Towards Stability in the Chapel

Language

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@ChapelLanguage



Language Stability



- Language stability is a feature of a programming language
 - guarantee that valid programs will continue to function
- Without language stability, programmers need to update code for each release
 - all this added work can reduce any productivity benefit the language offers
- Languages in wide use have two strategies for language stability:
 - 1. Don't change the language in a way that breaks existing programs
 - 2. Provide versions of the language (e.g. C99 or Python 3)

Language Versioning



- Providing versions of the language doesn't entirely solve the problem
 - programmers still need to update when migrating to the new version
 - the old version might eventually become unsupported
 - e.g. Python 2 is reaching end of life
- Language versioning does give programmers more control over when to update
- Some compilers can even apply newer optimization to older standards
 - e.g. C compilers with flags like --std=c99

Some History



- The Chapel language started development as a research prototype
 - Started in 2003 first public release was 0.8 in 2008
- Initial focus was to demonstrate key differentiating features
 - productive parallel and distributed programming
 - user-defined distributions
- Over time Chapel has become significantly more usable and performant
 - and the user community has grown
- Language stability is now important to Chapel users

Language Stability for Chapel



- In the past several years, we have been working towards language stability
 - Sometimes refer to the stable language version as "Chapel 2.0"
- Once the language is stable, the project will
 - commit to not breaking a set of core language features
 - adopt semantic versioning

Why is Language Stability Challenging?



- Could the project have just declared Chapel 1.14 as stable?
 - and committed not to change core features past that point?
- Doing so would have prevented addressing changes requested by users
- Stabilizing a language to soon leads to obvious problems never being fixed
 - e.g. Makefiles and tab characters
- There is a balance between addressing requests and stabilizing

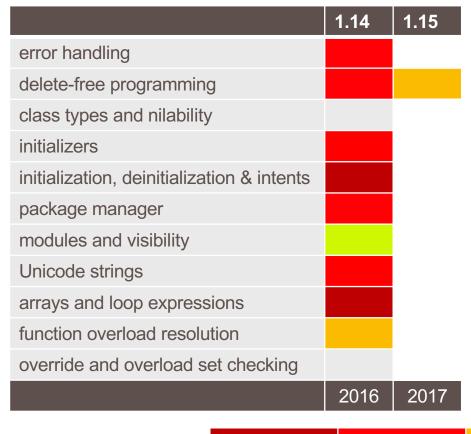
Changes Requested by Users



- Language support for error handling
- · Leak-free use of classes without needing to call 'delete'
- Classes that cannot store nil by default
- Robust class and record initializer support
- Language design that minimizes unnecessary copies and memory errors
- A package manager enabling the community to share libraries
- Support for Unicode strings
- Make the built-ins either 1-based or 0-based, not a mix of the two

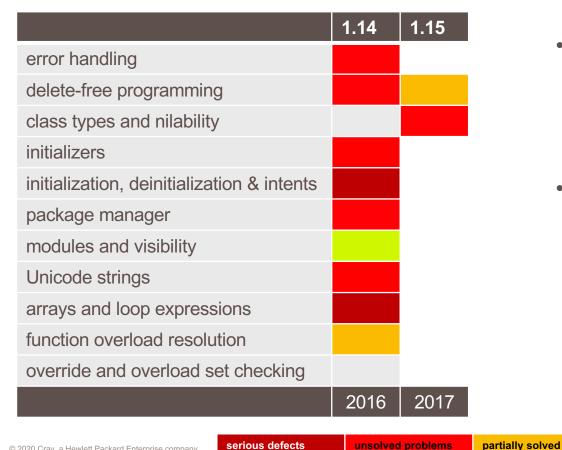


	1.14
error handling	
delete-free programming	
class types and nilability	
initializers	
initialization, deinitialization & intents	
package manager	
modules and visibility	
Unicode strings	
arrays and loop expressions	
function overload resolution	
override and overload set checking	
	2016





- New types Owned and Shared types lead to realization that class types should have nilable and nonnilable variants
- Partly due to issues of ownership transfer



- a Hewlett Packard Enterprise comp
- New types Owned and Shared types lead to realization that class types should have nilable and nonnilable variants
- Partly due to issues of ownership transfer

stable

mostly stable

Owned in 1.15



• Owned example from 1.15:

var myOwned = new Owned(new MyClass());

var otherOwned = myOwned;
// anotherOwned now stores nil
// both assignment and copy-initialization transfer ownership

- Ownership transfer adds a new way for variables to become 'nil'
 - increasing the chance of 'nil' dereference errors
 - Can these be caught at compile-time?



