Try, Not Halt: An Error Handling Strategy for Chapel

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Motivation

- Chapel lacked a general strategy for handling errors
  - 'halt()' and "error" out arguments are used in practice, but insufficient

- First cut at language-level design was modeled after Swift
Swift

- All calls that might throw must be marked with 'try'
  - Makes control flow clear with only local information

```swift
func canThrowErrors() throws {
    // ...
}

do {
    try canThrowErrors();
    try! canThrowErrors(); // will halt on failure
} catch {
    writeln("first call failed!");
}
```

- Community feedback was that this is verbose
  - (read: annoying)

- How can this be streamlined?
CHIP #8 investigated a few different options:

1. Make 'try' optional.
   - Inside 'do' blocks, users should already be aware of throwing calls
   - Outside 'do' blocks, calling fn signature can determine 'throw' or halt
   - Downside: errors silently passing through functions

2. Make 'try' optional, with a compiler flag.
   - Hardens code like Swift with the flag, otherwise the same as (1)

3. Eliminate 'do' from the syntax.
   - 'do' is already a keyword in Chapel
   - Replace it with a 'try' defined on compound statements
Current design and implementation

- Combination of (2) and (3) was chosen for the design
  - Full detail in CHIP #8

- Chapel 1.15 contains a draft implementation

- Offers basic functionality, but with significant limitations
  - Handling cannot yet span `begin` / `cobegin` / `coforall` / `forall` / `on`...
  - Virtual methods cannot yet throw
  - Halting errors do not yet print their type or message
  - Errors cannot yet be generic classes

- Seeking feedback on design and implementation
  - 'try' it out today!
Errors as classes

- Base class 'Error' is provided
  - For now, the initializer accepts a string argument

```java
class Error {
    var msg: string;
}
```

- 'Error' may be used directly, or as the root of a hierarchy
  - Standard set of 'Error' subclasses not currently included

```java
class MyError: Error {}

class MyIntError: Error {
    var i: int;
}
```
Throwing errors

● Throw an error with 'throw'

    // throwing a newly created error
    throw new Error("error message here");

    // throwing an error stored in a variable
    var e = new Error("test error");
    throw e;

● Mark procedures that can throw with 'throws'

    proc mayThrowErrors() throws { ... }

    proc mayThrowErrorsAlso(): A throws where { ... }

    proc mayNotThrowErrors() { ... }
"try' and 'try!' are used to handle thrown errors

- `{ }` blocks try to match to an associated 'catch' clause
- Single statements will not match any 'catch' clauses

```swift
try {
    mayThrowErrors();
    mayNotThrowErrors(); // non-throwing calls may be included
    mayThrowErrorsAlso();
}
try! mayThrowErrors(); // halts on error
```

- If an error is handled with no matching 'catch' clause:
  - 'try' propagates the error
    - To an outer 'try', or out of the procedure (which must be marked 'throws')
  - 'try!' halts instead of propagating
  - Single statement form relies on this behavior
try/catch

- 'catch' clause list matches against an 'Error' at run-time
- If a type filter matches the error, that block will be executed
- Lack of a type filter means that all errors match

```java
try {
    trickyOperation(badArg);
} catch err: IllegalArgumentError { // IllegalArgumentError, subtypes
    writeln("illegal argument!");
} catch err: MyError { // MyError, subtypes
    throw err;
} catch { // catch-all
    writeln("unknown error!");
}
```
Default and Strict mode

- Two modes to support the tradeoff between...
  - ensuring propagation of errors is clear (strict)
  - drafting code quickly (default)

- **Strict mode enforces visible control flow**
  - All calls to throwing procedures must be enclosed within 'try' / 'try!'
  - Otherwise, an error will be raised at compile-time

- **Default mode supports rapid prototyping**
  - Throwing calls need not be enclosed in 'try' / 'try!'
  - If the enclosing procedure is marked 'throws', propagate errors
  - Otherwise, halt on errors

- **Strict mode enabled with a compiler flag, --strict-errors**
  - Otherwise, compiler uses default mode
  - Expect to support more fine-grained approaches in the future
    - e.g., specify strictness per-module (or even per-function?)
Next steps

● Seek feedback on design and implementation

● Address the known limitations
  ● Especially with regards to parallelism and multilocal

● New features
  ● Create a standard set of 'Error' classes
  ● Enable throwing errors from iterators
  ● Implement a 'defer' construct for state cleanup
  ● Design and implement a fine-grained strict mode

● Integrate error handling into the standard library

● Handle runtime errors by throwing Chapel errors
Thank you! Questions?
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