My Project

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Chapter 1

MSDScript

Author

Tailang Cao

Second Author (if applicable)

Date

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Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 4

File Index

4.1 File List

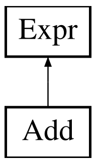
Here is a list of all documented files with brief descriptions:

Chapter 5

Class Documentation

5.1 Add Class Reference

Inheritance diagram for Add:



Public Member Functions

- Add (Expr ∗lhs, Expr ∗rhs)
- bool equals (Expr ∗e)
- int interp ()
- bool has_variable ()
- Expr ∗ subst (std::string, Expr ∗s)
- void print (std::ostream &ot)
- void pretty_print_dr (std::ostream &ot)
- void pretty_print (std::ostream &ot, precedence_t prec)

Public Member Functions inherited from Expr

- std::string **to_string** ()
- std::string **to_pretty_string** ()

Public Attributes

- Expr ∗ **lhs**
- Expr ∗ **rhs**

5.1.1 Constructor & Destructor Documentation

5.1.1.1 Add()

```
Add::Add (
            Expr ∗ lhs,
            Expr ∗ rhs )
```

this is the Add function

Parameters

lhs	
rhs	

5.1.2 Member Function Documentation

5.1.2.1 equals()

```
bool Add::equals (
             Expr * e )  [virtual]
```

Implements Expr.

5.1.2.2 has_variable()

```
bool Add::has_variable ( )  [virtual]
```

Implements Expr.

5.1.2.3 interp()

```
int Add::interp ( )  [virtual]
```

Implements Expr.

5.1.2.4 pretty_print()

```
void Add::pretty_print (
             std::ostream & ot,
             precedence_t prec )  [virtual]
```

Implements Expr.

5.1.2.5 pretty_print_dr()

```
void Add::pretty_print_dr (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.1.2.6 print()

```
void Add::print (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.1.2.7 subst()

```
Expr * Add::subst (
            std::string replace,
            Expr * s )  [virtual]
```

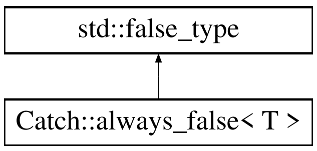
Implements Expr.

The documentation for this class was generated from the following files:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h
- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.cpp

5.2 Catch::always_false< T > Struct Template Reference

Inheritance diagram for Catch::always_false< T >:



The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.3 Catch::Detail::Approx Class Reference

Public Member Functions

- **Approx** (double value)
- Approx **operator-** () const
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  Approx **operator()** (T const &value)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  Approx (T const &value)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  Approx & **epsilon** (T const &newEpsilon)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  Approx & **margin** (T const &newMargin)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  Approx & **scale** (T const &newScale)
- std::string **toString** () const

Static Public Member Functions

- static Approx **custom** ()

Friends

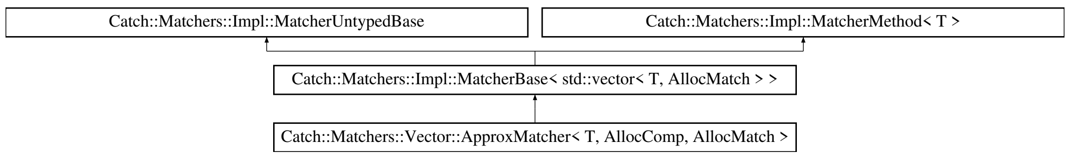
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator==** (const T &lhs, Approx const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator==** (Approx const &lhs, const T &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator!=** (T const &lhs, Approx const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator!=** (Approx const &lhs, T const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator<=** (T const &lhs, Approx const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator<=** (Approx const &lhs, T const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator>=** (T const &lhs, Approx const &rhs)
- template<typename T , typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  bool **operator>=** (Approx const &lhs, T const &rhs)

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.4 Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch > Struct Template Reference

Inheritance diagram for Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::vector< T, AllocMatch > >
Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- **ApproxMatcher** (std::vector< T, AllocComp > const &comparator)
- bool **match** (std::vector< T, AllocMatch > const &v) const override
- std::string describe () const override
- template<typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  ApproxMatcher & **epsilon** (T const &newEpsilon)
- template<typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  ApproxMatcher & **margin** (T const &newMargin)
- template<typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
  ApproxMatcher & **scale** (T const &newScale)

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Public Attributes

- std::vector< T, AllocComp > const & **m_comparator**
- Catch::Detail::Approx **approx** = Catch::Detail::Approx::custom()

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.4.1 Member Function Documentation

5.4.1.1 describe()

```
template<typename T , typename AllocComp , typename AllocMatch >
std::string Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch >::describe ( )
const  [inline], [override], [virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.5 Catch::Generators::as< T > Struct Template Reference

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.6 Catch::AssertionHandler Class Reference

Public Member Functions

- **AssertionHandler** (StringRef const &macroName, SourceLineInfo const &lineInfo, StringRef captured↩ Expression, ResultDisposition::Flags resultDisposition)
- template<typename T >
  void **handleExpr** (ExprLhs< T > const &expr)
- void **handleExpr** (ITransientExpression const &expr)
- void **handleMessage** (ResultWas::OfType resultType, StringRef const &message)
- void **handleExceptionThrownAsExpected** ()
- void **handleUnexpectedExceptionNotThrown** ()
- void **handleExceptionNotThrownAsExpected** ()
- void **handleThrowingCallSkipped** ()
- void **handleUnexpectedInflightException** ()
- void **complete** ()
- void **setCompleted** ()
- auto **allowThrows** () const -> bool

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.7 Catch::AssertionInfo Struct Reference

Public Attributes

- StringRef **macroName**
- SourceLineInfo **lineInfo**
- StringRef **capturedExpression**
- ResultDisposition::Flags **resultDisposition**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.8 Catch::AssertionReaction Struct Reference

Public Attributes

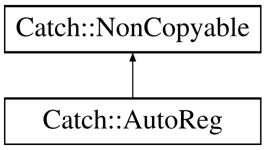
- bool **shouldDebugBreak** = false
- bool **shouldThrow** = false

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.9 Catch::AutoReg Struct Reference

Inheritance diagram for Catch::AutoReg:



Public Member Functions

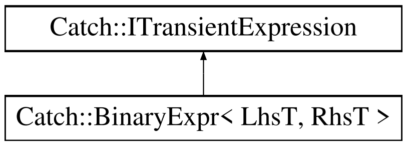
- **AutoReg** (ITestInvoker ∗invoker, SourceLineInfo const &lineInfo, StringRef const &classOrMethod, NameAndTags const &nameAndTags) noexcept

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.10 Catch::BinaryExpr< LhsT, RhsT > Class Template Reference

Inheritance diagram for Catch::BinaryExpr< LhsT, RhsT >:



Public Member Functions

- **BinaryExpr** (bool comparisonResult, LhsT lhs, StringRef op, RhsT rhs)
- template<typename T >
  auto **operator&&** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator||** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator==** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator!=** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator>** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator<** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator>=** (T) const -> BinaryExpr< LhsT, RhsT const & > const
- template<typename T >
  auto **operator<=** (T) const -> BinaryExpr< LhsT, RhsT const & > const

Public Member Functions inherited from Catch::ITransientExpression

- auto **isBinaryExpression** () const -> bool
- auto **getResult** () const -> bool
- **ITransientExpression** (bool isBinaryExpression, bool result)

Additional Inherited Members

Public Attributes inherited from Catch::ITransientExpression

- bool **m_isBinaryExpression**
- bool **m_result**

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.11 Catch::Capturer Class Reference

Public Member Functions

- **Capturer** (StringRef macroName, SourceLineInfo const &lineInfo, ResultWas::OfType resultType, StringRef names)
- void **captureValue** (size_t index, std::string const &value)
- template<typename T >
  void **captureValues** (size_t index, T const &value)
- template<typename T , typename... Ts>
  void **captureValues** (size_t index, T const &value, Ts const &... values)

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.12 Catch::Matchers::StdString::CasedString Struct Reference

Public Member Functions

- **CasedString** (std::string const &str, CaseSensitive::Choice caseSensitivity)
- std::string **adjustString** (std::string const &str) const
- std::string **caseSensitivitySuffix** () const

Public Attributes

- CaseSensitive::Choice **m_caseSensitivity**
- std::string **m_str**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.13 Catch::CaseSensitive Struct Reference

Public Types

- enum **Choice** { **Yes** , **No** }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

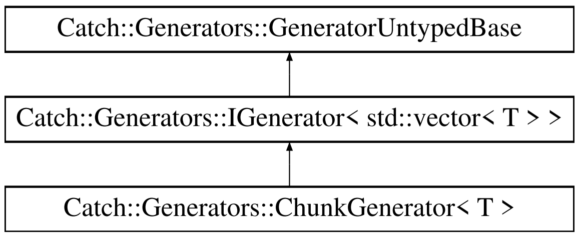
5.14 Catch_global_namespace_dummy Struct Reference

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.15 Catch::Generators::ChunkGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::ChunkGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< std::vector< T > >
Catch::Generators::ChunkGenerator< T >

Public Member Functions

- **ChunkGenerator** (size_t size, GeneratorWrapper< T > generator)
- std::vector< T > const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< std::vector< T > >

- using **type**

5.15.1 Member Function Documentation

5.15.1.1 get()

```
template<typename T >
std::vector< T > const & Catch::Generators::ChunkGenerator< T >::get ( ) const  [inline],
[override], [virtual]
```

Implements Catch::Generators::IGenerator< std::vector< T > >.

5.15.1.2 next()

```
template<typename T >
bool Catch::Generators::ChunkGenerator< T >::next ( )  [inline], [override], [virtual]
```

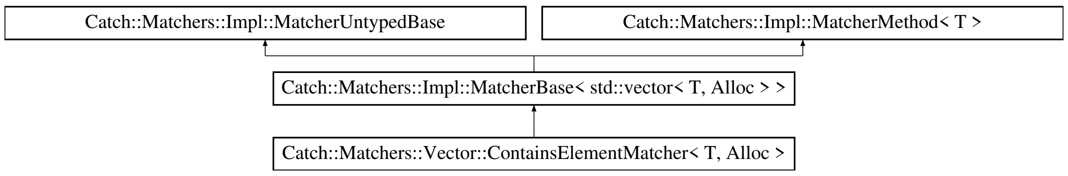
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.16 Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc > Struct Template Reference

Inheritance diagram for Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::vector< T, Alloc > >
Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc >

Public Member Functions

- **ContainsElementMatcher** (T const &comparator)
- bool **match** (std::vector< T, Alloc > const &v) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Public Attributes

- T const & **m_comparator**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.16.1 Member Function Documentation

5.16.1.1 describe()

```
template<typename T , typename Alloc >
std::string Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc >::describe ( ) const
[inline], [override], [virtual]
```

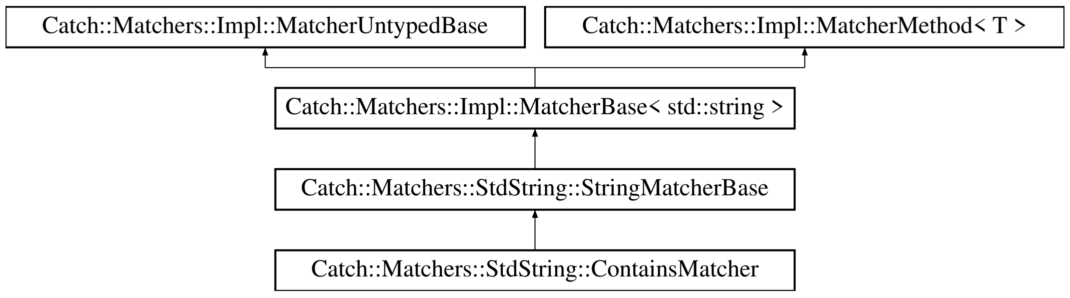
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.17 Catch::Matchers::StdString::ContainsMatcher Struct Reference

Inheritance diagram for Catch::Matchers::StdString::ContainsMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::StdString::ContainsMatcher

Public Member Functions

- **ContainsMatcher** (CasedString const &comparator)
- bool **match** (std::string const &source) const override

Public Member Functions inherited from Catch::Matchers::StdString::StringMatcherBase

- **StringMatcherBase** (std::string const &operation, CasedString const &comparator)
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Public Attributes inherited from Catch::Matchers::StdString::StringMatcherBase

- CasedString **m_comparator**
- std::string **m_operation**

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

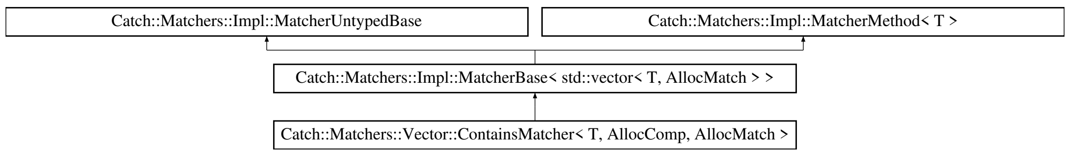
- std::string **m_cachedToString**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.18 Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch > Struct Template Reference

Inheritance diagram for Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::vector< T, AllocMatch > >
Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- **ContainsMatcher** (std::vector< T, AllocComp > const &comparator)
- bool **match** (std::vector< T, AllocMatch > const &v) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Public Attributes

- std::vector< T, AllocComp > const & **m_comparator**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.18.1 Member Function Documentation

5.18.1.1 describe()

```
template<typename T , typename AllocComp , typename AllocMatch >
std::string Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch >::describe ( )
const  [inline], [override], [virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.19 Catch::Counts Struct Reference

Public Member Functions

- Counts **operator-** (Counts const &other) const
- Counts & **operator+=** (Counts const &other)
- std::size_t **total** () const
- bool **allPassed** () const
- bool **allOk** () const

Public Attributes

- std::size_t **passed** = 0
- std::size_t **failed** = 0
- std::size_t **failedButOk** = 0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.20 Catch::Decomposer Struct Reference

Public Member Functions

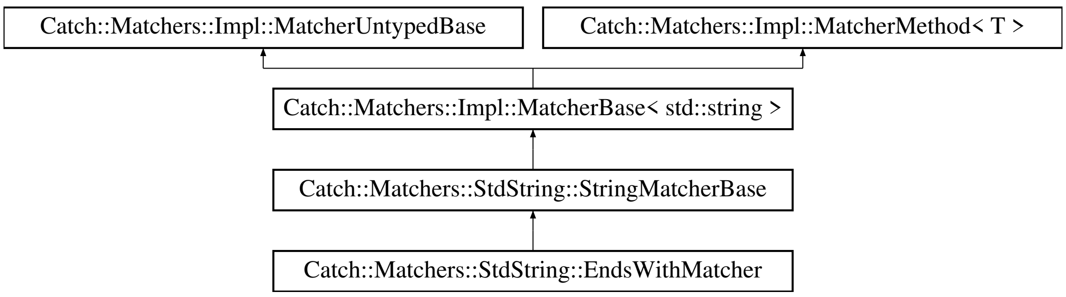
- template<typename T >
  auto **operator<=** (T const &lhs) -> ExprLhs< T const & >
- auto **operator<=** (bool value) -> ExprLhs< bool >

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.21 Catch::Matchers::StdString::EndsWithMatcher Struct Reference

Inheritance diagram for Catch::Matchers::StdString::EndsWithMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::StdString::EndsWithMatcher

Public Member Functions

- **EndsWithMatcher** (CasedString const &comparator)
- bool **match** (std::string const &source) const override

Public Member Functions inherited from Catch::Matchers::StdString::StringMatcherBase

- **StringMatcherBase** (std::string const &operation, CasedString const &comparator)
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Public Attributes inherited from Catch::Matchers::StdString::StringMatcherBase

- CasedString **m_comparator**
- std::string **m_operation**

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.22 Catch::Detail::EnumInfo Struct Reference

Public Member Functions

- StringRef **lookup** (int value) const

Public Attributes

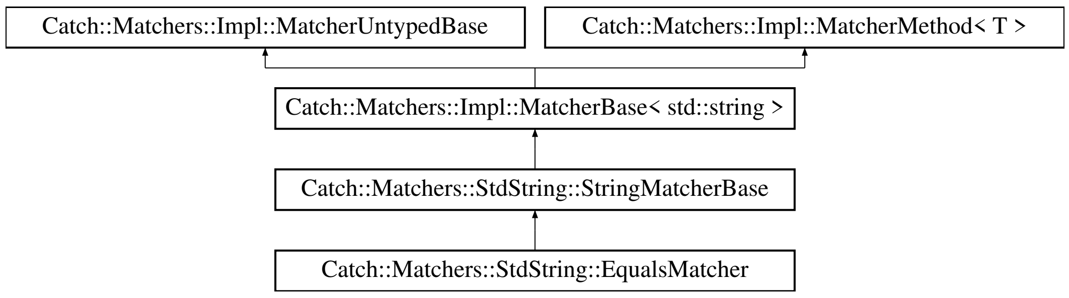
- StringRef **m_name**
- std::vector< std::pair< int, StringRef > > **m_values**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.23 Catch::Matchers::StdString::EqualsMatcher Struct Reference

Inheritance diagram for Catch::Matchers::StdString::EqualsMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::StdString::EqualsMatcher

Public Member Functions

- **EqualsMatcher** (CasedString const &comparator)
- bool **match** (std::string const &source) const override

Public Member Functions inherited from Catch::Matchers::StdString::StringMatcherBase

- **StringMatcherBase** (std::string const &operation, CasedString const &comparator)
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Public Attributes inherited from Catch::Matchers::StdString::StringMatcherBase

- CasedString **m_comparator**
- std::string **m_operation**

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

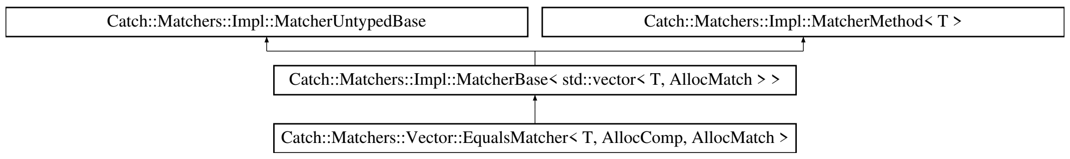
- std::string **m_cachedToString**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.24 Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch > Struct Template Reference

Inheritance diagram for Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::vector< T, AllocMatch > >
Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- **EqualsMatcher** (std::vector< T, AllocComp > const &comparator)
- bool **match** (std::vector< T, AllocMatch > const &v) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Public Attributes

- std::vector< T, AllocComp > const & **m_comparator**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.24.1 Member Function Documentation

5.24.1.1 describe()

```
template<typename T , typename AllocComp , typename AllocMatch >
std::string Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch >::describe ( )
const  [inline], [override], [virtual]
```

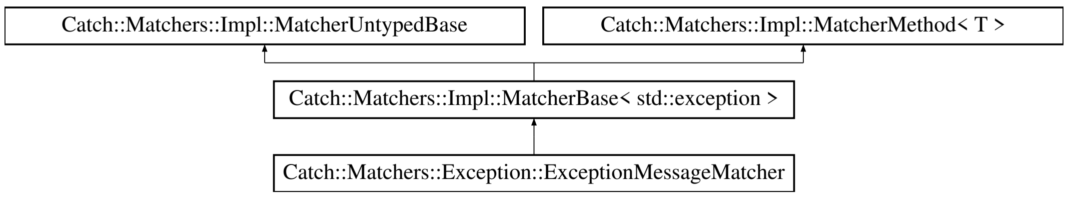
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.25 Catch::Matchers::Exception::ExceptionMessageMatcher Class Reference

Inheritance diagram for Catch::Matchers::Exception::ExceptionMessageMatcher:



Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::exception >
Catch::Matchers::Exception::ExceptionMessageMatcher

Public Member Functions

- **ExceptionMessageMatcher** (std::string const &message)
- bool **match** (std::exception const &ex) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.25.1 Member Function Documentation

5.25.1.1 describe()

```
std::string Catch::Matchers::Exception::ExceptionMessageMatcher::describe ( ) const  [override],
[virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.26 Catch::ExceptionTranslatorRegistrar Class Reference

Public Member Functions

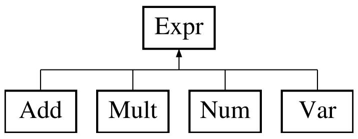
- template< typename T >
  ExceptionTranslatorRegistrar (std::string(∗translateFunction)(T &))

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.27 Expr Class Reference

Inheritance diagram for Expr:



Public Member Functions

- virtual bool **equals** (Expr ∗e)=0
- virtual int **interp** ()=0
- virtual bool **has_variable** ()=0
- virtual Expr ∗ **subst** (std::string, Expr ∗s)=0
- virtual void **print** (std::ostream &ot)=0
- virtual void **pretty_print** (std::ostream &ot, precedence_t prec)=0
- std::string **to_string** ()
- virtual void **pretty_print_dr** (std::ostream &ot)=0
- std::string **to_pretty_string** ()

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h

5.28 Catch::ExprLhs< LhsT > Class Template Reference

Public Member Functions

- **ExprLhs** (LhsT lhs)
- template<typename RhsT >
  auto **operator==** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- auto **operator==** (bool rhs) -> BinaryExpr< LhsT, bool > const
- template<typename RhsT >
  auto **operator!=** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- auto **operator!=** (bool rhs) -> BinaryExpr< LhsT, bool > const
- template<typename RhsT >
  auto **operator>** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator<** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator>=** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator<=** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator|** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator&** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const

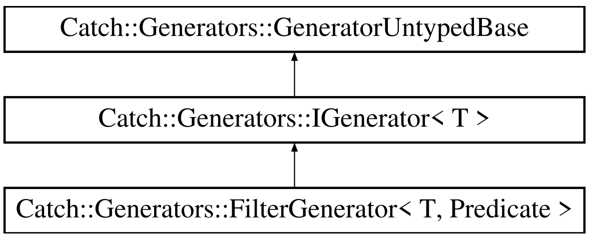
- template<typename RhsT >
  auto **operator^** (RhsT const &rhs) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator&&** (RhsT const &) -> BinaryExpr< LhsT, RhsT const & > const
- template<typename RhsT >
  auto **operator||** (RhsT const &) -> BinaryExpr< LhsT, RhsT const & > const
- auto **makeUnaryExpr** () const -> UnaryExpr< LhsT >

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.29 Catch::Generators::FilterGenerator< T, Predicate > Class Template Reference

Inheritance diagram for Catch::Generators::FilterGenerator< T, Predicate >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::FilterGenerator< T, Predicate >

Public Member Functions

- template<typename P = Predicate>
  FilterGenerator (P &&pred, GeneratorWrapper< T > &&generator)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.29.1 Member Function Documentation

5.29.1.1 get()

```
template<typename T , typename Predicate >
T const & Catch::Generators::FilterGenerator< T, Predicate >::get ( ) const  [inline], [override],
[virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.29.1.2 next()

```
template<typename T , typename Predicate >
bool Catch::Generators::FilterGenerator< T, Predicate >::next ( )  [inline], [override], [virtual]
```

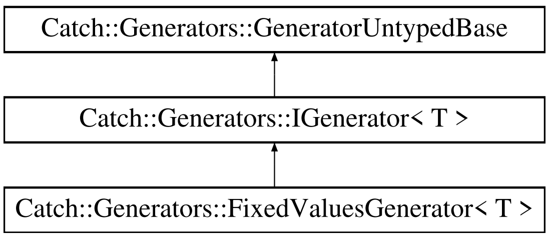
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.30 Catch::Generators::FixedValuesGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::FixedValuesGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::FixedValuesGenerator< T >

Public Member Functions

- **FixedValuesGenerator** (std::initializer_list< T > values)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.30.1 Member Function Documentation

5.30.1.1 get()

```
template<typename T >
T const & Catch::Generators::FixedValuesGenerator< T >::get ( ) const  [inline], [override],
[virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.30.1.2 next()

```
template<typename T >
bool Catch::Generators::FixedValuesGenerator< T >::next ( )  [inline], [override], [virtual]
```

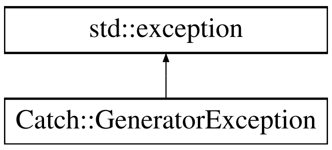
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.31 Catch::GeneratorException Class Reference

Inheritance diagram for Catch::GeneratorException:



Public Member Functions

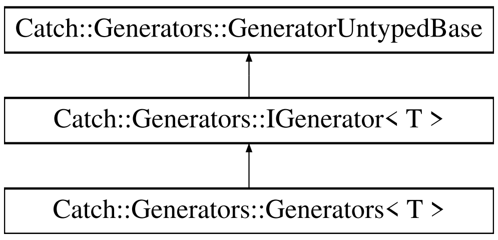
- **GeneratorException** (const char ∗msg)
- const char ∗ **what** () const noexcept override final

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.32 Catch::Generators::Generators< T > Class Template Reference

Inheritance diagram for Catch::Generators::Generators< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::Generators< T >

Public Member Functions

- template<typename... Gs>
  Generators (Gs &&... moreGenerators)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.32.1 Member Function Documentation

5.32.1.1 get()

```
template<typename T >
T const & Catch::Generators::Generators< T >::get ( ) const  [inline], [override], [virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.32.1.2 next()

```
template<typename T >
bool Catch::Generators::Generators< T >::next ( )  [inline], [override], [virtual]
```

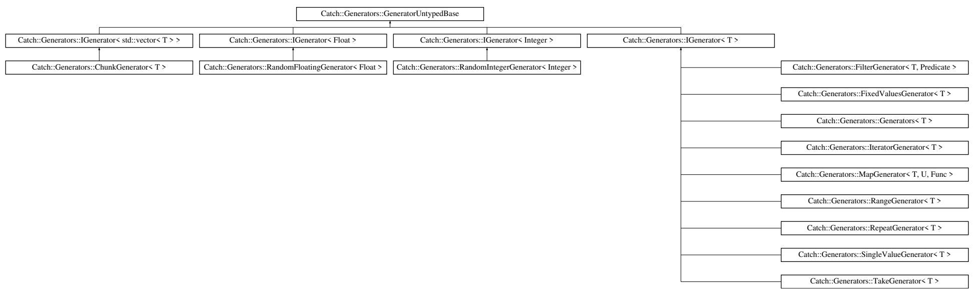
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.33 Catch::Generators::GeneratorUntypedBase Class Reference

Inheritance diagram for Catch::Generators::GeneratorUntypedBase:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< std::vector< T > >
Catch::Generators::IGenerator< Float >
Catch::Generators::IGenerator< Integer >
Catch::Generators::IGenerator< T >
Catch::Generators::ChunkGenerator< T >
Catch::Generators::RandomFloatingGenerator< Float >
Catch::Generators::RandomIntegerGenerator< Integer >
Catch::Generators::FilterGenerator< T, Predicate >
Catch::Generators::FixedValuesGenerator< T >
Catch::Generators::Generators< T >
Catch::Generators::IteratorGenerator< T >
Catch::Generators::MapGenerator< T, U, Func >
Catch::Generators::RangeGenerator< T >
Catch::Generators::RepeatGenerator< T >
Catch::Generators::SingleValueGenerator< T >
Catch::Generators::TakeGenerator< T >

Public Member Functions

- virtual bool **next** ()=0

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.34 Catch::Generators::GeneratorWrapper< T > Class Template Reference

Public Member Functions

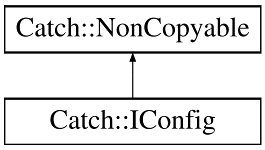
- **GeneratorWrapper** (std::unique_ptr< IGenerator< T > > generator)
- T const & **get** () const
- bool **next** ()

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.35 Catch::IConfig Struct Reference

Inheritance diagram for Catch::IConfig:



Public Member Functions

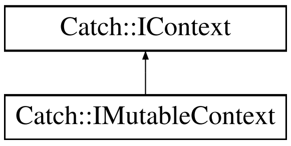
- virtual bool **allowThrows** () const =0
- virtual std::ostream & **stream** () const =0
- virtual std::string **name** () const =0
- virtual bool **includeSuccessfulResults** () const =0
- virtual bool **shouldDebugBreak** () const =0
- virtual bool **warnAboutMissingAssertions** () const =0
- virtual bool **warnAboutNoTests** () const =0
- virtual int **abortAfter** () const =0
- virtual bool **showInvisibles** () const =0
- virtual ShowDurations::OrNot **showDurations** () const =0
- virtual double **minDuration** () const =0
- virtual TestSpec const & **testSpec** () const =0
- virtual bool **hasTestFilters** () const =0
- virtual std::vector< std::string > const & **getTestsOrTags** () const =0
- virtual RunTests::InWhatOrder **runOrder** () const =0
- virtual unsigned int **rngSeed** () const =0
- virtual UseColour::YesOrNo **useColour** () const =0
- virtual std::vector< std::string > const & **getSectionsToRun** () const =0
- virtual Verbosity **verbosity** () const =0
- virtual bool **benchmarkNoAnalysis** () const =0
- virtual int **benchmarkSamples** () const =0
- virtual double **benchmarkConfidenceInterval** () const =0
- virtual unsigned int **benchmarkResamples** () const =0
- virtual std::chrono::milliseconds **benchmarkWarmupTime** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.36 Catch::IContext Struct Reference

Inheritance diagram for Catch::IContext:



Public Member Functions

- virtual IResultCapture ∗ **getResultCapture** ()=0
- virtual IRunner ∗ **getRunner** ()=0
- virtual IConfigPtr const & **getConfig** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.37 Catch::IExceptionTranslator Struct Reference

Public Member Functions

- virtual std::string **translate** (ExceptionTranslators::const_iterator it, ExceptionTranslators::const_iterator itEnd) const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.38 Catch::IExceptionTranslatorRegistry Struct Reference

Public Member Functions

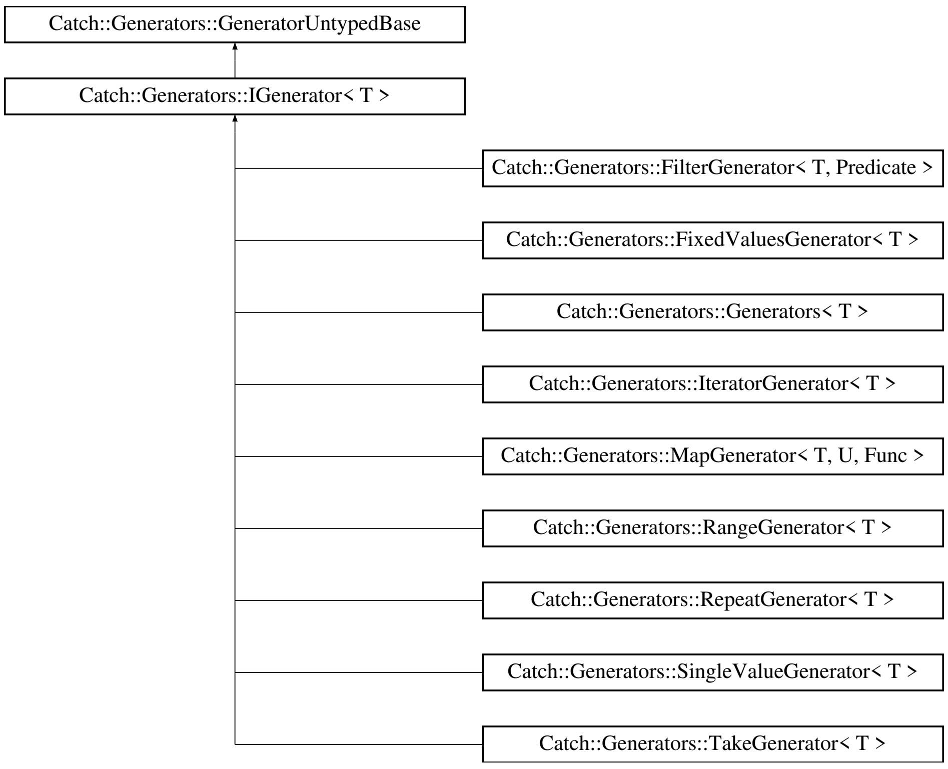
- virtual std::string **translateActiveException** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.39 Catch::Generators::IGenerator< T > Struct Template Reference

Inheritance diagram for Catch::Generators::IGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::FilterGenerator< T, Predicate >
Catch::Generators::FixedValuesGenerator< T >
Catch::Generators::Generators< T >
Catch::Generators::IteratorGenerator< T >
Catch::Generators::MapGenerator< T, U, Func >
Catch::Generators::RangeGenerator< T >
Catch::Generators::RepeatGenerator< T >
Catch::Generators::SingleValueGenerator< T >
Catch::Generators::TakeGenerator< T >

Public Types

- using **type** = T

Public Member Functions

- virtual T const & **get** () const =0

Public Member Functions inherited from Catch::Generators::GeneratorUntypedBase

- virtual bool **next** ()=0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.40 Catch::IGeneratorTracker Struct Reference

Public Member Functions

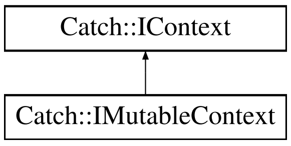
- virtual auto **hasGenerator** () const -> bool=0
- virtual auto **getGenerator** () const -> Generators::GeneratorBasePtr const &=0
- virtual void **setGenerator** (Generators::GeneratorBasePtr &&generator)=0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.41 Catch::IMutableContext Struct Reference

Inheritance diagram for Catch::IMutableContext:



Public Member Functions

- virtual void **setResultCapture** (IResultCapture ∗resultCapture)=0
- virtual void **setRunner** (IRunner ∗runner)=0
- virtual void **setConfig** (IConfigPtr const &config)=0

Public Member Functions inherited from Catch::IContext

- virtual IResultCapture ∗ **getResultCapture** ()=0
- virtual IRunner ∗ **getRunner** ()=0
- virtual IConfigPtr const & **getConfig** () const =0

Friends

- IMutableContext & **getCurrentMutableContext** ()
- void **cleanUpContext** ()

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.42 Catch::IMutableEnumValuesRegistry Struct Reference

Public Member Functions

- virtual Detail::EnumInfo const & **registerEnum** (StringRef enumName, StringRef allEnums, std::vector< int > const &values)=0
- template<typename E >
  Detail::EnumInfo const & **registerEnum** (StringRef enumName, StringRef allEnums, std::initializer_list< E > values)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.43 Catch::IMutableRegistryHub Struct Reference

Public Member Functions

- virtual void **registerReporter** (std::string const &name, IReporterFactoryPtr const &factory)=0
- virtual void **registerListener** (IReporterFactoryPtr const &factory)=0
- virtual void **registerTest** (TestCase const &testInfo)=0
- virtual void **registerTranslator** (const IExceptionTranslator ∗translator)=0
- virtual void **registerTagAlias** (std::string const &alias, std::string const &tag, SourceLineInfo const &line↩ Info)=0
- virtual void **registerStartupException** () noexcept=0
- virtual IMutableEnumValuesRegistry & **getMutableEnumValuesRegistry** ()=0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.44 Catch::IRegistryHub Struct Reference

Public Member Functions

- virtual IReporterRegistry const & **getReporterRegistry** () const =0
- virtual ITestCaseRegistry const & **getTestCaseRegistry** () const =0
- virtual ITagAliasRegistry const & **getTagAliasRegistry** () const =0
- virtual IExceptionTranslatorRegistry const & **getExceptionTranslatorRegistry** () const =0
- virtual StartupExceptionRegistry const & **getStartupExceptionRegistry** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.45 Catch::IResultCapture Struct Reference

Public Member Functions

- virtual bool **sectionStarted** (SectionInfo const &sectionInfo, Counts &assertions)=0
- virtual void **sectionEnded** (SectionEndInfo const &endInfo)=0
- virtual void **sectionEndedEarly** (SectionEndInfo const &endInfo)=0
- virtual auto **acquireGeneratorTracker** (StringRef generatorName, SourceLineInfo const &lineInfo) -> IGeneratorTracker &=0
- virtual void **pushScopedMessage** (MessageInfo const &message)=0
- virtual void **popScopedMessage** (MessageInfo const &message)=0
- virtual void **emplaceUnscopedMessage** (MessageBuilder const &builder)=0
- virtual void **handleFatalErrorCondition** (StringRef message)=0
- virtual void **handleExpr** (AssertionInfo const &info, ITransientExpression const &expr, AssertionReaction &reaction)=0
- virtual void **handleMessage** (AssertionInfo const &info, ResultWas::OfType resultType, StringRef const &message, AssertionReaction &reaction)=0

- virtual void **handleUnexpectedExceptionNotThrown** (AssertionInfo const &info, AssertionReaction &reaction)=0
- virtual void **handleUnexpectedInflightException** (AssertionInfo const &info, std::string const &message, AssertionReaction &reaction)=0
- virtual void **handleIncomplete** (AssertionInfo const &info)=0
- virtual void **handleNonExpr** (AssertionInfo const &info, ResultWas::OfType resultType, AssertionReaction &reaction)=0
- virtual bool **lastAssertionPassed** ()=0
- virtual void **assertionPassed** ()=0
- virtual std::string **getCurrentTestName** () const =0
- virtual const AssertionResult ∗ **getLastResult** () const =0
- virtual void **exceptionEarlyReported** ()=0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.46 Catch::IRunner Struct Reference

Public Member Functions

- virtual bool **aborting** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.47 Catch::is_callable< T > Struct Template Reference

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.48 Catch::is_callable< Fun(Args...)> Struct Template Reference

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.49 Catch::is_callable_tester Struct Reference

Static Public Member Functions

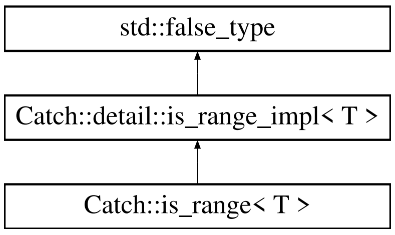
- template<typename Fun , typename... Args>
  static true_given< decltype(std::declval< Fun >()(std::declval< Args >()...))> **test** (int)
- template<typename... >
  static std::false_type **test** (...)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.50 Catch::is_range< T > Struct Template Reference

Inheritance diagram for Catch::is_range< T >:

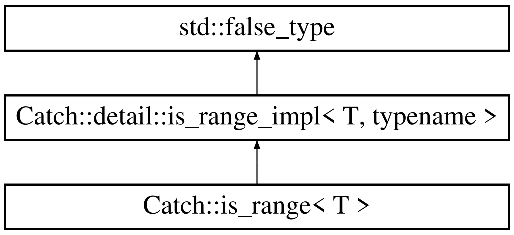


The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.51 Catch::detail::is_range_impl< T, typename > Struct Template Reference

Inheritance diagram for Catch::detail::is_range_impl< T, typename >:

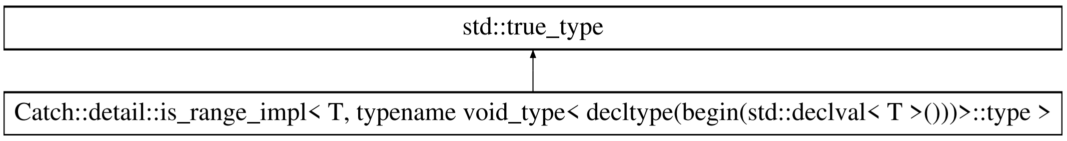


The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.52 Catch::detail::is_range_impl< T, typename void_type< decltype(begin(std::declval< T >()))>::type > Struct Template Reference

Inheritance diagram for Catch::detail::is_range_impl< T, typename void_type< decltype(begin(std::declval< T >()))>::type >:


std::true_type
Catch::detail::is_range_impl< T, typename void_type< decltype(begin(std::declval< T >()))>::type >

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.53 Catch::Detail::IsStreamInsertable< T > Class Template Reference

Static Public Attributes

- static const bool **value** = decltype(test<std::ostream, const T&>(0))::value

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.54 Catch::IStream Struct Reference

Public Member Functions

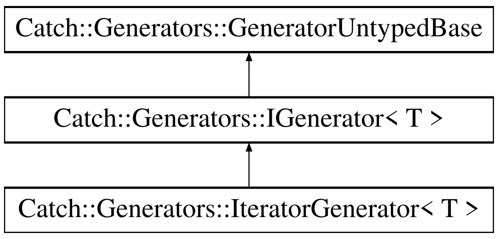
- virtual std::ostream & **stream** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.55 Catch::Generators::IteratorGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::IteratorGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::IteratorGenerator< T >

Public Member Functions

- template< typename InputIterator , typename InputSentinel >
  IteratorGenerator (InputIterator first, InputSentinel last)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.55.1 Member Function Documentation

5.55.1.1 get()

```
template<typename T >
T const & Catch::Generators::IteratorGenerator< T >::get ( ) const  [inline], [override],
[virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.55.1.2 next()