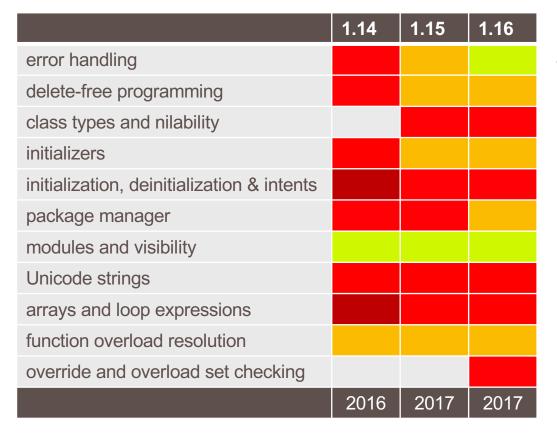
	1.14	1.15
error handling		
delete-free programming		
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	2016	2017



	1.14	1.15
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override and overload set checking		
	2016	2017

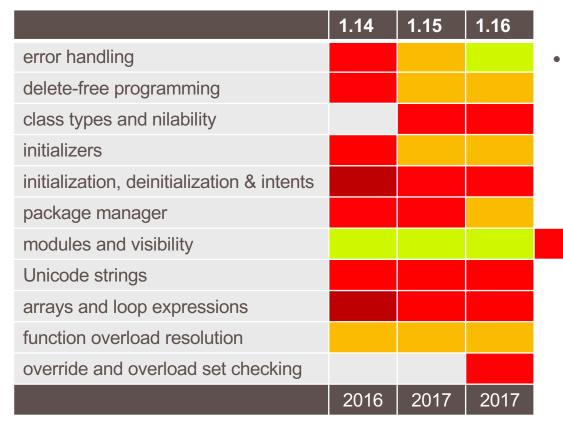


	1.14	1.15	1.16
error handling			
delete-free programming			
class types and nilability			
initializers			
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arrays and loop expressions			
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override and overload set checking			
	2016	2017	2017



 Users of new 'mason' manager in 1.16 demonstrated problems with module system





 Users of new 'mason' manager in 1.16 demonstrated problems with module system

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Module Issue Revealed by Mason



file hierarchy:	// AB.chpl	> chpl AB.chpl A/A.chpl B/B.chpl
•	use A;	warning: Ambiguous module source file
AB.chpl	use B;	using A/C.chpl over B/C.chpl
⊢— A/		
A.chpl	// A.chpl	
L Help.chpl	use Help; //	expecting A/Help.chpl
L B/		
B.chpl	// B.chpl	
L Help.chpl	use Help; //	expecting B/Help.chpl

• Module system needs to help distinguish local and global modules, somehow



	1.14	1.15	1.16
error handling			
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override and overload set checking			
	2016	2017	2017



	1.14	1.15	1.16	1.17
error handling				
delete-free programming				
class types and nilability				
initializers				
initialization, deinitialization & intents				
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Unicode strings				
arrays and loop expressions				
function overload resolution				
override and overload set checking				
	2016	2017	2017	2018

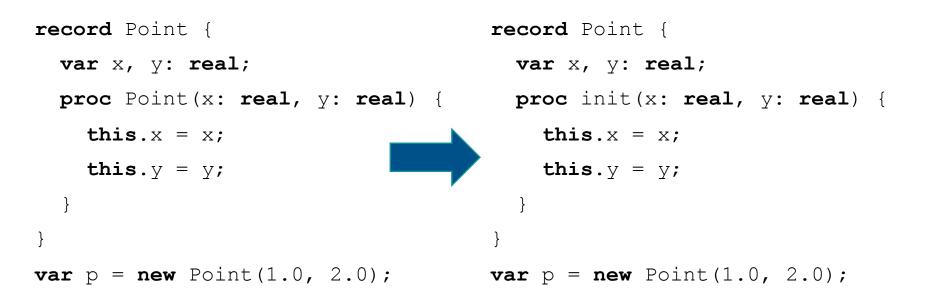
	1.14	1.15	1.16	1.17	1.18
error handling					
delete-free programming					х
class types and nilability					
initializers					х
initialization, deinitialization & intents					
package manager					
modules and visibility					
Unicode strings					
arrays and loop expressions					
function overload resolution					
override and overload set checking					
	2016	2017	2017	2018	2018



- Big breaking changes
 - initializers replace constructors
 - managed class types

