High Performance Fortran and the D System

Ken Kennedy
Center for Research on Parallel Computation
Rice University

1. HPF Status Report
2. Problems with HPF 1
   performance, missing features, tools
3. Responses
   HPF 2
   dHPF Compiler
   D System
HPF Goals

• Support for Scalable Parallel Systems
  - scaling from one to thousands of processors

• Focus on Data Parallelism
  - parallelism through subdivision of data domain

• Machine Independent Programming Support
  - object program achieves performance comparable to hand-coded MPI on each target machine on the same algorithm

• High Level of Abstraction
  - implicit generation of communication
Status

• Bad News
  - Acceptance of language has been slow in coming
    MPI has achieved penetration much faster
    compilers complex and slow to mature
    performance was initially disappointing
    additional features needed

• Good News
  - Compilers now available for every HPC platform
  - Applications beginning to emerge
  - Promising benchmark results
HPF Commercial Interest

• Announced HPF Products
  Applied Parallel Research
  CDAC
  Cray Research
  Digital Equipment
  Fujitsu
  Hitachi
  HP
  IBM
  Intel
  Meiko
  Motorola
  NA Software
  NEC
  Pacific Sierra Research
  Portland Group
  Sun
  Transtech

• Announced HPF Efforts
  ACE
  Lahey
  NAG
  nCUBE

• Interested
  EPC
  SGI
  Tera
**HPF Delivered Compilers 1**

- **Applied Parallel Research (xHPF)**
  - Supported by APR on:
    - IBM RS/6000, SP-1, SP-2, HP 9000 Workstations, DEC Alpha AXP Systems, Sun 4, CRAY T3D, Intel Paragon, Meiko CS-2, Parsytec PowerPC, Silicon Graphics Workstations, nCube
  - CM Fortran to HPF translator (cmf2hpf)

- **Digital**
  - Digital Unix Alpha workstations

- **IBM**
  - RS/6000 SP systems
  - Clusters of RISC System/6000 systems
HPF Delivered Compilers 2

- **Pacific Sierra Research (VAST HPF)**
  - Compilers planned for
    - SUN/Sparc, IBM RS/6000, HP 9000/700, SGI, DEC Alpha
  - Fortran 77 to HPF translator (VAST/77toHPF)

- **Portland Group**
  - CDAC PARAM 9000
  - CRAY T3D and CS 6400
  - HP SPP and Workstations
  - Intel Paragon
  - Meiko CS-2
  - Transtech Paramid
  - Supported by Portland Group on:
    - IBM SP-2, SGI POWER CHALLENGEarray, IBM, SGI and SUN (SPARC)
HPF Usage

• Installations
  - PGI reports over 100 site licenses

• Applications
  - 2 Grand Challenge projects using HPF
  - 10 Major Collaborations with PGI (8000-25,000 lines)
  - NCSA: PGI on SGI is migration platform for CM-5
  - European-funded applications (extension of Europort)
  - CRS4 Seismic Migration Code "GeoComp"
  - Amoco: Reservoir Modeling

• Benchmarks
  - NAS Benchmarks: PGI compiler within 20-50% of MPI on Class A benchmarks
  - Cornell HPF Study: IBM HPF compiler outperforms hand-coded MPI on a financial application
Problems for HPF

• Compilers slow to mature
  - Fortran 90 features supported inconsistently
  - compilation for highest efficiency complex
  - initially, efficiency of object programs unsatisfactory
  - early users may become discouraged

• Needed features are missing
  - support for irregular problems
  - task parallelism
  - high performance input/output

• Complex relationship between program and performance
  - explanatory and diagnostic tools are needed
• Consider New Features
  - irregular problems
  - task parallelism
  - parallel I/O?

• Based on
  - need
  - experience
  - reference applications suite

• Schedule
  - kickoff: Jan 30-31, 1995
  - working group meetings: May 1995-Nov 1996
  - standard available: Supercomputing 96, Nov 1996
New Language Organization

• Concern:
  - Slow progress toward highly-optimizing compilers

• Solution
  - Focus on a simple, implementable language, not much different from previous standard (HPF 1.1)
    some changes (HPF 1.2)
    some deletions (e.g. REALIGN and REDISTRIBUTE)
  - Identify strategies for portably efficient programming
  - Specify new or hard-to-implement features as Approved Extensions
    REALIGN and REDISTRIBUTE
    computation partitioning via ON clause
    irregular problem support
    task parallelism
D System Research Responses

• Compiler Optimization Research
  - dHPF research compiler
    new optimizations, new machine targets (e.g., DSM)
  - collaboration with Portland Group

• New Features
  - support for irregular problems
    collaboration with Joel Saltz
  - scalable I/O
    part of SIO initiative

• D System Tools
  - support for construction of efficient HPF programs
    intelligent editor displaying compiler feedback
    display of run-time information from Pablo (Dan Reed)
Summary

• HPF compilers emerging
  - language available on nearly every parallel system

• HPF 1 has some problems
  - performance
  - missing features
    irregular support, task parallelism, I/O
  - programming tools needed

• HPFF 2 is addressing language issues
  - focus on implementable language for performance
  - advanced features as Approved Extensions

• Rice research is developing new HPF technologies
  - advanced compiler optimization
  - support for new language features
  - programming tools
  - technology transfer to compiler vendors