```
template<typename T >
bool Catch::Generators::IteratorGenerator< T >::next ( )  [inline], [override], [virtual]
```

Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.56 Catch::ITestCaseRegistry Struct Reference

Public Member Functions

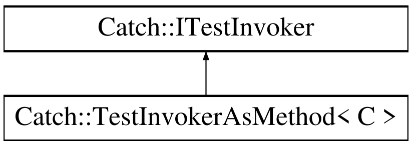
- virtual std::vector< TestCase > const & **getAllTests** () const =0
- virtual std::vector< TestCase > const & **getAllTestsSorted** (IConfig const &config) const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.57 Catch::ITestInvoker Struct Reference

Inheritance diagram for Catch::ITestInvoker:



Public Member Functions

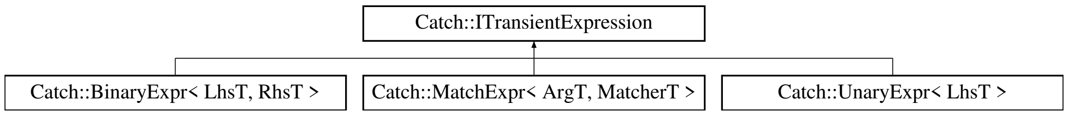
- virtual void **invoke** () const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.58 Catch::ITransientExpression Struct Reference

Inheritance diagram for Catch::ITransientExpression:


Catch::ITransientExpression
Catch::BinaryExpr< LhsT, RhsT >
Catch::MatchExpr< ArgT, MatcherT >
Catch::UnaryExpr< LhsT >

Public Member Functions

- auto **isBinaryExpression** () const -> bool
- auto **getResult** () const -> bool
- virtual void **streamReconstructedExpression** (std::ostream &os) const =0
- **ITransientExpression** (bool isBinaryExpression, bool result)

Public Attributes

- bool **m_isBinaryExpression**
- bool **m_result**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.59 Catch::LazyExpression Class Reference

Public Member Functions

- **LazyExpression** (bool isNegated)
- **LazyExpression** (LazyExpression const &other)
- LazyExpression & **operator=** (LazyExpression const &)=delete
- **operator bool** () const

Friends

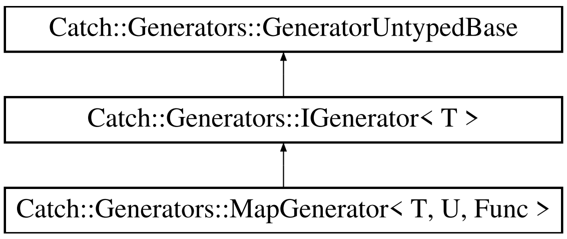
- class **AssertionHandler**
- struct **AssertionStats**
- class **RunContext**
- auto **operator**<< (std::ostream &os, LazyExpression const &lazyExpr) -> std::ostream &

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.60 Catch::Generators::MapGenerator< T, U, Func > Class Template Reference

Inheritance diagram for Catch::Generators::MapGenerator< T, U, Func >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::MapGenerator< T, U, Func >

Public Member Functions

- template<typename F2 = Func>
  MapGenerator (F2 &&function, GeneratorWrapper< U > &&generator)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.60.1 Member Function Documentation

5.60.1.1 get()

```
template<typename T , typename U , typename Func >
T const & Catch::Generators::MapGenerator< T, U, Func >::get ( ) const  [inline], [override],
[virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.60.1.2 next()

```
template<typename T , typename U , typename Func >
bool Catch::Generators::MapGenerator< T, U, Func >::next ( )  [inline], [override], [virtual]
```

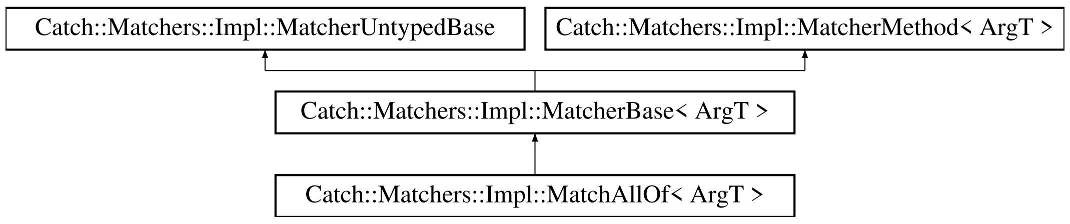
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.61 Catch::Matchers::Impl::MatchAllOf< ArgT > Struct Template Reference

Inheritance diagram for Catch::Matchers::Impl::MatchAllOf< ArgT >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< ArgT >
Catch::Matchers::Impl::MatcherBase< ArgT >
Catch::Matchers::Impl::MatchAllOf< ArgT >

Public Member Functions

- bool **match** (ArgT const &arg) const override
- std::string describe () const override
- MatchAllOf< ArgT > **operator&&** (MatcherBase< ArgT > const &other)

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< ArgT >

- MatchAllOf< ArgT > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< ArgT > **operator||** (MatcherBase const &other) const
- MatchNotOf< ArgT > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< ObjectT >

- virtual bool **match** (ObjectT const &arg) const =0

Public Attributes

- std::vector< MatcherBase< ArgT > const ∗ > **m_matchers**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.61.1 Member Function Documentation

5.61.1.1 describe()

```
template<typename ArgT >
std::string Catch::Matchers::Impl::MatchAllOf< ArgT >::describe ( ) const  [inline], [override],
[virtual]
```

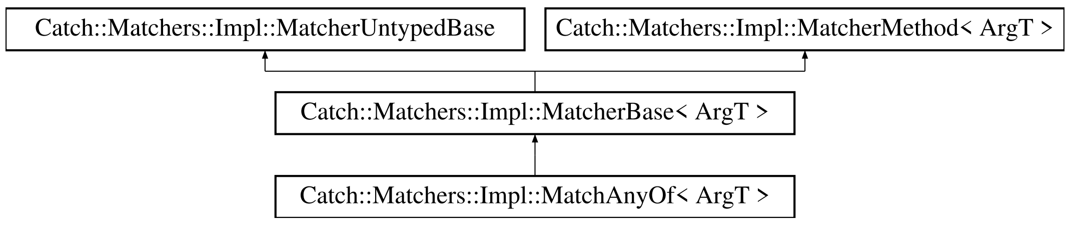
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.62 Catch::Matchers::Impl::MatchAnyOf< ArgT > Struct Template Reference

Inheritance diagram for Catch::Matchers::Impl::MatchAnyOf< ArgT >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< ArgT >
Catch::Matchers::Impl::MatcherBase< ArgT >
Catch::Matchers::Impl::MatchAnyOf< ArgT >

Public Member Functions

- bool **match** (ArgT const &arg) const override
- std::string describe () const override
- MatchAnyOf< ArgT > **operator||** (MatcherBase< ArgT > const &other)

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< ArgT >

- MatchAllOf< ArgT > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< ArgT > **operator||** (MatcherBase const &other) const
- MatchNotOf< ArgT > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< ObjectT >

- virtual bool **match** (ObjectT const &arg) const =0

Public Attributes

- std::vector< MatcherBase< ArgT > const * > **m_matchers**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.62.1 Member Function Documentation

5.62.1.1 describe()

```
template<typename ArgT >
std::string Catch::Matchers::Impl::MatchAnyOf< ArgT >::describe ( ) const  [inline], [override],
[virtual]
```

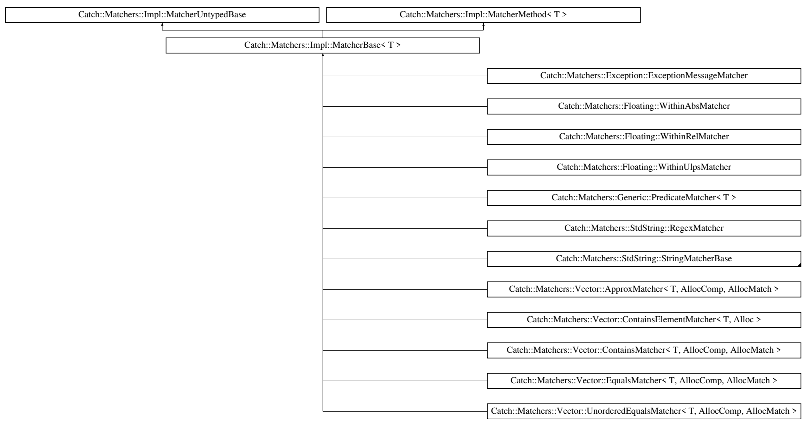
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.63 Catch::Matchers::Impl::MatcherBase< T > Struct Template Reference

Inheritance diagram for Catch::Matchers::Impl::MatcherBase< T >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< T >
Catch::Matchers::Exception::ExceptionMessageMatcher
Catch::Matchers::Floating::WithinAbsMatcher
Catch::Matchers::Floating::WithinRelMatcher
Catch::Matchers::Floating::WithinUlpsMatcher
Catch::Matchers::Generic::PredicateMatcher< T >
Catch::Matchers::StdString::RegexMatcher
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc >
Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- virtual std::string **describe** () const =0

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

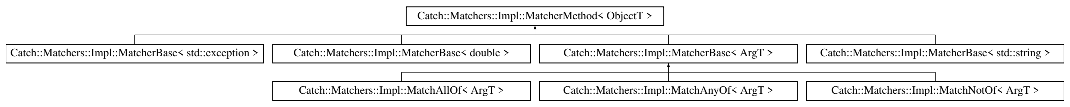
- std::string **m_cachedToString**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.64 Catch::Matchers::Impl::MatcherMethod< ObjectT > Struct Template Reference

Inheritance diagram for Catch::Matchers::Impl::MatcherMethod< ObjectT >:


Catch::Matchers::Impl::MatcherMethod< ObjectT >
Catch::Matchers::Impl::MatcherBase< std::exception >
Catch::Matchers::Impl::MatcherBase< double >
Catch::Matchers::Impl::MatcherBase< ArgT >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::Impl::MatchAllOf< ArgT >
Catch::Matchers::Impl::MatchAnyOf< ArgT >
Catch::Matchers::Impl::MatchNotOf< ArgT >

Public Member Functions

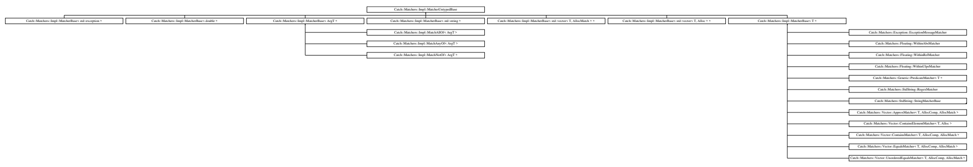
- virtual bool **match** (ObjectT const &arg) const =0

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.65 Catch::Matchers::Impl::MatcherUntypedBase Class Reference

Inheritance diagram for Catch::Matchers::Impl::MatcherUntypedBase:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherBase< std::exception >
Catch::Matchers::Impl::MatcherBase< double >
Catch::Matchers::Impl::MatcherBase< ArgT >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::Impl::MatcherBase< std::vector< T, AllocMatch > >
Catch::Matchers::Impl::MatcherBase< std::vector< T, Alloc > >
Catch::Matchers::Impl::MatcherBase< T >
Catch::Matchers::Impl::MatchAllOf< ArgT >
Catch::Matchers::Impl::MatchAnyOf< ArgT >
Catch::Matchers::Impl::MatchNotOf< ArgT >
Catch::Matchers::Exception::ExceptionMessageMatcher
Catch::Matchers::Floating::WithinAbsMatcher
Catch::Matchers::Floating::WithinRelMatcher
Catch::Matchers::Floating::WithinUlpsMatcher
Catch::Matchers::Generic::PredicateMatcher< T >
Catch::Matchers::StdString::RegexMatcher
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::Vector::ApproxMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::ContainsElementMatcher< T, Alloc >
Catch::Matchers::Vector::ContainsMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::EqualsMatcher< T, AllocComp, AllocMatch >
Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Protected Member Functions

- virtual std::string **describe** () const =0

Protected Attributes

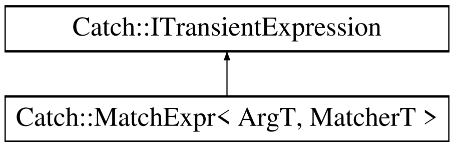
- std::string **m_cachedToString**

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.66 Catch::MatchExpr< ArgT, MatcherT > Class Template Reference

Inheritance diagram for Catch::MatchExpr< ArgT, MatcherT >:


Catch::ITransientExpression
Catch::MatchExpr< ArgT, MatcherT >

Public Member Functions

- **MatchExpr** (ArgT const &arg, MatcherT const &matcher, StringRef const &matcherString)
- void streamReconstructedExpression (std::ostream &os) const override

Public Member Functions inherited from Catch::ITransientExpression

- auto **isBinaryExpression** () const -> bool
- auto **getResult** () const -> bool
- **ITransientExpression** (bool isBinaryExpression, bool result)

Additional Inherited Members

Public Attributes inherited from Catch::ITransientExpression

- bool **m_isBinaryExpression**
- bool **m_result**

5.66.1 Member Function Documentation

5.66.1.1 streamReconstructedExpression()

```
template<typename ArgT , typename MatcherT >
void Catch::MatchExpr< ArgT, MatcherT >::streamReconstructedExpression (
            std::ostream & os ) const  [inline], [override], [virtual]
```

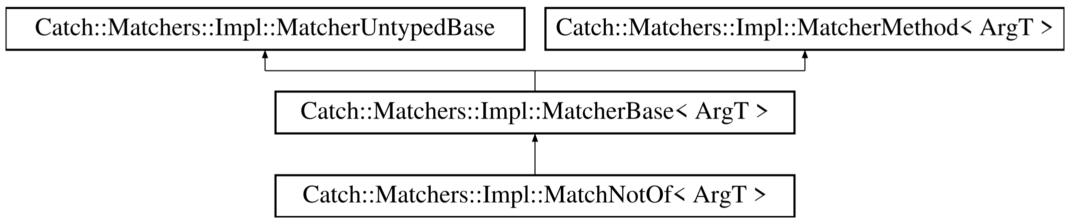
Implements Catch::ITransientExpression.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.67 Catch::Matchers::Impl::MatchNotOf< ArgT > Struct Template Reference

Inheritance diagram for Catch::Matchers::Impl::MatchNotOf< ArgT >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< ArgT >
Catch::Matchers::Impl::MatcherBase< ArgT >
Catch::Matchers::Impl::MatchNotOf< ArgT >

Public Member Functions

- **MatchNotOf** (MatcherBase< ArgT > const &underlyingMatcher)
- bool **match** (ArgT const &arg) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< ArgT >

- MatchAllOf< ArgT > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< ArgT > **operator||** (MatcherBase const &other) const
- MatchNotOf< ArgT > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< ObjectT >

- virtual bool **match** (ObjectT const &arg) const =0

Public Attributes

- MatcherBase< ArgT > const & **m_underlyingMatcher**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.67.1 Member Function Documentation

5.67.1.1 describe()

```
template<typename ArgT >
std::string Catch::Matchers::Impl::MatchNotOf< ArgT >::describe ( ) const  [inline], [override],
[virtual]
```

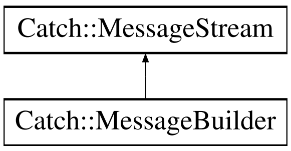
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.68 Catch::MessageBuilder Struct Reference

Inheritance diagram for Catch::MessageBuilder:



Public Member Functions

- **MessageBuilder** (StringRef const &macroName, SourceLineInfo const &lineInfo, ResultWas::OfType type)
- template<typename T >
  MessageBuilder & **operator**<< (T const &value)

Public Member Functions inherited from Catch::MessageStream

- template<typename T >
  MessageStream & **operator**<< (T const &value)

Public Attributes

- MessageInfo **m_info**

Public Attributes inherited from Catch::MessageStream

- ReusableStringStream **m_stream**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.69 Catch::MessageInfo Struct Reference

Public Member Functions

- **MessageInfo** (StringRef const &_macroName, SourceLineInfo const &_lineInfo, ResultWas::OfType _type)
- bool **operator==** (MessageInfo const &other) const
- bool **operator<** (MessageInfo const &other) const

Public Attributes

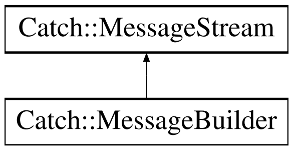
- StringRef **macroName**
- std::string **message**
- SourceLineInfo **lineInfo**
- ResultWas::OfType **type**
- unsigned int **sequence**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.70 Catch::MessageStream Struct Reference

Inheritance diagram for Catch::MessageStream:



Public Member Functions

- template<typename T >
  MessageStream & **operator<<** (T const &value)

Public Attributes

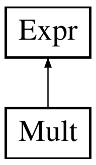
- ReusableStringStream **m_stream**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.71 Mult Class Reference

Inheritance diagram for Mult:



Public Member Functions

- Mult (Expr ∗lhs, Expr ∗rhs)
- bool equals (Expr ∗e)
- int interp ()
- bool has_variable ()
- Expr ∗ subst (std::string, Expr ∗s)
- void print (std::ostream &ot)
- void pretty_print_dr (std::ostream &ot)
- void pretty_print (std::ostream &ot, precedence_t prec)

Public Member Functions inherited from Expr

- std::string **to_string** ()
- std::string **to_pretty_string** ()

Public Attributes

- Expr ∗ **lhs**
- Expr ∗ **rhs**

5.71.1 Constructor & Destructor Documentation

5.71.1.1 Mult()

```
Mult::Mult (
            Expr * lhs,
            Expr * rhs )
```

this is the Mult function

Parameters

lhs	
rhs	

5.71.2 Member Function Documentation

5.71.2.1 equals()

```
bool Mult::equals (
            Expr * e )  [virtual]
```

Implements Expr.

5.71.2.2 has_variable()

```
bool Mult::has_variable ( )  [virtual]
```

Implements Expr.

5.71.2.3 interp()

```
int Mult::interp ( )  [virtual]
```

Implements Expr.

5.71.2.4 pretty_print()

```
void Mult::pretty_print (
            std::ostream & ot,
            precedence_t prec )  [virtual]
```

Implements Expr.

5.71.2.5 pretty_print_dr()

```
void Mult::pretty_print_dr (
            std::ostream & ot )  [virtual]
```

Implements Expr.

5.71.2.6 print()

```
void Mult::print (
            std::ostream & ot )  [virtual]
```

Implements Expr.

5.71.2.7 subst()

```
Expr * Mult::subst (
             std::string replace,
             Expr * s )  [virtual]
```

Implements Expr.

The documentation for this class was generated from the following files:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h
- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.cpp

5.72 Catch::NameAndTags Struct Reference

Public Member Functions

- **NameAndTags** (StringRef const &name_=StringRef(), StringRef const &tags_=StringRef()) noexcept

Public Attributes

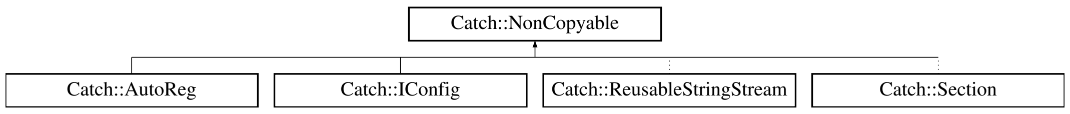
- StringRef **name**
- StringRef **tags**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.73 Catch::NonCopyable Class Reference

Inheritance diagram for Catch::NonCopyable:

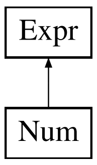


The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.74 Num Class Reference

Inheritance diagram for Num:



Public Member Functions

- Num (int val)
- bool equals (Expr ∗e)
- int interp ()
- bool has_variable ()
- Expr ∗ subst (std::string, Expr ∗s)
- void print (std::ostream &ot)
- void pretty_print_dr (std::ostream &ot)
- void pretty_print (std::ostream &ot, precedence_t prec)

Public Member Functions inherited from Expr

- std::string **to_string** ()
- std::string **to_pretty_string** ()

Public Attributes

- int **val**

5.74.1 Constructor & Destructor Documentation

5.74.1.1 Num()

```
Num::Num (
            int val )
```

this is the Num function

Parameters

val	

5.74.2 Member Function Documentation

5.74.2.1 equals()

```
bool Num::equals (
             Expr * e )  [virtual]
```

Implements Expr.

5.74.2.2 has_variable()

```
bool Num::has_variable ( )  [virtual]
```

Implements Expr.

5.74.2.3 interp()

```
int Num::interp ( )  [virtual]
```

Implements Expr.

5.74.2.4 pretty_print()

```
void Num::pretty_print (
             std::ostream & ot,
             precedence_t prec )  [virtual]
```

Implements Expr.

5.74.2.5 pretty_print_dr()

```
void Num::pretty_print_dr (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.74.2.6 print()

```
void Num::print (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.74.2.7 subst()

```
Expr * Num::subst (
            std::string replace,
            Expr * s )  [virtual]
```

Implements Expr.

The documentation for this class was generated from the following files:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h
- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.cpp

5.75 Catch::Option< T > Class Template Reference

Public Member Functions

- **Option** (T const &_value)
- **Option** (Option const &_other)
- Option & **operator=** (Option const &_other)
- Option & **operator=** (T const &_value)
- void **reset** ()
- T & **operator*** ()
- T const & **operator*** () const
- T * **operator->** ()
- const T * **operator->** () const
- T **valueOr** (T const &defaultValue) const
- bool **some** () const
- bool **none** () const
- bool **operator!** () const
- **operator bool** () const

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.76 Catch::pluralise Struct Reference

Public Member Functions

- **pluralise** (std::size_t count, std::string const &label)

Public Attributes

- std::size_t **m_count**
- std::string **m_label**

Friends

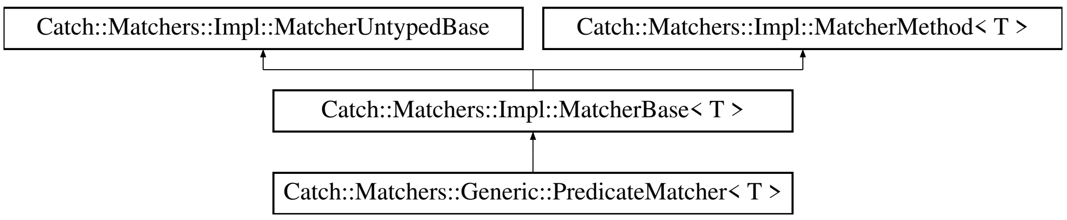
- std::ostream & **operator<<** (std::ostream &os, pluralise const &pluraliser)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.77 Catch::Matchers::Generic::PredicateMatcher< T > Class Template Reference

Inheritance diagram for Catch::Matchers::Generic::PredicateMatcher< T >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< T >
Catch::Matchers::Generic::PredicateMatcher< T >

Public Member Functions

- **PredicateMatcher** (std::function< bool(T const &)> const &elem, std::string const &descr)
- bool match (T const &item) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.77.1 Member Function Documentation

5.77.1.1 describe()

```
template<typename T >
std::string Catch::Matchers::Generic::PredicateMatcher< T >::describe ( ) const  [inline],
[override], [virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

5.77.1.2 match()

```
template<typename T >
bool Catch::Matchers::Generic::PredicateMatcher< T >::match (
             T const & item ) const  [inline], [override], [virtual]
```

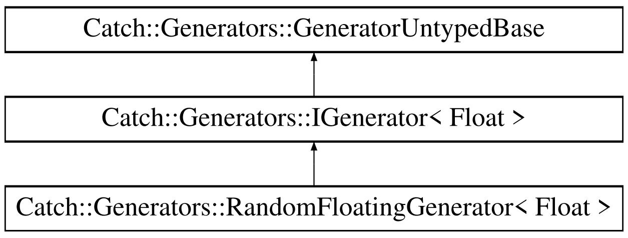
Implements Catch::Matchers::Impl::MatcherMethod< T >.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.78 Catch::Generators::RandomFloatingGenerator< Float > Class Template Reference

Inheritance diagram for Catch::Generators::RandomFloatingGenerator< Float >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< Float >
Catch::Generators::RandomFloatingGenerator< Float >

Public Member Functions

- **RandomFloatingGenerator** (Float a, Float b)
- Float const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< Float >

- using **type**

5.78.1 Member Function Documentation

5.78.1.1 get()

```
template<typename Float >
Float const & Catch::Generators::RandomFloatingGenerator< Float >::get ( ) const  [inline],
[override], [virtual]
```

Implements Catch::Generators::IGenerator< Float >.

5.78.1.2 next()

```
template<typename Float >
bool Catch::Generators::RandomFloatingGenerator< Float >::next ( )  [inline], [override],
[virtual]
```

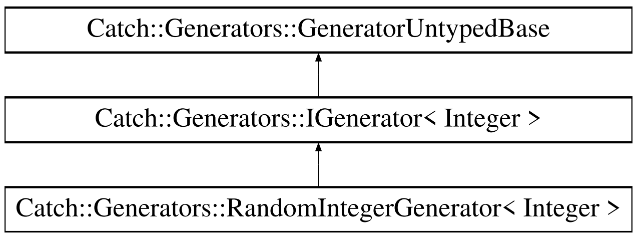
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.79 Catch::Generators::RandomIntegerGenerator< Integer > Class Template Reference

Inheritance diagram for Catch::Generators::RandomIntegerGenerator< Integer >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< Integer >
Catch::Generators::RandomIntegerGenerator< Integer >

Public Member Functions

- **RandomIntegerGenerator** (Integer a, Integer b)
- Integer const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< Integer >

- using **type**

5.79.1 Member Function Documentation

5.79.1.1 get()

```
template<typename Integer >
Integer const & Catch::Generators::RandomIntegerGenerator< Integer >::get ( ) const  [inline],
[override], [virtual]
```

Implements Catch::Generators::IGenerator< Integer >.

5.79.1.2 next()

```
template<typename Integer >
bool Catch::Generators::RandomIntegerGenerator< Integer >::next ( )  [inline], [override],
[virtual]
```

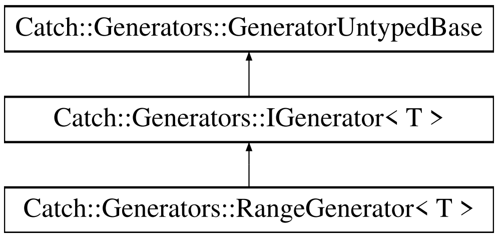
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.80 Catch::Generators::RangeGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::RangeGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::RangeGenerator< T >

Public Member Functions

- **RangeGenerator** (T const &start, T const &end, T const &step)
- **RangeGenerator** (T const &start, T const &end)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.80.1 Member Function Documentation

5.80.1.1 get()

```
template<typename T >
T const & Catch::Generators::RangeGenerator< T >::get ( ) const  [inline], [override], [virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.80.1.2 next()

```
template<typename T >
bool Catch::Generators::RangeGenerator< T >::next ( )  [inline], [override], [virtual]
```

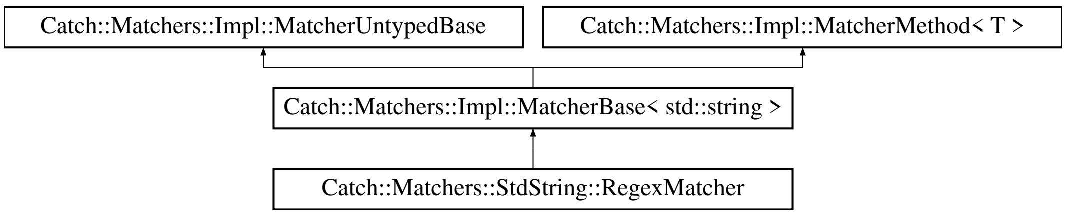
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.81 Catch::Matchers::StdString::RegexMatcher Struct Reference

Inheritance diagram for Catch::Matchers::StdString::RegexMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::RegexMatcher

Public Member Functions

- **RegexMatcher** (std::string regex, CaseSensitive::Choice caseSensitivity)
- bool **match** (std::string const &matchee) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator**|| (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.81.1 Member Function Documentation

5.81.1.1 describe()

```
std::string Catch::Matchers::StdString::RegexMatcher::describe ( ) const  [override], [virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.82 Catch::RegistrarForTagAliases Struct Reference

Public Member Functions

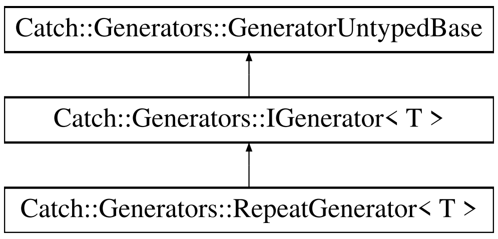
- **RegistrarForTagAliases** (char const ∗alias, char const ∗tag, SourceLineInfo const &lineInfo)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.83 Catch::Generators::RepeatGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::RepeatGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::RepeatGenerator< T >

Public Member Functions

- **RepeatGenerator** (size_t repeats, GeneratorWrapper< T > &&generator)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.83.1 Member Function Documentation

5.83.1.1 get()

```
template<typename T >
T const & Catch::Generators::RepeatGenerator< T >::get ( ) const  [inline], [override], [virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.83.1.2 next()

```
template<typename T >
bool Catch::Generators::RepeatGenerator< T >::next ( )  [inline], [override], [virtual]
```

Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.84 Catch::ResultDisposition Struct Reference

Public Types

- enum **Flags** { **Normal** = 0x01 , **ContinueOnFailure** = 0x02 , **FalseTest** = 0x04 , **SuppressFail** = 0x08 }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.85 Catch::ResultWas Struct Reference

Public Types

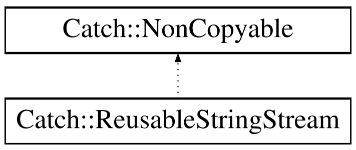
- enum **OfType** {
  Unknown = -1 , **Ok** = 0 , **Info** = 1 , **Warning** = 2 ,
  FailureBit = 0x10 , **ExpressionFailed** = FailureBit | 1 , **ExplicitFailure** = FailureBit | 2 , **Exception** = 0x100 | FailureBit ,
  ThrewException = Exception | 1 , **DidntThrowException** = Exception | 2 , **FatalErrorCondition** = 0x200 | FailureBit }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.86 Catch::ReusableStringStream Class Reference

Inheritance diagram for Catch::ReusableStringStream:



Public Member Functions

- auto **str** () const -> std::string
- template<typename T >
  auto **operator**<< (T const &value) -> ReusableStringStream &
- auto **get** () -> std::ostream &

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.87 Catch::RunTests Struct Reference

Public Types

- enum **InWhatOrder** { **InDeclarationOrder** , **InLexicographicalOrder** , **InRandomOrder** }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.88 Catch::ScopedMessage Class Reference

Public Member Functions

- **ScopedMessage** (MessageBuilder const &builder)
- **ScopedMessage** (ScopedMessage &duplicate)=delete
- **ScopedMessage** (ScopedMessage &&old)

Public Attributes

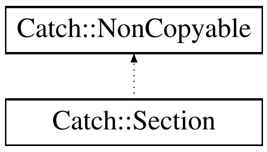
- MessageInfo **m_info**
- bool **m_moved**

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.89 Catch::Section Class Reference

Inheritance diagram for Catch::Section:



Public Member Functions

- **Section** (SectionInfo const &info)
- **operator bool** () const

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.90 Catch::SectionEndInfo Struct Reference

Public Attributes

- SectionInfo **sectionInfo**
- Counts **prevAssertions**
- double **durationInSeconds**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.91 Catch::SectionInfo Struct Reference

Public Member Functions

- **SectionInfo** (SourceLineInfo const &_lineInfo, std::string const &_name)
- **SectionInfo** (SourceLineInfo const &_lineInfo, std::string const &_name, std::string const &)

Public Attributes

- std::string **name**
- std::string **description**
- SourceLineInfo **lineInfo**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.92 Catch::ShowDurations Struct Reference

Public Types

- enum **OrNot** { **DefaultForReporter** , **Always** , **Never** }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.93 Catch::SimplePcg32 Class Reference

Public Types

- using **result_type** = std::uint32_t

Public Member Functions

- **SimplePcg32** (result_type seed_)
- void **seed** (result_type seed_)
- void **discard** (uint64_t skip)
- result_type **operator()** ()

Static Public Member Functions

- static constexpr result_type **min** ()
- static constexpr result_type **max** ()

Friends

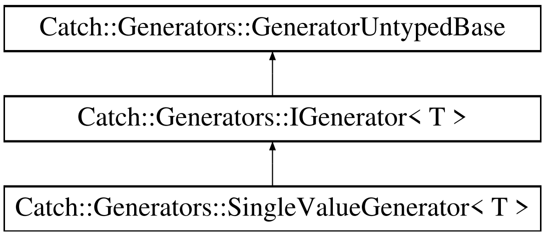
- bool **operator==** (SimplePcg32 const &lhs, SimplePcg32 const &rhs)
- bool **operator!=** (SimplePcg32 const &lhs, SimplePcg32 const &rhs)

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.94 Catch::Generators::SingleValueGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::SingleValueGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::SingleValueGenerator< T >

Public Member Functions

- **SingleValueGenerator** (T &&value)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.94.1 Member Function Documentation

5.94.1.1 get()

```
template<typename T >
T const & Catch::Generators::SingleValueGenerator< T >::get ( ) const  [inline], [override],
[virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.94.1.2 next()

```
template<typename T >
bool Catch::Generators::SingleValueGenerator< T >::next ( )  [inline], [override], [virtual]
```

Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.95 Catch::SourceLineInfo Struct Reference

Public Member Functions

- **SourceLineInfo** (char const ∗_file, std::size_t _line) noexcept
- **SourceLineInfo** (SourceLineInfo const &other)=default
- SourceLineInfo & **operator=** (SourceLineInfo const &)=default
- **SourceLineInfo** (SourceLineInfo &&) noexcept=default
- SourceLineInfo & **operator=** (SourceLineInfo &&) noexcept=default
- bool **empty** () const noexcept
- bool **operator==** (SourceLineInfo const &other) const noexcept
- bool **operator<** (SourceLineInfo const &other) const noexcept

Public Attributes

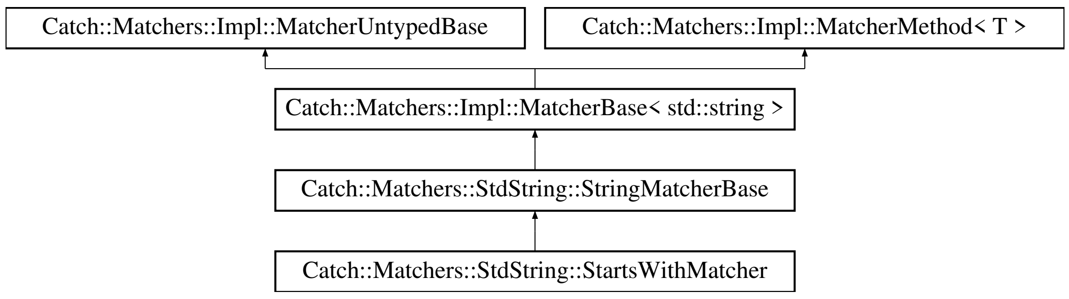
- char const ∗ **file**
- std::size_t **line**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.96 Catch::Matchers::StdString::StartsWithMatcher Struct Reference

Inheritance diagram for Catch::Matchers::StdString::StartsWithMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::StdString::StartsWithMatcher

Public Member Functions

- **StartsWithMatcher** (CasedString const &comparator)
- bool **match** (std::string const &source) const override

Public Member Functions inherited from Catch::Matchers::StdString::StringMatcherBase

- **StringMatcherBase** (std::string const &operation, CasedString const &comparator)
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator**|| (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Public Attributes inherited from Catch::Matchers::StdString::StringMatcherBase

- CasedString **m_comparator**
- std::string **m_operation**

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.97 Catch::StreamEndStop Struct Reference

Public Member Functions

- std::string **operator+** () const

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.98 Catch::StringMaker< T, typename > Struct Template Reference

Static Public Member Functions

- template<typename Fake = T>
  static std::enable_if<::Catch::Detail::IsStreamInsertable< Fake >::value, std::string >::type **convert** (const Fake &value)
- template<typename Fake = T>
  static std::enable_if<!::Catch::Detail::IsStreamInsertable< Fake >::value, std::string >::type **convert** (const Fake &value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.99 Catch::StringMaker< bool > Struct Reference

Static Public Member Functions

- static std::string **convert** (bool b)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.100 Catch::StringMaker< Catch::Detail::Approx > Struct Reference

Static Public Member Functions

- static std::string **convert** (Catch::Detail::Approx const &value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.101 Catch::StringMaker< char ∗ > Struct Reference

Static Public Member Functions

- static std::string **convert** (char ∗str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.102 Catch::StringMaker< char > Struct Reference

Static Public Member Functions

- static std::string **convert** (char c)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.103 Catch::StringMaker< char const ∗ > Struct Reference

Static Public Member Functions

- static std::string **convert** (char const ∗str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.104 Catch::StringMaker< char[SZ]> Struct Template Reference

Static Public Member Functions

- static std::string **convert** (char const ∗str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.105 Catch::StringMaker< double > Struct Reference

Static Public Member Functions

- static std::string **convert** (double value)

Static Public Attributes

- static int **precision**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.106 Catch::StringMaker< float > Struct Reference

Static Public Member Functions

- static std::string **convert** (float value)

Static Public Attributes

- static int **precision**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.107 Catch::StringMaker< int > Struct Reference

Static Public Member Functions

- static std::string **convert** (int value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.108 Catch::StringMaker< long > Struct Reference

Static Public Member Functions

- static std::string **convert** (long value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.109 Catch::StringMaker< long long > Struct Reference

Static Public Member Functions

- static std::string **convert** (long long value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.110 Catch::StringMaker< R C::* > Struct Template Reference

Static Public Member Functions

- static std::string **convert** (R C::*p)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.111 Catch::StringMaker< R, typename std::enable_if< is_range< R >::value &&!::Catch::Detail::IsStreamInsertable< R >::value >::type > Struct Template Reference

Static Public Member Functions

- static std::string **convert** (R const &range)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.112 Catch::StringMaker< signed char > Struct Reference

Static Public Member Functions

- static std::string **convert** (signed char c)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.113 Catch::StringMaker< signed char[SZ]> Struct Template Reference

Static Public Member Functions

- static std::string **convert** (signed char const ∗str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.114 Catch::StringMaker< std::nullptr_t > Struct Reference

Static Public Member Functions

- static std::string **convert** (std::nullptr_t)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.115 Catch::StringMaker< std::string > Struct Reference

Static Public Member Functions

- static std::string **convert** (const std::string &str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.116 Catch::StringMaker< std::wstring > Struct Reference

Static Public Member Functions

- static std::string **convert** (const std::wstring &wstr)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.117 Catch::StringMaker< T ∗ > Struct Template Reference

Static Public Member Functions

- template<typename U >
  static std::string **convert** (U ∗p)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.118 Catch::StringMaker< T[SZ]> Struct Template Reference

Static Public Member Functions

- static std::string **convert** (T const(&arr)[SZ])

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.119 Catch::StringMaker< unsigned char > Struct Reference

Static Public Member Functions

- static std::string **convert** (unsigned char c)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.120 Catch::StringMaker< unsigned char[SZ]> Struct Template Reference

Static Public Member Functions

- static std::string **convert** (unsigned char const ∗str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.121 Catch::StringMaker$<$ unsigned int $>$ Struct Reference

Static Public Member Functions

- static std::string **convert** (unsigned int value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.122 Catch::StringMaker$<$ unsigned long $>$ Struct Reference

Static Public Member Functions

- static std::string **convert** (unsigned long value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.123 Catch::StringMaker$<$ unsigned long long $>$ Struct Reference

Static Public Member Functions

- static std::string **convert** (unsigned long long value)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.124 Catch::StringMaker$<$ wchar_t $*$ $>$ Struct Reference

Static Public Member Functions

- static std::string **convert** (wchar_t $*$str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.125 Catch::StringMaker< wchar_t const * > Struct Reference

Static Public Member Functions

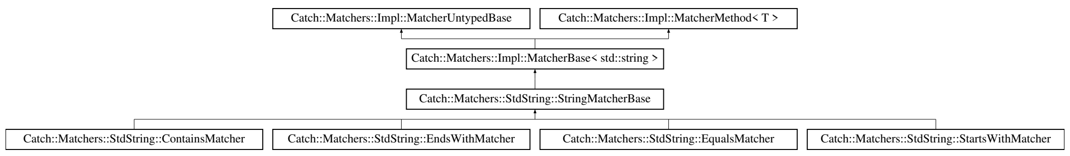
- static std::string **convert** (wchar_t const *str)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.126 Catch::Matchers::StdString::StringMatcherBase Struct Reference

Inheritance diagram for Catch::Matchers::StdString::StringMatcherBase:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::string >
Catch::Matchers::StdString::StringMatcherBase
Catch::Matchers::StdString::ContainsMatcher
Catch::Matchers::StdString::EndsWithMatcher
Catch::Matchers::StdString::EqualsMatcher
Catch::Matchers::StdString::StartsWithMatcher

Public Member Functions

- **StringMatcherBase** (std::string const &operation, CasedString const &comparator)
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Public Attributes

- CasedString **m_comparator**
- std::string **m_operation**

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.126.1 Member Function Documentation

5.126.1.1 describe()

```
std::string Catch::Matchers::StdString::StringMatcherBase::describe ( ) const  [override],
[virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.127 Catch::StringRef Class Reference

```
#include <catch.hpp>
```

Public Types

- using **size_type** = std::size_t
- using **const_iterator** = const char∗

Public Member Functions

- **StringRef** (char const ∗rawChars) noexcept
- constexpr **StringRef** (char const ∗rawChars, size_type size) noexcept
- **StringRef** (std::string const &stdString) noexcept
- **operator std::string** () const
- auto **operator==** (StringRef const &other) const noexcept -> bool
- auto **operator!=** (StringRef const &other) const noexcept -> bool
- auto **operator[ ]** (size_type index) const noexcept -> char
- constexpr auto **empty** () const noexcept -> bool
- constexpr auto **size** () const noexcept -> size_type
- auto **c_str** () const -> char const ∗
- auto **substr** (size_type start, size_type length) const noexcept -> StringRef
- auto **data** () const noexcept -> char const ∗
- constexpr auto **isNullTerminated** () const noexcept -> bool
- constexpr const_iterator **begin** () const
- constexpr const_iterator **end** () const

5.127.1 Detailed Description

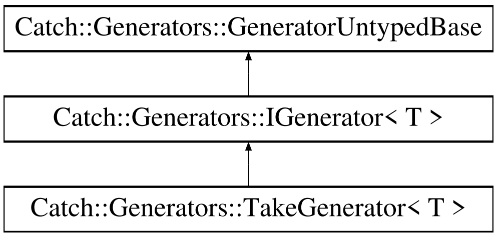
A non-owning string class (similar to the forthcoming std::string_view) Note that, because a StringRef may be a substring of another string, it may not be null terminated.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.128 Catch::Generators::TakeGenerator< T > Class Template Reference

Inheritance diagram for Catch::Generators::TakeGenerator< T >:


Catch::Generators::GeneratorUntypedBase
Catch::Generators::IGenerator< T >
Catch::Generators::TakeGenerator< T >

Public Member Functions

- **TakeGenerator** (size_t target, GeneratorWrapper< T > &&generator)
- T const & get () const override
- bool next () override

Additional Inherited Members

Public Types inherited from Catch::Generators::IGenerator< T >

- using **type** = T

5.128.1 Member Function Documentation

5.128.1.1 get()

```
template<typename T >
T const & Catch::Generators::TakeGenerator< T >::get ( ) const  [inline], [override], [virtual]
```

Implements Catch::Generators::IGenerator< T >.

