Chapel Overview

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Chapel Lightning Talks

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What is Chapel?

- An emerging parallel programming language
  - Design and development led by Cray Inc.
    - with contributions from academics, labs, industry
  - Initiated under the DARPA HPCS program

- Overall goal: Improve programmer productivity

- A work-in-progress
Chapel's Implementation

- Being developed as open source at GitHub
- Licensed as Apache software

Target Architectures:
- Cray architectures
- multicore desktops and laptops
- commodity clusters
- systems from other vendors
- (in-progress: CPU+accelerator hybrids, manycore, …)
Multiresolution Design: Support multiple tiers of features

- higher levels for programmability, productivity
- lower levels for greater degrees of control

Chapel language concepts

- Domain Maps
- Data Parallelism
- Task Parallelism
- Base Language
- Locality Control
- Target Machine

- build the higher-level concepts in terms of the lower
- permit the user to intermix layers arbitrarily
Chapel in a Nutshell: Task Parallelism, etc.

Variables and types for reasoning about system resources:
Locales: the collection of compute nodes on which the program is running
here: the node on which the current task is running

Syntactic constructs for creating task parallelism:
coforall (concurrent forall): creates a task per iteration

taskParallel.chpl

```chapel
coforall loc in Locales do
  on loc {
    const numTasks = here.maxTaskPar;
    coforall tid in 1..numTasks do
      wrtitef("Hello from task %n of %n running on %s\n", tid, numTasks, here.name);
  }
```

Control over locality/affinity:
on-clauses: task migration

Static type inference (optionally):
Supports programmability with performance

prompt> chpl taskParallel.chpl -o taskParallel
prompt> ./taskParallel --numLocales=2
Hello from task 1 of 4 running on n1032
Hello from task 4 of 4 running on n1032
Hello from task 2 of 4 running on n1033
Hello from task 1 of 4 running on n1033
Hello from task 3 of 4 running on n1032
Hello from task 3 of 4 running on n1033
Hello from task 2 of 4 running on n1032
Hello from task 4 of 4 running on n1033
Chapel in a Nutshell: Data Parallelism, etc.

Modules for namespace management:
*CyclicDist*: standard module providing cyclic distributions

Configuration variables and constants:
Never write an argument parser again (unless you want to)

Domains and Arrays:
Index sets and arrays that can optionally be distributed

Data parallel forall loops and operations:
Use available parallelism for data-driven computations

Domain maps
Describe how iterations over domains/arrays are mapped to locales

```
use CyclicDist;
config const n = 1000;
var D = {1..n, 1..n}
    dmapped Cyclic(startIdx = (1,1));
var A: [D] real;
forall (i,j) in D do
    A[i,j] = i + (j - 0.5)/n;
writeln(A);
```

```
prompt> chpl dataParallel.chpl -o dataParallel
prompt> ./dataParallel --numLocales=4 --n=5
1.1 1.3 1.5 1.7 1.9
2.1 2.3 2.5 2.7 2.9
3.1 3.3 3.5 3.7 3.9
4.1 4.3 4.5 4.7 4.9
5.1 5.3 5.5 5.7 5.9
```

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Where Will Today’s Talks Take Us?

Interoperability, multi-lingual programming, adoption

**taskParallel.chpl**

```chapel
coforall loc in Locales do
  on loc {
    const numTasks = here.maxTaskPar;
    coforall tid in 1..numTasks do
      writeln("Hello from task %n of %n running on %s\n", tid, numTasks, here.name);
  }
```

**dataParallel.chpl**

```chapel
use CyclicDist;
config const n = 1000;
var D = {1..n, 1..n}
  dmapped Cyclic(startIdx = (1,1));
var A: [D] real;
forall (i,j) in D do
  A[i,j] = i + (j - 0.5)/n;
writeln(A);
```
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