Try, Not Halt:
An Error Handling Strategy for Chapel

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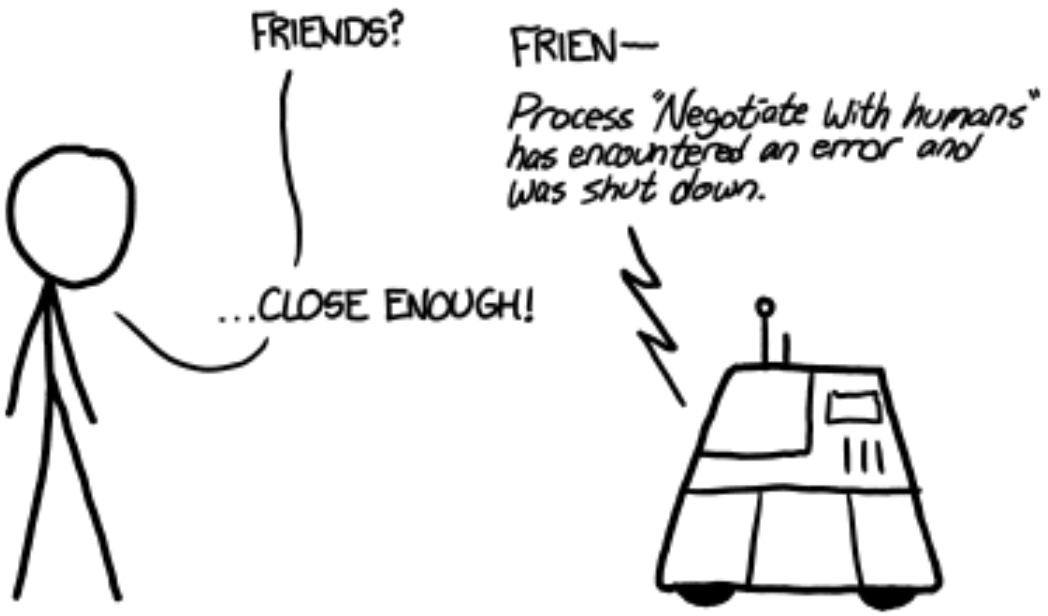
Motivation

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



credit xkcd

- **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

```
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?**

Swifter (Better, Faster, Stronger)

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

```
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

```
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/catch

- **'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

```
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

```
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 multilocale
- **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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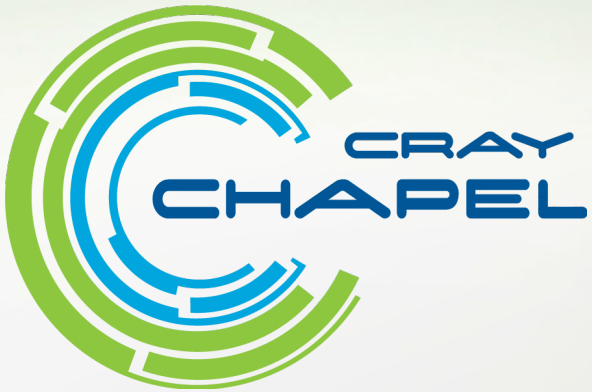

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