5.128.1.2 next()

```
template<typename T >
bool Catch::Generators::TakeGenerator< T >::next ( )  [inline], [override], [virtual]
```

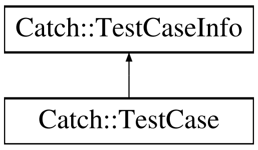
Implements Catch::Generators::GeneratorUntypedBase.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.129 Catch::TestCase Class Reference

Inheritance diagram for Catch::TestCase:



Public Member Functions

- **TestCase** (ITestInvoker ∗testCase, TestCaseInfo &&info)
- TestCase **withName** (std::string const &_newName) const
- void **invoke** () const
- TestCaseInfo const & **getTestCaseInfo** () const
- bool **operator==** (TestCase const &other) const
- bool **operator<** (TestCase const &other) const

Public Member Functions inherited from Catch::TestCaseInfo

- **TestCaseInfo** (std::string const &_name, std::string const &_className, std::string const &_description, std::vector< std::string > const &_tags, SourceLineInfo const &_lineInfo)
- bool **isHidden** () const
- bool **throws** () const
- bool **okToFail** () const
- bool **expectedToFail** () const
- std::string **tagsAsString** () const

Additional Inherited Members

Public Types inherited from Catch::TestCaseInfo

- enum **SpecialProperties** {
  None = 0 , **IsHidden** = 1 << 1 , **ShouldFail** = 1 << 2 , **MayFail** = 1 << 3 ,
  Throws = 1 << 4 , **NonPortable** = 1 << 5 , **Benchmark** = 1 << 6 }

Public Attributes inherited from Catch::TestCaseInfo

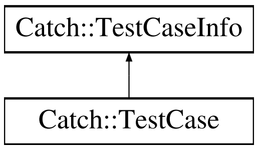
- std::string **name**
- std::string **className**
- std::string **description**
- std::vector< std::string > **tags**
- std::vector< std::string > **lcaseTags**
- SourceLineInfo **lineInfo**
- SpecialProperties **properties**

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.130 Catch::TestCaseInfo Struct Reference

Inheritance diagram for Catch::TestCaseInfo:



Public Types

- enum **SpecialProperties** {
  None = 0 , **IsHidden** = 1 << 1 , **ShouldFail** = 1 << 2 , **MayFail** = 1 << 3 ,
  Throws = 1 << 4 , **NonPortable** = 1 << 5 , **Benchmark** = 1 << 6 }

Public Member Functions

- **TestCaseInfo** (std::string const &_name, std::string const &_className, std::string const &_description, std::vector< std::string > const &_tags, SourceLineInfo const &_lineInfo)
- bool **isHidden** () const
- bool **throws** () const
- bool **okToFail** () const
- bool **expectedToFail** () const
- std::string **tagsAsString** () const

Public Attributes

- std::string **name**
- std::string **className**
- std::string **description**
- std::vector< std::string > **tags**
- std::vector< std::string > **lcaseTags**
- SourceLineInfo **lineInfo**
- SpecialProperties **properties**

Friends

- void **setTags** (TestCaseInfo &testCaseInfo, std::vector< std::string > tags)

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

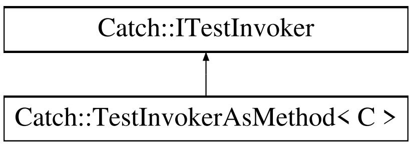
5.131 Catch::TestFailureException Struct Reference

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.132 Catch::TestInvokerAsMethod< C > Class Template Reference

Inheritance diagram for Catch::TestInvokerAsMethod< C >:



Public Member Functions

- **TestInvokerAsMethod** (void(C::∗testAsMethod)()) noexcept
- void invoke () const override

5.132.1 Member Function Documentation

5.132.1.1 invoke()

```
template<typename C >
void Catch::TestInvokerAsMethod< C >::invoke ( ) const  [inline], [override], [virtual]
```

Implements Catch::ITestInvoker.

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.133 Catch::Timer Class Reference

Public Member Functions

- void **start** ()
- auto **getElapsedNanoseconds** () const -> uint64_t
- auto **getElapsedMicroseconds** () const -> uint64_t
- auto **getElapsedMilliseconds** () const -> unsigned int
- auto **getElapsedSeconds** () const -> double

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.134 Catch::Totals Struct Reference

Public Member Functions

- Totals **operator-** (Totals const &other) const
- Totals & **operator+=** (Totals const &other)
- Totals **delta** (Totals const &prevTotals) const

Public Attributes

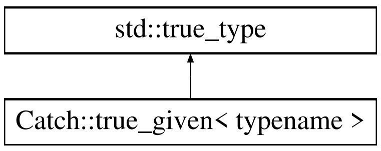
- int **error** = 0
- Counts **assertions**
- Counts **testCases**

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.135 Catch::true_given< typename > Struct Template Reference

Inheritance diagram for Catch::true_given< typename >:

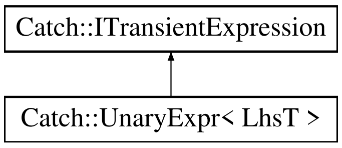


The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.136 Catch::UnaryExpr< LhsT > Class Template Reference

Inheritance diagram for Catch::UnaryExpr< LhsT >:



Public Member Functions

- **UnaryExpr** (LhsT lhs)

Public Member Functions inherited from Catch::ITransientExpression

- auto **isBinaryExpression** () const -> bool
- auto **getResult** () const -> bool
- **ITransientExpression** (bool isBinaryExpression, bool result)

Additional Inherited Members

Public Attributes inherited from Catch::ITransientExpression

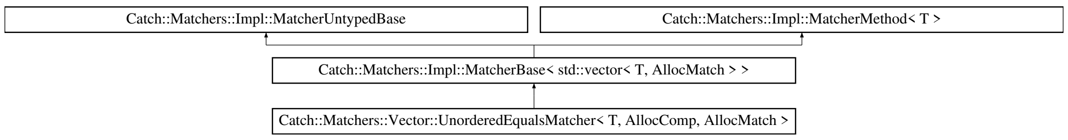
- bool **m_isBinaryExpression**
- bool **m_result**

The documentation for this class was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.137 Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch > Struct Template Reference

Inheritance diagram for Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch >:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< std::vector< T, AllocMatch > >
Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch >

Public Member Functions

- **UnorderedEqualsMatcher** (std::vector< T, AllocComp > const &target)
- bool **match** (std::vector< T, AllocMatch > const &vec) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.137.1 Member Function Documentation

5.137.1.1 describe()

```
template<typename T , typename AllocComp , typename AllocMatch >
std::string Catch::Matchers::Vector::UnorderedEqualsMatcher< T, AllocComp, AllocMatch >↩
::describe ( ) const  [inline], [override], [virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.138 Catch::UseColour Struct Reference

Public Types

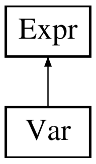
- enum **YesOrNo** { **Auto** , **Yes** , **No** }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.139 Var Class Reference

Inheritance diagram for Var:



Public Member Functions

- Var (std::string val)
- bool equals (Expr ∗e)
- int interp ()
- bool has_variable ()
- Expr ∗ subst (std::string, Expr ∗s)
- void print (std::ostream &ot)
- void pretty_print_dr (std::ostream &ot)
- void pretty_print (std::ostream &ot, precedence_t prec)

Public Member Functions inherited from Expr

- std::string **to_string** ()
- std::string **to_pretty_string** ()

Public Attributes

- std::string **val**

5.139.1 Constructor & Destructor Documentation

5.139.1.1 Var()

```
Var::Var (
            std::string val )
```

this is the value function

Parameters

val	

5.139.2 Member Function Documentation

5.139.2.1 equals()

```
bool Var::equals (
             Expr * e )  [virtual]
```

Implements Expr.

5.139.2.2 has_variable()

```
bool Var::has_variable ( )  [virtual]
```

Implements Expr.

5.139.2.3 interp()

```
int Var::interp ( )  [virtual]
```

Implements Expr.

5.139.2.4 pretty_print()

```
void Var::pretty_print (
             std::ostream & ot,
             precedence_t prec )  [virtual]
```

Implements Expr.

5.139.2.5 pretty_print_dr()

```
void Var::pretty_print_dr (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.139.2.6 print()

```
void Var::print (
             std::ostream & ot )  [virtual]
```

Implements Expr.

5.139.2.7 subst()

```
Expr * Var::subst (
            std::string replace,
            Expr * s )  [virtual]
```

Implements Expr.

The documentation for this class was generated from the following files:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h
- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.cpp

5.140 Catch::detail::void_type<... > Struct Template Reference

Public Types

- using **type** = void

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.141 Catch::WaitForKeypress Struct Reference

Public Types

- enum **When** { **Never** , **BeforeStart** = 1 , **BeforeExit** = 2 , **BeforeStartAndExit** = BeforeStart | BeforeExit }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.142 Catch::WarnAbout Struct Reference

Public Types

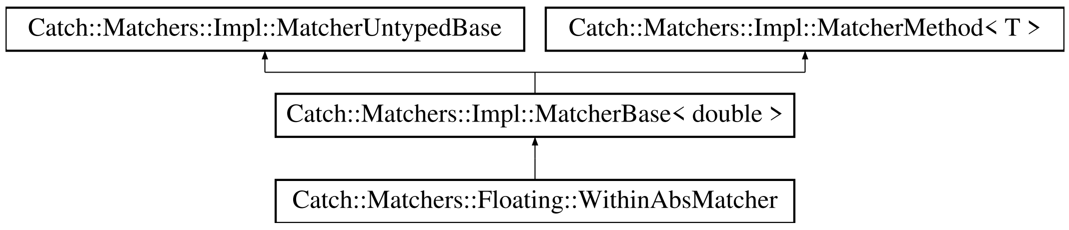
- enum **What** { **Nothing** = 0x00 , **NoAssertions** = 0x01 , **NoTests** = 0x02 }

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.143 Catch::Matchers::Floating::WithinAbsMatcher Struct Reference

Inheritance diagram for Catch::Matchers::Floating::WithinAbsMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< double >
Catch::Matchers::Floating::WithinAbsMatcher

Public Member Functions

- **WithinAbsMatcher** (double target, double margin)
- bool **match** (double const &matchee) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator**|| (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.143.1 Member Function Documentation

5.143.1.1 describe()

```
std::string Catch::Matchers::Floating::WithinAbsMatcher::describe ( ) const  [override], [virtual]
```

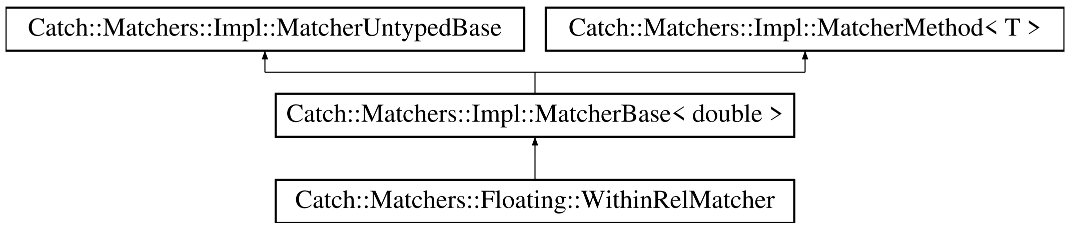
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.144 Catch::Matchers::Floating::WithinRelMatcher Struct Reference

Inheritance diagram for Catch::Matchers::Floating::WithinRelMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< double >
Catch::Matchers::Floating::WithinRelMatcher

Public Member Functions

- **WithinRelMatcher** (double target, double epsilon)
- bool **match** (double const &matchee) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator||** (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.144.1 Member Function Documentation

5.144.1.1 describe()

```
std::string Catch::Matchers::Floating::WithinRelMatcher::describe ( ) const  [override], [virtual]
```

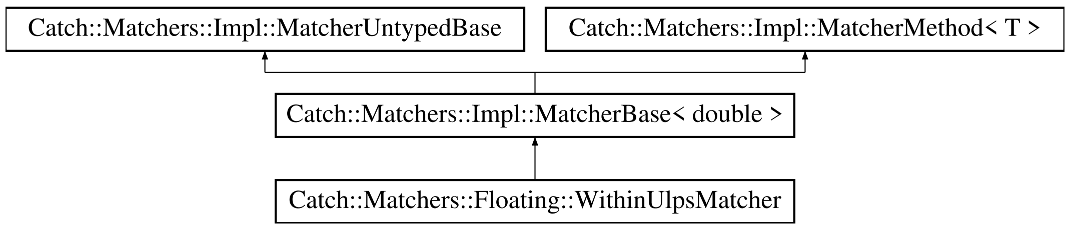
Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

5.145 Catch::Matchers::Floating::WithinUlpsMatcher Struct Reference

Inheritance diagram for Catch::Matchers::Floating::WithinUlpsMatcher:


Catch::Matchers::Impl::MatcherUntypedBase
Catch::Matchers::Impl::MatcherMethod< T >
Catch::Matchers::Impl::MatcherBase< double >
Catch::Matchers::Floating::WithinUlpsMatcher

Public Member Functions

- **WithinUlpsMatcher** (double target, uint64_t ulps, FloatingPointKind baseType)
- bool **match** (double const &matchee) const override
- std::string describe () const override

Public Member Functions inherited from Catch::Matchers::Impl::MatcherBase< T >

- MatchAllOf< T > **operator&&** (MatcherBase const &other) const
- MatchAnyOf< T > **operator**|| (MatcherBase const &other) const
- MatchNotOf< T > **operator!** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherUntypedBase

- **MatcherUntypedBase** (MatcherUntypedBase const &)=default
- MatcherUntypedBase & **operator=** (MatcherUntypedBase const &)=delete
- std::string **toString** () const

Public Member Functions inherited from Catch::Matchers::Impl::MatcherMethod< T >

- virtual bool **match** (T const &arg) const=0

Additional Inherited Members

Protected Attributes inherited from Catch::Matchers::Impl::MatcherUntypedBase

- std::string **m_cachedToString**

5.145.1 Member Function Documentation

5.145.1.1 describe()

```
std::string Catch::Matchers::Floating::WithinUlpsMatcher::describe ( ) const  [override],
[virtual]
```

Implements Catch::Matchers::Impl::MatcherUntypedBase.

The documentation for this struct was generated from the following file:

- /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

Chapter 6

File Documentation

6.1 /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/catch.hpp

```
/*
 *  Catch v2.13.7
 *  Generated: 2021-07-28 20:29:27.753164
 *  ----------------------------------------------------------
 *  This file has been merged from multiple headers. Please don't edit it directly
 *  Copyright (c) 2021 Two Blue Cubes Ltd. All rights reserved.
 *
 *  Distributed under the Boost Software License, Version 1.0. (See accompanying
 *  file LICENSE_1_0.txt or copy at http://www.boost.org/LICENSE_1_0.txt)
 */
#ifndef TWOBLUECUBES_SINGLE_INCLUDE_CATCH_HPP_INCLUDED
#define TWOBLUECUBES_SINGLE_INCLUDE_CATCH_HPP_INCLUDED
// start catch.hpp


#define CATCH_VERSION_MAJOR 2
#define CATCH_VERSION_MINOR 13
#define CATCH_VERSION_PATCH 7

#ifdef __clang__
#    pragma clang system_header
#elif defined __GNUC__
#    pragma GCC system_header
#endif

// start catch_suppress_warnings.h

#ifdef __clang__
#   ifdef __ICC // icpc defines the __clang__ macro
#       pragma warning(push)
#       pragma warning(disable: 161 1682)
#   else // __ICC
#       pragma clang diagnostic push
#       pragma clang diagnostic ignored "-Wpadded"
#       pragma clang diagnostic ignored "-Wswitch-enum"
#       pragma clang diagnostic ignored "-Wcovered-switch-default"
#    endif
#elif defined __GNUC__
     // Because REQUIREs trigger GCC's -Wparentheses, and because still
     // supported version of g++ have only buggy support for _Pragmas,
     // Wparentheses have to be suppressed globally.
#    pragma GCC diagnostic ignored "-Wparentheses" // See #674 for details

#    pragma GCC diagnostic push
#    pragma GCC diagnostic ignored "-Wunused-variable"
#    pragma GCC diagnostic ignored "-Wpadded"
#endif
// end catch_suppress_warnings.h
#if defined(CATCH_CONFIG_MAIN) || defined(CATCH_CONFIG_RUNNER)
#  define CATCH_IMPL
#  define CATCH_CONFIG_ALL_PARTS
#endif

// In the impl file, we want to have access to all parts of the headers
// Can also be used to sanely support PCHs
```

```
#if defined(CATCH_CONFIG_ALL_PARTS)
#  define CATCH_CONFIG_EXTERNAL_INTERFACES
#  if defined(CATCH_CONFIG_DISABLE_MATCHERS)
#    undef CATCH_CONFIG_DISABLE_MATCHERS
#  endif
#  if !defined(CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER)
#    define CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER
#  endif
#endif

#if !defined(CATCH_CONFIG_IMPL_ONLY)
// start catch_platform.h

// See e.g.:
// https://opensource.apple.com/source/CarbonHeaders/CarbonHeaders-18.1/TargetConditionals.h.auto.html
#ifdef __APPLE__
#  include <TargetConditionals.h>
#  if (defined(TARGET_OS_OSX) && TARGET_OS_OSX == 1) || \
      (defined(TARGET_OS_MAC) && TARGET_OS_MAC == 1)
#    define CATCH_PLATFORM_MAC
#  elif (defined(TARGET_OS_IPHONE) && TARGET_OS_IPHONE == 1)
#    define CATCH_PLATFORM_IPHONE
#  endif

#elif defined(linux) || defined(__linux) || defined(__linux__)
#  define CATCH_PLATFORM_LINUX

#elif defined(WIN32) || defined(__WIN32__) || defined(_WIN32) || defined(_MSC_VER) ||
defined(__MINGW32__)
#  define CATCH_PLATFORM_WINDOWS
#endif

// end catch_platform.h

#ifdef CATCH_IMPL
#  ifndef CLARA_CONFIG_MAIN
#    define CLARA_CONFIG_MAIN_NOT_DEFINED
#    define CLARA_CONFIG_MAIN
#  endif
#endif

// start catch_user_interfaces.h

namespace Catch {
    unsigned int rngSeed();
}

// end catch_user_interfaces.h
// start catch_tag_alias_autoregistrar.h

// start catch_common.h

// start catch_compiler_capabilities.h

// Detect a number of compiler features - by compiler
// The following features are defined:
//
// CATCH_CONFIG_COUNTER : is the __COUNTER__ macro supported?
// CATCH_CONFIG_WINDOWS_SEH : is Windows SEH supported?
// CATCH_CONFIG_POSIX_SIGNALS : are POSIX signals supported?
// CATCH_CONFIG_DISABLE_EXCEPTIONS : Are exceptions enabled?
// ****************
// Note to maintainers: if new toggles are added please document them
// in configuration.md, too
// ****************

// In general each macro has a _NO_<feature name> form
// (e.g. CATCH_CONFIG_NO_POSIX_SIGNALS) which disables the feature.
// Many features, at point of detection, define an _INTERNAL_ macro, so they
// can be combined, en-mass, with the _NO_ forms later.

#ifdef __cplusplus

#  if (__cplusplus >= 201402L) || (defined(_MSVC_LANG) && _MSVC_LANG >= 201402L)
#    define CATCH_CPP14_OR_GREATER
#  endif

#  if (__cplusplus >= 201703L) || (defined(_MSVC_LANG) && _MSVC_LANG >= 201703L)
#    define CATCH_CPP17_OR_GREATER
#  endif

#endif

// Only GCC compiler should be used in this block, so other compilers trying to
// mask themselves as GCC should be ignored.
#if defined(__GNUC__) && !defined(__clang__) && !defined(__ICC) && !defined(__CUDACC__) &&
!defined(__LCC__)
```

```
#    define CATCH_INTERNAL_START_WARNINGS_SUPPRESSION _Pragma( "GCC diagnostic push" )
#    define CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION  _Pragma( "GCC diagnostic pop" )

#    define CATCH_INTERNAL_IGNORE_BUT_WARN(...) (void)__builtin_constant_p(__VA_ARGS__)

#endif

#if defined(__clang__)

#    define CATCH_INTERNAL_START_WARNINGS_SUPPRESSION _Pragma( "clang diagnostic push" )
#    define CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION  _Pragma( "clang diagnostic pop" )

// As of this writing, IBM XL's implementation of __builtin_constant_p has a bug
// which results in calls to destructors being emitted for each temporary,
// without a matching initialization. In practice, this can result in something
// like `std::string::~string` being called on an uninitialized value.
//
// For example, this code will likely segfault under IBM XL:
// ```
// REQUIRE(std::string("12") + "34" == "1234")
// ```
//
// Therefore, `CATCH_INTERNAL_IGNORE_BUT_WARN` is not implemented.
#  if !defined(__ibmxl__) && !defined(__CUDACC__)
#    define CATCH_INTERNAL_IGNORE_BUT_WARN(...) (void)__builtin_constant_p(__VA_ARGS__) /*
NOLINT(cppcoreguidelines-pro-type-vararg, hicpp-vararg) */
#  endif

#    define CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
         _Pragma( "clang diagnostic ignored \"-Wexit-time-destructors\"" ) \
         _Pragma( "clang diagnostic ignored \"-Wglobal-constructors\"")

#    define CATCH_INTERNAL_SUPPRESS_PARENTHESES_WARNINGS \
         _Pragma( "clang diagnostic ignored \"-Wparentheses\"" )

#    define CATCH_INTERNAL_SUPPRESS_UNUSED_WARNINGS \
         _Pragma( "clang diagnostic ignored \"-Wunused-variable\"" )

#    define CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS \
         _Pragma( "clang diagnostic ignored \"-Wgnu-zero-variadic-macro-arguments\"" )

#    define CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
         _Pragma( "clang diagnostic ignored \"-Wunused-template\"" )

#endif // __clang__

// Assume that non-Windows platforms support posix signals by default
#if !defined(CATCH_PLATFORM_WINDOWS)
    #define CATCH_INTERNAL_CONFIG_POSIX_SIGNALS
#endif

// We know some environments not to support full POSIX signals
#if defined(__CYGWIN__) || defined(__QNX__) || defined(__EMSCRIPTEN__) || defined(__DJGPP__)
    #define CATCH_INTERNAL_CONFIG_NO_POSIX_SIGNALS
#endif

#ifdef __OS400__
#       define CATCH_INTERNAL_CONFIG_NO_POSIX_SIGNALS
#       define CATCH_CONFIG_COLOUR_NONE
#endif

// Android somehow still does not support std::to_string
#if defined(__ANDROID__)
#    define CATCH_INTERNAL_CONFIG_NO_CPP11_TO_STRING
#    define CATCH_INTERNAL_CONFIG_ANDROID_LOGWRITE
#endif

// Not all Windows environments support SEH properly
#if defined(__MINGW32__)
#    define CATCH_INTERNAL_CONFIG_NO_WINDOWS_SEH
#endif

// PS4
#if defined(__ORBIS__)
#    define CATCH_INTERNAL_CONFIG_NO_NEW_CAPTURE
#endif

// Cygwin
#ifdef __CYGWIN__

// Required for some versions of Cygwin to declare gettimeofday
// see: http://stackoverflow.com/questions/36901803/gettimeofday-not-declared-in-this-scope-cygwin
#   define _BSD_SOURCE
// some versions of cygwin (most) do not support std::to_string. Use the libstd check.
// https://gcc.gnu.org/onlinedocs/gcc-4.8.2/libstdc++/api/a01053_source.html line 2812-2813
# if !((__cplusplus >= 201103L) && defined(_GLIBCXX_USE_C99) \
           && !defined(_GLIBCXX_HAVE_BROKEN_VSWPRINTF))
```

```

#    define CATCH_INTERNAL_CONFIG_NO_CPP11_TO_STRING

# endif
#endif // __CYGWIN__

// Visual C++
#if defined(_MSC_VER)

#  define CATCH_INTERNAL_START_WARNINGS_SUPPRESSION __pragma( warning(push) )
#  define CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION  __pragma( warning(pop) )

// Universal Windows platform does not support SEH
// Or console colours (or console at all...)
#  if defined(WINAPI_FAMILY) && (WINAPI_FAMILY == WINAPI_FAMILY_APP)
#    define CATCH_CONFIG_COLOUR_NONE
#  else
#    define CATCH_INTERNAL_CONFIG_WINDOWS_SEH
#  endif

// MSVC traditional preprocessor needs some workaround for __VA_ARGS__
// _MSVC_TRADITIONAL == 0 means new conformant preprocessor
// _MSVC_TRADITIONAL == 1 means old traditional non-conformant preprocessor
#  if !defined(__clang__) // Handle Clang masquerading for msvc
#    if !defined(_MSVC_TRADITIONAL) || (defined(_MSVC_TRADITIONAL) && _MSVC_TRADITIONAL)
#      define CATCH_INTERNAL_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#    endif // MSVC_TRADITIONAL
#  endif // __clang__

#endif // _MSC_VER

#if defined(_REENTRANT) || defined(_MSC_VER)
// Enable async processing, as -pthread is specified or no additional linking is required
# define CATCH_INTERNAL_CONFIG_USE_ASYNC
#endif // _MSC_VER

// Check if we are compiled with -fno-exceptions or equivalent
#if defined(__EXCEPTIONS) || defined(__cpp_exceptions) || defined(_CPPUNWIND)
#  define CATCH_INTERNAL_CONFIG_EXCEPTIONS_ENABLED
#endif

// DJGPP
#ifdef __DJGPP__
#  define CATCH_INTERNAL_CONFIG_NO_WCHAR
#endif // __DJGPP__

// Embarcadero C++Build
#if defined(__BORLANDC__)
    #define CATCH_INTERNAL_CONFIG_POLYFILL_ISNAN
#endif


// Use of __COUNTER__ is suppressed during code analysis in
// CLion/AppCode 2017.2.x and former, because __COUNTER__ is not properly
// handled by it.
// Otherwise all supported compilers support COUNTER macro,
// but user still might want to turn it off
#if ( !defined(__JETBRAINS_IDE__) || __JETBRAINS_IDE__ >= 20170300L )
    #define CATCH_INTERNAL_CONFIG_COUNTER
#endif


// RTX is a special version of Windows that is real time.
// This means that it is detected as Windows, but does not provide
// the same set of capabilities as real Windows does.
#if defined(UNDER_RTSS) || defined(RTX64_BUILD)
    #define CATCH_INTERNAL_CONFIG_NO_WINDOWS_SEH
    #define CATCH_INTERNAL_CONFIG_NO_ASYNC
    #define CATCH_CONFIG_COLOUR_NONE
#endif

#if !defined(_GLIBCXX_USE_C99_MATH_TR1)
#define CATCH_INTERNAL_CONFIG_GLOBAL_NEXTAFTER
#endif

// Various stdlib support checks that require __has_include
#if defined(__has_include)
  // Check if string_view is available and usable
  #if __has_include(<string_view>) && defined(CATCH_CPP17_OR_GREATER)
  #    define CATCH_INTERNAL_CONFIG_CPP17_STRING_VIEW
  #endif

  // Check if optional is available and usable
  #  if __has_include(<optional>) && defined(CATCH_CPP17_OR_GREATER)
  #    define CATCH_INTERNAL_CONFIG_CPP17_OPTIONAL
  #  endif // __has_include(<optional>) && defined(CATCH_CPP17_OR_GREATER)

```

```
    // Check if byte is available and usable
    #  if __has_include(<cstddef>) && defined(CATCH_CPP17_OR_GREATER)
    #    include <cstddef>
    #    if defined(__cpp_lib_byte) && (__cpp_lib_byte > 0)
    #      define CATCH_INTERNAL_CONFIG_CPP17_BYTE
    #    endif
    #  endif // __has_include(<cstddef>) && defined(CATCH_CPP17_OR_GREATER)

    // Check if variant is available and usable
    #  if __has_include(<variant>) && defined(CATCH_CPP17_OR_GREATER)
    #    if defined(__clang__) && (__clang_major__ < 8)
           // work around clang bug with libstdc++ https://bugs.llvm.org/show_bug.cgi?id=31852
           // fix should be in clang 8, workaround in libstdc++ 8.2
    #      include <ciso646>
    #      if defined(__GLIBCXX__) && defined(_GLIBCXX_RELEASE) && (_GLIBCXX_RELEASE < 9)
    #        define CATCH_CONFIG_NO_CPP17_VARIANT
    #      else
    #        define CATCH_INTERNAL_CONFIG_CPP17_VARIANT
    #      endif // defined(__GLIBCXX__) && defined(_GLIBCXX_RELEASE) && (_GLIBCXX_RELEASE < 9)
    #    else
    #      define CATCH_INTERNAL_CONFIG_CPP17_VARIANT
    #    endif // defined(__clang__) && (__clang_major__ < 8)
    #  endif // __has_include(<variant>) && defined(CATCH_CPP17_OR_GREATER)
#endif // defined(__has_include)

#if defined(CATCH_INTERNAL_CONFIG_COUNTER) && !defined(CATCH_CONFIG_NO_COUNTER) &&
!defined(CATCH_CONFIG_COUNTER)
#   define CATCH_CONFIG_COUNTER
#endif
#if defined(CATCH_INTERNAL_CONFIG_WINDOWS_SEH) && !defined(CATCH_CONFIG_NO_WINDOWS_SEH) &&
!defined(CATCH_CONFIG_WINDOWS_SEH) && !defined(CATCH_INTERNAL_CONFIG_NO_WINDOWS_SEH)
#   define CATCH_CONFIG_WINDOWS_SEH
#endif
// This is set by default, because we assume that unix compilers are posix-signal-compatible by
default.
#if defined(CATCH_INTERNAL_CONFIG_POSIX_SIGNALS) && !defined(CATCH_INTERNAL_CONFIG_NO_POSIX_SIGNALS)
&& !defined(CATCH_CONFIG_NO_POSIX_SIGNALS) && !defined(CATCH_CONFIG_POSIX_SIGNALS)
#   define CATCH_CONFIG_POSIX_SIGNALS
#endif
// This is set by default, because we assume that compilers with no wchar_t support are just rare
exceptions.
#if !defined(CATCH_INTERNAL_CONFIG_NO_WCHAR) && !defined(CATCH_CONFIG_NO_WCHAR) &&
!defined(CATCH_CONFIG_WCHAR)
#   define CATCH_CONFIG_WCHAR
#endif

#if !defined(CATCH_INTERNAL_CONFIG_NO_CPP11_TO_STRING) && !defined(CATCH_CONFIG_NO_CPP11_TO_STRING) &&
!defined(CATCH_CONFIG_CPP11_TO_STRING)
#    define CATCH_CONFIG_CPP11_TO_STRING
#endif

#if defined(CATCH_INTERNAL_CONFIG_CPP17_OPTIONAL) && !defined(CATCH_CONFIG_NO_CPP17_OPTIONAL) &&
!defined(CATCH_CONFIG_CPP17_OPTIONAL)
#  define CATCH_CONFIG_CPP17_OPTIONAL
#endif

#if defined(CATCH_INTERNAL_CONFIG_CPP17_STRING_VIEW) && !defined(CATCH_CONFIG_NO_CPP17_STRING_VIEW) &&
!defined(CATCH_CONFIG_CPP17_STRING_VIEW)
#  define CATCH_CONFIG_CPP17_STRING_VIEW
#endif

#if defined(CATCH_INTERNAL_CONFIG_CPP17_VARIANT) && !defined(CATCH_CONFIG_NO_CPP17_VARIANT) &&
!defined(CATCH_CONFIG_CPP17_VARIANT)
#  define CATCH_CONFIG_CPP17_VARIANT
#endif

#if defined(CATCH_INTERNAL_CONFIG_CPP17_BYTE) && !defined(CATCH_CONFIG_NO_CPP17_BYTE) &&
!defined(CATCH_CONFIG_CPP17_BYTE)
#  define CATCH_CONFIG_CPP17_BYTE
#endif

#if defined(CATCH_CONFIG_EXPERIMENTAL_REDIRECT)
#  define CATCH_INTERNAL_CONFIG_NEW_CAPTURE
#endif

#if defined(CATCH_INTERNAL_CONFIG_NEW_CAPTURE) && !defined(CATCH_INTERNAL_CONFIG_NO_NEW_CAPTURE) &&
!defined(CATCH_CONFIG_NO_NEW_CAPTURE) && !defined(CATCH_CONFIG_NEW_CAPTURE)
#  define CATCH_CONFIG_NEW_CAPTURE
#endif

#if !defined(CATCH_INTERNAL_CONFIG_EXCEPTIONS_ENABLED) && !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
#  define CATCH_CONFIG_DISABLE_EXCEPTIONS
#endif

#if defined(CATCH_INTERNAL_CONFIG_POLYFILL_ISNAN) && !defined(CATCH_CONFIG_NO_POLYFILL_ISNAN) &&
!defined(CATCH_CONFIG_POLYFILL_ISNAN)
#  define CATCH_CONFIG_POLYFILL_ISNAN
```

```
#endif

#if defined(CATCH_INTERNAL_CONFIG_USE_ASYNC)  && !defined(CATCH_INTERNAL_CONFIG_NO_ASYNC) &&
!defined(CATCH_CONFIG_NO_USE_ASYNC) && !defined(CATCH_CONFIG_USE_ASYNC)
#  define CATCH_CONFIG_USE_ASYNC
#endif

#if defined(CATCH_INTERNAL_CONFIG_ANDROID_LOGWRITE) && !defined(CATCH_CONFIG_NO_ANDROID_LOGWRITE) &&
!defined(CATCH_CONFIG_ANDROID_LOGWRITE)
#  define CATCH_CONFIG_ANDROID_LOGWRITE
#endif

#if defined(CATCH_INTERNAL_CONFIG_GLOBAL_NEXTAFTER) && !defined(CATCH_CONFIG_NO_GLOBAL_NEXTAFTER) &&
!defined(CATCH_CONFIG_GLOBAL_NEXTAFTER)
#  define CATCH_CONFIG_GLOBAL_NEXTAFTER
#endif

// Even if we do not think the compiler has that warning, we still have
// to provide a macro that can be used by the code.
#if !defined(CATCH_INTERNAL_START_WARNINGS_SUPPRESSION)
#   define CATCH_INTERNAL_START_WARNINGS_SUPPRESSION
#endif
#if !defined(CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION)
#   define CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION
#endif
#if !defined(CATCH_INTERNAL_SUPPRESS_PARENTHESES_WARNINGS)
#   define CATCH_INTERNAL_SUPPRESS_PARENTHESES_WARNINGS
#endif
#if !defined(CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS)
#   define CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS
#endif
#if !defined(CATCH_INTERNAL_SUPPRESS_UNUSED_WARNINGS)
#   define CATCH_INTERNAL_SUPPRESS_UNUSED_WARNINGS
#endif
#if !defined(CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS)
#   define CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS
#endif

// The goal of this macro is to avoid evaluation of the arguments, but
// still have the compiler warn on problems inside...
#if !defined(CATCH_INTERNAL_IGNORE_BUT_WARN)
#   define CATCH_INTERNAL_IGNORE_BUT_WARN(...)
#endif

#if defined(__APPLE__) && defined(__apple_build_version__) && (__clang_major__ < 10)
#   undef CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS
#elif defined(__clang__) && (__clang_major__ < 5)
#   undef CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS
#endif

#if !defined(CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS)
#   define CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS
#endif

#if defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
#define CATCH_TRY if ((true))
#define CATCH_CATCH_ALL if ((false))
#define CATCH_CATCH_ANON(type) if ((false))
#else
#define CATCH_TRY try
#define CATCH_CATCH_ALL catch (...)
#define CATCH_CATCH_ANON(type) catch (type)
#endif

#if defined(CATCH_INTERNAL_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR) &&
!defined(CATCH_CONFIG_NO_TRADITIONAL_MSVC_PREPROCESSOR) &&
!defined(CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR)
#define CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#endif

// end catch_compiler_capabilities.h
#define INTERNAL_CATCH_UNIQUE_NAME_LINE2( name, line ) name##line
#define INTERNAL_CATCH_UNIQUE_NAME_LINE( name, line ) INTERNAL_CATCH_UNIQUE_NAME_LINE2( name, line )
#ifdef CATCH_CONFIG_COUNTER
#  define INTERNAL_CATCH_UNIQUE_NAME( name ) INTERNAL_CATCH_UNIQUE_NAME_LINE( name, __COUNTER__ )
#else
#  define INTERNAL_CATCH_UNIQUE_NAME( name ) INTERNAL_CATCH_UNIQUE_NAME_LINE( name, __LINE__ )
#endif

#include <iosfwd>
#include <string>
#include <cstdint>

// We need a dummy global operator« so we can bring it into Catch namespace later
struct Catch_global_namespace_dummy {};
std::ostream& operator«(std::ostream&, Catch_global_namespace_dummy);

