

Regent: Regions

CS315B Lecture 4

Regions

- A region is a (typed) collection
- Regions are the cross product of
 - An *index space*
 - A *field space*

Example 9

| | Bit |
|---|-------|
| 0 | false |
| 1 | false |
| 2 | false |
| 3 | false |
| 4 | false |
| 5 | true |
| 6 | true |
| 7 | true |
| 8 | true |
| 9 | false |

Discussion

- Regions are *the* way to organize large data collections in Regent
- Can have any number of fields
- Built-in support for 1D, 2D and 3D index spaces

Privileges

- A task that takes region arguments must
 - Declare its *privileges* on the region
 - Reads, Writes, Reduces
- The task may only perform operations for which it has privileges
 - Including any subtasks it calls
- Example 10

Prof. Aiken CS 315B Lecture 4

5

Legion Spy

- A tool for showing ordering dependencies
 - Very useful for figuring out why things are not running in parallel
- Workflow
 - Use Legion Prof to find idle time (white space)
 - Use Legion Spy to examine tasks that are delayed
 - What are they waiting for?!
- Example 11

Prof. Aiken CS 315B Lecture 4

6

Partitioning

- To enable parallelism on a region, *partition* it into smaller pieces
 - And then run a task on each piece
- Steps:
 - *Color* elements of the region
 - *Partition* the region, creating one subregion for each color

Prof. Aiken CS 315B Lecture 4

7

Partitioning Example

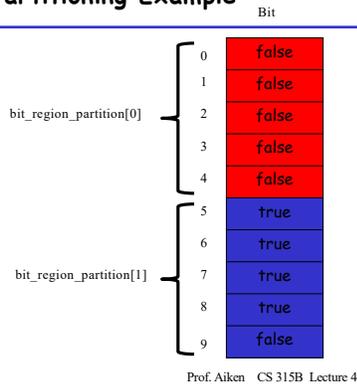
Bit

| | |
|---|-------|
| 0 | false |
| 1 | false |
| 2 | false |
| 3 | false |
| 4 | false |
| 5 | true |
| 6 | true |
| 7 | true |
| 8 | true |
| 9 | false |

Prof. Aiken CS 315B Lecture 4

8

Partitioning Example



Discussion

- Example 12
- Partitioning does not create copies
 - It names subsets of the data
- Partitioning does not remove the parent
 - It still exists and can be used
- Regions and partitions are first-class values
 - Can be created, destroyed, stored in data structures, passed to and returned from tasks

Prof. Aiken CS 315B Lecture 4

10

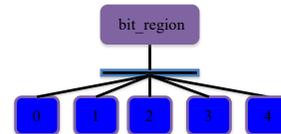
More Discussion

- The same data can be partitioned multiple ways
 - Again, these are just names for subsets
- Subregions can themselves be partitioned

Prof. Aiken CS 315B Lecture 4

11

Region Trees



Prof. Aiken CS 315B Lecture 4

12

Dependence Analysis

- Regent uses tasks region declarations to compute which tasks can run in parallel
 - What region is being accessed
 - Does it overlap with another region that is in use?
 - What field is being accessed
 - If a task is using an overlapping region, is it using the same field?
 - What are the privileges?
 - If two tasks are accessing the same field, are they both reading or both reducing?

Coherence

- Coherence is a fourth dimension of information for dependence analysis
 - How are *other* tasks allowed to use the region?
- For today, all coherence is *exclusive*
 - A task always has exclusive access to region arguments
 - The default (no need to declare)

A Crucial Fact

- Regent analyzes *sibling* tasks
 - Tasks launched directly by the same parent task
- Theorem: Analyzing dependencies between sibling tasks is sufficient to guarantee sequential semantics
- Never check for dependencies otherwise
 - Crucial to the overall design of Regent

Consequences

- Dependence analysis is a source of runtime overhead
- Can be reduced by reducing the number of sibling tasks
 - Group some tasks into subtasks
- But beware!
 - This may also reduce the available parallelism
- Example 14

Example 14

- Note that passing a region to a task does not mean the data is copied to where that task runs
 - C.f., `launcher` task must name the parent region for type checking reasons
- If the task doesn't touch a region/field, that data doesn't need to move

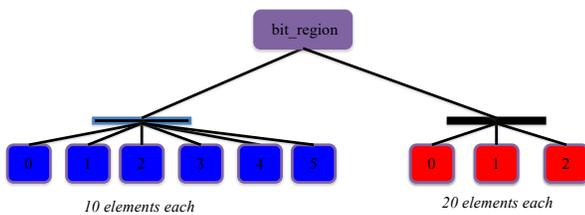
Fills

- A better way to initialize regions is to use *fill* operations

`fill(region.field, value)`

- Example 15

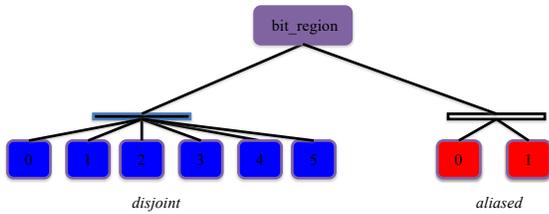
Multiple Partitions



Discussion

- Different views onto the same data
- Again, can have multiple views in use at the same time
- Regent will figure out the data dependencies
 - Example 16 & 17

Aliased Partitions



Example 18

- Equal partitions
- Aliased partitions

Summary

- Significant Regent applications have interesting region trees
 - Multiple views
 - Aliased partitions
 - Multiple levels of nesting
- And complex task dependencies
 - Subregions, fields, privileges, coherence
- Regions express locality
 - Data that will be used together
 - An example of a "local address space" design
 - Tasks can only access their region arguments