A beginner-friendly environment for exploring error messages in the Clojure programming language.

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Outline

Clojure Language and Syntax

What is Clojure? - Clojure language and Syntax

- Clojure is a part of the Lisp language family
- Syntax
  - prefix notation (operators before operands).
  - expressions are surrounded by parentheses.

Example: `(/ 9 3)` denotes 9 divided by 3

Clojure Language and Syntax

- Clojure is implemented in Java and runs on the Java Virtual Machine (JVM)
- Clojure code $\rightarrow$ Java code $\rightarrow$ JVM bytecode $\rightarrow$ executed on JVM

Clojure Language and Syntax

Clojure's REPL

- interactive environment for code evaluation
- Read → Evaluate → Print → Loop

```
Clojure 1.11.4
user=> (map pos? [-1 0 1])
(false false true)
user=>
```

Clojure's Error Messages

Clojure Exceptions

- an event or error that disrupts the normal flow of a program's execution
- Clojure syntax errors will also result in a Java exception

Error Messages

- generate when a exception occurs
- provide error type, cause, and location

Clojure's Error Messages

Anatomy of a Clojure Error Message

```
=> (/ 9 0)
Execution error (ArithmeticException) at user/eval1
(REPL:1).
Divide by zero
```

- `ArithmeticException`: The type of error that occurred.
- `user/eval1 (REPL:1)`: The location where the error happened (in this case, REPL, line 1).
- `Divide by zero`: The description of the error's cause.

Setup and Goals

Overview of Babel

- Tool designed to replace native Clojure messages to aid in understanding
- Relies heavily on the Clojure spec library to catch errors on function calls `Elena: We didn't introduce spec yet - can introduce it here; show "spec" and "other errors" in boldface or some such.`
- Maintains a dictionary of other errors (e.g. division by zero) that can't be spec'd, in order to rewrite them as well `Elena: Using RegEx to pull out different parts`

Usage

- Launching a REPL server in the Babel repository allows the tool to "hook" to it
- Initialization function `(setup-exc)` is called to begin intercepting error messages `Elena: I don't think we need to mention this`

Setup and Goals

Motivation `Elena: shouldn't this be before the previous slide?`

- Babel is a learning tool for beginners to Clojure and programming as a whole
- Clojure error messages contain awkward phrasing that may impede understanding

Example

Consider the error produced by the form below. What does it mean?

```
=> (count 1)
Execution error (UnsupportedOperationException) at
user/eval1529 (REPL:1).
count not supported on this type: Long
```

Setup and Goals

Exceptions Processing

Sending Data to Morse

- The Clojure REPL does not provide the proper hooks to effectively manipulate error message data.
- To get around this, we need to initialize Babel within a sub-REPL of the parent REPL session.
- Creating a sub-REPL allows us to introduce hooks that let us add preprocessing steps.

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Sub-REPL hooks

Babel uses the following hooks as part of error processing:

- `:init` Behavior on startup, launches a new Morse session connected to the current REPL.
- `:eval` Behavior on form evaluation. Stores the command and sends it to REPL and Morse.
- `:caught` Behavior on caught exception. Processes the error in Babel, and changes the Exception- String processing to instead create a vector of labelled pairs.

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Current State of the Project

- We have existing error messages without labels for many common errors of core functions.
- We can connect Morse to a REPL session, and have mirroring form evaluation.
- Most of the work this year was spent structuring things for integration with Morse viewers.
- The introduction of the error labeling and prototyping this was pivotal in enabling data formatting.
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```
user=> (even? 1 2)
Execution error (ArityException) at user/eval2044 (REPL:1).
Wrong number of args (2) passed to: clojure.core/even?
```

Figure: The output for the form `(even? 1 2)` in default Clojure.

```
Babel=> (even? 1 2)
(even? 1 2)
Wrong number of arguments in (even? 1 2): the function even? expects one argument but was given two arguments.
In Clojure interactive session on line 1.
```

Figure: The output for the form `(even? 1 2)` in Babel through the REPL.

Figure: The output for the form `(even? 1 2)` in Babel with Morse.

Future Work

- Expand data labeling to all Babel error messages, expanding our ability to use Morse viewers.
- Add hover text to viewers for specific terms to add definitions and supplementary information to the presented error message.
- Refining the end user work flow between working code and erroring code.
- Develop Morse viewers for other information, such as the stack trace, and full java error messages.

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Discussion

Questions?