System Networking: LAN, SAN, and NAS

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Network-Based Computing Paradigms

<table>
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<th>Attributes</th>
<th>Cluster Computing</th>
<th>Grid Computing</th>
<th>Pervasive computing</th>
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<td>Networking</td>
<td>System Area Network</td>
<td>Internet or Wide Area Network</td>
<td>Wireless LAN, IrDA</td>
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<td>Operating system support</td>
<td>Most UNIX and Windows variants</td>
<td>Most UNIX, Windows variants</td>
<td>Pocket PC (CE), Palm OS, Inferno, Chorus OS</td>
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<tr>
<td>Environment and tool sets</td>
<td>MPI, PVM, Score, Codine</td>
<td>GLOBUS, GSI, LEGION, CONDOR</td>
<td>JINI, UPnP, Bluetooth</td>
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Interconnection Networks Among Client Hosts, Servers, and Storage Devices

- **LAN**: Local-Area Network
- **SAN**: Storage-Area Network
- **NAS**: Network-Attached Storage
Scalable clusters providing SSI services are gradually replacing the SMP, cc-NUMA, and MPP in Servers, Web Sites, and Database Centers.

What are server clustering and Storage-Area Network (SAN)?
Storage-Area Network (SAN)

Storage Area Networking (SAN) separates data movement and storage from computing, allowing universal access and reducing traffic on the primary network.

- Fat or Thin Clients
- presenter Layer
- Presentation Layer
- Router to remote site or to other LANs
- Proxy Server (firewall)
- Application and Data Layer
- Application Server(s)
- Access to Internet (firewall)
- Database Server
- Storage Layer
- Disk Storage and Subsystems
- Tape Backup and Archive

Data Storage Management Toward SAN

- System Availability
  - System Management
  - Application Management
  - Performance Optimization
- Data Availability
  - Failover
  - Mirroring
  - Clustering
- Resource Optimization
  - Storage Management
  - Device Management
  - RAID
- Backup & Recovery
  - Storage Resource Management
  - Disaster Recovery
  - Storage Attached Storage
- Online Storage Optimization
  - Network Attached Storage
  - Hierarchical Storage Management
- Volume Management
  - Point Products
  - Unified Solutions
  - Integrated Storage Management

Issues in Cluster Design

- Size Scalability (physical & application)
- Enhanced Availability (failure management)
- Single System Image (Middleware, OS extensions)
- Fast Communication (networks & protocols)
- Load Balancing (CPU, Net, Memory, Disk)
- Security and Encryption (clusters and Grids)
- Distributed Environment (User friendly)
- Manageability (Jobs and resources)
- Programmability (simple API required)
- Applicability (cluster- and grid-awareness)

Trojans Cluster built at USC Internet and Grid Computing Laboratory

- Prototype has 8 servers housed in one rack.
- All server run with the Redhat Linux
- All server nodes are connected by a Gbps Ethernet
- The cluster is ported with DQS, LSF, MPI, PVM, TreadMarks, and NAS benchmarks, etc.

Web site: http://GridSec.usc.edu
**Trojans Cluster**: An SSI Cluster with Linux Extensions and Middleware for Collective I/O, Checkpointing, and Intrusion Response

- **Programming Environment**: (Java, C, Fortran, MPI, PVM)
- **Web Windows User Interface**
- **Other Subsystems**: (Database, OLTP, etc.)

**Single System Image Infrastructure**

**Availability Infrastructure**

- OS
- Node
- Gigabit Network Interconnect

**Value-Added Middleware Development**

(Hwang, et al, IEEE Concurrency, March 1999)

- User Applications
- Job Management System (GLUnix, LSF, Codine)
- Single File Hierarchy (NFS, AFS, xFS, Proxy)
- Distributed Shared Memory, (TreadMark, Wind Tunnel)
- Single Process Space
- Checkpointing and Process Migration
- Single I/O Space (SIOS)
- Cluster Hardware and OS Platform

**Cluster Middleware, Linux Extensions, and Hardware Support of High-Availability**

- **IP Packet Applications**
- **Cluster Management Middleware**
  - Fault Management
  - Availability Management
  - Failover Support
  - Failback Support
  - Packet Switching

- **Linux OS Extensions**: HA Interface, HA/HW Drivers
- **I/O Drivers**, Platform Management Drivers

- **Hardware Support**: Hotswap Devices, Router Interfaces
- **Redundant Cluster Interconnects**
- **Redundant Power**
- **Redundant Cooling**
Distributed Software RAID:
Redundant Array of Distributed Disks

- I/O bottleneck in server-client cluster architecture
- Local disks or RAID often fail with the hosts
- Cost-Effective for SAN-connected shared RAIDs

Remote disk accesses using a centralized NFS versus using Cooperative disk divers (CDD) at the kernel level

(a) Parallel disk I/O using the NFS in a server/client cluster.

(b) Using CDDs to achieve a SIOS in a serverless cluster.

Distributed RAID-X
Developed at USC
HA Clusters, SAN, RAID, and Backup Store

Cluster with Standby Server and SAN-attached RAIDs

Storage Area Networks:

HP Storage Area Networks (SAN):

Figure 18 Mapping of server clusters to multiple RAIDs and backup storages
Killer Applications of Clusters

- Numerous Scientific & Engineering Apps.
- Parametric Simulations
- Business Applications
  - E-commerce Applications (Amazon.com, eBay.com ….)
  - Database Applications (Oracle on cluster)
  - Decision Support Systems
- Internet Applications
  - Web servicing / searching (google.com, hotbot.com)
  - Infowares (yahoo.com, AOL.com)
  - ASPs (application service providers)
  - Computing Portals
- Mission Critical Applications
  - command control systems, banks, nuclear reactor control, star-war, and handling life threatening situations.

Increasing demand of cluster, grid and Pervasive applications

- LANs, clusters, Intranets, Internet, and Grids all demand security protection, fault-tolerance, and hacker-proof operations, which are crucial to the acceptance of a digital society in the new millennium.

- Distributed storage-area networks demands hardware or software support of a single I/O space and global file and database management not only in clusters but also in pervasive information grids.

- Many innovative applications exist in remote network services, E-commerce, telemedicine, distance education, collaborative design, pervasive computing, and digital entertainment, etc.

Information Technology for Business Globalization

- Business is managed globally, overcoming the barriers in time, distance, culture, and language
- Global supply chain management for multinational companies with headquarter, assembly plants, and distributors scattered over the world

Assigned Paper Readings:

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