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# Programming Models for NOW

Peter Steenkiste  
School of Computer Science  
Carnegie Mellon University

NOW Workshop, ASPLOS  
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## Outline

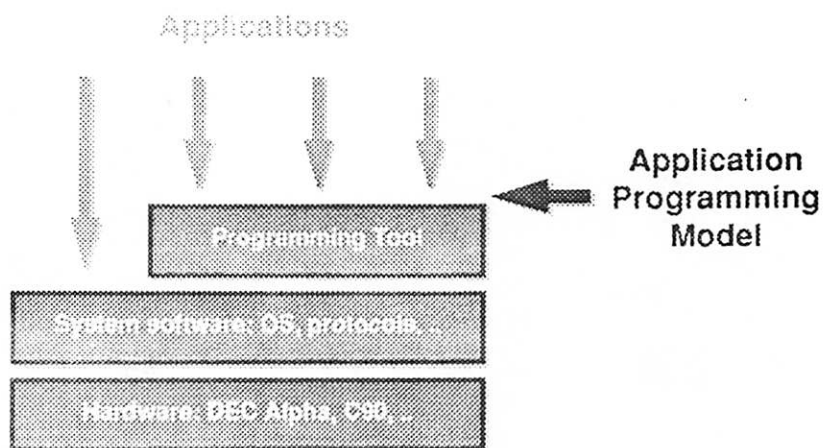
- Programming models and NOW
- Programming model features
- Relevant work at CMU
- Example models and tools at CMU
- Conclusion

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# Programming Model Definition



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## NOW

	Tightly-coupled Multicomputer	Workstation Cluster	Distributed Multicomputer
Nodes	Homogeneous		Heterogeneous
Usage	Dedicated/partitioned		Shared
Network: Topology	Regular		Irregular
Type	Proprietary		Commercial
Link Bandwidth	10 .. 200 MB/s	10 .. 100 MB/s	1 .. 20 MB/s
Bisection bandwidth	1 .. 100 GB/s	0.1 .. 10 GB/s	1 .. 500 MB/s

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# Programming Model Features

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- **Abstraction of the underlying system**
  - .. hide as many system details as possible
  - .. portably applications
- **Restricts use of the system**
  - .. easier to use for users
  - .. tools can make assumptions about the application
- **Provides information about the application**
  - .. automate distributed computing tasks
- **Need different programming models**
  - .. different levels of abstraction
  - .. different degrees of support
  - .. different levels of understanding of the problems

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# CMU NOW

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- **Nectar system (87-94)**
  - .. >10 applications
  - .. load balancing, Aroma, ...
- **Gigabit Nectar (91- )**
  - .. Nectar testbed
  - .. grand challenge applications
  - .. Dome, DCABB, Fx, ..
- **Multicomputing (93- )**
  - .. Dome, Scotch, ..

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## Tools

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- AL (Chen)
- Apply (Webb)
- Assign (O'Hallaron)
- Aroma (Nishikawa/Steenkiste)
- Adapt (Webb)
- Fx (Gross/O'Hallaron)
- Dome (Beguelin, 93-)
- DCABB (Kudva/Pekny)
- Midway (Bershad)

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## Automatic Load Balancing

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- **Distributed loop iterations**
  - .. need informations on loop structure and data dependences
  - .. AL, Fx, Dome
- **Automatic selection of load balancing parameters**
  - combine compile time and runtime information
  - .. compile time: support class of applications
  - » runtime: portability across systems
- **Architecture independent checkpointing**
  - .. needs similar information

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# Performance Automatic Load Balancing

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## Fx (Gross/O'Hallaron)

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- ◆ **Data parallelism using HPF constructs**
- ◆ **Extensions for tasks parallelism**
  - .. user hints following the HPF style
  - .. based on Assign programming model
- ◆ **Portable across many architectures**
  - .. iWarp, T3D, Paragon, clusters (PVM)
- ◆ **Both regular and irregular computations**

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## Use of Fx on Airshed

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## Performance Fx on Airshed

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## DCABB (Kudva/Pekny)

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- Programming model for search algorithms
- Automates all tasks associated with distributed implementation
  - .. start up and communication
  - .. load balancing
  - .. checkpointing
- But can be customized
  - .. node evaluation procedure
  - .. priorities of node
  - .. global tree context
  - .. termination conditions
  - .. cut planes

## Performance DCABB

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- Search is very sensitive to network performance