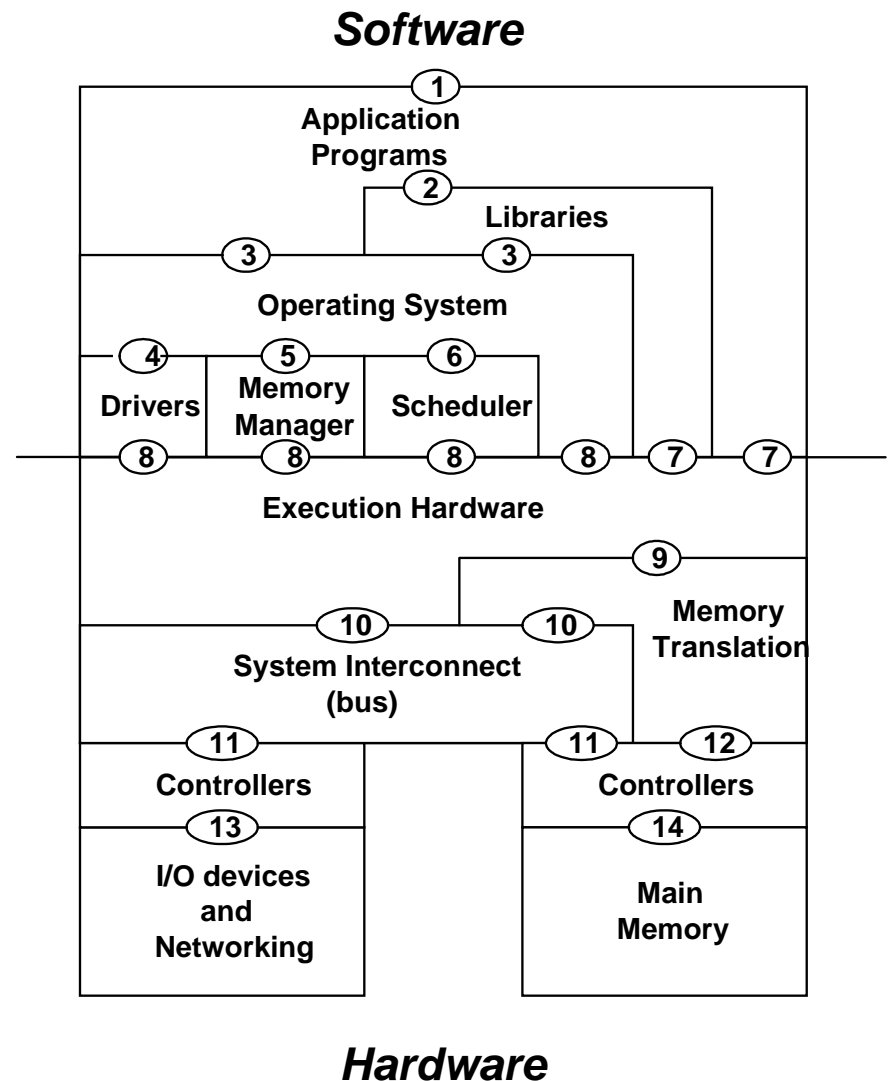# The Future of Architectures

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Abstractions

- Computer systems are built on levels of abstraction

- Higher level of abstraction hides details at lower levels
  - Example: files are an abstraction of a disk

- Architecture refers to the interface between levels of abstraction
  - Instruction Set Architecture
    - Major division between hardware and software
  - Application Binary Interface
    - Observed by user processes
    - User ISA + OS calls

Software

```
                    1
              Application
               Programs
                    2
                      Libraries
      3             3
           Operating System
   4      5       6
 Drivers Memory  Scheduler
         Manager
   8      8       8      8    7    7
           Execution Hardware
                              9
        10           10     Memory
        System Interconnect Translation
             (bus)
   11              11    12
 Controllers     Controllers
   13              14
 I/O devices     Main
   and          Memory
 Networking
```

Hardware

Evolution of Architectures

- Last 15 years
- Significant changes
  - Device level
  - Language level
  - OS level
  - Microarchitecture
- Few changes
  - ISA level
    - Mainstream ISAs today are not significantly different compared to those 40 years ago!

Evolution of Architectures

- Prediction for next 15 years
- Continued changes
  - Device level
  - Language level
  - OS level
  - Microarchitecture
  - ISA level
- Engine for changes
  - Shift in role of computers
  - Virtualization technology

Computers, Appliances, and Solutions

- Computers
  - Originally designed for simulation of physical events
  - Basic design remains the same today
- Appliances
  - Special purpose
    - Legacy less important
    - Fewer layers in software
    - Plenty of opportunity for new ISAs, OSes, etc.
- Solutions
  - Combination of heterogeneous computing elements and software spread across the globe to perform a task
    - These tasks, e.g. search, decision support, are different in characteristics from simulation tasks
    - Not just a "commercial" problem
  - Progress in this area not constrained by hardware technology

Virtualization

- Use of virtualization and virtual machines will be pervasive
  - Will allow interfaces to be decoupled from implementation
- Language VMs will allow new languages to be developed
- Security and maintenance will accelerate System VMs
  - Computing as a utility
- Virtualization of multiprocessor systems
  - Isolation of tasks from different points of view
    - Security, reliability, …

Appliances

- This will potentially be the area of maximum hardware innovation
  - New ISAs, new microarchitectures, new multiprocessor organizations
  - New technologies
- Compatibility will be less of an issue
  - Hence more flexibility
- Software and hardware designed as a unit
  - Large granularity interface
    - E.g. Java Virtual Machine

Non-deterministic Computing

- Decision-making systems will allow variability in results produced by a program
  - More resources, better results
- Applications will tolerate this variation
  - Competition will be on quality of solution for a given cost
  - Will potentially change the way programs are constructed and optimized

Implications for ISPASS community

- Performance analysis will have to deal with new metrics ….
  - Cost, deadlines, system-level objectives (SLO)
- …. and new models
  - Heterogeneity
    - Underlying platform becomes an option, not an input
- Variability of results (non-determinism) must be taken into consideration
  - Already an issue with multiprocessor workloads
- Need more work at the "solution" level
  - Trace-driven techniques are running out of steam