Initializers Replaced Constructors in 1.18





Initializers significantly more robust and capable than constructors

Managed Class Types in 1.18



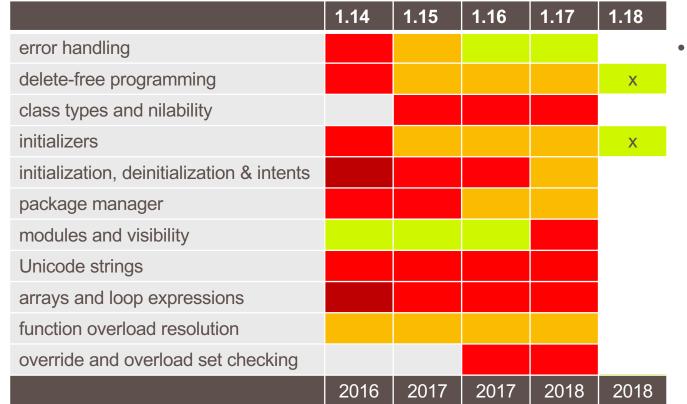
```
class C {
                                      class C {
  var x: int;
                                         var x: int;
proc main() {
                                      proc main() {
  var instance = new C(1);
                                         var instance = new owned C(1);
  var tmp: C = instance;
                                         var tmp: borrowed C = instance;
  delete instance;
                                        // instance automatically deleted here
```

- · Generally removed need for 'delete'
- Some memory errors are now caught at compile-time



	1.14	1.15	1.16	1.17	1.18
error handling					
delete-free programming					x
class types and nilability					
initializers					x
initialization, deinitialization & intents					
package manager					
modules and visibility					
Unicode strings					
arrays and loop expressions					
function overload resolution					
override and overload set checking					
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partially solved



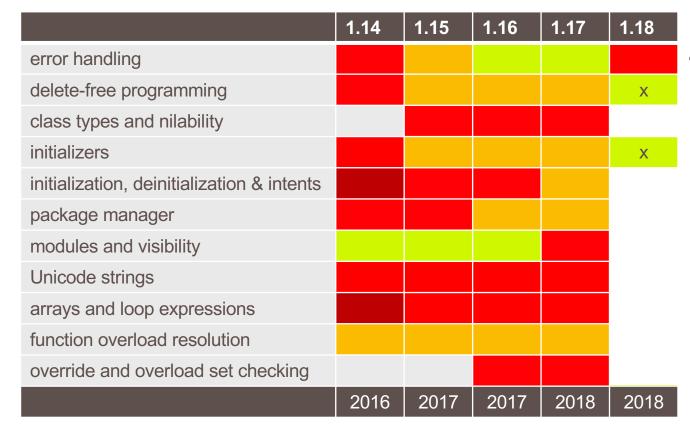


• Errors are classes

 So class changes caused problems for error handling

stable

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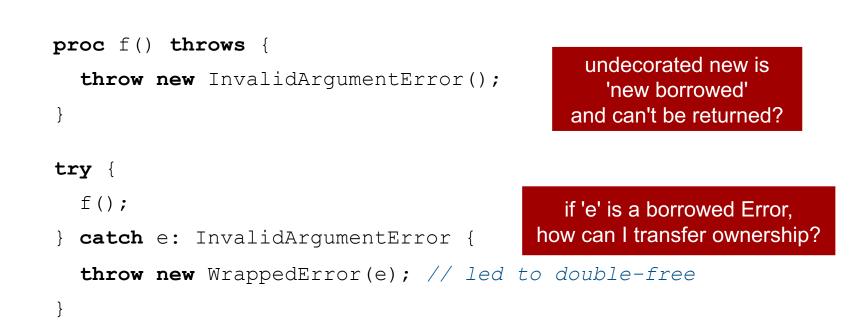
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 So class changes caused problems for error handling

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Error Handling Problem in 1.18







	1.14	1.15	1.16	1.17	1.18
error handling					
delete-free programming					Х
class types and nilability					
initializers					x
initialization, deinitialization & intents					
package manager					
modules and visibility					
Unicode strings					
arrays and loop expressions					
function overload resolution					
override and overload set checking					
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	1.14	1.15	1.16	1.17	1.18
error handling					
delete-free programming					x
class types and nilability					
initializers					x
initialization, deinitialization & intents					
package manager					
modules and visibility					
Unicode strings					
arrays and loop expressions					
function overload resolution					
override and overload set checking					
	2016	2017	2017	2018	2018

stable

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	1.14	1.15	1.16	1.17	1.18	1.19
error handling						
delete-free programming					Х	
class types and nilability						
initializers					Х	
initialization, deinitialization & intents						
package manager						
modules and visibility						
Unicode strings						
arrays and loop expressions						
function overload resolution						
override and overload set checking						
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	1.14	1.15	1.16	1.17	1.18	1.19	1.20		
error handling									
delete-free programming					x				
class types and nilability							х		
initializers			Big breaking change:						
initialization, deinitialization & intents			 Class types cannot store 'nil' by default 						
package manager									
modules and visibility									
Unicode strings									
arrays and loop expressions									
function overload resolution									
override and overload set checking									
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Non-Nilable Class Types in 1.20



```
class C {
   var x: int;
}
var a: borrowed C = ...;
var b: borrowed C = nil; // now an error in 1.20
var c: borrowed C; // now an error in 1.20
a = nil; // now an error in 1.20
```