```

```
namespace Catch {

    struct CaseSensitive { enum Choice {
        Yes,
        No
    }; };

    class NonCopyable {
        NonCopyable( NonCopyable const& )              = delete;
        NonCopyable( NonCopyable && )                  = delete;
        NonCopyable& operator = ( NonCopyable const& ) = delete;
        NonCopyable& operator = ( NonCopyable && )     = delete;

    protected:
        NonCopyable();
        virtual ~NonCopyable();
    };

    struct SourceLineInfo {

        SourceLineInfo() = delete;
        SourceLineInfo( char const* _file, std::size_t _line ) noexcept
        :   file( _file ),
            line( _line )
        {}

        SourceLineInfo( SourceLineInfo const& other )            = default;
        SourceLineInfo& operator = ( SourceLineInfo const& )     = default;
        SourceLineInfo( SourceLineInfo&& )              noexcept = default;
        SourceLineInfo& operator = ( SourceLineInfo&& ) noexcept = default;

        bool empty() const noexcept { return file[0] == '\0'; }
        bool operator == ( SourceLineInfo const& other ) const noexcept;
        bool operator < ( SourceLineInfo const& other ) const noexcept;

        char const* file;
        std::size_t line;
    };

    std::ostream& operator « ( std::ostream& os, SourceLineInfo const& info );

    // Bring in operator« from global namespace into Catch namespace
    // This is necessary because the overload of operator« above makes
    // lookup stop at namespace Catch
    using ::operator«;

    // Use this in variadic streaming macros to allow
    //    » +StreamEndStop
    // as well as
    //    » stuff +StreamEndStop
    struct StreamEndStop {
        std::string operator+() const;
    };
    template<typename T>
    T const& operator + ( T const& value, StreamEndStop ) {
        return value;
    }
}

#define CATCH_INTERNAL_LINEINFO \
    ::Catch::SourceLineInfo( __FILE__, static_cast<std::size_t>( __LINE__ ) )

// end catch_common.h
namespace Catch {

    struct RegistrarForTagAliases {
        RegistrarForTagAliases( char const* alias, char const* tag, SourceLineInfo const& lineInfo );
    };

} // end namespace Catch

#define CATCH_REGISTER_TAG_ALIAS( alias, spec ) \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
    CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
    namespace{ Catch::RegistrarForTagAliases INTERNAL_CATCH_UNIQUE_NAME( AutoRegisterTagAlias )(
alias, spec, CATCH_INTERNAL_LINEINFO ); } \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

// end catch_tag_alias_autoregistrar.h
// start catch_test_registry.h

// start catch_interfaces_testcase.h

#include <vector>

namespace Catch {

    class TestSpec;

    struct ITestInvoker {
        virtual void invoke () const = 0;
        virtual ~ITestInvoker();
    };

    class TestCase;
    struct IConfig;

    struct ITestCaseRegistry {
        virtual ~ITestCaseRegistry();
        virtual std::vector<TestCase> const& getAllTests() const = 0;
        virtual std::vector<TestCase> const& getAllTestsSorted( IConfig const& config ) const = 0;
    };

    bool isThrowSafe( TestCase const& testCase, IConfig const& config );
    bool matchTest( TestCase const& testCase, TestSpec const& testSpec, IConfig const& config );
    std::vector<TestCase> filterTests( std::vector<TestCase> const& testCases, TestSpec const&
testSpec, IConfig const& config );
    std::vector<TestCase> const& getAllTestCasesSorted( IConfig const& config );

}

// end catch_interfaces_testcase.h
// start catch_stringref.h

#include <cstddef>
#include <string>
#include <iosfwd>
#include <cassert>

namespace Catch {

    class StringRef {
    public:
        using size_type = std::size_t;
        using const_iterator = const char*;

    private:
        static constexpr char const* const s_empty = "";

        char const* m_start = s_empty;
        size_type m_size = 0;

    public: // construction
        constexpr StringRef() noexcept = default;

        StringRef( char const* rawChars ) noexcept;

        constexpr StringRef( char const* rawChars, size_type size ) noexcept
        :   m_start( rawChars ),
            m_size( size )
        {}

        StringRef( std::string const& stdString ) noexcept
        :   m_start( stdString.c_str() ),
            m_size( stdString.size() )
        {}

        explicit operator std::string() const {
            return std::string(m_start, m_size);
        }

    public: // operators
        auto operator == ( StringRef const& other ) const noexcept -> bool;
        auto operator != (StringRef const& other) const noexcept -> bool {
            return !(*this == other);
        }

        auto operator[] ( size_type index ) const noexcept -> char {
            assert(index < m_size);
            return m_start[index];
        }

    public: // named queries
        constexpr auto empty() const noexcept -> bool {
            return m_size == 0;
        }
        constexpr auto size() const noexcept -> size_type {
            return m_size;
        }

        // Returns the current start pointer. If the StringRef is not
        // null-terminated, throws std::domain_exception
        auto c_str() const -> char const*;

    public: // substrings and searches
        // Returns a substring of [start, start + length).
        // If start + length > size(), then the substring is [start, size()).
        // If start > size(), then the substring is empty.
        auto substr( size_type start, size_type length ) const noexcept -> StringRef;

        // Returns the current start pointer. May not be null-terminated.
        auto data() const noexcept -> char const*;

        constexpr auto isNullTerminated() const noexcept -> bool {
            return m_start[m_size] == '\0';
        }

    public: // iterators
        constexpr const_iterator begin() const { return m_start; }
        constexpr const_iterator end() const { return m_start + m_size; }
    };

    auto operator += ( std::string& lhs, StringRef const& sr ) -> std::string&;
    auto operator « ( std::ostream& os, StringRef const& sr ) -> std::ostream&;

    constexpr auto operator "" _sr( char const* rawChars, std::size_t size ) noexcept -> StringRef {
        return StringRef( rawChars, size );
    }
} // namespace Catch

constexpr auto operator "" _catch_sr( char const* rawChars, std::size_t size ) noexcept ->
Catch::StringRef {
    return Catch::StringRef( rawChars, size );
}

// end catch_stringref.h
// start catch_preprocessor.hpp


#define CATCH_RECURSION_LEVEL0(...) __VA_ARGS__
#define CATCH_RECURSION_LEVEL1(...)
CATCH_RECURSION_LEVEL0(CATCH_RECURSION_LEVEL0(CATCH_RECURSION_LEVEL0(__VA_ARGS__)))
#define CATCH_RECURSION_LEVEL2(...)
CATCH_RECURSION_LEVEL1(CATCH_RECURSION_LEVEL1(CATCH_RECURSION_LEVEL1(__VA_ARGS__)))
#define CATCH_RECURSION_LEVEL3(...)
CATCH_RECURSION_LEVEL2(CATCH_RECURSION_LEVEL2(CATCH_RECURSION_LEVEL2(__VA_ARGS__)))
#define CATCH_RECURSION_LEVEL4(...)
CATCH_RECURSION_LEVEL3(CATCH_RECURSION_LEVEL3(CATCH_RECURSION_LEVEL3(__VA_ARGS__)))
#define CATCH_RECURSION_LEVEL5(...)
CATCH_RECURSION_LEVEL4(CATCH_RECURSION_LEVEL4(CATCH_RECURSION_LEVEL4(__VA_ARGS__)))

#ifdef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define INTERNAL_CATCH_EXPAND_VARGS(...) __VA_ARGS__
// MSVC needs more evaluations
#define CATCH_RECURSION_LEVEL6(...)
CATCH_RECURSION_LEVEL5(CATCH_RECURSION_LEVEL5(CATCH_RECURSION_LEVEL5(__VA_ARGS__)))
#define CATCH_RECURSE(...)  CATCH_RECURSION_LEVEL6(CATCH_RECURSION_LEVEL6(__VA_ARGS__))
#else
#define CATCH_RECURSE(...)  CATCH_RECURSION_LEVEL5(__VA_ARGS__)
#endif

#define CATCH_REC_END(...)
#define CATCH_REC_OUT

#define CATCH_EMPTY()
#define CATCH_DEFER(id) id CATCH_EMPTY()

#define CATCH_REC_GET_END2() 0, CATCH_REC_END
#define CATCH_REC_GET_END1(...) CATCH_REC_GET_END2
#define CATCH_REC_GET_END(...) CATCH_REC_GET_END1
#define CATCH_REC_NEXT0(test, next, ...) next CATCH_REC_OUT
#define CATCH_REC_NEXT1(test, next) CATCH_DEFER ( CATCH_REC_NEXT0 ) ( test, next, 0)
#define CATCH_REC_NEXT(test, next)  CATCH_REC_NEXT1(CATCH_REC_GET_END test, next)

#define CATCH_REC_LIST0(f, x, peek, ...) , f(x) CATCH_DEFER ( CATCH_REC_NEXT(peek, CATCH_REC_LIST1) )
( f, peek, __VA_ARGS__ )
#define CATCH_REC_LIST1(f, x, peek, ...) , f(x) CATCH_DEFER ( CATCH_REC_NEXT(peek, CATCH_REC_LIST0) )
( f, peek, __VA_ARGS__ )
#define CATCH_REC_LIST2(f, x, peek, ...)   f(x) CATCH_DEFER ( CATCH_REC_NEXT(peek, CATCH_REC_LIST1) )
( f, peek, __VA_ARGS__ )

#define CATCH_REC_LIST0_UD(f, userdata, x, peek, ...) , f(userdata, x) CATCH_DEFER (
CATCH_REC_NEXT(peek, CATCH_REC_LIST1_UD) ) ( f, userdata, peek, __VA_ARGS__ )
#define CATCH_REC_LIST1_UD(f, userdata, x, peek, ...) , f(userdata, x) CATCH_DEFER (
CATCH_REC_NEXT(peek, CATCH_REC_LIST0_UD) ) ( f, userdata, peek, __VA_ARGS__ )
#define CATCH_REC_LIST2_UD(f, userdata, x, peek, ...)   f(userdata, x) CATCH_DEFER (
CATCH_REC_NEXT(peek, CATCH_REC_LIST1_UD) ) ( f, userdata, peek, __VA_ARGS__ )

// Applies the function macro `f` to each of the remaining parameters, inserts commas between the
results,
// and passes userdata as the first parameter to each invocation,
// e.g. CATCH_REC_LIST_UD(f, x, a, b, c) evaluates to f(x, a), f(x, b), f(x, c)
#define CATCH_REC_LIST_UD(f, userdata, ...) CATCH_RECURSE(CATCH_REC_LIST2_UD(f, userdata, __VA_ARGS__, ()()(), ()()(), ()()(), 0))

#define CATCH_REC_LIST(f, ...) CATCH_RECURSE(CATCH_REC_LIST2(f, __VA_ARGS__, ()()(), ()()(), ()()(), 0))

#define INTERNAL_CATCH_EXPAND1(param) INTERNAL_CATCH_EXPAND2(param)
#define INTERNAL_CATCH_EXPAND2(...) INTERNAL_CATCH_NO## __VA_ARGS__
#define INTERNAL_CATCH_DEF(...) INTERNAL_CATCH_DEF __VA_ARGS__
#define INTERNAL_CATCH_NOINTERNAL_CATCH_DEF
#define INTERNAL_CATCH_STRINGIZE(...) INTERNAL_CATCH_STRINGIZE2(__VA_ARGS__)
#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define INTERNAL_CATCH_STRINGIZE2(...) #__VA_ARGS__
#define INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS(param) INTERNAL_CATCH_STRINGIZE(INTERNAL_CATCH_REMOVE_PARENS(param))
#else
// MSVC is adding extra space and needs another indirection to expand INTERNAL_CATCH_NOINTERNAL_CATCH_DEF
#define INTERNAL_CATCH_STRINGIZE2(...) INTERNAL_CATCH_STRINGIZE3(__VA_ARGS__)
#define INTERNAL_CATCH_STRINGIZE3(...) #__VA_ARGS__
#define INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS(param) (INTERNAL_CATCH_STRINGIZE(INTERNAL_CATCH_REMOVE_PARENS(param)) + 1)
#endif

#define INTERNAL_CATCH_MAKE_NAMESPACE2(...) ns_##__VA_ARGS__
#define INTERNAL_CATCH_MAKE_NAMESPACE(name) INTERNAL_CATCH_MAKE_NAMESPACE2(name)

#define INTERNAL_CATCH_REMOVE_PARENS(...) INTERNAL_CATCH_EXPAND1(INTERNAL_CATCH_DEF __VA_ARGS__)

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define INTERNAL_CATCH_MAKE_TYPE_LIST2(...) decltype(get_wrapper<INTERNAL_CATCH_REMOVE_PARENS_GEN(__VA_ARGS__)>())
#define INTERNAL_CATCH_MAKE_TYPE_LIST(...) INTERNAL_CATCH_MAKE_TYPE_LIST2(INTERNAL_CATCH_REMOVE_PARENS(__VA_ARGS__))
#else
#define INTERNAL_CATCH_MAKE_TYPE_LIST2(...) INTERNAL_CATCH_EXPAND_VARGS(decltype(get_wrapper<INTERNAL_CATCH_REMOVE_PARENS_GEN(__VA_ARGS__)>()))
#define INTERNAL_CATCH_MAKE_TYPE_LIST(...) INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_MAKE_TYPE_LIST2(INTERNAL_CATCH_REMOVE_PARENS(__VA_ARGS__)))
#endif

#define INTERNAL_CATCH_MAKE_TYPE_LISTS_FROM_TYPES(...)\
    CATCH_REC_LIST(INTERNAL_CATCH_MAKE_TYPE_LIST,__VA_ARGS__)

#define INTERNAL_CATCH_REMOVE_PARENS_1_ARG(_0) INTERNAL_CATCH_REMOVE_PARENS(_0)
#define INTERNAL_CATCH_REMOVE_PARENS_2_ARG(_0, _1) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_1_ARG(_1)
#define INTERNAL_CATCH_REMOVE_PARENS_3_ARG(_0, _1, _2) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_2_ARG(_1, _2)
#define INTERNAL_CATCH_REMOVE_PARENS_4_ARG(_0, _1, _2, _3) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_3_ARG(_1, _2, _3)
#define INTERNAL_CATCH_REMOVE_PARENS_5_ARG(_0, _1, _2, _3, _4) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_4_ARG(_1, _2, _3, _4)
#define INTERNAL_CATCH_REMOVE_PARENS_6_ARG(_0, _1, _2, _3, _4, _5) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_5_ARG(_1, _2, _3, _4, _5)
#define INTERNAL_CATCH_REMOVE_PARENS_7_ARG(_0, _1, _2, _3, _4, _5, _6) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_6_ARG(_1, _2, _3, _4, _5, _6)
#define INTERNAL_CATCH_REMOVE_PARENS_8_ARG(_0, _1, _2, _3, _4, _5, _6, _7) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_7_ARG(_1, _2, _3, _4, _5, _6, _7)
#define INTERNAL_CATCH_REMOVE_PARENS_9_ARG(_0, _1, _2, _3, _4, _5, _6, _7, _8) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_8_ARG(_1, _2, _3, _4, _5, _6, _7, _8)
#define INTERNAL_CATCH_REMOVE_PARENS_10_ARG(_0, _1, _2, _3, _4, _5, _6, _7, _8, _9) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_9_ARG(_1, _2, _3, _4, _5, _6, _7, _8, _9)
#define INTERNAL_CATCH_REMOVE_PARENS_11_ARG(_0, _1, _2, _3, _4, _5, _6, _7, _8, _9, _10) INTERNAL_CATCH_REMOVE_PARENS(_0), INTERNAL_CATCH_REMOVE_PARENS_10_ARG(_1, _2, _3, _4, _5, _6, _7, _8, _9, _10)

#define INTERNAL_CATCH_VA_NARGS_IMPL(_0, _1, _2, _3, _4, _5, _6, _7, _8, _9, _10, N, ...) N

#define INTERNAL_CATCH_TYPE_GEN\
    template<typename...> struct TypeList {};\
    template<typename...Ts>\
    constexpr auto get_wrapper() noexcept -> TypeList<Ts...> { return {}; }\
    template<template<typename...> class...> struct TemplateTypeList{};\
    template<template<typename...> class...Cs>\
    constexpr auto get_wrapper() noexcept -> TemplateTypeList<Cs...> { return {}; }\
    template<typename...>\
    struct append;\
    template<typename...>\
    struct rewrap;\
    template<template<typename...> class, typename...>\
    struct create;\
    template<template<typename...> class, typename>\
    struct convert;\
    \
    template<typename T> \
    struct append<T> { using type = T; };\
    template< template<typename...> class L1, typename...E1, template<typename...> class L2, typename...E2, typename...Rest>\
    struct append<L1<E1...>, L2<E2...>, Rest...> { using type = typename append<L1<E1...,E2...>, Rest...>::type; };\
    template< template<typename...> class L1, typename...E1, typename...Rest>\
    struct append<L1<E1...>, TypeList<mpl_::na>, Rest...> { using type = L1<E1...>; };\
    \
    template< template<typename...> class Container, template<typename...> class List, typename...elems>\
    struct rewrap<TemplateTypeList<Container>, List<elems...» { using type = TypeList<Container<elems...»; };\
    template< template<typename...> class Container, template<typename...> class List, class...Elems, typename...Elements>\
    struct rewrap<TemplateTypeList<Container>, List<Elems...>, Elements...> { using type = typename append<TypeList<Container<Elems...», typename rewrap<TemplateTypeList<Container>, Elements...>::type>::type; };\
    \
    template<template <typename...> class Final, template< typename...> class...Containers, typename...Types>\
    struct create<Final, TemplateTypeList<Containers...>, TypeList<Types...» { using type = typename append<Final<>, typename rewrap<TemplateTypeList<Containers>, Types...>::type...>::type; };\
    template<template <typename...> class Final, template <typename...> class List, typename...Ts>\
    struct convert<Final, List<Ts...» { using type = typename append<Final<>,TypeList<Ts>...>::type; };

#define INTERNAL_CATCH_NTTP_1(signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)> struct Nttp{};\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    constexpr auto get_wrapper() noexcept -> Nttp<__VA_ARGS__> { return {}; } \
    template<template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class...> struct NttpTemplateTypeList{};\
    template<template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class...Cs>\
    constexpr auto get_wrapper() noexcept -> NttpTemplateTypeList<Cs...> { return {}; } \
    \
    template< template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class Container, template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class List, INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    struct rewrap<NttpTemplateTypeList<Container>, List<__VA_ARGS__» { using type = TypeList<Container<__VA_ARGS__»; };\
    template< template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class Container, template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class List, INTERNAL_CATCH_REMOVE_PARENS(signature), typename...Elements>\
    struct rewrap<NttpTemplateTypeList<Container>, List<__VA_ARGS__>, Elements...> { using type = typename append<TypeList<Container<__VA_ARGS__», typename rewrap<NttpTemplateTypeList<Container>, Elements...>::type>::type; };\
    template<template <typename...> class Final, template<INTERNAL_CATCH_REMOVE_PARENS(signature)> class...Containers, typename...Types>\
    struct create<Final, NttpTemplateTypeList<Containers...>, TypeList<Types...» { using type = typename append<Final<>, typename rewrap<NttpTemplateTypeList<Containers>, Types...>::type...>::type; };

#define INTERNAL_CATCH_DECLARE_SIG_TEST0(TestName)
#define INTERNAL_CATCH_DECLARE_SIG_TEST1(TestName, signature)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    static void TestName()
#define INTERNAL_CATCH_DECLARE_SIG_TEST_X(TestName, signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    static void TestName()

#define INTERNAL_CATCH_DEFINE_SIG_TEST0(TestName)
#define INTERNAL_CATCH_DEFINE_SIG_TEST1(TestName, signature)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    static void TestName()
#define INTERNAL_CATCH_DEFINE_SIG_TEST_X(TestName, signature,...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    static void TestName()

#define INTERNAL_CATCH_NTTP_REGISTER0(TestFunc, signature)\
    template<typename Type>\
    void reg_test(TypeList<Type>, Catch::NameAndTags nameAndTags)\
    {\
        Catch::AutoReg( Catch::makeTestInvoker(&TestFunc<Type>), CATCH_INTERNAL_LINEINFO, Catch::StringRef(), nameAndTags);\
    }

#define INTERNAL_CATCH_NTTP_REGISTER(TestFunc, signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    void reg_test(Nttp<__VA_ARGS__>, Catch::NameAndTags nameAndTags)\
    {\
        Catch::AutoReg( Catch::makeTestInvoker(&TestFunc<__VA_ARGS__>), CATCH_INTERNAL_LINEINFO, Catch::StringRef(), nameAndTags);\
    }

#define INTERNAL_CATCH_NTTP_REGISTER_METHOD0(TestName, signature, ...)\
    template<typename Type>\
    void reg_test(TypeList<Type>, Catch::StringRef className, Catch::NameAndTags nameAndTags)\
    {\
        Catch::AutoReg( Catch::makeTestInvoker(&TestName<Type>::test), CATCH_INTERNAL_LINEINFO,
className, nameAndTags);\
    }

#define INTERNAL_CATCH_NTTP_REGISTER_METHOD(TestName, signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)>\
    void reg_test(Nttp<__VA_ARGS__>, Catch::StringRef className, Catch::NameAndTags nameAndTags)\
    {\
        Catch::AutoReg( Catch::makeTestInvoker(&TestName<__VA_ARGS__>::test), CATCH_INTERNAL_LINEINFO,
className, nameAndTags);\
    }

#define INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD0(TestName, ClassName)
#define INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD1(TestName, ClassName, signature)\
    template<typename TestType> \
    struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName)<TestType> { \
        void test();\
    }

#define INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X(TestName, ClassName, signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)> \
    struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName)<__VA_ARGS__> { \
        void test();\
    }

#define INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD0(TestName)
#define INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD1(TestName, signature)\
    template<typename TestType> \
    void INTERNAL_CATCH_MAKE_NAMESPACE(TestName)::TestName<TestType>::test()
#define INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X(TestName, signature, ...)\
    template<INTERNAL_CATCH_REMOVE_PARENS(signature)> \
    void INTERNAL_CATCH_MAKE_NAMESPACE(TestName)::TestName<__VA_ARGS__>::test()

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define INTERNAL_CATCH_NTTP_0
#define INTERNAL_CATCH_NTTP_GEN(...) INTERNAL_CATCH_VA_NARGS_IMPL(__VA_ARGS__,
INTERNAL_CATCH_NTTP_1(__VA_ARGS__), INTERNAL_CATCH_NTTP_1(__VA_ARGS__),
INTERNAL_CATCH_NTTP_1(__VA_ARGS__), INTERNAL_CATCH_NTTP_1(__VA_ARGS__),
INTERNAL_CATCH_NTTP_1(__VA_ARGS__), INTERNAL_CATCH_NTTP_1( __VA_ARGS__), INTERNAL_CATCH_NTTP_1(
__VA_ARGS__), INTERNAL_CATCH_NTTP_1( __VA_ARGS__), INTERNAL_CATCH_NTTP_1(
__VA_ARGS__),INTERNAL_CATCH_NTTP_1( __VA_ARGS__), INTERNAL_CATCH_NTTP_0)
#define INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD(TestName, ...) INTERNAL_CATCH_VA_NARGS_IMPL( "dummy",
__VA_ARGS__, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD1, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD0)(TestName, __VA_ARGS__)
#define INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD(TestName, ClassName, ...) INTERNAL_CATCH_VA_NARGS_IMPL(
"dummy", __VA_ARGS__,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHOI
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD1, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD0)(TestName, ClassName,
__VA_ARGS__)
#define INTERNAL_CATCH_NTTP_REG_METHOD_GEN(TestName, ...) INTERNAL_CATCH_VA_NARGS_IMPL( "dummy",
__VA_ARGS__, INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD0,
INTERNAL_CATCH_NTTP_REGISTER_METHOD0)(TestName, __VA_ARGS__)
#define INTERNAL_CATCH_NTTP_REG_GEN(TestFunc, ...) INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER0, INTERNAL_CATCH_NTTP_REGISTER0)(TestFunc, __VA_ARGS__)
#define INTERNAL_CATCH_DEFINE_SIG_TEST(TestName, ...) INTERNAL_CATCH_VA_NARGS_IMPL( "dummy",
__VA_ARGS__, INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DEFINE_SIG_TEST1,
INTERNAL_CATCH_DEFINE_SIG_TEST0)(TestName, __VA_ARGS__)
#define INTERNAL_CATCH_DECLARE_SIG_TEST(TestName, ...) INTERNAL_CATCH_VA_NARGS_IMPL( "dummy",
__VA_ARGS__, INTERNAL_CATCH_DECLARE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_X, INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_X, INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST1, INTERNAL_CATCH_DECLARE_SIG_TEST0)(TestName, __VA_ARGS__)
#define INTERNAL_CATCH_REMOVE_PARENS_GEN(...) INTERNAL_CATCH_VA_NARGS_IMPL(__VA_ARGS__,
INTERNAL_CATCH_REMOVE_PARENS_11_ARG,INTERNAL_CATCH_REMOVE_PARENS_10_ARG,INTERNAL_CATCH_REMOVE_PARENS_9_ARG,INTERNAL_CAT(
#else
#define INTERNAL_CATCH_NTTP_0(signature)
#define INTERNAL_CATCH_NTTP_GEN(...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL(__VA_ARGS__, INTERNAL_CATCH_NTTP_1,
INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_1,
INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_1,
INTERNAL_CATCH_NTTP_1,INTERNAL_CATCH_NTTP_1, INTERNAL_CATCH_NTTP_0)( __VA_ARGS__))
#define INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD(TestName, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD1, INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD0)(TestName,
__VA_ARGS__))
#define INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD(TestName, ClassName, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD_X,INTERNAL_CATCH_DECLARE_SIG_TEST_METHO
INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD1, INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD0)(TestName, ClassName,
__VA_ARGS__))
#define INTERNAL_CATCH_NTTP_REG_METHOD_GEN(TestName, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD,
INTERNAL_CATCH_NTTP_REGISTER_METHOD, INTERNAL_CATCH_NTTP_REGISTER_METHOD0,
INTERNAL_CATCH_NTTP_REGISTER_METHOD0)(TestName, __VA_ARGS__))
#define INTERNAL_CATCH_NTTP_REG_GEN(TestFunc, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER, INTERNAL_CATCH_NTTP_REGISTER,
INTERNAL_CATCH_NTTP_REGISTER0, INTERNAL_CATCH_NTTP_REGISTER0)(TestFunc, __VA_ARGS__))
#define INTERNAL_CATCH_DEFINE_SIG_TEST(TestName, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X, INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DEFINE_SIG_TEST1,
INTERNAL_CATCH_DEFINE_SIG_TEST0)(TestName, __VA_ARGS__))
#define INTERNAL_CATCH_DECLARE_SIG_TEST(TestName, ...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL( "dummy", __VA_ARGS__,
INTERNAL_CATCH_DECLARE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_X, INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST_X, INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DEFINE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,INTERNAL_CATCH_DECLARE_SIG_TEST_X,
INTERNAL_CATCH_DECLARE_SIG_TEST1, INTERNAL_CATCH_DECLARE_SIG_TEST0)(TestName, __VA_ARGS__))
#define INTERNAL_CATCH_REMOVE_PARENS_GEN(...)
INTERNAL_CATCH_EXPAND_VARGS(INTERNAL_CATCH_VA_NARGS_IMPL(__VA_ARGS__,
INTERNAL_CATCH_REMOVE_PARENS_11_ARG,INTERNAL_CATCH_REMOVE_PARENS_10_ARG,INTERNAL_CATCH_REMOVE_PARENS_9_ARG,INTERNAL_CAT
#endif

// end catch_preprocessor.hpp
// start catch_meta.hpp


#include <type_traits>

namespace Catch {
    template<typename T>
    struct always_false : std::false_type {};

    template <typename> struct true_given : std::true_type {};
    struct is_callable_tester {
        template <typename Fun, typename... Args>
        true_given<decltype(std::declval<Fun>()(std::declval<Args>()...))> static test(int);
        template <typename...>
        std::false_type static test(...);
    };

    template <typename T>
    struct is_callable;

    template <typename Fun, typename... Args>
    struct is_callable<Fun(Args...)> : decltype(is_callable_tester::test<Fun, Args...>(0)) {};

#if defined(__cpp_lib_is_invocable) && __cpp_lib_is_invocable >= 201703
    // std::result_of is deprecated in C++17 and removed in C++20. Hence, it is
    // replaced with std::invoke_result here.
    template <typename Func, typename... U>
    using FunctionReturnType = std::remove_reference_t<std::remove_cv_t<std::invoke_result_t<Func,
U...»>;
#else
    // Keep ::type here because we still support C++11
    template <typename Func, typename... U>
    using FunctionReturnType = typename std::remove_reference<typename std::remove_cv<typename
std::result_of<Func(U...)>::type>::type>::type;
#endif

} // namespace Catch

namespace mpl_{
    struct na;
}

// end catch_meta.hpp
namespace Catch {

template<typename C>
class TestInvokerAsMethod : public ITestInvoker {
    void (C::*m_testAsMethod)();
public:
    TestInvokerAsMethod( void (C::*testAsMethod)() ) noexcept : m_testAsMethod( testAsMethod ) {}

    void invoke() const override {
        C obj;
        (obj.*m_testAsMethod)();
    }
};

auto makeTestInvoker( void(*testAsFunction)() ) noexcept -> ITestInvoker*;

template<typename C>
auto makeTestInvoker( void (C::*testAsMethod)() ) noexcept -> ITestInvoker* {
    return new(std::nothrow) TestInvokerAsMethod<C>( testAsMethod );
}

struct NameAndTags {
    NameAndTags( StringRef const& name_ = StringRef(), StringRef const& tags_ = StringRef() )
noexcept;
    StringRef name;
    StringRef tags;
};

struct AutoReg : NonCopyable {
    AutoReg( ITestInvoker* invoker, SourceLineInfo const& lineInfo, StringRef const& classOrMethod,
NameAndTags const& nameAndTags ) noexcept;
    ~AutoReg();
};

} // end namespace Catch

#if defined(CATCH_CONFIG_DISABLE)
    #define INTERNAL_CATCH_TESTCASE_NO_REGISTRATION( TestName, ... ) \
        static void TestName()
    #define INTERNAL_CATCH_TESTCASE_METHOD_NO_REGISTRATION( TestName, ClassName, ... ) \
        namespace{                        \
            struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName) { \
                void test();              \
            };                            \
        }                                 \
        void TestName::test()
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION_2( TestName, TestFunc, Name, Tags,
Signature, ... )  \
        INTERNAL_CATCH_DEFINE_SIG_TEST(TestFunc, INTERNAL_CATCH_REMOVE_PARENS(Signature))
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION_2( TestNameClass, TestName,
ClassName, Name, Tags, Signature, ... )    \
        namespace{                                                                                  \
            namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName) {                                      \
            INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD(TestName, ClassName,
INTERNAL_CATCH_REMOVE_PARENS(Signature));\
        }                                                                                           \
        }                                                                                           \
        INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD(TestName, INTERNAL_CATCH_REMOVE_PARENS(Signature))

    #ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(Name, Tags, ...) \
            INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, typename TestType,
__VA_ARGS__ )
    #else
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(Name, Tags, ...) \
            INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION_2(
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ),
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags,
typename TestType, __VA_ARGS__ ) )
    #endif

    #ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(Name, Tags, Signature, ...) \
            INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, Signature, __VA_ARGS__ )
```

```
    #else
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(Name, Tags, Signature, ...) \
            INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, Signature, __VA_ARGS__ ) )
    #endif

    #ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION( ClassName, Name, Tags,... ) \
            INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, typename T, __VA_ARGS__ )
    #else
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION( ClassName, Name, Tags,... ) \
            INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, typename T, __VA_ARGS__ ) )
    #endif

    #ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION( ClassName, Name, Tags, Signature, ... ) \
            INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, Signature, __VA_ARGS__ )
    #else
        #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION( ClassName, Name, Tags, Signature, ... ) \
            INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, Signature, __VA_ARGS__ ) )
    #endif
#endif

    #define INTERNAL_CATCH_TESTCASE2( TestName, ... ) \
        static void TestName(); \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        namespace{ Catch::AutoReg INTERNAL_CATCH_UNIQUE_NAME( autoRegistrar )( Catch::makeTestInvoker( &TestName ), CATCH_INTERNAL_LINEINFO, Catch::StringRef(), Catch::NameAndTags{ __VA_ARGS__ } ); } /* NOLINT */ \
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        static void TestName()
    #define INTERNAL_CATCH_TESTCASE( ... ) \
        INTERNAL_CATCH_TESTCASE2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_S_T____ ), __VA_ARGS__ )

    #define INTERNAL_CATCH_METHOD_AS_TEST_CASE( QualifiedMethod, ... ) \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        namespace{ Catch::AutoReg INTERNAL_CATCH_UNIQUE_NAME( autoRegistrar )( Catch::makeTestInvoker( &QualifiedMethod ), CATCH_INTERNAL_LINEINFO, "&" #QualifiedMethod, Catch::NameAndTags{ __VA_ARGS__ } ); } /* NOLINT */ \
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

    #define INTERNAL_CATCH_TEST_CASE_METHOD2( TestName, ClassName, ... )\
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        namespace{ \
            struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName) { \
                void test(); \
            }; \
            Catch::AutoReg INTERNAL_CATCH_UNIQUE_NAME( autoRegistrar ) ( Catch::makeTestInvoker( &TestName::test ), CATCH_INTERNAL_LINEINFO, #ClassName, Catch::NameAndTags{ __VA_ARGS__ } ); /* NOLINT */ \
        } \
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        void TestName::test()
    #define INTERNAL_CATCH_TEST_CASE_METHOD( ClassName, ... ) \
        INTERNAL_CATCH_TEST_CASE_METHOD2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_S_T____ ), ClassName, __VA_ARGS__ )

    #define INTERNAL_CATCH_REGISTER_TESTCASE( Function, ... ) \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        Catch::AutoReg INTERNAL_CATCH_UNIQUE_NAME( autoRegistrar )( Catch::makeTestInvoker( Function ), CATCH_INTERNAL_LINEINFO, Catch::StringRef(), Catch::NameAndTags{ __VA_ARGS__ } ); /* NOLINT */ \
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_2(TestName, TestFunc, Name, Tags, Signature, ... )\
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
        INTERNAL_CATCH_DECLARE_SIG_TEST(TestFunc, INTERNAL_CATCH_REMOVE_PARENS(Signature));\
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName){\
            INTERNAL_CATCH_TYPE_GEN\
            INTERNAL_CATCH_NTTP_GEN(INTERNAL_CATCH_REMOVE_PARENS(Signature))\
            INTERNAL_CATCH_NTTP_REG_GEN(TestFunc,INTERNAL_CATCH_REMOVE_PARENS(Signature))\
            template<typename...Types> \
            struct TestName{\
                TestName(){\
                    int index = 0;                                    \
                    constexpr char const* tmpl_types[] = {CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, __VA_ARGS__)};\
                    using expander = int[];\
                    (void)expander{(reg_test(Types{}, Catch::NameAndTags{ Name " - " + std::string(tmpl_types[index]), Tags } ), index++)... };/* NOLINT */ \
                }\
            };\
            static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){\
            TestName<INTERNAL_CATCH_MAKE_TYPE_LISTS_FROM_TYPES(__VA_ARGS__)>();\
            return 0;\
        }();\
        }\
        }\
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        INTERNAL_CATCH_DEFINE_SIG_TEST(TestFunc,INTERNAL_CATCH_REMOVE_PARENS(Signature))

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE(Name, Tags, ...) \
        INTERNAL_CATCH_TEMPLATE_TEST_CASE_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, typename TestType, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE(Name, Tags, ...) \
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, typename TestType, __VA_ARGS__ ) )
#endif

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG(Name, Tags, Signature, ...) \
        INTERNAL_CATCH_TEMPLATE_TEST_CASE_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, Signature, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG(Name, Tags, Signature, ...) \
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, Signature, __VA_ARGS__ ) )
#endif

    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE2(TestName, TestFuncName, Name, Tags, Signature, TmplTypes, TypesList) \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION                      \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS                      \
        CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS                \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS              \
        template<typename TestType> static void TestFuncName();       \
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName) {                                    \
            INTERNAL_CATCH_TYPE_GEN                                                  \
            INTERNAL_CATCH_NTTP_GEN(INTERNAL_CATCH_REMOVE_PARENS(Signature))         \
            template<typename... Types>                               \
            struct TestName {                                         \
                void reg_tests() {                                          \
                    int index = 0;                                    \
                    using expander = int[];                           \
                    constexpr char const* tmpl_types[] = {CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, INTERNAL_CATCH_REMOVE_PARENS(TmplTypes))};\
                    constexpr char const* types_list[] = {CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, INTERNAL_CATCH_REMOVE_PARENS(TypesList))};\
                    constexpr auto num_types = sizeof(types_list) / sizeof(types_list[0]);\
                    (void)expander{(Catch::AutoReg( Catch::makeTestInvoker( &TestFuncName<Types> ), CATCH_INTERNAL_LINEINFO, Catch::StringRef(), Catch::NameAndTags{ Name " - " + std::string(tmpl_types[index / num_types]) + "<" + std::string(types_list[index % num_types]) + ">", Tags } ), index++)... };/* NOLINT */\
                }                                                     \
            };                                                        \
            static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){ \
                using TestInit = typename create<TestName, decltype(get_wrapper<INTERNAL_CATCH_REMOVE_PARENS(TmplTypes)>()), TypeList<INTERNAL_CATCH_MAKE_TYPE_LISTS_FROM_TYPES(INTERNAL_CATCH_REMOVE_PARENS(TypesList))»::type; \
                TestInit t;                                           \
                t.reg_tests();                                        \
                return 0;                                             \
            }();                                                      \
        }                                                             \
        }                                                             \
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION                       \
        template<typename TestType>                                   \
        static void TestFuncName()

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE(Name, Tags, ...)\
        INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE2(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, typename T,__VA_ARGS__)
#else
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE(Name, Tags, ...)\
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE2(
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ),
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags,
typename T, __VA_ARGS__ ) )
#endif

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG(Name, Tags, Signature, ...)\
        INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE2(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, Signature, __VA_ARGS__)
#else
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG(Name, Tags, Signature, ...)\
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE2(
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ),
INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags,
Signature, __VA_ARGS__ ) )
#endif

    #define INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_2(TestName, TestFunc, Name, Tags, TmplList)\
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
        template<typename TestType> static void TestFunc();       \
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName){\
        INTERNAL_CATCH_TYPE_GEN\
        template<typename... Types>                               \
        struct TestName {                                         \
            void reg_tests() {                                          \
                int index = 0;                                    \
                using expander = int[];                           \
                (void)expander{(Catch::AutoReg( Catch::makeTestInvoker( &TestFunc<Types> ),
CATCH_INTERNAL_LINEINFO, Catch::StringRef(), Catch::NameAndTags{ Name " - " +
std::string(INTERNAL_CATCH_STRINGIZE(TmplList)) + " - " + std::to_string(index), Tags } ), index++)...
};/* NOLINT */\
            }                                                     \
        };\
        static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){ \
                using TestInit = typename convert<TestName, TmplList>::type; \
                TestInit t;                                           \
                t.reg_tests();                                        \
                return 0;                                             \
            }();                                                      \
        }}\
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION                       \
        template<typename TestType>                                   \
        static void TestFunc()

    #define INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE(Name, Tags, TmplList) \
        INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_2( INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), Name, Tags, TmplList )

    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_2( TestNameClass, TestName, ClassName, Name,
Tags, Signature, ... ) \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName){ \
            INTERNAL_CATCH_TYPE_GEN\
            INTERNAL_CATCH_NTTP_GEN(INTERNAL_CATCH_REMOVE_PARENS(Signature))\
            INTERNAL_CATCH_DECLARE_SIG_TEST_METHOD(TestName, ClassName,
INTERNAL_CATCH_REMOVE_PARENS(Signature));\
            INTERNAL_CATCH_NTTP_REG_METHOD_GEN(TestName, INTERNAL_CATCH_REMOVE_PARENS(Signature))\
            template<typename...Types> \
            struct TestNameClass{\
                TestNameClass(){\
                    int index = 0;                                    \
                    constexpr char const* tmpl_types[] =
{CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, __VA_ARGS__)};\
                    using expander = int[];\
                    (void)expander{(reg_test(Types{}, #ClassName, Catch::NameAndTags{ Name " - " + std::string(tmpl_types[index]), Tags } ), index++)... };/* NOLINT */ \
                }\
            };\
            static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){\
                TestNameClass<INTERNAL_CATCH_MAKE_TYPE_LISTS_FROM_TYPES(__VA_ARGS__)>();\
                return 0;\
        }();\
        }\
        }\
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        INTERNAL_CATCH_DEFINE_SIG_TEST_METHOD(TestName, INTERNAL_CATCH_REMOVE_PARENS(Signature))

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( ClassName, Name, Tags,... ) \
        INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, typename T, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( ClassName, Name, Tags,... ) \
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, typename T, __VA_ARGS__ ) )
#endif

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( ClassName, Name, Tags, Signature, ... ) \
        INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, Signature, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( ClassName, Name, Tags, Signature, ... ) \
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____C_L_A_S_S____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ) , ClassName, Name, Tags, Signature, __VA_ARGS__ ) )
#endif

    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_2(TestNameClass, TestName, ClassName, Name, Tags, Signature, TmplTypes, TypesList)\
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_ZERO_VARIADIC_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
        template<typename TestType> \
            struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName <TestType>) { \
                void test();\
            };\
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestNameClass) {\
            INTERNAL_CATCH_TYPE_GEN                  \
            INTERNAL_CATCH_NTTP_GEN(INTERNAL_CATCH_REMOVE_PARENS(Signature))\
            template<typename...Types>\
            struct TestNameClass{\
                void reg_tests(){\
                    int index = 0;\
                    using expander = int[];\
                    constexpr char const* tmpl_types[] = {CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, INTERNAL_CATCH_REMOVE_PARENS(TmplTypes))};\
                    constexpr char const* types_list[] = {CATCH_REC_LIST(INTERNAL_CATCH_STRINGIZE_WITHOUT_PARENS, INTERNAL_CATCH_REMOVE_PARENS(TypesList))};\
                    constexpr auto num_types = sizeof(types_list) / sizeof(types_list[0]);\
                    (void)expander{(Catch::AutoReg( Catch::makeTestInvoker( &TestName<Types>::test ), CATCH_INTERNAL_LINEINFO, #ClassName, Catch::NameAndTags{ Name " - " + std::string(tmpl_types[index / num_types]) + "<" + std::string(types_list[index % num_types]) + ">", Tags } ), index++)... };/* NOLINT */ \
                }\
            };\
            static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){\
                using TestInit = typename create<TestNameClass, decltype(get_wrapper<INTERNAL_CATCH_REMOVE_PARENS(TmplTypes)>()), TypeList<INTERNAL_CATCH_MAKE_TYPE_LISTS_FROM_TYPES(INTERNAL_CATCH_REMOVE_PARENS(TypesList))»::type;\
                TestInit t;\
                t.reg_tests();\
                return 0;\
            }(); \
        }\
        }\
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        template<typename TestType> \
        void TestName<TestType>::test()

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( ClassName, Name, Tags, ... )\
        INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), ClassName, Name, Tags, typename T, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( ClassName, Name, Tags, ... )\
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), ClassName, Name, Tags, typename T,__VA_ARGS__ ) )
#endif

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( ClassName, Name, Tags, Signature, ... )\
        INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), ClassName, Name, Tags, Signature, __VA_ARGS__ )
#else
    #define INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( ClassName, Name, Tags, Signature, ... )\
        INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), ClassName, Name, Tags, Signature,__VA_ARGS__ ) )
#endif

    #define INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_METHOD_2( TestNameClass, TestName, ClassName, Name, Tags, TmplList) \
        CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
        CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
        CATCH_INTERNAL_SUPPRESS_UNUSED_TEMPLATE_WARNINGS \
        template<typename TestType> \
        struct TestName : INTERNAL_CATCH_REMOVE_PARENS(ClassName <TestType>) { \
            void test();\
        };\
        namespace {\
        namespace INTERNAL_CATCH_MAKE_NAMESPACE(TestName){ \
            INTERNAL_CATCH_TYPE_GEN\
            template<typename...Types>\
            struct TestNameClass{\
                void reg_tests(){\
                    int index = 0;\
                    using expander = int[];\
                    (void)expander{(Catch::AutoReg( Catch::makeTestInvoker( &TestName<Types>::test ), CATCH_INTERNAL_LINEINFO, #ClassName, Catch::NameAndTags{ Name " - " + std::string(INTERNAL_CATCH_STRINGIZE(TmplList)) + " - " + std::to_string(index), Tags } ), index++)... };/* NOLINT */ \
                }\
            };\
            static int INTERNAL_CATCH_UNIQUE_NAME( globalRegistrar ) = [](){\
                using TestInit = typename convert<TestNameClass, TmplList>::type;\
                TestInit t;\
                t.reg_tests();\
                return 0;\
            }(); \
        }}\
        CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        template<typename TestType> \
        void TestName<TestType>::test()

#define INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_METHOD(ClassName, Name, Tags, TmplList) \
        INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_METHOD_2( INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____ ), INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_M_P_L_A_T_E____T_E_S_T____F_U_N_C____ ), ClassName, Name, Tags, TmplList )

// end catch_test_registry.h
// start catch_capture.hpp

// start catch_assertionhandler.h

// start catch_assertioninfo.h

// start catch_result_type.h

namespace Catch {

    // ResultWas::OfType enum
    struct ResultWas { enum OfType {
        Unknown = -1,
        Ok = 0,
        Info = 1,
        Warning = 2,

        FailureBit = 0x10,

        ExpressionFailed = FailureBit | 1,
        ExplicitFailure = FailureBit | 2,

        Exception = 0x100 | FailureBit,

        ThrewException = Exception | 1,
        DidntThrowException = Exception | 2,

        FatalErrorCondition = 0x200 | FailureBit

    }; };

    bool isOk( ResultWas::OfType resultType );
    bool isJustInfo( int flags );

    // ResultDisposition::Flags enum
    struct ResultDisposition { enum Flags {
        Normal = 0x01,

        ContinueOnFailure = 0x02,   // Failures fail test, but execution continues
        FalseTest = 0x04,           // Prefix expression with !
        SuppressFail = 0x08         // Failures are reported but do not fail the test
    }; };

    ResultDisposition::Flags operator | ( ResultDisposition::Flags lhs, ResultDisposition::Flags rhs
);

    bool shouldContinueOnFailure( int flags );
    inline bool isFalseTest( int flags ) { return ( flags & ResultDisposition::FalseTest ) != 0; }
    bool shouldSuppressFailure( int flags );

} // end namespace Catch

// end catch_result_type.h
namespace Catch {

    struct AssertionInfo
    {
        StringRef macroName;
        SourceLineInfo lineInfo;
        StringRef capturedExpression;
        ResultDisposition::Flags resultDisposition;

        // We want to delete this constructor but a compiler bug in 4.8 means
        // the struct is then treated as non-aggregate
        //AssertionInfo() = delete;
    };

} // end namespace Catch

// end catch_assertioninfo.h
// start catch_decomposer.h

// start catch_tostring.h

#include <vector>
#include <cstddef>
#include <type_traits>
#include <string>
// start catch_stream.h

#include <iosfwd>
#include <cstddef>
#include <ostream>

namespace Catch {

    std::ostream& cout();
    std::ostream& cerr();
    std::ostream& clog();

    class StringRef;

    struct IStream {
        virtual ~IStream();
        virtual std::ostream& stream() const = 0;
    };

    auto makeStream( StringRef const &filename ) -> IStream const*;

    class ReusableStringStream : NonCopyable {
        std::size_t m_index;
        std::ostream* m_oss;
    public:
        ReusableStringStream();
        ~ReusableStringStream();

        auto str() const -> std::string;

        template<typename T>
        auto operator « ( T const& value ) -> ReusableStringStream& {
            *m_oss « value;
            return *this;
        }
        auto get() -> std::ostream& { return *m_oss; }
    };
}

// end catch_stream.h
// start catch_interfaces_enum_values_registry.h

#include <vector>

namespace Catch {

    namespace Detail {
        struct EnumInfo {
            StringRef m_name;
            std::vector<std::pair<int, StringRef» m_values;

            ~EnumInfo();

            StringRef lookup( int value ) const;
        };
    } // namespace Detail

    struct IMutableEnumValuesRegistry {
        virtual ~IMutableEnumValuesRegistry();

        virtual Detail::EnumInfo const& registerEnum( StringRef enumName, StringRef allEnums,
std::vector<int> const& values ) = 0;

        template<typename E>
        Detail::EnumInfo const& registerEnum( StringRef enumName, StringRef allEnums,
std::initializer_list<E> values ) {
            static_assert(sizeof(int) >= sizeof(E), "Cannot serialize enum to int");
            std::vector<int> intValues;
            intValues.reserve( values.size() );
            for( auto enumValue : values )
                intValues.push_back( static_cast<int>( enumValue ) );
            return registerEnum( enumName, allEnums, intValues );
        }
    };

} // Catch

// end catch_interfaces_enum_values_registry.h

#ifdef CATCH_CONFIG_CPP17_STRING_VIEW
#include <string_view>
#endif

#ifdef __OBJC__
// start catch_objc_arc.hpp

#import <Foundation/Foundation.h>

#ifdef __has_feature
#define CATCH_ARC_ENABLED __has_feature(objc_arc)
#else
#define CATCH_ARC_ENABLED 0
#endif

void arcSafeRelease( NSObject* obj );
id performOptionalSelector( id obj, SEL sel );

#if !CATCH_ARC_ENABLED
inline void arcSafeRelease( NSObject* obj ) {
    [obj release];
}
inline id performOptionalSelector( id obj, SEL sel ) {
    if( [obj respondsToSelector: sel] )
        return [obj performSelector: sel];
    return nil;
}
#define CATCH_UNSAFE_UNRETAINED
#define CATCH_ARC_STRONG
#else
inline void arcSafeRelease( NSObject* ){}
inline id performOptionalSelector( id obj, SEL sel ) {
#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Warc-performSelector-leaks"
#endif
```

```
    if( [obj respondsToSelector: sel] )
        return [obj performSelector: sel];
#ifdef __clang__
#pragma clang diagnostic pop
#endif
    return nil;
}
#define CATCH_UNSAFE_UNRETAINED __unsafe_unretained
#define CATCH_ARC_STRONG __strong
#endif

// end catch_objc_arc.hpp
#endif

#ifdef _MSC_VER
#pragma warning(push)
#pragma warning(disable:4180) // We attempt to stream a function (address) by const&, which MSVC
complains about but is harmless
#endif

namespace Catch {
    namespace Detail {

        extern const std::string unprintableString;

        std::string rawMemoryToString( const void *object, std::size_t size );

        template<typename T>
        std::string rawMemoryToString( const T& object ) {
          return rawMemoryToString( &object, sizeof(object) );
        }

        template<typename T>
        class IsStreamInsertable {
            template<typename Stream, typename U>
            static auto test(int)
                -> decltype(std::declval<Stream&>() « std::declval<U>(), std::true_type());

            template<typename, typename>
            static auto test(...)->std::false_type;

        public:
            static const bool value = decltype(test<std::ostream, const T&>(0))::value;
        };

        template<typename E>
        std::string convertUnknownEnumToString( E e );

        template<typename T>
        typename std::enable_if<
            !std::is_enum<T>::value && !std::is_base_of<std::exception, T>::value,
        std::string>::type convertUnstreamable( T const& ) {
            return Detail::unprintableString;
        }
        template<typename T>
        typename std::enable_if<
            !std::is_enum<T>::value && std::is_base_of<std::exception, T>::value,
         std::string>::type convertUnstreamable(T const& ex) {
            return ex.what();
        }

        template<typename T>
        typename std::enable_if<
            std::is_enum<T>::value
        , std::string>::type convertUnstreamable( T const& value ) {
            return convertUnknownEnumToString( value );
        }

#if defined(_MANAGED)
        template<typename T>
        std::string clrReferenceToString( T^ ref ) {
            if (ref == nullptr)
                return std::string("null");
            auto bytes = System::Text::Encoding::UTF8->GetBytes(ref->ToString());
            cli::pin_ptr<System::Byte> p = &bytes[0];
            return std::string(reinterpret_cast<char const *>(p), bytes->Length);
        }
#endif

    } // namespace Detail

    // If we decide for C++14, change these to enable_if_ts
    template <typename T, typename = void>
    struct StringMaker {
        template <typename Fake = T>
        static
        typename std::enable_if<::Catch::Detail::IsStreamInsertable<Fake>::value, std::string>::type
```

```
            convert(const Fake& value) {
                ReusableStringStream rss;
                // NB: call using the function-like syntax to avoid ambiguity with
                // user-defined templated operator« under clang.
                rss.operator«(value);
                return rss.str();
        }

        template <typename Fake = T>
        static
        typename std::enable_if<!::Catch::Detail::IsStreamInsertable<Fake>::value, std::string>::type
            convert( const Fake& value ) {
#if !defined(CATCH_CONFIG_FALLBACK_STRINGIFIER)
            return Detail::convertUnstreamable(value);
#else
            return CATCH_CONFIG_FALLBACK_STRINGIFIER(value);
#endif
        }
    };

    namespace Detail {

        // This function dispatches all stringification requests inside of Catch.
        // Should be preferably called fully qualified, like ::Catch::Detail::stringify
        template <typename T>
        std::string stringify(const T& e) {
            return ::Catch::StringMaker<typename std::remove_cv<typename
std::remove_reference<T>::type>::type>::convert(e);
        }

        template<typename E>
        std::string convertUnknownEnumToString( E e ) {
            return ::Catch::Detail::stringify(static_cast<typename std::underlying_type<E>::type>(e));
        }

#if defined(_MANAGED)
        template <typename T>
        std::string stringify( T^ e ) {
            return ::Catch::StringMaker<T^>::convert(e);
        }
#endif

    } // namespace Detail

    // Some predefined specializations

    template<>
    struct StringMaker<std::string> {
        static std::string convert(const std::string& str);
    };

#ifdef CATCH_CONFIG_CPP17_STRING_VIEW
    template<>
    struct StringMaker<std::string_view> {
        static std::string convert(std::string_view str);
    };
#endif

    template<>
    struct StringMaker<char const *> {
        static std::string convert(char const * str);
    };
    template<>
    struct StringMaker<char *> {
        static std::string convert(char * str);
    };

#ifdef CATCH_CONFIG_WCHAR
    template<>
    struct StringMaker<std::wstring> {
        static std::string convert(const std::wstring& wstr);
    };

# ifdef CATCH_CONFIG_CPP17_STRING_VIEW
    template<>
    struct StringMaker<std::wstring_view> {
        static std::string convert(std::wstring_view str);
    };
# endif

    template<>
    struct StringMaker<wchar_t const *> {
        static std::string convert(wchar_t const * str);
    };
    template<>
    struct StringMaker<wchar_t *> {
        static std::string convert(wchar_t * str);
    };
#endif

    // TBD: Should we use `strnlen' to ensure that we don't go out of the buffer,
    //      while keeping string semantics?
    template<int SZ>
    struct StringMaker<char[SZ]> {
        static std::string convert(char const* str) {
            return ::Catch::Detail::stringify(std::string{ str });
        }
    };
    template<int SZ>
    struct StringMaker<signed char[SZ]> {
        static std::string convert(signed char const* str) {
            return ::Catch::Detail::stringify(std::string{ reinterpret_cast<char const *>(str) });
        }
    };
    template<int SZ>
    struct StringMaker<unsigned char[SZ]> {
        static std::string convert(unsigned char const* str) {
            return ::Catch::Detail::stringify(std::string{ reinterpret_cast<char const *>(str) });
        }
    };

#if defined(CATCH_CONFIG_CPP17_BYTE)
    template<>
    struct StringMaker<std::byte> {
        static std::string convert(std::byte value);
    };
#endif // defined(CATCH_CONFIG_CPP17_BYTE)
    template<>
    struct StringMaker<int> {
        static std::string convert(int value);
    };
    template<>
    struct StringMaker<long> {
        static std::string convert(long value);
    };
    template<>
    struct StringMaker<long long> {
        static std::string convert(long long value);
    };
    template<>
    struct StringMaker<unsigned int> {
        static std::string convert(unsigned int value);
    };
    template<>
    struct StringMaker<unsigned long> {
        static std::string convert(unsigned long value);
    };
    template<>
    struct StringMaker<unsigned long long> {
        static std::string convert(unsigned long long value);
    };

    template<>
    struct StringMaker<bool> {
        static std::string convert(bool b);
    };

    template<>
    struct StringMaker<char> {
        static std::string convert(char c);
    };
    template<>
    struct StringMaker<signed char> {
        static std::string convert(signed char c);
    };
    template<>
    struct StringMaker<unsigned char> {
        static std::string convert(unsigned char c);
    };

    template<>
    struct StringMaker<std::nullptr_t> {
        static std::string convert(std::nullptr_t);
    };

    template<>
    struct StringMaker<float> {
        static std::string convert(float value);
        static int precision;
    };

    template<>
    struct StringMaker<double> {
        static std::string convert(double value);
        static int precision;
    };

    template <typename T>
    struct StringMaker<T*> {
        template <typename U>
        static std::string convert(U* p) {
            if (p) {
                return ::Catch::Detail::rawMemoryToString(p);
            } else {
                return "nullptr";
            }
        }
    };

    template <typename R, typename C>
    struct StringMaker<R C::*> {
        static std::string convert(R C::* p) {
            if (p) {
                return ::Catch::Detail::rawMemoryToString(p);
            } else {
                return "nullptr";
            }
        }
    };

#if defined(_MANAGED)
    template <typename T>
    struct StringMaker<T^> {
        static std::string convert( T^ ref ) {
            return ::Catch::Detail::clrReferenceToString(ref);
        }
    };
#endif

    namespace Detail {
        template<typename InputIterator, typename Sentinel = InputIterator>
        std::string rangeToString(InputIterator first, Sentinel last) {
            ReusableStringStream rss;
            rss « "{ ";
            if (first != last) {
                rss « ::Catch::Detail::stringify(*first);
                for (++first; first != last; ++first)
                    rss « ", " « ::Catch::Detail::stringify(*first);
            }
            rss « " }";
            return rss.str();
        }
    }

#ifdef __OBJC__
    template<>
    struct StringMaker<NSString*> {
        static std::string convert(NSString * nsstring) {
            if (!nsstring)
                return "nil";
            return std::string("@") + [nsstring UTF8String];
        }
    };
    template<>
    struct StringMaker<NSObject*> {
        static std::string convert(NSObject* nsObject) {
            return ::Catch::Detail::stringify([nsObject description]);
        }

    };
    namespace Detail {
        inline std::string stringify( NSString* nsstring ) {
            return StringMaker<NSString*>::convert( nsstring );
        }

    } // namespace Detail
#endif // __OBJC__

} // namespace Catch

// Separate std-lib types stringification, so it can be selectively enabled
// This means that we do not bring in

#if defined(CATCH_CONFIG_ENABLE_ALL_STRINGMAKERS)
#  define CATCH_CONFIG_ENABLE_PAIR_STRINGMAKER
#  define CATCH_CONFIG_ENABLE_TUPLE_STRINGMAKER
#  define CATCH_CONFIG_ENABLE_VARIANT_STRINGMAKER
#  define CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER
#  define CATCH_CONFIG_ENABLE_OPTIONAL_STRINGMAKER
#endif

