Transitioning from Constructors to Initializers in Chapel

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Constructors were less than ideal

• Served their purpose but had some issues, including:

- Required an argument per generic field
 - Purely for compiler use, couldn't change value of param/type fields in body proc MyType.MyType(type t, x) {

```
this.x = x;
```

}

- User constructors always called default constructor
 - Could result in double initialization of fields (or more)
- Default constructor always generated
 - User couldn't prevent creating an instance by specifying all fields
- Lack of clarity on when copies are made
- Many other issues





Developed initializers as a replacement

Can avoid duplicate initialization

• User initializers do not call a default initializer

One name across all types

• Not as fragile w.r.t. type name changes

Arguments not tied to fields, so can omit any subset

```
proc init(val) { // t field no longer requires an argument
    t = val.type; // type and param fields can be set in the body like other fields
    x = val;
}
```

Overall, just better!



Initializer structure

// from modules/internal/ChapelError.chpl	
class IllegalArgumentError : Error {	
<pre>var formal: string;</pre>	
<pre>var info: string;</pre>	Field initialization occurs in order, starting with inherited fields
<pre>proc init(info: string) {</pre>	
<pre>// super.init(); // this.formal = ""; this.info = info; }</pre> If no explicit call to the parent initializer, one with zero arguments will be inserted	
Skipped fields on the current class are given their declared value if provided, or the default value for the type.	



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Inheritance example

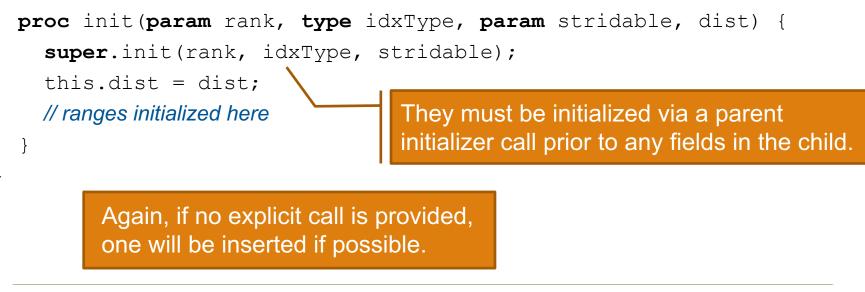
// from modules/internal/DefaultRectangular.chpl

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class DefaultRectangularDom: BaseRectangularDom {

- var dist: DefaultDist;
- var ranges : rank*range(idxType,bounded,stridable);

Inherited fields can be used in the type or default value of fields on the current class



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Calling other initializers defined on the type

```
// from modules/standard/DateTime.chpl
record timedelta {
  ... // fields, etc.
  proc init(timestamp: real) {
    this.init(seconds = timestamp: int,
           microseconds=((timestamp - timestamp: int)*1000000): int);
  }
                     For code reuse, calls the other initializer
  proc init(days=0, seconds=0, microseconds=0,
             milliseconds=0, minutes=0, hours=0, weeks=0) { ... }
                   This initializer performs the brunt of the work
```

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Method calls

Methods can only be called on initialized things

- Until all fields on current type are initialized, could give bad behavior
- Initializers forbid method calls prior to super.init() call
 - After super.init(), can call methods defined on parent types
- Signal that the current type is initialized with this.complete()
 - Allows methods on current type, but not full dynamic dispatch