var bb: borrowed C? = nil; // OK in 1.20, C? is a nilable class type

• Helps discover more errors at compile time and make safer code the default



	1.14	1.15	1.16	1.17	1.18	1.19	1.20
error handling							
delete-free programming					Х		
class types and nilability							x
initializers					Х		
initialization, deinitialization & intents							
package manager							
modules and visibility							
Unicode strings							
arrays and loop expressions							
function overload resolution							
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	1.14	1.15	1.1	6	1.17	1.18	1.19	1.20	
error handling									
delete-free programming						Х			
class types and nilability								x	
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modules and visibility				 Non-nilable class types cannot be default initialized 					
Unicode strings									
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function overload resolution				Non-nilable owned cannot be					
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Non-Nilable Initialization in 1.20



```
var x: owned MyClass;
try {
  var arg = ...;
  ... lots of code setting arg ...
  x = new MyClass(arg);
}
```

• Needed a way to write such patterns without needing nilable variables

Non-Nilable Ownership Transfer in 1.20



var x: owned MyClass = new MyClass(1);

- Needed a way to address this type system gap
 - preferably, without completely prohibiting such patterns



	1.14	1.15	1.16	1.17	1.18	1.19	1.20
error handling							
delete-free programming					Х		
class types and nilability							x
initializers					Х		
initialization, deinitialization & intents							
package manager							
modules and visibility							
Unicode strings							
arrays and loop expressions							
function overload resolution							
override and overload set checking							
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	1.14	1.15	1.16	1.17	1.18	1.19	1.20
error handling							
delete-free programming					Х		
class types and nilability							x
initializers					Х		
initialization, deinitialization & intents							
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Unicode strings							
arrays and loop expressions							
function overload resolution							
override and overload set checking							
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	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21		
error handling										
delete-free programming					х					
class types and nilability							х			
initializers					х					
initialization, deinitialization & intents										
package manager										
modules and visibility								x		
Unicode strings				 Breal 	kina ch	ande.				
arrays and loop expressions					0	0				
function overload resolution				 Module visibility is much tighter 						
override and overload set checking										
	2016	2017	2017	2018	2018	2019	2019	2020		

Module System Improvements



• Import statements are new and support a more resilient coding style:

```
import MyModule;
writeln(MyModule.sym1); // Enabled by the 'import'
writeln(sym1); // Not enabled, won't work
```

- 'use' statements are private by default
- 'use' and 'import' statements can request relative module paths

use this.Submodule; //Uses module defined within current module
use super.SiblingModule; //Uses module defined in parent module

- These improvements support mason packages
 - by considering the possibility of module name collisions across packages



	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21
error handling								
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initialization, deinitialization & intents								
package manager								
modules and visibility								x
Unicode strings								
arrays and loop expressions								
function overload resolution								
override and overload set checking								
	2016	2017	2017	2018	2018	2019	2019	2020

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	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21
error handling								
delete-free programming					Х			
class types and nilability							Х	
initializers					Х			
initialization, deinitialization & intents								
package manager								
modules and visibility								x
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arrays and loop expressions								
function overload resolution								
override and overload set checking								
	2016	2017	2017	2018	2018	2019	2019	2020

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0-based indexing



- We polled Chapel users about switching to 0-based indexing
 - Most said they would prefer it, if we were designing the language from scratch
 - Most were not terribly concerned about updating their existing Chapel code
 - Most expressed concern about the expected impact to other users
- After studying the impact on key codes, we decided to switch to 0-based
- Did so in a separate release 1.22 to make migrating code easier
- Change impacts many types: tuples, strings, bytes, array literals, lists, ...

var t = (1.2, 3.4); // t(1) was 1.2; it's now 3.4, and t(0) is 1.2

Changes Requested by Users



- Language support for error handling
- Leak-free use of classes without needing to call 'delete'
- Classes that cannot store nil by default
- Robust class and record initializer support
- Language design that minimizes unnecessary copies and memory errors
- A package manager enabling the community to share libraries
- Support for Unicode strings
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- Make the built-ins either 1-based or 0-based, not a mix of the two
- Have not needed major changes to the unique features of Chapel:
 - parallelism and distributed programming

Stabilization Next Steps



- Adding constrained generics
- Addressing problems with point-of-instantiation in function resolution
- Improving array initialization
 - currently does default initialization + assignment instead of copy initialization
- Stabilizing the standard libraries
- The <u>1.21/1.22 release notes</u> have much more detail
 - about problems addressed in 1.21 to support language stability
 - about areas not yet included in stabilization

Questions?



	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21
error handling								
delete-free programming					Х			
class types and nilability							Х	
initializers					Х			
initialization, deinitialization & intents								
package manager								
modules and visibility								x
Unicode strings								
arrays and loop expressions								
function overload resolution								
override and overload set checking								
	2016	2017	2017	2018	2018	2019	2019	2020

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