```

```
// Separate std::pair specialization
#if defined(CATCH_CONFIG_ENABLE_PAIR_STRINGMAKER)
#include <utility>
namespace Catch {
    template<typename T1, typename T2>
    struct StringMaker<std::pair<T1, T2> > {
        static std::string convert(const std::pair<T1, T2>& pair) {
            ReusableStringStream rss;
            rss « "{ "
                « ::Catch::Detail::stringify(pair.first)
                « ", "
                « ::Catch::Detail::stringify(pair.second)
                « " }";
            return rss.str();
        }
    };
}
#endif // CATCH_CONFIG_ENABLE_PAIR_STRINGMAKER

#if defined(CATCH_CONFIG_ENABLE_OPTIONAL_STRINGMAKER) && defined(CATCH_CONFIG_CPP17_OPTIONAL)
#include <optional>
namespace Catch {
    template<typename T>
    struct StringMaker<std::optional<T> > {
        static std::string convert(const std::optional<T>& optional) {
            ReusableStringStream rss;
            if (optional.has_value()) {
                rss « ::Catch::Detail::stringify(*optional);
            } else {
                rss « "{ }";
            }
            return rss.str();
        }
    };
}
#endif // CATCH_CONFIG_ENABLE_OPTIONAL_STRINGMAKER

// Separate std::tuple specialization
#if defined(CATCH_CONFIG_ENABLE_TUPLE_STRINGMAKER)
#include <tuple>
namespace Catch {
    namespace Detail {
        template<
            typename Tuple,
            std::size_t N = 0,
            bool = (N < std::tuple_size<Tuple>::value)
            >
            struct TupleElementPrinter {
            static void print(const Tuple& tuple, std::ostream& os) {
                os « (N ? ", " : " ")
                    « ::Catch::Detail::stringify(std::get<N>(tuple));
                TupleElementPrinter<Tuple, N + 1>::print(tuple, os);
            }
        };

        template<
            typename Tuple,
            std::size_t N
        >
            struct TupleElementPrinter<Tuple, N, false> {
            static void print(const Tuple&, std::ostream&) {}
        };

    }

    template<typename ...Types>
    struct StringMaker<std::tuple<Types...» {
        static std::string convert(const std::tuple<Types...>& tuple) {
            ReusableStringStream rss;
            rss « '{';
            Detail::TupleElementPrinter<std::tuple<Types...»::print(tuple, rss.get());
            rss « " }";
            return rss.str();
        }
    };
}
#endif // CATCH_CONFIG_ENABLE_TUPLE_STRINGMAKER

#if defined(CATCH_CONFIG_ENABLE_VARIANT_STRINGMAKER) && defined(CATCH_CONFIG_CPP17_VARIANT)
#include <variant>
namespace Catch {
    template<>
    struct StringMaker<std::monostate> {
        static std::string convert(const std::monostate&) {
            return "{ }";
        }
    };

    template<typename... Elements>
    struct StringMaker<std::variant<Elements...>> {
        static std::string convert(const std::variant<Elements...>& variant) {
            if (variant.valueless_by_exception()) {
                return "{valueless variant}";
            } else {
                return std::visit(
                    [](const auto& value) {
                        return ::Catch::Detail::stringify(value);
                    },
                    variant
                );
            }
        }
    };
}
#endif // CATCH_CONFIG_ENABLE_VARIANT_STRINGMAKER

namespace Catch {
    // Import begin/ end from std here
    using std::begin;
    using std::end;

    namespace detail {
        template <typename...>
        struct void_type {
            using type = void;
        };

        template <typename T, typename = void>
        struct is_range_impl : std::false_type {
        };

        template <typename T>
        struct is_range_impl<T, typename void_type<decltype(begin(std::declval<T>()))>::type> :
std::true_type {
        };
    } // namespace detail

    template <typename T>
    struct is_range : detail::is_range_impl<T> {
    };

#if defined(_MANAGED) // Managed types are never ranges
    template <typename T>
    struct is_range<T^> {
        static const bool value = false;
    };
#endif

    template<typename Range>
    std::string rangeToString( Range const& range ) {
        return ::Catch::Detail::rangeToString( begin( range ), end( range ) );
    }

    // Handle vector<bool> specially
    template<typename Allocator>
    std::string rangeToString( std::vector<bool, Allocator> const& v ) {
        ReusableStringStream rss;
        rss << "{ ";
        bool first = true;
        for( bool b : v ) {
            if( first )
                first = false;
            else
                rss << ", ";
            rss << ::Catch::Detail::stringify( b );
        }
        rss << " }";
        return rss.str();
    }

    template<typename R>
    struct StringMaker<R, typename std::enable_if<is_range<R>::value &&
!::Catch::Detail::IsStreamInsertable<R>::value>::type> {
        static std::string convert( R const& range ) {
            return rangeToString( range );
        }
    };

    template <typename T, int SZ>
    struct StringMaker<T[SZ]> {
        static std::string convert(T const(&arr)[SZ]) {
            return rangeToString(arr);
        }
    };
```

```

} // namespace Catch

// Separate std::chrono::duration specialization
#if defined(CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER)
#include <ctime>
#include <ratio>
#include <chrono>

namespace Catch {

template <class Ratio>
struct ratio_string {
    static std::string symbol();
};

template <class Ratio>
std::string ratio_string<Ratio>::symbol() {
    Catch::ReusableStringStream rss;
    rss « ’[’ « Ratio::num « ’/’
        « Ratio::den « ’]’;
    return rss.str();
}
template <>
struct ratio_string<std::atto> {
    static std::string symbol();
};
template <>
struct ratio_string<std::femto> {
    static std::string symbol();
};
template <>
struct ratio_string<std::pico> {
    static std::string symbol();
};
template <>
struct ratio_string<std::nano> {
    static std::string symbol();
};
template <>
struct ratio_string<std::micro> {
    static std::string symbol();
};
template <>
struct ratio_string<std::milli> {
    static std::string symbol();
};

    // std::chrono::duration specializations
    template<typename Value, typename Ratio>
    struct StringMaker<std::chrono::duration<Value, Ratio» {
        static std::string convert(std::chrono::duration<Value, Ratio> const& duration) {
            ReusableStringStream rss;
            rss « duration.count() « ’ ’ « ratio_string<Ratio>::symbol() « ’s’;
            return rss.str();
        }
    };
    template<typename Value>
    struct StringMaker<std::chrono::duration<Value, std::ratio<1»> {
        static std::string convert(std::chrono::duration<Value, std::ratio<1» const& duration) {
            ReusableStringStream rss;
            rss « duration.count() « " s";
            return rss.str();
        }
    };
    template<typename Value>
    struct StringMaker<std::chrono::duration<Value, std::ratio<60»> {
        static std::string convert(std::chrono::duration<Value, std::ratio<60» const& duration) {
            ReusableStringStream rss;
            rss « duration.count() « " m";
            return rss.str();
        }
    };
    template<typename Value>
    struct StringMaker<std::chrono::duration<Value, std::ratio<3600»> {
        static std::string convert(std::chrono::duration<Value, std::ratio<3600» const& duration) {
            ReusableStringStream rss;
            rss « duration.count() « " h";
            return rss.str();
        }
    };

    // std::chrono::time_point specialization
    // Generic time_point cannot be specialized, only std::chrono::time_point<system_clock>
    template<typename Clock, typename Duration>
    struct StringMaker<std::chrono::time_point<Clock, Duration» {
        static std::string convert(std::chrono::time_point<Clock, Duration> const& time_point) {
            return ::Catch::Detail::stringify(time_point.time_since_epoch()) + " since epoch";
        }
    };
    // std::chrono::time_point<system_clock> specialization
    template<typename Duration>
    struct StringMaker<std::chrono::time_point<std::chrono::system_clock, Duration» {
        static std::string convert(std::chrono::time_point<std::chrono::system_clock, Duration> const&
time_point) {
            auto converted = std::chrono::system_clock::to_time_t(time_point);

#ifdef _MSC_VER
            std::tm timeInfo = {};
            gmtime_s(&timeInfo, &converted);
#else
            std::tm* timeInfo = std::gmtime(&converted);
#endif

            auto const timeStampSize = sizeof("2017-01-16T17:06:45Z");
            char timeStamp[timeStampSize];
            const char * const fmt = "%Y-%m-%dT%H:%M:%SZ";

#ifdef _MSC_VER
            std::strftime(timeStamp, timeStampSize, fmt, &timeInfo);
#else
            std::strftime(timeStamp, timeStampSize, fmt, timeInfo);
#endif
            return std::string(timeStamp);
        }
    };
}
#endif // CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER

#define INTERNAL_CATCH_REGISTER_ENUM( enumName, ... ) \
namespace Catch { \
    template<> struct StringMaker<enumName> { \
        static std::string convert( enumName value ) { \
            static const auto& enumInfo =
::Catch::getMutableRegistryHub().getMutableEnumValuesRegistry().registerEnum( #enumName, #__VA_ARGS__,
{ __VA_ARGS__ } ); \
            return static_cast<std::string>(enumInfo.lookup( static_cast<int>( value ) )); \
        } \
    }; \
}

#define CATCH_REGISTER_ENUM( enumName, ... ) INTERNAL_CATCH_REGISTER_ENUM( enumName, __VA_ARGS__ )

#ifdef _MSC_VER
#pragma warning(pop)
#endif

// end catch_tostring.h
#include <iosfwd>

#ifdef _MSC_VER
#pragma warning(push)
#pragma warning(disable:4389) // '==' : signed/unsigned mismatch
#pragma warning(disable:4018) // more "signed/unsigned mismatch"
#pragma warning(disable:4312) // Converting int to T* using reinterpret_cast (issue on x64 platform)
#pragma warning(disable:4180) // qualifier applied to function type has no meaning
#pragma warning(disable:4800) // Forcing result to true or false
#endif

namespace Catch {

    struct ITransientExpression {
        auto isBinaryExpression() const -> bool { return m_isBinaryExpression; }
        auto getResult() const -> bool { return m_result; }
        virtual void streamReconstructedExpression( std::ostream &os ) const = 0;

        ITransientExpression( bool isBinaryExpression, bool result )
        :   m_isBinaryExpression( isBinaryExpression ),
            m_result( result )
        {}

        // We don't actually need a virtual destructor, but many static analysers
        // complain if it's not here :-(
        virtual ~ITransientExpression();

        bool m_isBinaryExpression;
        bool m_result;

    };

    void formatReconstructedExpression( std::ostream &os, std::string const& lhs, StringRef op,
std::string const& rhs );

    template<typename LhsT, typename RhsT>
    class BinaryExpr  : public ITransientExpression {
        LhsT m_lhs;
        StringRef m_op;
        RhsT m_rhs;

        void streamReconstructedExpression( std::ostream &os ) const override {
            formatReconstructedExpression
                    ( os, Catch::Detail::stringify( m_lhs ), m_op, Catch::Detail::stringify( m_rhs )
);
        }

    public:
        BinaryExpr( bool comparisonResult, LhsT lhs, StringRef op, RhsT rhs )
        :   ITransientExpression{ true, comparisonResult },
            m_lhs( lhs ),
            m_op( op ),
            m_rhs( rhs )
        {}

        template<typename T>
        auto operator && ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator || ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator == ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator != ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator > ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator < ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator >= ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename T>
        auto operator <= ( T ) const -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<T>::value,
            "chained comparisons are not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }
    };

    template<typename LhsT>
    class UnaryExpr : public ITransientExpression {
        LhsT m_lhs;

        void streamReconstructedExpression( std::ostream &os ) const override {
            os « Catch::Detail::stringify( m_lhs );
        }

    public:
        explicit UnaryExpr( LhsT lhs )
        :   ITransientExpression{ false, static_cast<bool>(lhs) },
            m_lhs( lhs )
        {}
    };

    // Specialised comparison functions to handle equality comparisons between ints and pointers (NULL
deduces as an int)
    template<typename LhsT, typename RhsT>
    auto compareEqual( LhsT const& lhs, RhsT const& rhs ) -> bool { return static_cast<bool>(lhs ==
rhs); }
    template<typename T>
    auto compareEqual( T* const& lhs, int rhs ) -> bool { return lhs == reinterpret_cast<void const*>(
rhs ); }
    template<typename T>
    auto compareEqual( T* const& lhs, long rhs ) -> bool { return lhs == reinterpret_cast<void
const*>( rhs ); }
    template<typename T>
    auto compareEqual( int lhs, T* const& rhs ) -> bool { return reinterpret_cast<void const*>( lhs )
== rhs; }
    template<typename T>
    auto compareEqual( long lhs, T* const& rhs ) -> bool { return reinterpret_cast<void const*>( lhs )
== rhs; }

    template<typename LhsT, typename RhsT>
    auto compareNotEqual( LhsT const& lhs, RhsT&& rhs ) -> bool { return static_cast<bool>(lhs !=
rhs); }
    template<typename T>
    auto compareNotEqual( T* const& lhs, int rhs ) -> bool { return lhs != reinterpret_cast<void
const*>( rhs ); }
    template<typename T>
    auto compareNotEqual( T* const& lhs, long rhs ) -> bool { return lhs != reinterpret_cast<void
const*>( rhs ); }
    template<typename T>
    auto compareNotEqual( int lhs, T* const& rhs ) -> bool { return reinterpret_cast<void const*>( lhs
) != rhs; }
    template<typename T>
    auto compareNotEqual( long lhs, T* const& rhs ) -> bool { return reinterpret_cast<void const*>(
lhs ) != rhs; }

    template<typename LhsT>
    class ExprLhs {
        LhsT m_lhs;
    public:
        explicit ExprLhs( LhsT lhs ) : m_lhs( lhs ) {}

        template<typename RhsT>
        auto operator == ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { compareEqual( m_lhs, rhs ), m_lhs, "==", rhs };
        }
        auto operator == ( bool rhs ) -> BinaryExpr<LhsT, bool> const {
            return { m_lhs == rhs, m_lhs, "==", rhs };
        }

        template<typename RhsT>
        auto operator != ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { compareNotEqual( m_lhs, rhs ), m_lhs, "!=", rhs };
        }
        auto operator != ( bool rhs ) -> BinaryExpr<LhsT, bool> const {
            return { m_lhs != rhs, m_lhs, "!=", rhs };
        }

        template<typename RhsT>
        auto operator > ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs > rhs), m_lhs, ">", rhs };
        }
        template<typename RhsT>
        auto operator < ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs < rhs), m_lhs, "<", rhs };
        }
        template<typename RhsT>
        auto operator >= ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs >= rhs), m_lhs, ">=", rhs };
        }
        template<typename RhsT>
        auto operator <= ( RhsT const& rhs ) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs <= rhs), m_lhs, "<=", rhs };
        }
        template <typename RhsT>
        auto operator | (RhsT const& rhs) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs | rhs), m_lhs, "|", rhs };
        }
        template <typename RhsT>
        auto operator & (RhsT const& rhs) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs & rhs), m_lhs, "&", rhs };
        }
        template <typename RhsT>
        auto operator ^ (RhsT const& rhs) -> BinaryExpr<LhsT, RhsT const&> const {
            return { static_cast<bool>(m_lhs ^ rhs), m_lhs, "^", rhs };
        }

        template<typename RhsT>
        auto operator && ( RhsT const& ) -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<RhsT>::value,
            "operator&& is not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        template<typename RhsT>
        auto operator || ( RhsT const& ) -> BinaryExpr<LhsT, RhsT const&> const {
            static_assert(always_false<RhsT>::value,
            "operator|| is not supported inside assertions, "
            "wrap the expression inside parentheses, or decompose it");
        }

        auto makeUnaryExpr() const -> UnaryExpr<LhsT> {
            return UnaryExpr<LhsT>{ m_lhs };
        }
    };

    void handleExpression( ITransientExpression const& expr );

    template<typename T>
    void handleExpression( ExprLhs<T> const& expr ) {
        handleExpression( expr.makeUnaryExpr() );
    }

    struct Decomposer {
        template<typename T>
        auto operator <= ( T const& lhs ) -> ExprLhs<T const&> {
            return ExprLhs<T const&>{ lhs };
        }

        auto operator <=( bool value ) -> ExprLhs<bool> {
            return ExprLhs<bool>{ value };
        }
    };

} // end namespace Catch

#ifdef _MSC_VER
#pragma warning(pop)
#endif

// end catch_decomposer.h
// start catch_interfaces_capture.h

#include <string>
#include <chrono>

namespace Catch {

    class AssertionResult;
    struct AssertionInfo;
    struct SectionInfo;
    struct SectionEndInfo;
    struct MessageInfo;
    struct MessageBuilder;
    struct Counts;
    struct AssertionReaction;
    struct SourceLineInfo;

    struct ITransientExpression;
    struct IGeneratorTracker;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
    struct BenchmarkInfo;
    template <typename Duration = std::chrono::duration<double, std::nano»
    struct BenchmarkStats;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

    struct IResultCapture {

        virtual ~IResultCapture();

        virtual bool sectionStarted(    SectionInfo const& sectionInfo,
                                        Counts& assertions ) = 0;
        virtual void sectionEnded( SectionEndInfo const& endInfo ) = 0;
        virtual void sectionEndedEarly( SectionEndInfo const& endInfo ) = 0;

        virtual auto acquireGeneratorTracker( StringRef generatorName, SourceLineInfo const& lineInfo
) -> IGeneratorTracker& = 0;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        virtual void benchmarkPreparing( std::string const& name ) = 0;
        virtual void benchmarkStarting( BenchmarkInfo const& info ) = 0;
        virtual void benchmarkEnded( BenchmarkStats<> const& stats ) = 0;
        virtual void benchmarkFailed( std::string const& error ) = 0;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

        virtual void pushScopedMessage( MessageInfo const& message ) = 0;
        virtual void popScopedMessage( MessageInfo const& message ) = 0;

        virtual void emplaceUnscopedMessage( MessageBuilder const& builder ) = 0;

        virtual void handleFatalErrorCondition( StringRef message ) = 0;

        virtual void handleExpr
                (   AssertionInfo const& info,
                    ITransientExpression const& expr,
                    AssertionReaction& reaction ) = 0;
        virtual void handleMessage
                (   AssertionInfo const& info,
                    ResultWas::OfType resultType,
                    StringRef const& message,
                    AssertionReaction& reaction ) = 0;
        virtual void handleUnexpectedExceptionNotThrown
                (   AssertionInfo const& info,
                    AssertionReaction& reaction ) = 0;
        virtual void handleUnexpectedInflightException
                (   AssertionInfo const& info,
                    std::string const& message,
                    AssertionReaction& reaction ) = 0;
        virtual void handleIncomplete
                (   AssertionInfo const& info ) = 0;
        virtual void handleNonExpr
                (   AssertionInfo const &info,
                    ResultWas::OfType resultType,
                    AssertionReaction &reaction ) = 0;

        virtual bool lastAssertionPassed() = 0;
        virtual void assertionPassed() = 0;

        // Deprecated, do not use:
        virtual std::string getCurrentTestName() const = 0;
        virtual const AssertionResult* getLastResult() const = 0;
        virtual void exceptionEarlyReported() = 0;
    };

    IResultCapture& getResultCapture();
}

// end catch_interfaces_capture.h
namespace Catch {

    struct TestFailureException{};
    struct AssertionResultData;
    struct IResultCapture;
    class RunContext;

    class LazyExpression {
        friend class AssertionHandler;
        friend struct AssertionStats;
        friend class RunContext;

        ITransientExpression const* m_transientExpression = nullptr;
        bool m_isNegated;
    public:
        LazyExpression( bool isNegated );
        LazyExpression( LazyExpression const& other );
        LazyExpression& operator = ( LazyExpression const& ) = delete;

        explicit operator bool() const;

        friend auto operator « ( std::ostream& os, LazyExpression const& lazyExpr ) -> std::ostream&;
    };

    struct AssertionReaction {
        bool shouldDebugBreak = false;
        bool shouldThrow = false;
    };

    class AssertionHandler {
        AssertionInfo m_assertionInfo;
        AssertionReaction m_reaction;
        bool m_completed = false;
        IResultCapture& m_resultCapture;

    public:
        AssertionHandler
            (   StringRef const& macroName,
                SourceLineInfo const& lineInfo,
                StringRef capturedExpression,
                ResultDisposition::Flags resultDisposition );
        ~AssertionHandler() {
            if ( !m_completed ) {
                m_resultCapture.handleIncomplete( m_assertionInfo );
            }
        }

        template<typename T>
        void handleExpr( ExprLhs<T> const& expr ) {
            handleExpr( expr.makeUnaryExpr() );
        }
        void handleExpr( ITransientExpression const& expr );

        void handleMessage(ResultWas::OfType resultType, StringRef const& message);

        void handleExceptionThrownAsExpected();
        void handleUnexpectedExceptionNotThrown();
        void handleExceptionNotThrownAsExpected();
        void handleThrowingCallSkipped();
        void handleUnexpectedInflightException();

        void complete();
        void setCompleted();

        // query
        auto allowThrows() const -> bool;
    };

    void handleExceptionMatchExpr( AssertionHandler& handler, std::string const& str, StringRef const&
matcherString );

} // namespace Catch

// end catch_assertionhandler.h
// start catch_message.h

#include <string>
#include <vector>

namespace Catch {

    struct MessageInfo {
        MessageInfo(    StringRef const& _macroName,
                        SourceLineInfo const& _lineInfo,
                        ResultWas::OfType _type );

        StringRef macroName;
        std::string message;
        SourceLineInfo lineInfo;
        ResultWas::OfType type;
        unsigned int sequence;

        bool operator == ( MessageInfo const& other ) const;
        bool operator < ( MessageInfo const& other ) const;
    private:
        static unsigned int globalCount;
    };

    struct MessageStream {

        template<typename T>
        MessageStream& operator « ( T const& value ) {
            m_stream « value;
            return *this;
        }

        ReusableStringStream m_stream;
    };

    struct MessageBuilder : MessageStream {
        MessageBuilder( StringRef const& macroName,
                        SourceLineInfo const& lineInfo,
                        ResultWas::OfType type );

        template<typename T>
        MessageBuilder& operator « ( T const& value ) {
            m_stream « value;
            return *this;
        }

        MessageInfo m_info;
    };

    class ScopedMessage {
    public:
        explicit ScopedMessage( MessageBuilder const& builder );
        ScopedMessage( ScopedMessage& duplicate ) = delete;
        ScopedMessage( ScopedMessage&& old );
        ~ScopedMessage();

        MessageInfo m_info;
        bool m_moved;
    };

    class Capturer {
        std::vector<MessageInfo> m_messages;
        IResultCapture& m_resultCapture = getResultCapture();
        size_t m_captured = 0;
    public:
        Capturer( StringRef macroName, SourceLineInfo const& lineInfo, ResultWas::OfType resultType,
StringRef names );
        ~Capturer();

        void captureValue( size_t index, std::string const& value );

        template<typename T>
        void captureValues( size_t index, T const& value ) {
            captureValue( index, Catch::Detail::stringify( value ) );
        }

        template<typename T, typename... Ts>
        void captureValues( size_t index, T const& value, Ts const&... values ) {
            captureValue( index, Catch::Detail::stringify(value) );
            captureValues( index+1, values... );
        }
    };

} // end namespace Catch

// end catch_message.h
#if !defined(CATCH_CONFIG_DISABLE)

#if !defined(CATCH_CONFIG_DISABLE_STRINGIFICATION)
  #define CATCH_INTERNAL_STRINGIFY(...) #__VA_ARGS__
#else
  #define CATCH_INTERNAL_STRINGIFY(...) "Disabled by CATCH_CONFIG_DISABLE_STRINGIFICATION"
#endif

#if defined(CATCH_CONFIG_FAST_COMPILE) || defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)

// Another way to speed-up compilation is to omit local try-catch for REQUIRE*
// macros.
#define INTERNAL_CATCH_TRY
#define INTERNAL_CATCH_CATCH( capturer )

#else // CATCH_CONFIG_FAST_COMPILE

#define INTERNAL_CATCH_TRY try
#define INTERNAL_CATCH_CATCH( handler ) catch(...) { handler.handleUnexpectedInflightException(); }

#endif

#define INTERNAL_CATCH_REACT( handler ) handler.complete();

#define INTERNAL_CATCH_TEST( macroName, resultDisposition, ... ) \
    do { \
        CATCH_INTERNAL_IGNORE_BUT_WARN(__VA_ARGS__); \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO,
CATCH_INTERNAL_STRINGIFY(__VA_ARGS__), resultDisposition ); \
        INTERNAL_CATCH_TRY { \
            CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
            CATCH_INTERNAL_SUPPRESS_PARENTHESES_WARNINGS \
            catchAssertionHandler.handleExpr( Catch::Decomposer() <= __VA_ARGS__ ); \
            CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
        } INTERNAL_CATCH_CATCH( catchAssertionHandler ) \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( (void)0, (false) && static_cast<bool>( !!(__VA_ARGS__) ) )

#define INTERNAL_CATCH_IF( macroName, resultDisposition, ... ) \
    INTERNAL_CATCH_TEST( macroName, resultDisposition, __VA_ARGS__ ); \
    if( Catch::getResultCapture().lastAssertionPassed() )

#define INTERNAL_CATCH_ELSE( macroName, resultDisposition, ... ) \
    INTERNAL_CATCH_TEST( macroName, resultDisposition, __VA_ARGS__ ); \
    if( !Catch::getResultCapture().lastAssertionPassed() )

#define INTERNAL_CATCH_NO_THROW( macroName, resultDisposition, ... ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO,
CATCH_INTERNAL_STRINGIFY(__VA_ARGS__), resultDisposition ); \
        try { \
            static_cast<void>(__VA_ARGS__); \
            catchAssertionHandler.handleExceptionNotThrownAsExpected(); \
        } \
        catch( ... ) { \
            catchAssertionHandler.handleUnexpectedInflightException(); \
        } \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#define INTERNAL_CATCH_THROWS( macroName, resultDisposition, ... ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, CATCH_INTERNAL_STRINGIFY(__VA_ARGS__), resultDisposition); \
        if( catchAssertionHandler.allowThrows() ) \
            try { \
                static_cast<void>(__VA_ARGS__); \
                catchAssertionHandler.handleUnexpectedExceptionNotThrown(); \
            } \
            catch( ... ) { \
                catchAssertionHandler.handleExceptionThrownAsExpected(); \
            } \
        else \
            catchAssertionHandler.handleThrowingCallSkipped(); \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#define INTERNAL_CATCH_THROWS_AS( macroName, exceptionType, resultDisposition, expr ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, CATCH_INTERNAL_STRINGIFY(expr) ", " CATCH_INTERNAL_STRINGIFY(exceptionType), resultDisposition ); \
        if( catchAssertionHandler.allowThrows() ) \
            try { \
                static_cast<void>(expr); \
                catchAssertionHandler.handleUnexpectedExceptionNotThrown(); \
            } \
            catch( exceptionType const& ) { \
                catchAssertionHandler.handleExceptionThrownAsExpected(); \
            } \
            catch( ... ) { \
                catchAssertionHandler.handleUnexpectedInflightException(); \
            } \
        else \
            catchAssertionHandler.handleThrowingCallSkipped(); \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#define INTERNAL_CATCH_MSG( macroName, messageType, resultDisposition, ... ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, Catch::StringRef(), resultDisposition ); \
        catchAssertionHandler.handleMessage( messageType, ( Catch::MessageStream() « __VA_ARGS__ + ::Catch::StreamEndStop() ).m_stream.str() ); \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#define INTERNAL_CATCH_CAPTURE( varName, macroName, ... ) \
    auto varName = Catch::Capturer( macroName, CATCH_INTERNAL_LINEINFO, Catch::ResultWas::Info, #__VA_ARGS__ ); \
    varName.captureValues( 0, __VA_ARGS__ )

#define INTERNAL_CATCH_INFO( macroName, log ) \
    Catch::ScopedMessage INTERNAL_CATCH_UNIQUE_NAME( scopedMessage )( Catch::MessageBuilder( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, Catch::ResultWas::Info ) « log );

#define INTERNAL_CATCH_UNSCOPED_INFO( macroName, log ) \
    Catch::getResultCapture().emplaceUnscopedMessage( Catch::MessageBuilder( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, Catch::ResultWas::Info ) « log )

// Although this is matcher-based, it can be used with just a string
#define INTERNAL_CATCH_THROWS_STR_MATCHES( macroName, resultDisposition, matcher, ... ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, CATCH_INTERNAL_STRINGIFY(__VA_ARGS__) ", " CATCH_INTERNAL_STRINGIFY(matcher), resultDisposition ); \
        if( catchAssertionHandler.allowThrows() ) \
            try { \
                static_cast<void>(__VA_ARGS__); \
                catchAssertionHandler.handleUnexpectedExceptionNotThrown(); \
            } \
            catch( ... ) { \
                Catch::handleExceptionMatchExpr( catchAssertionHandler, matcher, #matcher##_catch_sr ); \
            } \
        else \
            catchAssertionHandler.handleThrowingCallSkipped(); \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#endif // CATCH_CONFIG_DISABLE

// end catch_capture.hpp
// start catch_section.h

// start catch_section_info.h

// start catch_totals.h

#include <cstddef>

namespace Catch {

    struct Counts {
        Counts operator - ( Counts const& other ) const;
        Counts& operator += ( Counts const& other );

        std::size_t total() const;
        bool allPassed() const;
        bool allOk() const;

        std::size_t passed = 0;
        std::size_t failed = 0;
        std::size_t failedButOk = 0;
    };

    struct Totals {

        Totals operator - ( Totals const& other ) const;
        Totals& operator += ( Totals const& other );

        Totals delta( Totals const& prevTotals ) const;

        int error = 0;
        Counts assertions;
        Counts testCases;
    };
}

// end catch_totals.h
#include <string>

namespace Catch {

    struct SectionInfo {
        SectionInfo
            (   SourceLineInfo const& _lineInfo,
                std::string const& _name );

        // Deprecated
        SectionInfo
            (   SourceLineInfo const& _lineInfo,
                std::string const& _name,
                std::string const& ) : SectionInfo( _lineInfo, _name ) {}

        std::string name;
        std::string description; // !Deprecated: this will always be empty
        SourceLineInfo lineInfo;
    };

    struct SectionEndInfo {
        SectionInfo sectionInfo;
        Counts prevAssertions;
        double durationInSeconds;
    };

} // end namespace Catch

// end catch_section_info.h
// start catch_timer.h

#include <cstdint>

namespace Catch {

    auto getCurrentNanosecondsSinceEpoch() -> uint64_t;
    auto getEstimatedClockResolution() -> uint64_t;

    class Timer {
        uint64_t m_nanoseconds = 0;
    public:
        void start();
        auto getElapsedNanoseconds() const -> uint64_t;
        auto getElapsedMicroseconds() const -> uint64_t;
        auto getElapsedMilliseconds() const -> unsigned int;
        auto getElapsedSeconds() const -> double;
    };

} // namespace Catch