Method call / this.complete() example

```
// from modules/internal/String.chpl
record string {
  ... // fields, other initializers, etc.
  proc init(cs: c string, length: int = cs.length,
              isowned: bool = true, needToCopy: bool = true) {
      this.isowned = isowned;
      this.complete(); ____
                                      Initializes all remaining fields
      const cs len = length;
      this.reinitString(cs:bufferType, cs len, cs_len+1, needToCopy);
                               The method called helps set up the type, but is
                               used in other places so it relies on the fields having an initial value.
     Can also send `this` as argument to
     other functions once fields are ready
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```

Summary of init()

• Given a class hierarchy:

• Classes A through D form a hierarchy: D:C:B:A

In D.init(), object starts as nothing (a blob of memory)

• Implication: You can't do much with it yet

• After D's call to super.init(), object is a C

- Implication: You can do anything with it that you could do with a C
- Plus, you can also assign to D fields to help turn it into a D

• Object becomes a D:

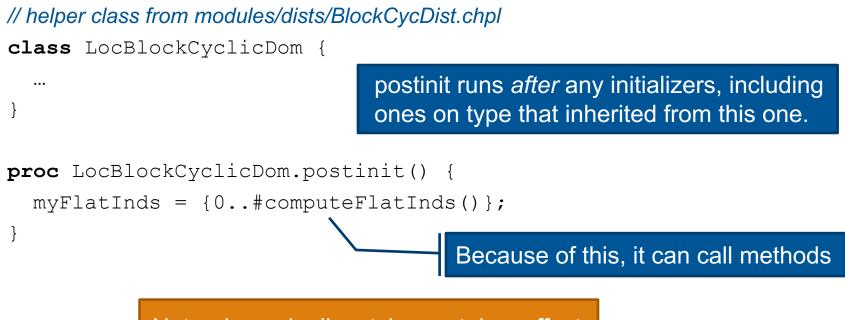
- After D's call to D.complete(), or
- After D's call to this.init(), or
- After D.init() returns



postinit example

// helper class from modules/dists/BlockCycDist.chpl **class** LocBlockCyclicDom { param rank: int; Type defines lots of fields type idxType; param stridable: bool; **const** globDom: BlockCyclicDom(rank, idxType, stridable); var myStarts: domain(rank, idxType, stridable=true); var myFlatInds: domain(1); proc LocBlockCyclicDom.postinit() { myFlatInds = {0..#computeFlatInds()}; } Only one needs a different value than the declared Could redefine default initializer, but not really worth it, so use a postinit method instead ANALYZE COMPUTE STORF Copyright 2018 Cray Inc.

postinit example



Note: dynamic dispatch now takes effect



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Copy initializers



var x: R = ...;
var y = x; // copies x

proc foo(in val: R) { ... } // copies argument

• Could change a type's copy behavior in constructor world

• But finicky and complex



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Copy initializer example

```
// From modules/standard/IO.chpl
                                            Can write special kind of initializer
                                            called a copy initializer
record file {
  var home: locale = here;
  var file internal:qio file ptr t = QIO FILE PTR NULL;
                                        The compiler provides a default copy
                                        initializer if no explicit one is provided,
proc file.init(x: file) {
                                        which just copies all fields
  this.home = x.home;
  this. file internal = x. file internal;
  this.complete();
  on home {
    qio file retain (file internal);
                               In this particular case, we want to also
                               reference count the _file_internal field.
```



Initializers: Status

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- Initializers are overall in pretty good shape
- Most library/internal modules converted to initializers
 - Exception:
 - Shared: special initCopy/autoCopy functions not converted to copy init
- Most tests converted to initializers
 - Out of ~8,500 tests...
 - ... 26 remain unconverted due to bugs or unimplemented features
 - ... 28 others will be removed once constructors are deprecated





Initializers: Next Steps

• Finish compiler-generated initializers

- Fix internal compiler errors
- Some expressions cannot be used as default values for fields yet
 - E.g., parallel loops, conditional expressions

• Fix bugs

- Nested types when at least one of the types is generic
- Generic instantiation when generic fields initialized in conditional

• • • •

Deprecate constructors



Initializers: Next Steps

• Finalize design decisions:

- Finalize copy initializers
- Finalize type initializer story
 - User might want to permit shorter type declarations, for instance:
 var twoTypes: SomeType(int, real);
 var bothSameType: SomeType(int);
- Allow users to opt into retaining compiler's default 'init()'?
 - Currently squashed by user's 'init()'

Support incomplete initialization when explicitly requested

• Also known as the 'noinit' feature



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