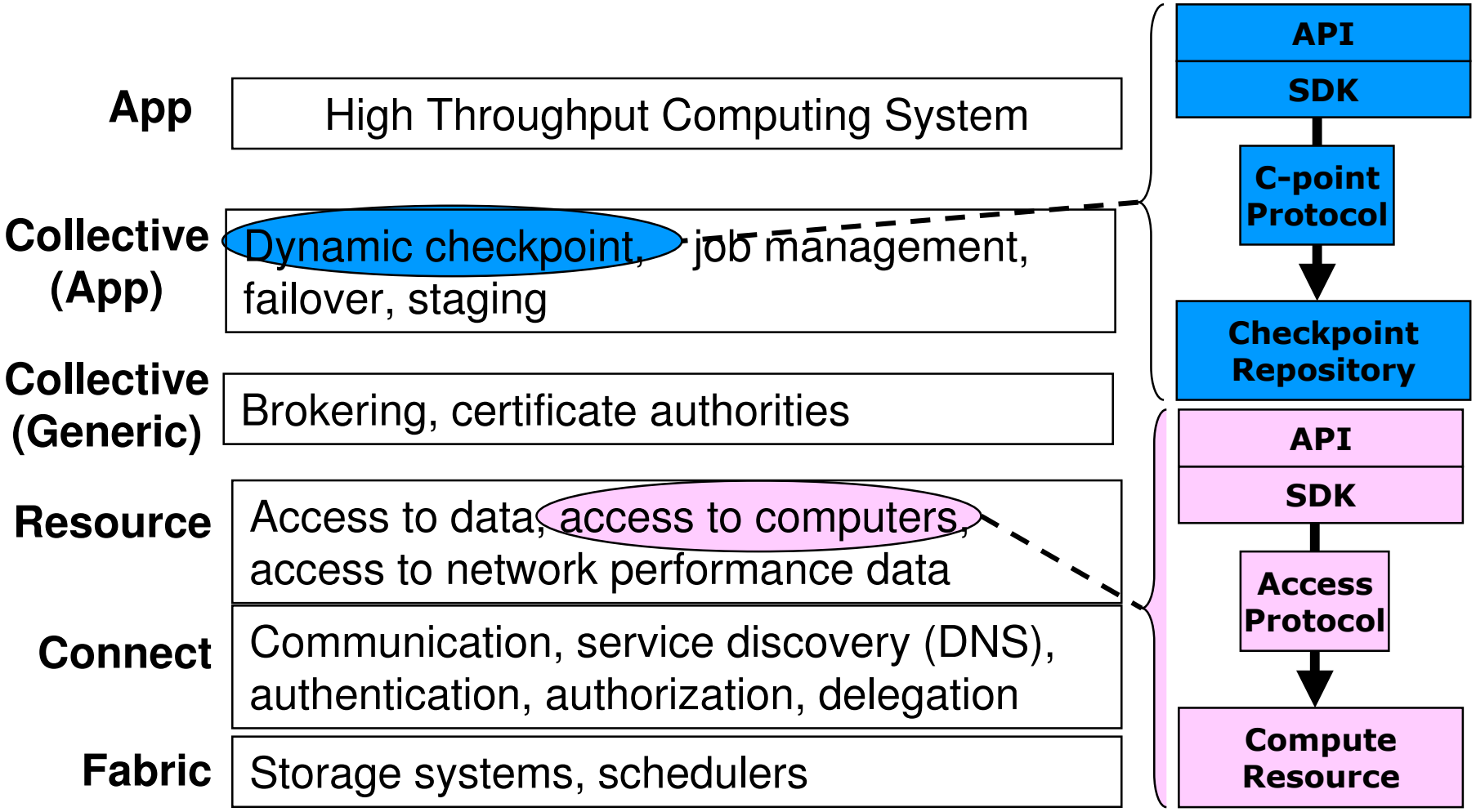
Grid Computing :One view of Requirements

1) New approaches to problem solving
   - Data Grids, distributed computing, peer-to-peer, collaboration grids,

2) Structuring and writing programs
   - Abstractions, tools

3) Enabling resource sharing across distinct institutions
   - Resource discovery, access, reservation, allocation; authentication, authorization, policy; communication; fault detection and notification; …

High-Throughput Computing System for Making Grid Computing Routines



Data Grid Architecture

App	Discipline-Specific Data Grid Application
Collective (App)	Coherency control, replica selection, task management, virtual data catalog, virtual data code catalog, …
Collective (Generic)	Replica catalog, replica management, co-allocation, certificate authorities, metadata catalogs,
Resource	Access to data, access to computers, access to network performance data, …
Connect	Communication, service discovery (DNS), authentication, authorization, delegation
Fabric	Storage systems, clusters, networks, network caches, …

Programming and Systems Problems

- The programming problem
  - Facilitate development of sophisticated apps
  - Facilitate code sharing
  - Requires programming environments (APIs, SDKs, tools)
- The systems problem
  - Facilitate coordinated use of diverse resources
  - Facilitate infrastructure sharing

    e.g., certificate authorities, information services
  - Requires systems

    protocols, services

Grid Programming Technologies

- "Grid applications" are incredibly diverse (data, collaboration, computing, sensors, …)
  - Seems unlikely there is one solution
- Most applications have been written "from scratch," with or without Grid services
- Application-specific libraries have been shown to provide significant benefits
- No new language, programming model, etc., has yet emerged that transforms things
  - But certainly still quite possible

Grid Programming Technologies

What are you planning to do next ?

- Designing and developing new technologies to support data grids, distributed infrastructure for managing terabytes / petabytes of data
- Supporting the ongoing construction of Grid Infrastructure
- Automatic techniques for negotiation of resource usage,policy and accounting in large-scale grid environment
- Investigating new application programming models, tools, frameworks an algorithms for Grid Computing

Grid Computing :Summary

- The Grid problem: Resource sharing & coordinated problem solving in dynamic, multi-institutional virtual organizations

- Grid architecture emphasizes *systems problem*
  - Protocols & services, to facilitate interoperability and shared infrastructure services

- Globus Toolkit™: APIs, SDKs, and tools which implement Grid protocols & services
  - Provides basic software infrastructure for suite of tools addressing the programming problem

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Thank you