```

```
// end catch_timer.h
#include <string>

namespace Catch {

    class Section : NonCopyable {
    public:
        Section( SectionInfo const& info );
        ~Section();

        // This indicates whether the section should be executed or not
        explicit operator bool() const;

    private:
        SectionInfo m_info;

        std::string m_name;
        Counts m_assertions;
        bool m_sectionIncluded;
        Timer m_timer;
    };

} // end namespace Catch

#define INTERNAL_CATCH_SECTION( ... ) \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
    CATCH_INTERNAL_SUPPRESS_UNUSED_WARNINGS \
    if( Catch::Section const& INTERNAL_CATCH_UNIQUE_NAME( catch_internal_Section ) = Catch::SectionInfo( CATCH_INTERNAL_LINEINFO, __VA_ARGS__ ) ) \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

#define INTERNAL_CATCH_DYNAMIC_SECTION( ... ) \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
    CATCH_INTERNAL_SUPPRESS_UNUSED_WARNINGS \
    if( Catch::Section const& INTERNAL_CATCH_UNIQUE_NAME( catch_internal_Section ) = Catch::SectionInfo( CATCH_INTERNAL_LINEINFO, (Catch::ReusableStringStream() « __VA_ARGS__).str() ) ) \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

// end catch_section.h
// start catch_interfaces_exception.h

// start catch_interfaces_registry_hub.h

#include <string>
#include <memory>

namespace Catch {

    class TestCase;
    struct ITestCaseRegistry;
    struct IExceptionTranslatorRegistry;
    struct IExceptionTranslator;
    struct IReporterRegistry;
    struct IReporterFactory;
    struct ITagAliasRegistry;
    struct IMutableEnumValuesRegistry;

    class StartupExceptionRegistry;

    using IReporterFactoryPtr = std::shared_ptr<IReporterFactory>;

    struct IRegistryHub {
        virtual ~IRegistryHub();

        virtual IReporterRegistry const& getReporterRegistry() const = 0;
        virtual ITestCaseRegistry const& getTestCaseRegistry() const = 0;
        virtual ITagAliasRegistry const& getTagAliasRegistry() const = 0;
        virtual IExceptionTranslatorRegistry const& getExceptionTranslatorRegistry() const = 0;

        virtual StartupExceptionRegistry const& getStartupExceptionRegistry() const = 0;
    };

    struct IMutableRegistryHub {
        virtual ~IMutableRegistryHub();
        virtual void registerReporter( std::string const& name, IReporterFactoryPtr const& factory ) = 0;
        virtual void registerListener( IReporterFactoryPtr const& factory ) = 0;
        virtual void registerTest( TestCase const& testInfo ) = 0;
        virtual void registerTranslator( const IExceptionTranslator* translator ) = 0;
        virtual void registerTagAlias( std::string const& alias, std::string const& tag, SourceLineInfo const& lineInfo ) = 0;
        virtual void registerStartupException() noexcept = 0;
        virtual IMutableEnumValuesRegistry& getMutableEnumValuesRegistry() = 0;
    };

    IRegistryHub const& getRegistryHub();
    IMutableRegistryHub& getMutableRegistryHub();
    void cleanUp();
    std::string translateActiveException();

}

// end catch_interfaces_registry_hub.h
#if defined(CATCH_CONFIG_DISABLE)
    #define INTERNAL_CATCH_TRANSLATE_EXCEPTION_NO_REG( translatorName, signature) \
        static std::string translatorName( signature )
#endif

#include <exception>
#include <string>
#include <vector>

namespace Catch {
    using exceptionTranslateFunction = std::string(*)();

    struct IExceptionTranslator;
    using ExceptionTranslators = std::vector<std::unique_ptr<IExceptionTranslator const»;

    struct IExceptionTranslator {
        virtual ~IExceptionTranslator();
        virtual std::string translate( ExceptionTranslators::const_iterator it,
ExceptionTranslators::const_iterator itEnd ) const = 0;
    };

    struct IExceptionTranslatorRegistry {
        virtual ~IExceptionTranslatorRegistry();

        virtual std::string translateActiveException() const = 0;
    };

    class ExceptionTranslatorRegistrar {
        template<typename T>
        class ExceptionTranslator : public IExceptionTranslator {
        public:

            ExceptionTranslator( std::string(*translateFunction)( T& ) )
            : m_translateFunction( translateFunction )
            {}

            std::string translate( ExceptionTranslators::const_iterator it,
ExceptionTranslators::const_iterator itEnd ) const override {
#if defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
                return "";
#else
                try {
                    if( it == itEnd )
                        std::rethrow_exception(std::current_exception());
                    else
                        return (*it)->translate( it+1, itEnd );
                }
                catch( T& ex ) {
                    return m_translateFunction( ex );
                }
#endif
            }

        protected:
            std::string(*m_translateFunction)( T& );
        };

    public:
        template<typename T>
        ExceptionTranslatorRegistrar( std::string(*translateFunction)( T& ) ) {
            getMutableRegistryHub().registerTranslator
                ( new ExceptionTranslator<T>( translateFunction ) );
        }
    };
}

#define INTERNAL_CATCH_TRANSLATE_EXCEPTION2( translatorName, signature ) \
    static std::string translatorName( signature ); \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION \
    CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS \
    namespace{ Catch::ExceptionTranslatorRegistrar INTERNAL_CATCH_UNIQUE_NAME(
catch_internal_ExceptionRegistrar )( &translatorName ); } \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION \
    static std::string translatorName( signature )

#define INTERNAL_CATCH_TRANSLATE_EXCEPTION( signature ) INTERNAL_CATCH_TRANSLATE_EXCEPTION2(
INTERNAL_CATCH_UNIQUE_NAME( catch_internal_ExceptionTranslator ), signature )

// end catch_interfaces_exception.h
// start catch_approx.h

```

```
#include <type_traits>

namespace Catch {
namespace Detail {

    class Approx {
    private:
        bool equalityComparisonImpl(double other) const;
        // Validates the new margin (margin >= 0)
        // out-of-line to avoid including stdexcept in the header
        void setMargin(double margin);
        // Validates the new epsilon (0 < epsilon < 1)
        // out-of-line to avoid including stdexcept in the header
        void setEpsilon(double epsilon);

    public:
        explicit Approx ( double value );

        static Approx custom();

        Approx operator-() const;


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        Approx operator()( T const& value ) {
            Approx approx( static_cast<double>(value) );
            approx.m_epsilon = m_epsilon;
            approx.m_margin = m_margin;
            approx.m_scale = m_scale;
            return approx;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        explicit Approx( T const& value ): Approx(static_cast<double>(value))
        {}


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator == ( const T& lhs, Approx const& rhs ) {
            auto lhs_v = static_cast<double>(lhs);
            return rhs.equalityComparisonImpl(lhs_v);
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator == ( Approx const& lhs, const T& rhs ) {
            return operator==( rhs, lhs );
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator != ( T const& lhs, Approx const& rhs ) {
            return !operator==( lhs, rhs );
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator != ( Approx const& lhs, T const& rhs ) {
            return !operator==( rhs, lhs );
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator <= ( T const& lhs, Approx const& rhs ) {
            return static_cast<double>(lhs) < rhs.m_value || lhs == rhs;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator <= ( Approx const& lhs, T const& rhs ) {
            return lhs.m_value < static_cast<double>(rhs) || lhs == rhs;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator >= ( T const& lhs, Approx const& rhs ) {
            return static_cast<double>(lhs) > rhs.m_value || lhs == rhs;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        friend bool operator >= ( Approx const& lhs, T const& rhs ) {
            return lhs.m_value > static_cast<double>(rhs) || lhs == rhs;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        Approx& epsilon( T const& newEpsilon ) {
            double epsilonAsDouble = static_cast<double>(newEpsilon);
            setEpsilon(epsilonAsDouble);
            return *this;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        Approx& margin( T const& newMargin ) {
            double marginAsDouble = static_cast<double>(newMargin);
            setMargin(marginAsDouble);
            return *this;
        }


template <typename T, typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
        Approx& scale( T const& newScale ) {
            m_scale = static_cast<double>(newScale);
            return *this;
        }

        std::string toString() const;

    private:
        double m_epsilon;
        double m_margin;
        double m_scale;
        double m_value;
    };
} // end namespace Detail

namespace literals {
    Detail::Approx operator "" _a(long double val);
    Detail::Approx operator "" _a(unsigned long long val);
} // end namespace literals

template<>
struct StringMaker<Catch::Detail::Approx> {
    static std::string convert(Catch::Detail::Approx const& value);
};

} // end namespace Catch

// end catch_approx.h
// start catch_string_manip.h

#include <string>
#include <iosfwd>
#include <vector>

namespace Catch {

    bool startsWith( std::string const& s, std::string const& prefix );
    bool startsWith( std::string const& s, char prefix );
    bool endsWith( std::string const& s, std::string const& suffix );
    bool endsWith( std::string const& s, char suffix );
    bool contains( std::string const& s, std::string const& infix );
    void toLowerInPlace( std::string& s );
    std::string toLower( std::string const& s );
    std::string trim( std::string const& str );
    StringRef trim(StringRef ref);

    // !!! Be aware, returns refs into original string - make sure original string outlives them
    std::vector<StringRef> splitStringRef( StringRef str, char delimiter );
    bool replaceInPlace( std::string& str, std::string const& replaceThis, std::string const& withThis
);

    struct pluralise {
        pluralise( std::size_t count, std::string const& label );

        friend std::ostream& operator « ( std::ostream& os, pluralise const& pluraliser );

        std::size_t m_count;
        std::string m_label;
    };
}

// end catch_string_manip.h
#ifndef CATCH_CONFIG_DISABLE_MATCHERS
// start catch_capture_matchers.h

// start catch_matchers.h

#include <string>
#include <vector>

```

```
namespace Catch {
namespace Matchers {
    namespace Impl {

        template<typename ArgT> struct MatchAllOf;
        template<typename ArgT> struct MatchAnyOf;
        template<typename ArgT> struct MatchNotOf;

        class MatcherUntypedBase {
        public:
            MatcherUntypedBase() = default;
            MatcherUntypedBase ( MatcherUntypedBase const& ) = default;
            MatcherUntypedBase& operator = ( MatcherUntypedBase const& ) = delete;
            std::string toString() const;

        protected:
            virtual ~MatcherUntypedBase();
            virtual std::string describe() const = 0;
            mutable std::string m_cachedToString;
        };

#ifdef __clang__
#    pragma clang diagnostic push
#    pragma clang diagnostic ignored "-Wnon-virtual-dtor"
#endif

        template<typename ObjectT>
        struct MatcherMethod {
            virtual bool match( ObjectT const& arg ) const = 0;
        };

#if defined(__OBJC__)
        // Hack to fix Catch GH issue #1661. Could use id for generic Object support.
        // use of const for Object pointers is very uncommon and under ARC it causes some kind of
signature mismatch that breaks compilation
        template<>
        struct MatcherMethod<NSString*> {
            virtual bool match( NSString* arg ) const = 0;
        };
#endif

#ifdef __clang__
#    pragma clang diagnostic pop
#endif

        template<typename T>
        struct MatcherBase : MatcherUntypedBase, MatcherMethod<T> {

            MatchAllOf<T> operator && ( MatcherBase const& other ) const;
            MatchAnyOf<T> operator || ( MatcherBase const& other ) const;
            MatchNotOf<T> operator ! () const;
        };

        template<typename ArgT>
        struct MatchAllOf : MatcherBase<ArgT> {
            bool match( ArgT const& arg ) const override {
                for( auto matcher : m_matchers ) {
                    if (!matcher->match(arg))
                        return false;
                }
                return true;
            }
            std::string describe() const override {
                std::string description;
                description.reserve( 4 + m_matchers.size()*32 );
                description += "( ";
                bool first = true;
                for( auto matcher : m_matchers ) {
                    if( first )
                        first = false;
                    else
                        description += " and ";
                    description += matcher->toString();
                }
                description += " )";
                return description;
            }

            MatchAllOf<ArgT> operator && ( MatcherBase<ArgT> const& other ) {
                auto copy(*this);
                copy.m_matchers.push_back( &other );
                return copy;
            }

            std::vector<MatcherBase<ArgT> const*> m_matchers;
        };
        template<typename ArgT>
        struct MatchAnyOf : MatcherBase<ArgT> {

            bool match( ArgT const& arg ) const override {
                for( auto matcher : m_matchers ) {
                    if (matcher->match(arg))
                        return true;
                }
                return false;
            }
            std::string describe() const override {
                std::string description;
                description.reserve( 4 + m_matchers.size()*32 );
                description += "( ";
                bool first = true;
                for( auto matcher : m_matchers ) {
                    if( first )
                        first = false;
                    else
                        description += " or ";
                    description += matcher->toString();
                }
                description += " )";
                return description;
            }

            MatchAnyOf<ArgT> operator || ( MatcherBase<ArgT> const& other ) {
                auto copy(*this);
                copy.m_matchers.push_back( &other );
                return copy;
            }

            std::vector<MatcherBase<ArgT> const*> m_matchers;
        };

        template<typename ArgT>
        struct MatchNotOf : MatcherBase<ArgT> {

            MatchNotOf( MatcherBase<ArgT> const& underlyingMatcher ) : m_underlyingMatcher(
underlyingMatcher ) {}

            bool match( ArgT const& arg ) const override {
                return !m_underlyingMatcher.match( arg );
            }

            std::string describe() const override {
                return "not " + m_underlyingMatcher.toString();
            }
            MatcherBase<ArgT> const& m_underlyingMatcher;
        };

        template<typename T>
        MatchAllOf<T> MatcherBase<T>::operator && ( MatcherBase const& other ) const {
            return MatchAllOf<T>() && *this && other;
        }
        template<typename T>
        MatchAnyOf<T> MatcherBase<T>::operator || ( MatcherBase const& other ) const {
            return MatchAnyOf<T>() || *this || other;
        }
        template<typename T>
        MatchNotOf<T> MatcherBase<T>::operator ! () const {
            return MatchNotOf<T>( *this );
        }

    } // namespace Impl

} // namespace Matchers

using namespace Matchers;
using Matchers::Impl::MatcherBase;

} // namespace Catch

// end catch_matchers.h
// start catch_matchers_exception.hpp

namespace Catch {
namespace Matchers {
namespace Exception {

class ExceptionMessageMatcher : public MatcherBase<std::exception> {
    std::string m_message;
public:

    ExceptionMessageMatcher(std::string const& message):
        m_message(message)
    {}

    bool match(std::exception const& ex) const override;

    std::string describe() const override;
};

} // namespace Exception

Exception::ExceptionMessageMatcher Message(std::string const& message);

} // namespace Matchers
} // namespace Catch

// end catch_matchers_exception.hpp
// start catch_matchers_floating.h

namespace Catch {
namespace Matchers {

    namespace Floating {

        enum class FloatingPointKind : uint8_t;

        struct WithinAbsMatcher : MatcherBase<double> {
            WithinAbsMatcher(double target, double margin);
            bool match(double const& matchee) const override;
            std::string describe() const override;
        private:
            double m_target;
            double m_margin;
        };

        struct WithinUlpsMatcher : MatcherBase<double> {
            WithinUlpsMatcher(double target, uint64_t ulps, FloatingPointKind baseType);
            bool match(double const& matchee) const override;
            std::string describe() const override;
        private:
            double m_target;
            uint64_t m_ulps;
            FloatingPointKind m_type;
        };

        // Given IEEE-754 format for floats and doubles, we can assume
        // that float -> double promotion is lossless. Given this, we can
        // assume that if we do the standard relative comparison of
        // |lhs - rhs| <= epsilon * max(fabs(lhs), fabs(rhs)), then we get
        // the same result if we do this for floats, as if we do this for
        // doubles that were promoted from floats.
        struct WithinRelMatcher : MatcherBase<double> {
            WithinRelMatcher(double target, double epsilon);
            bool match(double const& matchee) const override;
            std::string describe() const override;
        private:
            double m_target;
            double m_epsilon;
        };

    } // namespace Floating

    // The following functions create the actual matcher objects.
    // This allows the types to be inferred
    Floating::WithinUlpsMatcher WithinULP(double target, uint64_t maxUlpDiff);
    Floating::WithinUlpsMatcher WithinULP(float target, uint64_t maxUlpDiff);
    Floating::WithinAbsMatcher WithinAbs(double target, double margin);
    Floating::WithinRelMatcher WithinRel(double target, double eps);
    // defaults epsilon to 100*numeric_limits<double>::epsilon()
    Floating::WithinRelMatcher WithinRel(double target);
    Floating::WithinRelMatcher WithinRel(float target, float eps);
    // defaults epsilon to 100*numeric_limits<float>::epsilon()
    Floating::WithinRelMatcher WithinRel(float target);

} // namespace Matchers
} // namespace Catch

// end catch_matchers_floating.h
// start catch_matchers_generic.hpp

#include <functional>
#include <string>

namespace Catch {
namespace Matchers {
namespace Generic {

namespace Detail {
    std::string finalizeDescription(const std::string& desc);
}

```

```
template <typename T>
class PredicateMatcher : public MatcherBase<T> {
    std::function<bool(T const&)> m_predicate;
    std::string m_description;
public:

    PredicateMatcher(std::function<bool(T const&)> const& elem, std::string const& descr)
        :m_predicate(std::move(elem)),
        m_description(Detail::finalizeDescription(descr))
    {}

    bool match( T const& item ) const override {
        return m_predicate(item);
    }

    std::string describe() const override {
        return m_description;
    }
};

} // namespace Generic

    // The following functions create the actual matcher objects.
    // The user has to explicitly specify type to the function, because
    // inferring std::function<bool(T const&)> is hard (but possible) and
    // requires a lot of TMP.
    template<typename T>
    Generic::PredicateMatcher<T> Predicate(std::function<bool(T const&)> const& predicate, std::string
const& description = "") {
        return Generic::PredicateMatcher<T>(predicate, description);
    }

} // namespace Matchers
} // namespace Catch

// end catch_matchers_generic.hpp
// start catch_matchers_string.h

#include <string>

namespace Catch {
namespace Matchers {

    namespace StdString {

        struct CasedString
        {
            CasedString( std::string const& str, CaseSensitive::Choice caseSensitivity );
            std::string adjustString( std::string const& str ) const;
            std::string caseSensitivitySuffix() const;

            CaseSensitive::Choice m_caseSensitivity;
            std::string m_str;
        };

        struct StringMatcherBase : MatcherBase<std::string> {
            StringMatcherBase( std::string const& operation, CasedString const& comparator );
            std::string describe() const override;

            CasedString m_comparator;
            std::string m_operation;
        };

        struct EqualsMatcher : StringMatcherBase {
            EqualsMatcher( CasedString const& comparator );
            bool match( std::string const& source ) const override;
        };
        struct ContainsMatcher : StringMatcherBase {
            ContainsMatcher( CasedString const& comparator );
            bool match( std::string const& source ) const override;
        };
        struct StartsWithMatcher : StringMatcherBase {
            StartsWithMatcher( CasedString const& comparator );
            bool match( std::string const& source ) const override;
        };
        struct EndsWithMatcher : StringMatcherBase {
            EndsWithMatcher( CasedString const& comparator );
            bool match( std::string const& source ) const override;
        };

        struct RegexMatcher : MatcherBase<std::string> {
            RegexMatcher( std::string regex, CaseSensitive::Choice caseSensitivity );
            bool match( std::string const& matchee ) const override;
            std::string describe() const override;

        private:
            std::string m_regex;
            CaseSensitive::Choice m_caseSensitivity;
        };

    } // namespace StdString

    // The following functions create the actual matcher objects.
    // This allows the types to be inferred

    StdString::EqualsMatcher Equals( std::string const& str, CaseSensitive::Choice caseSensitivity =
CaseSensitive::Yes );
    StdString::ContainsMatcher Contains( std::string const& str, CaseSensitive::Choice caseSensitivity
= CaseSensitive::Yes );
    StdString::EndsWithMatcher EndsWith( std::string const& str, CaseSensitive::Choice caseSensitivity
= CaseSensitive::Yes );
    StdString::StartsWithMatcher StartsWith( std::string const& str, CaseSensitive::Choice
caseSensitivity = CaseSensitive::Yes );
    StdString::RegexMatcher Matches( std::string const& regex, CaseSensitive::Choice caseSensitivity =
CaseSensitive::Yes );

} // namespace Matchers
} // namespace Catch

// end catch_matchers_string.h
// start catch_matchers_vector.h

#include <algorithm>

namespace Catch {
namespace Matchers {

    namespace Vector {
        template<typename T, typename Alloc>
        struct ContainsElementMatcher : MatcherBase<std::vector<T, Alloc» {

            ContainsElementMatcher(T const &comparator) : m_comparator( comparator) {}

            bool match(std::vector<T, Alloc> const &v) const override {
                for (auto const& el : v) {
                    if (el == m_comparator) {
                        return true;
                    }
                }
                return false;
            }

            std::string describe() const override {
                return "Contains: " + ::Catch::Detail::stringify( m_comparator );
            }

            T const& m_comparator;
        };

        template<typename T, typename AllocComp, typename AllocMatch>
        struct ContainsMatcher : MatcherBase<std::vector<T, AllocMatch» {

            ContainsMatcher(std::vector<T, AllocComp> const &comparator) : m_comparator( comparator )
{}

            bool match(std::vector<T, AllocMatch> const &v) const override {
                // !TBD: see note in EqualsMatcher
                if (m_comparator.size() > v.size())
                    return false;
                for (auto const& comparator : m_comparator) {
                    auto present = false;
                    for (const auto& el : v) {
                        if (el == comparator) {
                            present = true;
                            break;
                        }
                    }
                    if (!present) {
                        return false;
                    }
                }
                return true;
            }
            std::string describe() const override {
                return "Contains: " + ::Catch::Detail::stringify( m_comparator );
            }

            std::vector<T, AllocComp> const& m_comparator;
        };

        template<typename T, typename AllocComp, typename AllocMatch>
        struct EqualsMatcher : MatcherBase<std::vector<T, AllocMatch» {

            EqualsMatcher(std::vector<T, AllocComp> const &comparator) : m_comparator( comparator ) {}

            bool match(std::vector<T, AllocMatch> const &v) const override {
                // !TBD: This currently works if all elements can be compared using !=
                // - a more general approach would be via a compare template that defaults
                // to using !=. but could be specialised for, e.g. std::vector<T, Alloc> etc
                // - then just call that directly
                if (m_comparator.size() != v.size())
                    return false;
                for (std::size_t i = 0; i < v.size(); ++i)
                    if (m_comparator[i] != v[i])
                        return false;
                return true;
            }
            std::string describe() const override {
                return "Equals: " + ::Catch::Detail::stringify( m_comparator );
            }
            std::vector<T, AllocComp> const& m_comparator;
        };

        template<typename T, typename AllocComp, typename AllocMatch>
        struct ApproxMatcher : MatcherBase<std::vector<T, AllocMatch» {

            ApproxMatcher(std::vector<T, AllocComp> const& comparator) : m_comparator( comparator ) {}

            bool match(std::vector<T, AllocMatch> const &v) const override {
                if (m_comparator.size() != v.size())
                    return false;
                for (std::size_t i = 0; i < v.size(); ++i)
                    if (m_comparator[i] != approx(v[i]))
                        return false;
                return true;
            }
            std::string describe() const override {
                return "is approx: " + ::Catch::Detail::stringify( m_comparator );
            }

template <typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
            ApproxMatcher& epsilon( T const& newEpsilon ) {
                approx.epsilon(newEpsilon);
                return *this;
            }

template <typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
            ApproxMatcher& margin( T const& newMargin ) {
                approx.margin(newMargin);
                return *this;
            }

template <typename = typename std::enable_if<std::is_constructible<double, T>::value>::type>
            ApproxMatcher& scale( T const& newScale ) {
                approx.scale(newScale);
                return *this;
            }

            std::vector<T, AllocComp> const& m_comparator;
            mutable Catch::Detail::Approx approx = Catch::Detail::Approx::custom();
        };

        template<typename T, typename AllocComp, typename AllocMatch>
        struct UnorderedEqualsMatcher : MatcherBase<std::vector<T, AllocMatch» {
            UnorderedEqualsMatcher(std::vector<T, AllocComp> const& target) : m_target(target) {}
            bool match(std::vector<T, AllocMatch> const& vec) const override {
                if (m_target.size() != vec.size()) {
                    return false;
                }
                return std::is_permutation(m_target.begin(), m_target.end(), vec.begin());
            }

            std::string describe() const override {
                return "UnorderedEquals: " + ::Catch::Detail::stringify(m_target);
            }
        private:
            std::vector<T, AllocComp> const& m_target;
        };

    } // namespace Vector

    // The following functions create the actual matcher objects.
    // This allows the types to be inferred

    template<typename T, typename AllocComp = std::allocator<T>, typename AllocMatch = AllocComp>
    Vector::ContainsMatcher<T, AllocComp, AllocMatch> Contains( std::vector<T, AllocComp> const&
comparator ) {
        return Vector::ContainsMatcher<T, AllocComp, AllocMatch>( comparator );
    }

    template<typename T, typename Alloc = std::allocator<T»
    Vector::ContainsElementMatcher<T, Alloc> VectorContains( T const& comparator ) {
        return Vector::ContainsElementMatcher<T, Alloc>( comparator );
    }

    template<typename T, typename AllocComp = std::allocator<T>, typename AllocMatch = AllocComp>
    Vector::EqualsMatcher<T, AllocComp, AllocMatch> Equals( std::vector<T, AllocComp> const& comparator ) {
        return Vector::EqualsMatcher<T, AllocComp, AllocMatch>( comparator );
    }

    template<typename T, typename AllocComp = std::allocator<T>, typename AllocMatch = AllocComp>
    Vector::ApproxMatcher<T, AllocComp, AllocMatch> Approx( std::vector<T, AllocComp> const& comparator ) {
        return Vector::ApproxMatcher<T, AllocComp, AllocMatch>( comparator );
    }

    template<typename T, typename AllocComp = std::allocator<T>, typename AllocMatch = AllocComp>
    Vector::UnorderedEqualsMatcher<T, AllocComp, AllocMatch> UnorderedEquals(std::vector<T, AllocComp> const& target) {
        return Vector::UnorderedEqualsMatcher<T, AllocComp, AllocMatch>( target );
    }

} // namespace Matchers
} // namespace Catch

// end catch_matchers_vector.h
namespace Catch {

    template<typename ArgT, typename MatcherT>
    class MatchExpr : public ITransientExpression {
        ArgT const& m_arg;
        MatcherT m_matcher;
        StringRef m_matcherString;
    public:
        MatchExpr( ArgT const& arg, MatcherT const& matcher, StringRef const& matcherString )
        :   ITransientExpression{ true, matcher.match( arg ) },
            m_arg( arg ),
            m_matcher( matcher ),
            m_matcherString( matcherString )
        {}

        void streamReconstructedExpression( std::ostream &os ) const override {
            auto matcherAsString = m_matcher.toString();
            os « Catch::Detail::stringify( m_arg ) « ' ';
            if( matcherAsString == Detail::unprintableString )
                os « m_matcherString;
            else
                os « matcherAsString;
        }
    };

    using StringMatcher = Matchers::Impl::MatcherBase<std::string>;

    void handleExceptionMatchExpr( AssertionHandler& handler, StringMatcher const& matcher, StringRef const& matcherString  );

    template<typename ArgT, typename MatcherT>
    auto makeMatchExpr( ArgT const& arg, MatcherT const& matcher, StringRef const& matcherString  ) -> MatchExpr<ArgT, MatcherT> {
        return MatchExpr<ArgT, MatcherT>( arg, matcher, matcherString );
    }

} // namespace Catch

#define INTERNAL_CHECK_THAT( macroName, matcher, resultDisposition, arg ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, CATCH_INTERNAL_STRINGIFY(arg) ", " CATCH_INTERNAL_STRINGIFY(matcher), resultDisposition ); \
        INTERNAL_CATCH_TRY { \
            catchAssertionHandler.handleExpr( Catch::makeMatchExpr( arg, matcher, #matcher##_catch_sr ) ); \
        } INTERNAL_CATCH_CATCH( catchAssertionHandler ) \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

#define INTERNAL_CATCH_THROWS_MATCHES( macroName, exceptionType, resultDisposition, matcher, ... ) \
    do { \
        Catch::AssertionHandler catchAssertionHandler( macroName##_catch_sr, CATCH_INTERNAL_LINEINFO, CATCH_INTERNAL_STRINGIFY(__VA_ARGS__) ", " CATCH_INTERNAL_STRINGIFY(exceptionType) ", " CATCH_INTERNAL_STRINGIFY(matcher), resultDisposition ); \
        if( catchAssertionHandler.allowThrows() ) \
            try { \
                static_cast<void>(__VA_ARGS__ ); \
                catchAssertionHandler.handleUnexpectedExceptionNotThrown(); \
            } \
            catch( exceptionType const& ex ) { \
                catchAssertionHandler.handleExpr( Catch::makeMatchExpr( ex, matcher,
#matcher##_catch_sr ) ); \
            } \
            catch( ... ) { \
                catchAssertionHandler.handleUnexpectedInflightException(); \
            } \
        else \
            catchAssertionHandler.handleThrowingCallSkipped(); \
        INTERNAL_CATCH_REACT( catchAssertionHandler ) \
    } while( false )

// end catch_capture_matchers.h
#endif
// start catch_generators.hpp

// start catch_interfaces_generatortracker.h


#include <memory>

namespace Catch {

    namespace Generators {
        class GeneratorUntypedBase {
        public:
            GeneratorUntypedBase() = default;
            virtual ~GeneratorUntypedBase();
            // Attempts to move the generator to the next element
             //
             // Returns true iff the move succeeded (and a valid element
             // can be retrieved).
            virtual bool next() = 0;
        };
        using GeneratorBasePtr = std::unique_ptr<GeneratorUntypedBase>;

    } // namespace Generators

    struct IGeneratorTracker {
        virtual ~IGeneratorTracker();
        virtual auto hasGenerator() const -> bool = 0;
        virtual auto getGenerator() const -> Generators::GeneratorBasePtr const& = 0;
        virtual void setGenerator( Generators::GeneratorBasePtr&& generator ) = 0;
    };

} // namespace Catch

// end catch_interfaces_generatortracker.h
// start catch_enforce.h

#include <exception>

namespace Catch {
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
    template <typename Ex>
    [[noreturn]]
    void throw_exception(Ex const& e) {
        throw e;
    }
#else // ^^ Exceptions are enabled //  Exceptions are disabled vv
    [[noreturn]]
    void throw_exception(std::exception const& e);
#endif

    [[noreturn]]
    void throw_logic_error(std::string const& msg);
    [[noreturn]]
    void throw_domain_error(std::string const& msg);
    [[noreturn]]
    void throw_runtime_error(std::string const& msg);

} // namespace Catch;

#define CATCH_MAKE_MSG(...) \
    (Catch::ReusableStringStream() « __VA_ARGS__).str()

#define CATCH_INTERNAL_ERROR(...) \
    Catch::throw_logic_error(CATCH_MAKE_MSG( CATCH_INTERNAL_LINEINFO « ": Internal Catch2 error: " «
__VA_ARGS__))

#define CATCH_ERROR(...) \
    Catch::throw_domain_error(CATCH_MAKE_MSG( __VA_ARGS__ ))

#define CATCH_RUNTIME_ERROR(...) \
    Catch::throw_runtime_error(CATCH_MAKE_MSG( __VA_ARGS__ ))

#define CATCH_ENFORCE( condition, ... ) \
    do{ if( !(condition) ) CATCH_ERROR( __VA_ARGS__ ); } while(false)

```

```
// end catch_enforce.h
#include <memory>
#include <vector>
#include <cassert>

#include <utility>
#include <exception>

namespace Catch {

class GeneratorException : public std::exception {
    const char* const m_msg = "";

public:
    GeneratorException(const char* msg):
        m_msg(msg)
    {}

    const char* what() const noexcept override final;
};

namespace Generators {

    // !TBD move this into its own location?
    namespace pf{
        template<typename T, typename... Args>
        std::unique_ptr<T> make_unique( Args&&... args ) {
            return std::unique_ptr<T>(new T(std::forward<Args>(args)...));
        }
    }

    template<typename T>
    struct IGenerator : GeneratorUntypedBase {
        virtual ~IGenerator() = default;

        // Returns the current element of the generator
        //
        // \Precondition The generator is either freshly constructed,
        // or the last call to `next()` returned true
        virtual T const& get() const = 0;
        using type = T;
    };

    template<typename T>
    class SingleValueGenerator final : public IGenerator<T> {
        T m_value;
    public:
        SingleValueGenerator(T&& value) : m_value(std::move(value)) {}

        T const& get() const override {
            return m_value;
        }
        bool next() override {
            return false;
        }
    };

    template<typename T>
    class FixedValuesGenerator final : public IGenerator<T> {
        static_assert(!std::is_same<T, bool>::value,
            "FixedValuesGenerator does not support bools because of std::vector<bool>"
            "specialization, use SingleValue Generator instead.");
        std::vector<T> m_values;
        size_t m_idx = 0;
    public:
        FixedValuesGenerator( std::initializer_list<T> values ) : m_values( values ) {}

        T const& get() const override {
            return m_values[m_idx];
        }
        bool next() override {
            ++m_idx;
            return m_idx < m_values.size();
        }
    };

    template <typename T>
    class GeneratorWrapper final {
        std::unique_ptr<IGenerator<T» m_generator;
    public:
        GeneratorWrapper(std::unique_ptr<IGenerator<T>> generator):
            m_generator(std::move(generator))
        {}
        T const& get() const {
            return m_generator->get();
        }
        bool next() {
            return m_generator->next();
        }
    };

    template <typename T>
    GeneratorWrapper<T> value(T&& value) {
        return GeneratorWrapper<T>(pf::make_unique<SingleValueGenerator<T>>(std::forward<T>(value)));
    }
    template <typename T>
    GeneratorWrapper<T> values(std::initializer_list<T> values) {
        return GeneratorWrapper<T>(pf::make_unique<FixedValuesGenerator<T>>(values));
    }

    template<typename T>
    class Generators : public IGenerator<T> {
        std::vector<GeneratorWrapper<T>» m_generators;
        size_t m_current = 0;

        void populate(GeneratorWrapper<T>&& generator) {
            m_generators.emplace_back(std::move(generator));
        }
        void populate(T&& val) {
            m_generators.emplace_back(value(std::forward<T>(val)));
        }
        template<typename U>
        void populate(U&& val) {
            populate(T(std::forward<U>(val)));
        }
        template<typename U, typename... Gs>
        void populate(U&& valueOrGenerator, Gs &&... moreGenerators) {
            populate(std::forward<U>(valueOrGenerator));
            populate(std::forward<Gs>(moreGenerators)...);
        }

    public:
        template <typename... Gs>
        Generators(Gs &&... moreGenerators) {
            m_generators.reserve(sizeof...(Gs));
            populate(std::forward<Gs>(moreGenerators)...);
        }

        T const& get() const override {
            return m_generators[m_current].get();
        }

        bool next() override {
            if (m_current >= m_generators.size()) {
                return false;
            }
            const bool current_status = m_generators[m_current].next();
            if (!current_status) {
                ++m_current;
            }
            return m_current < m_generators.size();
        }
    };

    template<typename... Ts>
    GeneratorWrapper<std::tuple<Ts...» table( std::initializer_list<std::tuple<typename
std::decay<Ts>::type...» tuples ) {
        return values<std::tuple<Ts...»( tuples );
    }

    // Tag type to signal that a generator sequence should convert arguments to a specific type
    template <typename T>
    struct as {};

    template<typename T, typename... Gs>
    auto makeGenerators( GeneratorWrapper<T>&& generator, Gs &&... moreGenerators ) -> Generators<T> {
        return Generators<T>(std::move(generator), std::forward<Gs>(moreGenerators)...);
    }
    template<typename T>
    auto makeGenerators( GeneratorWrapper<T>&& generator ) -> Generators<T> {
        return Generators<T>(std::move(generator));
    }
    template<typename T, typename... Gs>
    auto makeGenerators( T&& val, Gs &&... moreGenerators ) -> Generators<T> {
        return makeGenerators( value( std::forward<T>( val ) ), std::forward<Gs>( moreGenerators )...
);
    }
    template<typename T, typename U, typename... Gs>
    auto makeGenerators( as<T>, U&& val, Gs &&... moreGenerators ) -> Generators<T> {
        return makeGenerators( value( T( std::forward<U>( val ) ) ), std::forward<Gs>( moreGenerators
)... );
    }

    auto acquireGeneratorTracker( StringRef generatorName, SourceLineInfo const& lineInfo ) ->
```

```
IGeneratorTracker&;

    template<typename L>
    // Note: The type after -> is weird, because VS2015 cannot parse
    //       the expression used in the typedef inside, when it is in
    //       return type. Yeah.
    auto generate( StringRef generatorName, SourceLineInfo const& lineInfo, L const&
generatorExpression ) -> decltype(std::declval<decltype(generatorExpression())>().get()) {
        using UnderlyingType = typename decltype(generatorExpression())::type;

        IGeneratorTracker& tracker = acquireGeneratorTracker( generatorName, lineInfo );
        if (!tracker.hasGenerator()) {
            tracker.setGenerator(pf::make_unique<Generators<UnderlyingType»(generatorExpression()));
        }

        auto const& generator = static_cast<IGenerator<UnderlyingType> const&>(
*tracker.getGenerator() );
        return generator.get();
    }

} // namespace Generators
} // namespace Catch

#define GENERATE( ... ) \
    Catch::Generators::generate( INTERNAL_CATCH_STRINGIZE(INTERNAL_CATCH_UNIQUE_NAME(generator)), \
                                 CATCH_INTERNAL_LINEINFO, \
                                 [ ]{ using namespace Catch::Generators; return makeGenerators(
__VA_ARGS__ ); } ) //NOLINT(google-build-using-namespace)
#define GENERATE_COPY( ... ) \
    Catch::Generators::generate( INTERNAL_CATCH_STRINGIZE(INTERNAL_CATCH_UNIQUE_NAME(generator)), \
                                 CATCH_INTERNAL_LINEINFO, \
                                 [=]{ using namespace Catch::Generators; return makeGenerators(
__VA_ARGS__ ); } ) //NOLINT(google-build-using-namespace)
#define GENERATE_REF( ... ) \
    Catch::Generators::generate( INTERNAL_CATCH_STRINGIZE(INTERNAL_CATCH_UNIQUE_NAME(generator)), \
                                 CATCH_INTERNAL_LINEINFO, \
                                 [&]{ using namespace Catch::Generators; return makeGenerators(
__VA_ARGS__ ); } ) //NOLINT(google-build-using-namespace)

// end catch_generators.hpp
// start catch_generators_generic.hpp

namespace Catch {
namespace Generators {

    template <typename T>
    class TakeGenerator : public IGenerator<T> {
        GeneratorWrapper<T> m_generator;
        size_t m_returned = 0;
        size_t m_target;
    public:
        TakeGenerator(size_t target, GeneratorWrapper<T>&& generator):
            m_generator(std::move(generator)),
            m_target(target)
        {
            assert(target != 0 && "Empty generators are not allowed");
        }
        T const& get() const override {
            return m_generator.get();
        }
        bool next() override {
            ++m_returned;
            if (m_returned >= m_target) {
                return false;
            }

            const auto success = m_generator.next();
            // If the underlying generator does not contain enough values
            // then we cut short as well
            if (!success) {
                m_returned = m_target;
            }
            return success;
        }
    };

    template <typename T>
    GeneratorWrapper<T> take(size_t target, GeneratorWrapper<T>&& generator) {
        return GeneratorWrapper<T>(pf::make_unique<TakeGenerator<T>>(target, std::move(generator)));
    }

    template <typename T, typename Predicate>
    class FilterGenerator : public IGenerator<T> {
        GeneratorWrapper<T> m_generator;
        Predicate m_predicate;
    public:
        template <typename P = Predicate>
        FilterGenerator(P&& pred, GeneratorWrapper<T>&& generator):
            m_generator(std::move(generator)),
            m_predicate(std::forward<P>(pred))
        {
            if (!m_predicate(m_generator.get())) {
                // It might happen that there are no values that pass the
                // filter. In that case we throw an exception.
                auto has_initial_value = next();
                if (!has_initial_value) {
                    Catch::throw_exception(GeneratorException("No valid value found in filtered generator"));
                }
            }
        }

        T const& get() const override {
            return m_generator.get();
        }

        bool next() override {
            bool success = m_generator.next();
            if (!success) {
                return false;
            }
            while (!m_predicate(m_generator.get()) && (success = m_generator.next()) == true);
            return success;
        }
    };

    template <typename T, typename Predicate>
    GeneratorWrapper<T> filter(Predicate&& pred, GeneratorWrapper<T>&& generator) {
        return
GeneratorWrapper<T>(std::unique_ptr<IGenerator<T>>(pf::make_unique<FilterGenerator<T, Predicate>>(std::forward<Predicate
std::move(generator))));
    }

    template <typename T>
    class RepeatGenerator : public IGenerator<T> {
        static_assert(!std::is_same<T, bool>::value,
            "RepeatGenerator currently does not support bools"
            "because of std::vector<bool> specialization");
        GeneratorWrapper<T> m_generator;
        mutable std::vector<T> m_returned;
        size_t m_target_repeats;
        size_t m_current_repeat = 0;
        size_t m_repeat_index = 0;
    public:
        RepeatGenerator(size_t repeats, GeneratorWrapper<T>&& generator):
            m_generator(std::move(generator)),
            m_target_repeats(repeats)
        {
            assert(m_target_repeats > 0 && "Repeat generator must repeat at least once");
        }

        T const& get() const override {
            if (m_current_repeat == 0) {
                m_returned.push_back(m_generator.get());
                return m_returned.back();
            }
            return m_returned[m_repeat_index];
        }

        bool next() override {
            // There are 2 basic cases:
            // 1) We are still reading the generator
            // 2) We are reading our own cache

            // In the first case, we need to poke the underlying generator.
            // If it happily moves, we are left in that state, otherwise it is time to start reading from our cache
            if (m_current_repeat == 0) {
                const auto success = m_generator.next();
                if (!success) {
                    ++m_current_repeat;
                }
                return m_current_repeat < m_target_repeats;
            }

            // In the second case, we need to move indices forward and check that we haven't run up against the end
            ++m_repeat_index;
            if (m_repeat_index == m_returned.size()) {
                m_repeat_index = 0;
                ++m_current_repeat;
            }
            return m_current_repeat < m_target_repeats;
        }
    };

    template <typename T>
    GeneratorWrapper<T> repeat(size_t repeats, GeneratorWrapper<T>&& generator) {
        return GeneratorWrapper<T>(pf::make_unique<RepeatGenerator<T>>(repeats, std::move(generator)));
    }

    template <typename T, typename U, typename Func>
    class MapGenerator : public IGenerator<T> {
        // TBD: provide static assert for mapping function, for friendly error message
        GeneratorWrapper<U> m_generator;
        Func m_function;
        // To avoid returning dangling reference, we have to save the values
        T m_cache;
    public:
        template <typename F2 = Func>
        MapGenerator(F2&& function, GeneratorWrapper<U>&& generator) :
            m_generator(std::move(generator)),
            m_function(std::forward<F2>(function)),
            m_cache(m_function(m_generator.get()))
        {}

        T const& get() const override {
            return m_cache;
        }
        bool next() override {
            const auto success = m_generator.next();
            if (success) {
                m_cache = m_function(m_generator.get());
            }
            return success;
        }
    };

    template <typename Func, typename U, typename T = FunctionReturnType<Func, U»
    GeneratorWrapper<T> map(Func&& function, GeneratorWrapper<U>&& generator) {
        return GeneratorWrapper<T>(
            pf::make_unique<MapGenerator<T, U, Func>>(std::forward<Func>(function), std::move(generator))
        );
    }

    template <typename T, typename U, typename Func>
    GeneratorWrapper<T> map(Func&& function, GeneratorWrapper<U>&& generator) {
        return GeneratorWrapper<T>(
            pf::make_unique<MapGenerator<T, U, Func>>(std::forward<Func>(function), std::move(generator))
        );
    }

    template <typename T>
    class ChunkGenerator final : public IGenerator<std::vector<T» {
        std::vector<T> m_chunk;
        size_t m_chunk_size;
        GeneratorWrapper<T> m_generator;
        bool m_used_up = false;
    public:
        ChunkGenerator(size_t size, GeneratorWrapper<T> generator) :
            m_chunk_size(size), m_generator(std::move(generator))
        {
            m_chunk.reserve(m_chunk_size);
            if (m_chunk_size != 0) {
                m_chunk.push_back(m_generator.get());
                for (size_t i = 1; i < m_chunk_size; ++i) {
                    if (!m_generator.next()) {
                        Catch::throw_exception(GeneratorException("Not enough values to initialize the first chunk"));
                    }
                    m_chunk.push_back(m_generator.get());
                }
            }
        }
        std::vector<T> const& get() const override {
            return m_chunk;
        }
        bool next() override {
            m_chunk.clear();
            for (size_t idx = 0; idx < m_chunk_size; ++idx) {
                if (!m_generator.next()) {
                    return false;
                }
                m_chunk.push_back(m_generator.get());
            }
            return true;
        }
    };

    template <typename T>
    GeneratorWrapper<std::vector<T>> chunk(size_t size, GeneratorWrapper<T>&& generator) {
        return GeneratorWrapper<std::vector<T>>(
            pf::make_unique<ChunkGenerator<T»(size, std::move(generator))
        );
    }

} // namespace Generators
} // namespace Catch

// end catch_generators_generic.hpp
// start catch_generators_specific.hpp

// start catch_context.h

#include <memory>

namespace Catch {

    struct IResultCapture;
    struct IRunner;
    struct IConfig;
    struct IMutableContext;

    using IConfigPtr = std::shared_ptr<IConfig const>;

    struct IContext
    {
        virtual ~IContext();

        virtual IResultCapture* getResultCapture() = 0;
        virtual IRunner* getRunner() = 0;
        virtual IConfigPtr const& getConfig() const = 0;
    };

    struct IMutableContext : IContext
    {
        virtual ~IMutableContext();
        virtual void setResultCapture( IResultCapture* resultCapture ) = 0;
        virtual void setRunner( IRunner* runner ) = 0;
        virtual void setConfig( IConfigPtr const& config ) = 0;

    private:
        static IMutableContext *currentContext;
        friend IMutableContext& getCurrentMutableContext();
        friend void cleanUpContext();
        static void createContext();
    };

    inline IMutableContext& getCurrentMutableContext()
    {
        if( !IMutableContext::currentContext )
            IMutableContext::createContext();
        // NOLINTNEXTLINE(clang-analyzer-core.uninitialized.UndefReturn)
        return *IMutableContext::currentContext;
    }

    inline IContext& getCurrentContext()
    {
        return getCurrentMutableContext();
    }

    void cleanUpContext();

    class SimplePcg32;
    SimplePcg32& rng();
}

// end catch_context.h
// start catch_interfaces_config.h

// start catch_option.hpp

namespace Catch {

    // An optional type
    template<typename T>
    class Option {
    public:
        Option() : nullableValue( nullptr ) {}
        Option( T const& _value )
        : nullableValue( new( storage ) T( _value ) )
        {}
        Option( Option const& _other )
        : nullableValue( _other ? new( storage ) T( *_other ) : nullptr )
        {}

        ~Option() {
            reset();
        }

        Option& operator= ( Option const& _other ) {
            if( &_other != this ) {
                reset();
                if( _other )
                    nullableValue = new( storage ) T( *_other );
            }
            return *this;
        }
        Option& operator = ( T const& _value ) {
            reset();
            nullableValue = new( storage ) T( _value );
            return *this;
        }

        void reset() {
            if( nullableValue )
                nullableValue->~T();
            nullableValue = nullptr;
        }

        T& operator*() { return *nullableValue; }
        T const& operator*() const { return *nullableValue; }
        T* operator->() { return nullableValue; }
        const T* operator->() const { return nullableValue; }

        T valueOr( T const& defaultValue ) const {
            return nullableValue ? *nullableValue : defaultValue;
        }

        bool some() const { return nullableValue != nullptr; }
        bool none() const { return nullableValue == nullptr; }

        bool operator !() const { return nullableValue == nullptr; }
        explicit operator bool() const {
            return some();
        }

    private:
        T *nullableValue;
        alignas(alignof(T)) char storage[sizeof(T)];
    };

} // end namespace Catch

// end catch_option.hpp
#include <chrono>
#include <iosfwd>
#include <string>
#include <vector>
#include <memory>

namespace Catch {

    enum class Verbosity {
        Quiet = 0,
        Normal,
        High
    };

    struct WarnAbout { enum What {
        Nothing = 0x00,
        NoAssertions = 0x01,
        NoTests = 0x02
    }; };

    struct ShowDurations { enum OrNot {
        DefaultForReporter,
        Always,
        Never
    }; };
    struct RunTests { enum InWhatOrder {
        InDeclarationOrder,
        InLexicographicalOrder,
        InRandomOrder
    }; };
    struct UseColour { enum YesOrNo {
        Auto,
        Yes,
        No
    }; };
    struct WaitForKeypress { enum When {
        Never,
        BeforeStart = 1,
        BeforeExit = 2,
        BeforeStartAndExit = BeforeStart | BeforeExit
    }; };

    class TestSpec;

    struct IConfig : NonCopyable {

        virtual ~IConfig();

        virtual bool allowThrows() const = 0;
        virtual std::ostream& stream() const = 0;
        virtual std::string name() const = 0;
        virtual bool includeSuccessfulResults() const = 0;
        virtual bool shouldDebugBreak() const = 0;
        virtual bool warnAboutMissingAssertions() const = 0;
        virtual bool warnAboutNoTests() const = 0;
        virtual int abortAfter() const = 0;
        virtual bool showInvisibles() const = 0;
        virtual ShowDurations::OrNot showDurations() const = 0;
        virtual double minDuration() const = 0;
        virtual TestSpec const& testSpec() const = 0;
        virtual bool hasTestFilters() const = 0;
        virtual std::vector<std::string> const& getTestsOrTags() const = 0;
        virtual RunTests::InWhatOrder runOrder() const = 0;
        virtual unsigned int rngSeed() const = 0;
        virtual UseColour::YesOrNo useColour() const = 0;
        virtual std::vector<std::string> const& getSectionsToRun() const = 0;
        virtual Verbosity verbosity() const = 0;

        virtual bool benchmarkNoAnalysis() const = 0;
        virtual int benchmarkSamples() const = 0;
        virtual double benchmarkConfidenceInterval() const = 0;
        virtual unsigned int benchmarkResamples() const = 0;
        virtual std::chrono::milliseconds benchmarkWarmupTime() const = 0;
    };

    using IConfigPtr = std::shared_ptr<IConfig const>;
}

// end catch_interfaces_config.h
// start catch_random_number_generator.h

#include <cstdint>

namespace Catch {

    // This is a simple implementation of C++11 Uniform Random Number
    // Generator. It does not provide all operators, because Catch2
    // does not use it, but it should behave as expected inside stdlib's
    // distributions.
    // The implementation is based on the PCG family (http://pcg-random.org)
    class SimplePcg32 {
        using state_type = std::uint64_t;
    public:
        using result_type = std::uint32_t;
        static constexpr result_type (min)() {
            return 0;
        }
        static constexpr result_type (max)() {
            return static_cast<result_type>(-1);
        }

        // Provide some default initial state for the default constructor
        SimplePcg32():SimplePcg32(0xed743cc4U) {}

        explicit SimplePcg32(result_type seed_);

        void seed(result_type seed_);
        void discard(uint64_t skip);

        result_type operator()();

    private:
        friend bool operator==(SimplePcg32 const& lhs, SimplePcg32 const& rhs);
        friend bool operator!=(SimplePcg32 const& lhs, SimplePcg32 const& rhs);

        // In theory we also need operator« and operator»
        // In practice we do not use them, so we will skip them for now

        std::uint64_t m_state;
        // This part of the state determines which "stream" of the numbers
        // is chosen -- we take it as a constant for Catch2, so we only
        // need to deal with seeding the main state.
        // Picked by reading 8 bytes from `/dev/random` :-)
        static const std::uint64_t s_inc = (0x13ed0cc53f939476ULL « 1ULL) | 1ULL;
    };

} // end namespace Catch

// end catch_random_number_generator.h
#include <random>

namespace Catch {
namespace Generators {

template <typename Float>
class RandomFloatingGenerator final : public IGenerator<Float> {
    Catch::SimplePcg32& m_rng;
    std::uniform_real_distribution<Float> m_dist;
    Float m_current_number;
public:

    RandomFloatingGenerator(Float a, Float b):
        m_rng(rng()),
        m_dist(a, b) {
        static_cast<void>(next());
    }

    Float const& get() const override {
        return m_current_number;
    }
    bool next() override {
        m_current_number = m_dist(m_rng);
        return true;
    }
};

template <typename Integer>
class RandomIntegerGenerator final : public IGenerator<Integer> {
    Catch::SimplePcg32& m_rng;
    std::uniform_int_distribution<Integer> m_dist;
    Integer m_current_number;
public:

    RandomIntegerGenerator(Integer a, Integer b):
        m_rng(rng()),
        m_dist(a, b) {
        static_cast<void>(next());
    }

    Integer const& get() const override {
        return m_current_number;
    }
    bool next() override {
        m_current_number = m_dist(m_rng);
        return true;
    }
};

// TODO: Ideally this would be also constrained against the various char types,
//       but I don't expect users to run into that in practice.
template <typename T>
typename std::enable_if<std::is_integral<T>::value && !std::is_same<T, bool>::value,
GeneratorWrapper<T>>::type
random(T a, T b) {
    return GeneratorWrapper<T>(
        pf::make_unique<RandomIntegerGenerator<T>>(a, b)
    );
}

template <typename T>
typename std::enable_if<std::is_floating_point<T>::value,
GeneratorWrapper<T>>::type
random(T a, T b) {
    return GeneratorWrapper<T>(
        pf::make_unique<RandomFloatingGenerator<T>>(a, b)
    );
}

template <typename T>
class RangeGenerator final : public IGenerator<T> {
    T m_current;
    T m_end;
    T m_step;
    bool m_positive;

public:
    RangeGenerator(T const& start, T const& end, T const& step):
        m_current(start),
        m_end(end),
        m_step(step),
        m_positive(m_step > T(0))
    {
        assert(m_current != m_end && "Range start and end cannot be equal");
        assert(m_step != T(0) && "Step size cannot be zero");
        assert(((m_positive && m_current <= m_end) || (!m_positive && m_current >= m_end)) && "Step
moves away from end");
    }

    RangeGenerator(T const& start, T const& end):
        RangeGenerator(start, end, (start < end) ? T(1) : T(-1))
    {}

    T const& get() const override {
        return m_current;
    }

    bool next() override {
        m_current += m_step;
        return (m_positive) ? (m_current < m_end) : (m_current > m_end);
    }
};

template <typename T>
GeneratorWrapper<T> range(T const& start, T const& end, T const& step) {
    static_assert(std::is_arithmetic<T>::value && !std::is_same<T, bool>::value, "Type must be
numeric");
    return GeneratorWrapper<T>(pf::make_unique<RangeGenerator<T>>(start, end, step));
}

template <typename T>
GeneratorWrapper<T> range(T const& start, T const& end) {
    static_assert(std::is_integral<T>::value && !std::is_same<T, bool>::value, "Type must be an
integer");
    return GeneratorWrapper<T>(pf::make_unique<RangeGenerator<T>>(start, end));
}

template <typename T>
class IteratorGenerator final : public IGenerator<T> {
    static_assert(!std::is_same<T, bool>::value,
        "IteratorGenerator currently does not support bools"
        "because of std::vector<bool> specialization");

    std::vector<T> m_elems;
    size_t m_current = 0;
public:
    template <typename InputIterator, typename InputSentinel>
    IteratorGenerator(InputIterator first, InputSentinel last):m_elems(first, last) {
        if (m_elems.empty()) {
            Catch::throw_exception(GeneratorException("IteratorGenerator received no valid values"));
        }
    }

    T const& get() const override {
        return m_elems[m_current];
    }

    bool next() override {
        ++m_current;
        return m_current != m_elems.size();
    }
};

template <typename InputIterator,
          typename InputSentinel,
          typename ResultType = typename std::iterator_traits<InputIterator>::value_type>
GeneratorWrapper<ResultType> from_range(InputIterator from, InputSentinel to) {
    return GeneratorWrapper<ResultType>(pf::make_unique<IteratorGenerator<ResultType>>(from, to));
}

template <typename Container,
          typename ResultType = typename Container::value_type>
GeneratorWrapper<ResultType> from_range(Container const& cnt) {
    return GeneratorWrapper<ResultType>(pf::make_unique<IteratorGenerator<ResultType>>(cnt.begin(),
cnt.end()));
}

} // namespace Generators
} // namespace Catch

// end catch_generators_specific.hpp

// These files are included here so the single_include script doesn't put them
// in the conditionally compiled sections
// start catch_test_case_info.h

#include <string>
#include <vector>
#include <memory>
```

```

#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Wpadded"
#endif

namespace Catch {

    struct ITestInvoker;

    struct TestCaseInfo {
        enum SpecialProperties{
            None = 0,
            IsHidden = 1 « 1,
            ShouldFail = 1 « 2,
            MayFail = 1 « 3,
            Throws = 1 « 4,
            NonPortable = 1 « 5,
            Benchmark = 1 « 6
        };

        TestCaseInfo(   std::string const& _name,
                        std::string const& _className,
                        std::string const& _description,
                        std::vector<std::string> const& _tags,
                        SourceLineInfo const& _lineInfo );

        friend void setTags( TestCaseInfo& testCaseInfo, std::vector<std::string> tags );

        bool isHidden() const;
        bool throws() const;
        bool okToFail() const;
        bool expectedToFail() const;

        std::string tagsAsString() const;

        std::string name;
        std::string className;
        std::string description;
        std::vector<std::string> tags;
        std::vector<std::string> lcaseTags;
        SourceLineInfo lineInfo;
        SpecialProperties properties;
    };

    class TestCase : public TestCaseInfo {
    public:

        TestCase( ITestInvoker* testCase, TestCaseInfo&& info );

        TestCase withName( std::string const& _newName ) const;

        void invoke() const;

        TestCaseInfo const& getTestCaseInfo() const;

        bool operator == ( TestCase const& other ) const;
        bool operator < ( TestCase const& other ) const;

    private:
        std::shared_ptr<ITestInvoker> test;
    };

    TestCase makeTestCase(  ITestInvoker* testCase,
                            std::string const& className,
                            NameAndTags const& nameAndTags,
                            SourceLineInfo const& lineInfo );
}

#ifdef __clang__
#pragma clang diagnostic pop
#endif

// end catch_test_case_info.h
// start catch_interfaces_runner.h

namespace Catch {

    struct IRunner {
        virtual ~IRunner();
        virtual bool aborting() const = 0;
    };
}

// end catch_interfaces_runner.h

#ifdef __OBJC__
```

```
// start catch_objc.hpp

#import <objc/runtime.h>

#include <string>

// NB. Any general catch headers included here must be included
// in catch.hpp first to make sure they are included by the single
// header for non obj-usage

// This protocol is really only here for (self) documenting purposes, since
// all its methods are optional.
@protocol OcFixture

@optional

-(void) setUp;
-(void) tearDown;

@end

namespace Catch {

    class OcMethod : public ITestInvoker {

    public:
        OcMethod( Class cls, SEL sel ) : m_cls( cls ), m_sel( sel ) {}

        virtual void invoke() const {
            id obj = [[m_cls alloc] init];

            performOptionalSelector( obj, @selector(setUp)  );
            performOptionalSelector( obj, m_sel );
            performOptionalSelector( obj, @selector(tearDown)  );

            arcSafeRelease( obj );
        }
    private:
        virtual ~OcMethod() {}

        Class m_cls;
        SEL m_sel;
    };

    namespace Detail{

        inline std::string getAnnotation(   Class cls,
                                            std::string const& annotationName,
                                            std::string const& testCaseName ) {
            NSString* selStr = [[NSString alloc] initWithFormat:@"Catch_%s_%s",
annotationName.c_str(), testCaseName.c_str()];
            SEL sel = NSSelectorFromString( selStr );
            arcSafeRelease( selStr );
            id value = performOptionalSelector( cls, sel );
            if( value )
                return [(NSString*)value UTF8String];
            return "";
        }
    }

    inline std::size_t registerTestMethods() {
        std::size_t noTestMethods = 0;
        int noClasses = objc_getClassList( nullptr, 0 );

        Class* classes = (CATCH_UNSAFE_UNRETAINED Class *)malloc( sizeof(Class) * noClasses);
        objc_getClassList( classes, noClasses );

        for( int c = 0; c < noClasses; c++ ) {
            Class cls = classes[c];
            {
                u_int count;
                Method* methods = class_copyMethodList( cls, &count );
                for( u_int m = 0; m < count ; m++ ) {
                    SEL selector = method_getName(methods[m]);
                    std::string methodName = sel_getName(selector);
                    if( startsWith( methodName, "Catch_TestCase_" ) ) {
                        std::string testCaseName = methodName.substr( 15 );
                        std::string name = Detail::getAnnotation( cls, "Name", testCaseName );
                        std::string desc = Detail::getAnnotation( cls, "Description", testCaseName );
                        const char* className = class_getName( cls );

                        getMutableRegistryHub().registerTest( makeTestCase( new OcMethod( cls,
selector ), className, NameAndTags( name.c_str(), desc.c_str() ), SourceLineInfo("",0) ) );
                        noTestMethods++;
                    }
                }
                free(methods);
            }
        }
        return noTestMethods;
    }

#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)

    namespace Matchers {
        namespace Impl {
        namespace NSStringMatchers {

            struct StringHolder : MatcherBase<NSString*>{
                StringHolder( NSString* substr ) : m_substr( [substr copy] ){}
                StringHolder( StringHolder const& other ) : m_substr( [other.m_substr copy] ){}
                StringHolder() {
                    arcSafeRelease( m_substr );
                }

                bool match( NSString* str ) const override {
                    return false;
                }

                NSString* CATCH_ARC_STRONG m_substr;
            };

            struct Equals : StringHolder {
                Equals( NSString* substr ) : StringHolder( substr ){}

                bool match( NSString* str ) const override {
                    return  (str != nil || m_substr == nil ) &&
                            [str isEqualToString:m_substr];
                }

                std::string describe() const override {
                    return "equals string: " + Catch::Detail::stringify( m_substr );
                }
            };

            struct Contains : StringHolder {
                Contains( NSString* substr ) : StringHolder( substr ){}

                bool match( NSString* str ) const override {
                    return  (str != nil || m_substr == nil ) &&
                            [str rangeOfString:m_substr].location != NSNotFound;
                }

                std::string describe() const override {
                    return "contains string: " + Catch::Detail::stringify( m_substr );
                }
            };

            struct StartsWith : StringHolder {
                StartsWith( NSString* substr ) : StringHolder( substr ){}

                bool match( NSString* str ) const override {
                    return  (str != nil || m_substr == nil ) &&
                            [str rangeOfString:m_substr].location == 0;
                }

                std::string describe() const override {
                    return "starts with: " + Catch::Detail::stringify( m_substr );
                }
            };
            struct EndsWith : StringHolder {
                EndsWith( NSString* substr ) : StringHolder( substr ){}

                bool match( NSString* str ) const override {
                    return  (str != nil || m_substr == nil ) &&
                            [str rangeOfString:m_substr].location == [str length] - [m_substr length];
                }

                std::string describe() const override {
                    return "ends with: " + Catch::Detail::stringify( m_substr );
                }
            };

        } // namespace NSStringMatchers
        } // namespace Impl

        inline Impl::NSStringMatchers::Equals
            Equals( NSString* substr ){ return Impl::NSStringMatchers::Equals( substr ); }

        inline Impl::NSStringMatchers::Contains
            Contains( NSString* substr ){ return Impl::NSStringMatchers::Contains( substr ); }

        inline Impl::NSStringMatchers::StartsWith
            StartsWith( NSString* substr ){ return Impl::NSStringMatchers::StartsWith( substr ); }

        inline Impl::NSStringMatchers::EndsWith
            EndsWith( NSString* substr ){ return Impl::NSStringMatchers::EndsWith( substr ); }

    } // namespace Matchers

    using namespace Matchers;

#endif // CATCH_CONFIG_DISABLE_MATCHERS

} // namespace Catch

#define OC_MAKE_UNIQUE_NAME( root, uniqueSuffix ) root##uniqueSuffix
#define OC_TEST_CASE2( name, desc, uniqueSuffix ) \
+(NSString*) OC_MAKE_UNIQUE_NAME( Catch_Name_test_, uniqueSuffix ) \
{ \
return @ name; \
} \
+(NSString*) OC_MAKE_UNIQUE_NAME( Catch_Description_test_, uniqueSuffix ) \
{ \
return @ desc; \
} \
-(void) OC_MAKE_UNIQUE_NAME( Catch_TestCase_test_, uniqueSuffix )

#define OC_TEST_CASE( name, desc ) OC_TEST_CASE2( name, desc, __LINE__ )

// end catch_objc.hpp
#endif

// Benchmarking needs the externally-facing parts of reporters to work
#if defined(CATCH_CONFIG_EXTERNAL_INTERFACES) || defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
// start catch_external_interfaces.h

// start catch_reporter_bases.hpp

// start catch_interfaces_reporter.h

// start catch_config.hpp

// start catch_test_spec_parser.h

#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Wpadded"
#endif

// start catch_test_spec.h

#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Wpadded"
#endif

// start catch_wildcard_pattern.h

namespace Catch
{
    class WildcardPattern {
        enum WildcardPosition {
            NoWildcard = 0,
            WildcardAtStart = 1,
            WildcardAtEnd = 2,
            WildcardAtBothEnds = WildcardAtStart | WildcardAtEnd
        };

    public:

        WildcardPattern( std::string const& pattern, CaseSensitive::Choice caseSensitivity );
        virtual ~WildcardPattern() = default;
        virtual bool matches( std::string const& str ) const;

    private:
        std::string normaliseString( std::string const& str ) const;
        CaseSensitive::Choice m_caseSensitivity;
        WildcardPosition m_wildcard = NoWildcard;
        std::string m_pattern;
    };
}

// end catch_wildcard_pattern.h
#include <string>
#include <vector>
#include <memory>

namespace Catch {

    struct IConfig;

    class TestSpec {
        class Pattern {
        public:
            explicit Pattern( std::string const& name );
            virtual ~Pattern();
            virtual bool matches( TestCaseInfo const& testCase ) const = 0;
            std::string const& name() const;
        private:
            std::string const m_name;
        };
        using PatternPtr = std::shared_ptr<Pattern>;

        class NamePattern : public Pattern {
        public:
            explicit NamePattern( std::string const& name, std::string const& filterString );
            bool matches( TestCaseInfo const& testCase ) const override;
        private:
            WildcardPattern m_wildcardPattern;
        };

        class TagPattern : public Pattern {
        public:
            explicit TagPattern( std::string const& tag, std::string const& filterString );
            bool matches( TestCaseInfo const& testCase ) const override;
        private:
            std::string m_tag;
        };

        class ExcludedPattern : public Pattern {
        public:
            explicit ExcludedPattern( PatternPtr const& underlyingPattern );
            bool matches( TestCaseInfo const& testCase ) const override;
        private:
            PatternPtr m_underlyingPattern;
        };

        struct Filter {
            std::vector<PatternPtr> m_patterns;

            bool matches( TestCaseInfo const& testCase ) const;
            std::string name() const;
        };

    public:
        struct FilterMatch {
            std::string name;
            std::vector<TestCase const*> tests;
        };
        using Matches = std::vector<FilterMatch>;
        using vectorStrings = std::vector<std::string>;

        bool hasFilters() const;
        bool matches( TestCaseInfo const& testCase ) const;
        Matches matchesByFilter( std::vector<TestCase> const& testCases, IConfig const& config )
const;
        const vectorStrings & getInvalidArgs() const;

    private:
        std::vector<Filter> m_filters;
        std::vector<std::string> m_invalidArgs;
        friend class TestSpecParser;
    };
}

#ifdef __clang__
#pragma clang diagnostic pop
#endif

// end catch_test_spec.h
// start catch_interfaces_tag_alias_registry.h

#include <string>

namespace Catch {

    struct TagAlias;

    struct ITagAliasRegistry {
        virtual ~ITagAliasRegistry();
        // Nullptr if not present
        virtual TagAlias const* find( std::string const& alias ) const = 0;
        virtual std::string expandAliases( std::string const& unexpandedTestSpec ) const = 0;

        static ITagAliasRegistry const& get();
    };

```

```
} // end namespace Catch

// end catch_interfaces_tag_alias_registry.h
namespace Catch {

    class TestSpecParser {
        enum Mode{ None, Name, QuotedName, Tag, EscapedName };
        Mode m_mode = None;
        Mode lastMode = None;
        bool m_exclusion = false;
        std::size_t m_pos = 0;
        std::size_t m_realPatternPos = 0;
        std::string m_arg;
        std::string m_substring;
        std::string m_patternName;
        std::vector<std::size_t> m_escapeChars;
        TestSpec::Filter m_currentFilter;
        TestSpec m_testSpec;
        ITagAliasRegistry const* m_tagAliases = nullptr;

    public:
        TestSpecParser( ITagAliasRegistry const& tagAliases );

        TestSpecParser& parse( std::string const& arg );
        TestSpec testSpec();

    private:
        bool visitChar( char c );
        void startNewMode( Mode mode );
        bool processNoneChar( char c );
        void processNameChar( char c );
        bool processOtherChar( char c );
        void endMode();
        void escape();
        bool isControlChar( char c ) const;
        void saveLastMode();
        void revertBackToLastMode();
        void addFilter();
        bool separate();

        // Handles common preprocessing of the pattern for name/tag patterns
        std::string preprocessPattern();
        // Adds the current pattern as a test name
        void addNamePattern();
        // Adds the current pattern as a tag
        void addTagPattern();

        inline void addCharToPattern(char c) {
            m_substring += c;
            m_patternName += c;
            m_realPatternPos++;
        }

    };
    TestSpec parseTestSpec( std::string const& arg );

} // namespace Catch

#ifdef __clang__
#pragma clang diagnostic pop
#endif

// end catch_test_spec_parser.h
// Libstdc++ doesn't like incomplete classes for unique_ptr

#include <memory>
#include <vector>
#include <string>

#ifndef CATCH_CONFIG_CONSOLE_WIDTH
#define CATCH_CONFIG_CONSOLE_WIDTH 80
#endif

namespace Catch {

    struct IStream;

    struct ConfigData {
        bool listTests = false;
        bool listTags = false;
        bool listReporters = false;
        bool listTestNamesOnly = false;

        bool showSuccessfulTests = false;
        bool shouldDebugBreak = false;
        bool noThrow = false;
        bool showHelp = false;
        bool showInvisibles = false;
        bool filenamesAsTags = false;
        bool libIdentify = false;

        int abortAfter = -1;
        unsigned int rngSeed = 0;

        bool benchmarkNoAnalysis = false;
        unsigned int benchmarkSamples = 100;
        double benchmarkConfidenceInterval = 0.95;
        unsigned int benchmarkResamples = 100000;
        std::chrono::milliseconds::rep benchmarkWarmupTime = 100;

        Verbosity verbosity = Verbosity::Normal;
        WarnAbout::What warnings = WarnAbout::Nothing;
        ShowDurations::OrNot showDurations = ShowDurations::DefaultForReporter;
        double minDuration = -1;
        RunTests::InWhatOrder runOrder = RunTests::InDeclarationOrder;
        UseColour::YesOrNo useColour = UseColour::Auto;
        WaitForKeypress::When waitForKeypress = WaitForKeypress::Never;

        std::string outputFilename;
        std::string name;
        std::string processName;
#ifndef CATCH_CONFIG_DEFAULT_REPORTER
#define CATCH_CONFIG_DEFAULT_REPORTER "console"
#endif
        std::string reporterName = CATCH_CONFIG_DEFAULT_REPORTER;
#undef CATCH_CONFIG_DEFAULT_REPORTER

        std::vector<std::string> testsOrTags;
        std::vector<std::string> sectionsToRun;
    };

    class Config : public IConfig {
    public:

        Config() = default;
        Config( ConfigData const& data );
        virtual ~Config() = default;

        std::string const& getFilename() const;

        bool listTests() const;
        bool listTestNamesOnly() const;
        bool listTags() const;
        bool listReporters() const;

        std::string getProcessName() const;
        std::string const& getReporterName() const;

        std::vector<std::string> const& getTestsOrTags() const override;
        std::vector<std::string> const& getSectionsToRun() const override;

        TestSpec const& testSpec() const override;
        bool hasTestFilters() const override;

        bool showHelp() const;

        // IConfig interface
        bool allowThrows() const override;
        std::ostream& stream() const override;
        std::string name() const override;
        bool includeSuccessfulResults() const override;
        bool warnAboutMissingAssertions() const override;
        bool warnAboutNoTests() const override;
        ShowDurations::OrNot showDurations() const override;
        double minDuration() const override;
        RunTests::InWhatOrder runOrder() const override;
        unsigned int rngSeed() const override;
        UseColour::YesOrNo useColour() const override;
        bool shouldDebugBreak() const override;
        int abortAfter() const override;
        bool showInvisibles() const override;
        Verbosity verbosity() const override;
        bool benchmarkNoAnalysis() const override;
        int benchmarkSamples() const override;
        double benchmarkConfidenceInterval() const override;
        unsigned int benchmarkResamples() const override;
        std::chrono::milliseconds benchmarkWarmupTime() const override;

    private:

        IStream const* openStream();
        ConfigData m_data;

        std::unique_ptr<IStream const> m_stream;
        TestSpec m_testSpec;
        bool m_hasTestFilters = false;
    };

} // end namespace Catch

// end catch_config.hpp
// start catch_assertionresult.h

#include <string>

namespace Catch {

    struct AssertionResultData
    {
        AssertionResultData() = delete;

        AssertionResultData( ResultWas::OfType _resultType, LazyExpression const& _lazyExpression );

        std::string message;
        mutable std::string reconstructedExpression;
        LazyExpression lazyExpression;
        ResultWas::OfType resultType;

        std::string reconstructExpression() const;
    };

    class AssertionResult {
    public:
        AssertionResult() = delete;
        AssertionResult( AssertionInfo const& info, AssertionResultData const& data );

        bool isOk() const;
        bool succeeded() const;
        ResultWas::OfType getResultType() const;
        bool hasExpression() const;
        bool hasMessage() const;
        std::string getExpression() const;
        std::string getExpressionInMacro() const;
        bool hasExpandedExpression() const;
        std::string getExpandedExpression() const;
        std::string getMessage() const;
        SourceLineInfo getSourceInfo() const;
        StringRef getTestMacroName() const;

    //protected:
        AssertionInfo m_info;
        AssertionResultData m_resultData;
    };

} // end namespace Catch

// end catch_assertionresult.h
#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
// start catch_estimate.hpp

 // Statistics estimates


namespace Catch {
    namespace Benchmark {
        template <typename Duration>
        struct Estimate {
            Duration point;
            Duration lower_bound;
            Duration upper_bound;
            double confidence_interval;

            template <typename Duration2>
            operator Estimate<Duration2>() const {
                return { point, lower_bound, upper_bound, confidence_interval };
            }
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_estimate.hpp
// start catch_outlier_classification.hpp

// Outlier information

namespace Catch {
    namespace Benchmark {
        struct OutlierClassification {
            int samples_seen = 0;
            int low_severe = 0;     // more than 3 times IQR below Q1
            int low_mild = 0;       // 1.5 to 3 times IQR below Q1
            int high_mild = 0;      // 1.5 to 3 times IQR above Q3
            int high_severe = 0;    // more than 3 times IQR above Q3

            int total() const {
                return low_severe + low_mild + high_mild + high_severe;
            }
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_outlier_classification.hpp

#include <iterator>
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

#include <string>
#include <iosfwd>
#include <map>
#include <set>
#include <memory>
#include <algorithm>

namespace Catch {

    struct ReporterConfig {
        explicit ReporterConfig( IConfigPtr const& _fullConfig );

        ReporterConfig( IConfigPtr const& _fullConfig, std::ostream& _stream );

        std::ostream& stream() const;
        IConfigPtr fullConfig() const;

    private:
        std::ostream* m_stream;
        IConfigPtr m_fullConfig;
    };

    struct ReporterPreferences {
        bool shouldRedirectStdOut = false;
        bool shouldReportAllAssertions = false;
    };

    template<typename T>
    struct LazyStat : Option<T> {
        LazyStat& operator=( T const& _value ) {
            Option<T>::operator=( _value );
            used = false;
            return *this;
        }
        void reset() {
            Option<T>::reset();
            used = false;
        }
        bool used = false;
    };

    struct TestRunInfo {
        TestRunInfo( std::string const& _name );
        std::string name;
    };
    struct GroupInfo {
        GroupInfo(  std::string const& _name,
                    std::size_t _groupIndex,
                    std::size_t _groupsCount );

        std::string name;
        std::size_t groupIndex;
        std::size_t groupsCounts;
    };

    struct AssertionStats {
        AssertionStats( AssertionResult const& _assertionResult,
                        std::vector<MessageInfo> const& _infoMessages,
                        Totals const& _totals );

        AssertionStats( AssertionStats const& )              = default;
        AssertionStats( AssertionStats && )                  = default;
        AssertionStats& operator = ( AssertionStats const& ) = delete;
        AssertionStats& operator = ( AssertionStats && )     = delete;
        virtual ~AssertionStats();

        AssertionResult assertionResult;
        std::vector<MessageInfo> infoMessages;
        Totals totals;
    };

    struct SectionStats {
        SectionStats(   SectionInfo const& _sectionInfo,
                        Counts const& _assertions,
                        double _durationInSeconds,
                        bool _missingAssertions );
        SectionStats( SectionStats const& )              = default;
        SectionStats( SectionStats && )                  = default;
        SectionStats& operator = ( SectionStats const& ) = default;
        SectionStats& operator = ( SectionStats && )     = default;
        virtual ~SectionStats();

        SectionInfo sectionInfo;
        Counts assertions;
        double durationInSeconds;
        bool missingAssertions;
    };

    struct TestCaseStats {
        TestCaseStats(  TestCaseInfo const& _testInfo,
                        Totals const& _totals,
                        std::string const& _stdOut,
                        std::string const& _stdErr,
                        bool _aborting );

        TestCaseStats( TestCaseStats const& )              = default;
        TestCaseStats( TestCaseStats && )                  = default;
        TestCaseStats& operator = ( TestCaseStats const& ) = default;
        TestCaseStats& operator = ( TestCaseStats && )     = default;
        virtual ~TestCaseStats();

        TestCaseInfo testInfo;
        Totals totals;
        std::string stdOut;
        std::string stdErr;
        bool aborting;
    };

    struct TestGroupStats {
        TestGroupStats( GroupInfo const& _groupInfo,
                        Totals const& _totals,
                        bool _aborting );
        TestGroupStats( GroupInfo const& _groupInfo );

        TestGroupStats( TestGroupStats const& )              = default;
        TestGroupStats( TestGroupStats && )                  = default;
        TestGroupStats& operator = ( TestGroupStats const& ) = default;
        TestGroupStats& operator = ( TestGroupStats && )     = default;
        virtual ~TestGroupStats();

        GroupInfo groupInfo;
        Totals totals;
        bool aborting;
    };

    struct TestRunStats {
        TestRunStats(   TestRunInfo const& _runInfo,
                        Totals const& _totals,
                        bool _aborting );

        TestRunStats( TestRunStats const& )              = default;
        TestRunStats( TestRunStats && )                  = default;
        TestRunStats& operator = ( TestRunStats const& ) = default;
        TestRunStats& operator = ( TestRunStats && )     = default;
        virtual ~TestRunStats();

        TestRunInfo runInfo;
        Totals totals;
        bool aborting;
    };

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
    struct BenchmarkInfo {
        std::string name;
        double estimatedDuration;
        int iterations;
        int samples;
        unsigned int resamples;
        double clockResolution;
        double clockCost;
    };

    template <class Duration>
    struct BenchmarkStats {
        BenchmarkInfo info;

        std::vector<Duration> samples;
        Benchmark::Estimate<Duration> mean;
        Benchmark::Estimate<Duration> standardDeviation;
        Benchmark::OutlierClassification outliers;
        double outlierVariance;

        template <typename Duration2>
        operator BenchmarkStats<Duration2>() const {
            std::vector<Duration2> samples2;
            samples2.reserve(samples.size());
            std::transform(samples.begin(), samples.end(), std::back_inserter(samples2), [](Duration
d) { return Duration2(d); });
            return {
                info,
                std::move(samples2),
                mean,
                standardDeviation,
                outliers,
                outlierVariance,
            };
        }
    };
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

    struct IStreamingReporter {
        virtual ~IStreamingReporter() = default;

        // Implementing class must also provide the following static methods:
        // static std::string getDescription();
        // static std::set<Verbosity> getSupportedVerbosities()

        virtual ReporterPreferences getPreferences() const = 0;

        virtual void noMatchingTestCases( std::string const& spec ) = 0;

        virtual void reportInvalidArguments(std::string const&) {}

        virtual void testRunStarting( TestRunInfo const& testRunInfo ) = 0;
        virtual void testGroupStarting( GroupInfo const& groupInfo ) = 0;

        virtual void testCaseStarting( TestCaseInfo const& testInfo ) = 0;
        virtual void sectionStarting( SectionInfo const& sectionInfo ) = 0;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        virtual void benchmarkPreparing( std::string const& ) {}
        virtual void benchmarkStarting( BenchmarkInfo const& ) {}
        virtual void benchmarkEnded( BenchmarkStats<> const& ) {}
        virtual void benchmarkFailed( std::string const& ) {}
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

        virtual void assertionStarting( AssertionInfo const& assertionInfo ) = 0;

        // The return value indicates if the messages buffer should be cleared:
        virtual bool assertionEnded( AssertionStats const& assertionStats ) = 0;

        virtual void sectionEnded( SectionStats const& sectionStats ) = 0;
        virtual void testCaseEnded( TestCaseStats const& testCaseStats ) = 0;
        virtual void testGroupEnded( TestGroupStats const& testGroupStats ) = 0;
        virtual void testRunEnded( TestRunStats const& testRunStats ) = 0;

        virtual void skipTest( TestCaseInfo const& testInfo ) = 0;

        // Default empty implementation provided
        virtual void fatalErrorEncountered( StringRef name );

        virtual bool isMulti() const;
    };
    using IStreamingReporterPtr = std::unique_ptr<IStreamingReporter>;

    struct IReporterFactory {
        virtual ~IReporterFactory();
        virtual IStreamingReporterPtr create( ReporterConfig const& config ) const = 0;
        virtual std::string getDescription() const = 0;
    };
    using IReporterFactoryPtr = std::shared_ptr<IReporterFactory>;

    struct IReporterRegistry {
        using FactoryMap = std::map<std::string, IReporterFactoryPtr>;
        using Listeners = std::vector<IReporterFactoryPtr>;

        virtual ~IReporterRegistry();
        virtual IStreamingReporterPtr create( std::string const& name, IConfigPtr const& config )
const = 0;
        virtual FactoryMap const& getFactories() const = 0;
        virtual Listeners const& getListeners() const = 0;
    };

} // end namespace Catch

// end catch_interfaces_reporter.h
```

```
#include <algorithm>
#include <cstring>
#include <cfloat>
#include <cstdio>
#include <cassert>
#include <memory>
#include <ostream>

namespace Catch {
    void prepareExpandedExpression(AssertionResult& result);

    // Returns double formatted as %.3f (format expected on output)
    std::string getFormattedDuration( double duration );

    bool shouldShowDuration( IConfig const& config, double duration );

    std::string serializeFilters( std::vector<std::string> const& container );

    template<typename DerivedT>
    struct StreamingReporterBase : IStreamingReporter {

        StreamingReporterBase( ReporterConfig const& _config )
        :   m_config( _config.fullConfig() ),
            stream( _config.stream() )
        {
            m_reporterPrefs.shouldRedirectStdOut = false;
            if( !DerivedT::getSupportedVerbosities().count( m_config->verbosity() ) )
                CATCH_ERROR( "Verbosity level not supported by this reporter" );
        }

        ReporterPreferences getPreferences() const override {
            return m_reporterPrefs;
        }

        static std::set<Verbosity> getSupportedVerbosities() {
            return { Verbosity::Normal };
        }

        ~StreamingReporterBase() override = default;

        void noMatchingTestCases(std::string const&) override {}

        void reportInvalidArguments(std::string const&) override {}

        void testRunStarting(TestRunInfo const& _testRunInfo) override {
            currentTestRunInfo = _testRunInfo;
        }

        void testGroupStarting(GroupInfo const& _groupInfo) override {
            currentGroupInfo = _groupInfo;
        }

        void testCaseStarting(TestCaseInfo const& _testInfo) override  {
            currentTestCaseInfo = _testInfo;
        }
        void sectionStarting(SectionInfo const& _sectionInfo) override {
            m_sectionStack.push_back(_sectionInfo);
        }

        void sectionEnded(SectionStats const& /* _sectionStats */) override {
            m_sectionStack.pop_back();
        }
        void testCaseEnded(TestCaseStats const& /* _testCaseStats */) override {
            currentTestCaseInfo.reset();
        }
        void testGroupEnded(TestGroupStats const& /* _testGroupStats */) override {
            currentGroupInfo.reset();
        }
        void testRunEnded(TestRunStats const& /* _testRunStats */) override {
            currentTestCaseInfo.reset();
            currentGroupInfo.reset();
            currentTestRunInfo.reset();
        }

        void skipTest(TestCaseInfo const&) override {
            // Don't do anything with this by default.
            // It can optionally be overridden in the derived class.
        }

        IConfigPtr m_config;
        std::ostream& stream;

        LazyStat<TestRunInfo> currentTestRunInfo;
        LazyStat<GroupInfo> currentGroupInfo;
        LazyStat<TestCaseInfo> currentTestCaseInfo;

        std::vector<SectionInfo> m_sectionStack;
        ReporterPreferences m_reporterPrefs;
    };

    template<typename DerivedT>
    struct CumulativeReporterBase : IStreamingReporter {
        template<typename T, typename ChildNodeT>
        struct Node {
            explicit Node( T const& _value ) : value( _value ) {}
            virtual ~Node() {}

            using ChildNodes = std::vector<std::shared_ptr<ChildNodeT»;
            T value;
            ChildNodes children;
        };
        struct SectionNode {
            explicit SectionNode(SectionStats const& _stats) : stats(_stats) {}
            virtual ~SectionNode() = default;

            bool operator == (SectionNode const& other) const {
                return stats.sectionInfo.lineInfo == other.stats.sectionInfo.lineInfo;
            }
            bool operator == (std::shared_ptr<SectionNode> const& other) const {
                return operator==(*other);
            }

            SectionStats stats;
            using ChildSections = std::vector<std::shared_ptr<SectionNode»;
            using Assertions = std::vector<AssertionStats>;
            ChildSections childSections;
            Assertions assertions;
            std::string stdOut;
            std::string stdErr;
        };

        struct BySectionInfo {
            BySectionInfo( SectionInfo const& other ) : m_other( other ) {}
            BySectionInfo( BySectionInfo const& other ) : m_other( other.m_other ) {}
            bool operator() (std::shared_ptr<SectionNode> const& node) const {
                return ((node->stats.sectionInfo.name == m_other.name) &&
                        (node->stats.sectionInfo.lineInfo == m_other.lineInfo));
            }
            void operator=(BySectionInfo const&) = delete;

        private:
            SectionInfo const& m_other;
        };

        using TestCaseNode = Node<TestCaseStats, SectionNode>;
        using TestGroupNode = Node<TestGroupStats, TestCaseNode>;
        using TestRunNode = Node<TestRunStats, TestGroupNode>;

        CumulativeReporterBase( ReporterConfig const& _config )
        :   m_config( _config.fullConfig() ),
            stream( _config.stream() )
        {
            m_reporterPrefs.shouldRedirectStdOut = false;
            if( !DerivedT::getSupportedVerbosities().count( m_config->verbosity() ) )
                CATCH_ERROR( "Verbosity level not supported by this reporter" );
        }
        ~CumulativeReporterBase() override = default;

        ReporterPreferences getPreferences() const override {
            return m_reporterPrefs;
        }

        static std::set<Verbosity> getSupportedVerbosities() {
            return { Verbosity::Normal };
        }

        void testRunStarting( TestRunInfo const& ) override {}
        void testGroupStarting( GroupInfo const& ) override {}

        void testCaseStarting( TestCaseInfo const& ) override {}

        void sectionStarting( SectionInfo const& sectionInfo ) override {
            SectionStats incompleteStats( sectionInfo, Counts(), 0, false );
            std::shared_ptr<SectionNode> node;
            if( m_sectionStack.empty() ) {
                if( !m_rootSection )
                    m_rootSection = std::make_shared<SectionNode>( incompleteStats );
                node = m_rootSection;
            }
            else {
                SectionNode& parentNode = *m_sectionStack.back();
                auto it =
                    std::find_if(   parentNode.childSections.begin(),
                                    parentNode.childSections.end(),
                                    BySectionInfo( sectionInfo ) );
                if( it == parentNode.childSections.end() ) {
                    node = std::make_shared<SectionNode>( incompleteStats );
                    parentNode.childSections.push_back( node );
                }
                else
                    node = *it;
            }
            m_sectionStack.push_back( node );
            m_deepestSection = std::move(node);
        }

        void assertionStarting(AssertionInfo const&) override {}

        bool assertionEnded(AssertionStats const& assertionStats) override {
            assert(!m_sectionStack.empty());
            // AssertionResult holds a pointer to a temporary DecomposedExpression,
            // which getExpandedExpression() calls to build the expression string.
            // Our section stack copy of the assertionResult will likely outlive the
            // temporary, so it must be expanded or discarded now to avoid calling
            // a destroyed object later.
            prepareExpandedExpression(const_cast<AssertionResult&>( assertionStats.assertionResult )
);
            SectionNode& sectionNode = *m_sectionStack.back();
            sectionNode.assertions.push_back(assertionStats);
            return true;
        }
        void sectionEnded(SectionStats const& sectionStats) override {
            assert(!m_sectionStack.empty());
            SectionNode& node = *m_sectionStack.back();
            node.stats = sectionStats;
            m_sectionStack.pop_back();
        }
        void testCaseEnded(TestCaseStats const& testCaseStats) override {
            auto node = std::make_shared<TestCaseNode>(testCaseStats);
            assert(m_sectionStack.size() == 0);
            node->children.push_back(m_rootSection);
            m_testCases.push_back(node);
            m_rootSection.reset();

            assert(m_deepestSection);
            m_deepestSection->stdOut = testCaseStats.stdOut;
            m_deepestSection->stdErr = testCaseStats.stdErr;
        }
        void testGroupEnded(TestGroupStats const& testGroupStats) override {
            auto node = std::make_shared<TestGroupNode>(testGroupStats);
            node->children.swap(m_testCases);
            m_testGroups.push_back(node);
        }
        void testRunEnded(TestRunStats const& testRunStats) override {
            auto node = std::make_shared<TestRunNode>(testRunStats);
            node->children.swap(m_testGroups);
            m_testRuns.push_back(node);
            testRunEndedCumulative();
        }
        virtual void testRunEndedCumulative() = 0;

        void skipTest(TestCaseInfo const&) override {}

        IConfigPtr m_config;
        std::ostream& stream;
        std::vector<AssertionStats> m_assertions;
        std::vector<std::vector<std::shared_ptr<SectionNode>>> m_sections;
        std::vector<std::shared_ptr<TestCaseNode>> m_testCases;
        std::vector<std::shared_ptr<TestGroupNode>> m_testGroups;

        std::vector<std::shared_ptr<TestRunNode>> m_testRuns;

        std::shared_ptr<SectionNode> m_rootSection;
        std::shared_ptr<SectionNode> m_deepestSection;
        std::vector<std::shared_ptr<SectionNode>> m_sectionStack;
        ReporterPreferences m_reporterPrefs;
    };

    template<char C>
    char const* getLineOfChars() {
        static char line[CATCH_CONFIG_CONSOLE_WIDTH] = {0};
        if( !*line ) {
            std::memset( line, C, CATCH_CONFIG_CONSOLE_WIDTH-1 );
            line[CATCH_CONFIG_CONSOLE_WIDTH-1] = 0;
        }
        return line;
    }

    struct TestEventListenerBase : StreamingReporterBase<TestEventListenerBase> {
        TestEventListenerBase( ReporterConfig const& _config );

        static std::set<Verbosity> getSupportedVerbosities();

        void assertionStarting(AssertionInfo const&) override;
        bool assertionEnded(AssertionStats const&) override;
    };

} // end namespace Catch

// end catch_reporter_bases.hpp
// start catch_console_colour.h

namespace Catch {

    struct Colour {
        enum Code {
            None = 0,

            White,
            Red,
            Green,
            Blue,
            Cyan,
            Yellow,
            Grey,

            Bright = 0x10,

            BrightRed = Bright | Red,
            BrightGreen = Bright | Green,
            LightGrey = Bright | Grey,
            BrightWhite = Bright | White,
            BrightYellow = Bright | Yellow,

            // By intention
            FileName = LightGrey,
            Warning = BrightYellow,
            ResultError = BrightRed,
            ResultSuccess = BrightGreen,
            ResultExpectedFailure = Warning,

            Error = BrightRed,
            Success = Green,

            OriginalExpression = Cyan,
            ReconstructedExpression = BrightYellow,

            SecondaryText = LightGrey,
            Headers = White
        };

        // Use constructed object for RAII guard
        Colour( Code _colourCode );
        Colour( Colour&& other ) noexcept;
        Colour& operator=( Colour&& other ) noexcept;
        ~Colour();

        // Use static method for one-shot changes
        static void use( Code _colourCode );

    private:
        bool m_moved = false;
    };

    std::ostream& operator « ( std::ostream& os, Colour const& );

} // end namespace Catch

// end catch_console_colour.h
// start catch_reporter_registrars.hpp


namespace Catch {

    template<typename T>
    class ReporterRegistrar {

        class ReporterFactory : public IReporterFactory {

            IStreamingReporterPtr create( ReporterConfig const& config ) const override {
                return std::unique_ptr<T>( new T( config ) );
            }

            std::string getDescription() const override {
                return T::getDescription();
            }
        };

    public:

        explicit ReporterRegistrar( std::string const& name ) {
            getMutableRegistryHub().registerReporter( name, std::make_shared<ReporterFactory>() );
        }
    };

    template<typename T>
    class ListenerRegistrar {

        class ListenerFactory : public IReporterFactory {

            IStreamingReporterPtr create( ReporterConfig const& config ) const override {
                return std::unique_ptr<T>( new T( config ) );
            }
            std::string getDescription() const override {
                return std::string();
            }
        };

    public:

        ListenerRegistrar() {
            getMutableRegistryHub().registerListener( std::make_shared<ListenerFactory>() );
        }
    };
}

#if !defined(CATCH_CONFIG_DISABLE)

#define CATCH_REGISTER_REPORTER( name, reporterType ) \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION         \
    CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS          \
    namespace{ Catch::ReporterRegistrar<reporterType> catch_internal_RegistrarFor##reporterType( name
); } \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

#define CATCH_REGISTER_LISTENER( listenerType ) \
    CATCH_INTERNAL_START_WARNINGS_SUPPRESSION   \
    CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS    \
    namespace{ Catch::ListenerRegistrar<listenerType> catch_internal_RegistrarFor##listenerType; } \
    CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION
#else // CATCH_CONFIG_DISABLE

#define CATCH_REGISTER_REPORTER(name, reporterType)
#define CATCH_REGISTER_LISTENER(listenerType)

#endif // CATCH_CONFIG_DISABLE

// end catch_reporter_registrars.hpp
// Allow users to base their work off existing reporters
// start catch_reporter_compact.h

namespace Catch {

    struct CompactReporter : StreamingReporterBase<CompactReporter> {

        using StreamingReporterBase::StreamingReporterBase;

        ~CompactReporter() override;

        static std::string getDescription();

        void noMatchingTestCases(std::string const& spec) override;

        void assertionStarting(AssertionInfo const&) override;

        bool assertionEnded(AssertionStats const& _assertionStats) override;

        void sectionEnded(SectionStats const& _sectionStats) override;

        void testRunEnded(TestRunStats const& _testRunStats) override;

    };

} // end namespace Catch

// end catch_reporter_compact.h
// start catch_reporter_console.h

#if defined(_MSC_VER)
#pragma warning(push)
#pragma warning(disable:4061) // Not all labels are EXPLICITLY handled in switch
                              // Note that 4062 (not all labels are handled
                              // and default is missing) is enabled
#endif

```

```
namespace Catch {
    // Fwd decls
    struct SummaryColumn;
    class TablePrinter;

    struct ConsoleReporter : StreamingReporterBase<ConsoleReporter> {
        std::unique_ptr<TablePrinter> m_tablePrinter;

        ConsoleReporter(ReporterConfig const& config);
        ~ConsoleReporter() override;
        static std::string getDescription();

        void noMatchingTestCases(std::string const& spec) override;

        void reportInvalidArguments(std::string const&arg) override;

        void assertionStarting(AssertionInfo const&) override;

        bool assertionEnded(AssertionStats const& _assertionStats) override;

        void sectionStarting(SectionInfo const& _sectionInfo) override;
        void sectionEnded(SectionStats const& _sectionStats) override;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        void benchmarkPreparing(std::string const& name) override;
        void benchmarkStarting(BenchmarkInfo const& info) override;
        void benchmarkEnded(BenchmarkStats<> const& stats) override;
        void benchmarkFailed(std::string const& error) override;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

        void testCaseEnded(TestCaseStats const& _testCaseStats) override;
        void testGroupEnded(TestGroupStats const& _testGroupStats) override;
        void testRunEnded(TestRunStats const& _testRunStats) override;
        void testRunStarting(TestRunInfo const& _testRunInfo) override;
    private:

        void lazyPrint();

        void lazyPrintWithoutClosingBenchmarkTable();
        void lazyPrintRunInfo();
        void lazyPrintGroupInfo();
        void printTestCaseAndSectionHeader();

        void printClosedHeader(std::string const& _name);
        void printOpenHeader(std::string const& _name);

        // if string has a : in first line will set indent to follow it on
        // subsequent lines
        void printHeaderString(std::string const& _string, std::size_t indent = 0);

        void printTotals(Totals const& totals);
        void printSummaryRow(std::string const& label, std::vector<SummaryColumn> const& cols,
std::size_t row);

        void printTotalsDivider(Totals const& totals);
        void printSummaryDivider();
        void printTestFilters();

    private:
        bool m_headerPrinted = false;
    };

} // end namespace Catch

#if defined(_MSC_VER)
#pragma warning(pop)
#endif

// end catch_reporter_console.h
// start catch_reporter_junit.h

// start catch_xmlwriter.h

#include <vector>

namespace Catch {
    enum class XmlFormatting {
        None = 0x00,
        Indent = 0x01,
        Newline = 0x02,
    };

    XmlFormatting operator | (XmlFormatting lhs, XmlFormatting rhs);
    XmlFormatting operator & (XmlFormatting lhs, XmlFormatting rhs);

    class XmlEncode {
    public:
        enum ForWhat { ForTextNodes, ForAttributes };

        XmlEncode( std::string const& str, ForWhat forWhat = ForTextNodes );

        void encodeTo( std::ostream& os ) const;

        friend std::ostream& operator « ( std::ostream& os, XmlEncode const& xmlEncode );

    private:
        std::string m_str;
        ForWhat m_forWhat;
    };

    class XmlWriter {
    public:

        class ScopedElement {
        public:
            ScopedElement( XmlWriter* writer, XmlFormatting fmt );

            ScopedElement( ScopedElement&& other ) noexcept;
            ScopedElement& operator=( ScopedElement&& other ) noexcept;

            ~ScopedElement();

            ScopedElement& writeText( std::string const& text, XmlFormatting fmt =
XmlFormatting::Newline | XmlFormatting::Indent );

            template<typename T>
            ScopedElement& writeAttribute( std::string const& name, T const& attribute ) {
                m_writer->writeAttribute( name, attribute );
                return *this;
            }

        private:
            mutable XmlWriter* m_writer = nullptr;
            XmlFormatting m_fmt;
        };

        XmlWriter( std::ostream& os = Catch::cout() );
        ~XmlWriter();

        XmlWriter( XmlWriter const& ) = delete;
        XmlWriter& operator=( XmlWriter const& ) = delete;

        XmlWriter& startElement( std::string const& name, XmlFormatting fmt = XmlFormatting::Newline |
XmlFormatting::Indent);

        ScopedElement scopedElement( std::string const& name, XmlFormatting fmt =
XmlFormatting::Newline | XmlFormatting::Indent);

        XmlWriter& endElement(XmlFormatting fmt = XmlFormatting::Newline | XmlFormatting::Indent);

        XmlWriter& writeAttribute( std::string const& name, std::string const& attribute );

        XmlWriter& writeAttribute( std::string const& name, bool attribute );

        template<typename T>
        XmlWriter& writeAttribute( std::string const& name, T const& attribute ) {
            ReusableStringStream rss;
            rss « attribute;
            return writeAttribute( name, rss.str() );
        }

        XmlWriter& writeText( std::string const& text, XmlFormatting fmt = XmlFormatting::Newline |
XmlFormatting::Indent);

        XmlWriter& writeComment(std::string const& text, XmlFormatting fmt = XmlFormatting::Newline |
XmlFormatting::Indent);

        void writeStylesheetRef( std::string const& url );

        XmlWriter& writeBlankLine();

        void ensureTagClosed();

    private:

        void applyFormatting(XmlFormatting fmt);

        void writeDeclaration();

        void newlineIfNecessary();

        bool m_tagIsOpen = false;
        bool m_needsNewline = false;
        std::vector<std::string> m_tags;
        std::string m_indent;
        std::ostream& m_os;
    };

}

// end catch_xmlwriter.h
namespace Catch {

    class JunitReporter : public CumulativeReporterBase<JunitReporter> {
    public:
        JunitReporter(ReporterConfig const& _config);

        ~JunitReporter() override;

        static std::string getDescription();

        void noMatchingTestCases(std::string const& /*spec*/) override;

        void testRunStarting(TestRunInfo const& runInfo) override;

        void testGroupStarting(GroupInfo const& groupInfo) override;

        void testCaseStarting(TestCaseInfo const& testCaseInfo) override;
        bool assertionEnded(AssertionStats const& assertionStats) override;

        void testCaseEnded(TestCaseStats const& testCaseStats) override;

        void testGroupEnded(TestGroupStats const& testGroupStats) override;

        void testRunEndedCumulative() override;

        void writeGroup(TestGroupNode const& groupNode, double suiteTime);

        void writeTestCase(TestCaseNode const& testCaseNode);

        void writeSection( std::string const& className,
                           std::string const& rootName,
                           SectionNode const& sectionNode,
                           bool testOkToFail );

        void writeAssertions(SectionNode const& sectionNode);
        void writeAssertion(AssertionStats const& stats);

        XmlWriter xml;
        Timer suiteTimer;
        std::string stdOutForSuite;
        std::string stdErrForSuite;
        unsigned int unexpectedExceptions = 0;
        bool m_okToFail = false;
    };

} // end namespace Catch

// end catch_reporter_junit.h
// start catch_reporter_xml.h

namespace Catch {
    class XmlReporter : public StreamingReporterBase<XmlReporter> {
    public:
        XmlReporter(ReporterConfig const& _config);

        ~XmlReporter() override;

        static std::string getDescription();

        virtual std::string getStylesheetRef() const;

        void writeSourceInfo(SourceLineInfo const& sourceInfo);

    public: // StreamingReporterBase

        void noMatchingTestCases(std::string const& s) override;

        void testRunStarting(TestRunInfo const& testInfo) override;

        void testGroupStarting(GroupInfo const& groupInfo) override;

        void testCaseStarting(TestCaseInfo const& testInfo) override;

        void sectionStarting(SectionInfo const& sectionInfo) override;

        void assertionStarting(AssertionInfo const&) override;

        bool assertionEnded(AssertionStats const& assertionStats) override;

        void sectionEnded(SectionStats const& sectionStats) override;

        void testCaseEnded(TestCaseStats const& testCaseStats) override;

        void testGroupEnded(TestGroupStats const& testGroupStats) override;

        void testRunEnded(TestRunStats const& testRunStats) override;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        void benchmarkPreparing(std::string const& name) override;
        void benchmarkStarting(BenchmarkInfo const&) override;
        void benchmarkEnded(BenchmarkStats<> const&) override;
        void benchmarkFailed(std::string const&) override;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

    private:
        Timer m_testCaseTimer;
        XmlWriter m_xml;
        int m_sectionDepth = 0;
    };

} // end namespace Catch

// end catch_reporter_xml.h

// end catch_external_interfaces.h
#endif

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
// start catch_benchmarking_all.hpp

// A proxy header that includes all of the benchmarking headers to allow
// concise include of the benchmarking features. You should prefer the
// individual includes in standard use.

// start catch_benchmark.hpp

 // Benchmark

// start catch_chronometer.hpp

// User-facing chronometer


// start catch_clock.hpp

// Clocks


#include <chrono>
#include <ratio>

namespace Catch {
    namespace Benchmark {
        template <typename Clock>
        using ClockDuration = typename Clock::duration;
        template <typename Clock>
        using FloatDuration = std::chrono::duration<double, typename Clock::period>;

        template <typename Clock>
        using TimePoint = typename Clock::time_point;

        using default_clock = std::chrono::steady_clock;

        template <typename Clock>
        struct now {
            TimePoint<Clock> operator()() const {
                return Clock::now();
            }
        };

        using fp_seconds = std::chrono::duration<double, std::ratio<1»;
    } // namespace Benchmark
} // namespace Catch

// end catch_clock.hpp
// start catch_optimizer.hpp

 // Hinting the optimizer


#if defined(_MSC_VER)
#   include <atomic> // atomic_thread_fence
#endif

namespace Catch {
    namespace Benchmark {
#if defined(__GNUC__) || defined(__clang__)
```

```
        template <typename T>
        inline void keep_memory(T* p) {
            asm volatile("" : : "g"(p) : "memory");
        }
        inline void keep_memory() {
            asm volatile("" : : : "memory");
        }

        namespace Detail {
            inline void optimizer_barrier() { keep_memory(); }
        } // namespace Detail
#elif defined(_MSC_VER)

#pragma optimize("", off)
        template <typename T>
        inline void keep_memory(T* p) {
            // thanks @milleniumbug
            *reinterpret_cast<char volatile*>(p) = *reinterpret_cast<char const volatile*>(p);
        }
        // TODO equivalent keep_memory()
#pragma optimize("", on)

        namespace Detail {
            inline void optimizer_barrier() {
                std::atomic_thread_fence(std::memory_order_seq_cst);
            }
        } // namespace Detail

#endif

        template <typename T>
        inline void deoptimize_value(T&& x) {
            keep_memory(&x);
        }

        template <typename Fn, typename... Args>
        inline auto invoke_deoptimized(Fn&& fn, Args&&... args) -> typename
std::enable_if<!std::is_same<void, decltype(fn(args...))>::value>::type {
            deoptimize_value(std::forward<Fn>(fn) (std::forward<Args...>(args...)));
        }

        template <typename Fn, typename... Args>
        inline auto invoke_deoptimized(Fn&& fn, Args&&... args) -> typename
std::enable_if<std::is_same<void, decltype(fn(args...))>::value>::type {
            std::forward<Fn>(fn) (std::forward<Args...>(args...));
        }
    } // namespace Benchmark
} // namespace Catch

// end catch_optimizer.hpp
// start catch_complete_invoke.hpp

// Invoke with a special case for void


#include <type_traits>
#include <utility>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename T>
            struct CompleteType { using type = T; };
            template <>
            struct CompleteType<void> { struct type {}; };

            template <typename T>
            using CompleteType_t = typename CompleteType<T>::type;

            template <typename Result>
            struct CompleteInvoker {
                template <typename Fun, typename... Args>
                static Result invoke(Fun&& fun, Args&&... args) {
                    return std::forward<Fun>(fun)(std::forward<Args>(args)...);
                }
            };
            template <>
            struct CompleteInvoker<void> {
                template <typename Fun, typename... Args>
                static CompleteType_t<void> invoke(Fun&& fun, Args&&... args) {
                    std::forward<Fun>(fun)(std::forward<Args>(args)...);
                    return {};
                }
            };

            // invoke and not return void :(
            template <typename Fun, typename... Args>
            CompleteType_t<FunctionReturnType<Fun, Args...» complete_invoke(Fun&& fun, Args&&... args)
{
                return CompleteInvoker<FunctionReturnType<Fun,
Args...»::invoke(std::forward<Fun>(fun), std::forward<Args>(args)...);
            }

            const std::string benchmarkErrorMsg = "a benchmark failed to run successfully";
        } // namespace Detail

        template <typename Fun>
        Detail::CompleteType_t<FunctionReturnType<Fun» user_code(Fun&& fun) {
            CATCH_TRY{
                return Detail::complete_invoke(std::forward<Fun>(fun));
            } CATCH_CATCH_ALL{
                getResultCapture().benchmarkFailed(translateActiveException());
                CATCH_RUNTIME_ERROR(Detail::benchmarkErrorMsg);
            }
        }
    } // namespace Benchmark
} // namespace Catch

// end catch_complete_invoke.hpp
namespace Catch {
    namespace Benchmark {
        namespace Detail {
            struct ChronometerConcept {
                virtual void start() = 0;
                virtual void finish() = 0;
                virtual ~ChronometerConcept() = default;
            };
            template <typename Clock>
            struct ChronometerModel final : public ChronometerConcept {
                void start() override { started = Clock::now(); }
                void finish() override { finished = Clock::now(); }

                ClockDuration<Clock> elapsed() const { return finished - started; }

                TimePoint<Clock> started;
                TimePoint<Clock> finished;
            };
        } // namespace Detail

        struct Chronometer {
        public:
            template <typename Fun>
            void measure(Fun&& fun) { measure(std::forward<Fun>(fun), is_callable<Fun(int)>()); }

            int runs() const { return k; }

            Chronometer(Detail::ChronometerConcept& meter, int k)
                : impl(&meter)
                , k(k) {}

        private:
            template <typename Fun>
            void measure(Fun&& fun, std::false_type) {
                measure([&fun](int) { return fun(); }, std::true_type());
            }

            template <typename Fun>
            void measure(Fun&& fun, std::true_type) {
                Detail::optimizer_barrier();
                impl->start();
                for (int i = 0; i < k; ++i) invoke_deoptimized(fun, i);
                impl->finish();
                Detail::optimizer_barrier();
            }

            Detail::ChronometerConcept* impl;
            int k;
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_chronometer.hpp
// start catch_environment.hpp

// Environment information


namespace Catch {
    namespace Benchmark {
        template <typename Duration>
        struct EnvironmentEstimate {
            Duration mean;
            OutlierClassification outliers;

            template <typename Duration2>
            operator EnvironmentEstimate<Duration2>() const {
                return { mean, outliers };
            }
        };
        template <typename Clock>
        struct Environment {
            using clock_type = Clock;
            EnvironmentEstimate<FloatDuration<Clock>> clock_resolution;
            EnvironmentEstimate<FloatDuration<Clock>> clock_cost;
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_environment.hpp
// start catch_execution_plan.hpp

 // Execution plan


// start catch_benchmark_function.hpp

 // Dumb std::function implementation for consistent call overhead


#include <cassert>
#include <type_traits>
#include <utility>
#include <memory>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename T>
            using Decay = typename std::decay<T>::type;
            template <typename T, typename U>
            struct is_related
                : std::is_same<Decay<T>, Decay<U>> {};

            struct BenchmarkFunction {
            private:
                struct callable {
                    virtual void call(Chronometer meter) const = 0;
                    virtual callable* clone() const = 0;
                    virtual ~callable() = default;
                };
                template <typename Fun>
                struct model : public callable {
                    model(Fun&& fun) : fun(std::move(fun)) {}
                    model(Fun const& fun) : fun(fun) {}

                    model<Fun>* clone() const override { return new model<Fun>(*this); }

                    void call(Chronometer meter) const override {
                        call(meter, is_callable<Fun(Chronometer)>());
                    }
                    void call(Chronometer meter, std::true_type) const {
                        fun(meter);
                    }
                    void call(Chronometer meter, std::false_type) const {
                        meter.measure(fun);
                    }

                    Fun fun;
                };

                struct do_nothing { void operator()() const {} };

                template <typename T>
                BenchmarkFunction(model<T>* c) : f(c) {}

            public:
                BenchmarkFunction()
                    : f(new model<do_nothing>{ {} }) {}

                template <typename Fun,
                    typename std::enable_if<!is_related<Fun, BenchmarkFunction>::value, int>::type =
0>
                    BenchmarkFunction(Fun&& fun)
                    : f(new model<typename std::decay<Fun>::type>(std::forward<Fun>(fun))) {}

                BenchmarkFunction(BenchmarkFunction&& that)
                    : f(std::move(that.f)) {}

                BenchmarkFunction(BenchmarkFunction const& that)
                    : f(that.f->clone()) {}

                BenchmarkFunction& operator=(BenchmarkFunction&& that) {
                    f = std::move(that.f);
                    return *this;
                }

                BenchmarkFunction& operator=(BenchmarkFunction const& that) {
                    f.reset(that.f->clone());
                    return *this;
                }

                void operator()(Chronometer meter) const { f->call(meter); }

            private:
                std::unique_ptr<callable> f;
            };
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_benchmark_function.hpp
// start catch_repeat.hpp

// repeat algorithm


#include <type_traits>
#include <utility>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename Fun>
            struct repeater {
                void operator()(int k) const {
                    for (int i = 0; i < k; ++i) {
                        fun();
                    }
                }
                Fun fun;
            };
            template <typename Fun>
            repeater<typename std::decay<Fun>::type> repeat(Fun&& fun) {
                return { std::forward<Fun>(fun) };
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_repeat.hpp
// start catch_run_for_at_least.hpp

// Run a function for a minimum amount of time


// start catch_measure.hpp

// Measure


// start catch_timing.hpp

// Timing


#include <tuple>
#include <type_traits>

namespace Catch {
    namespace Benchmark {
        template <typename Duration, typename Result>
        struct Timing {
            Duration elapsed;
            Result result;
            int iterations;
        };
        template <typename Clock, typename Func, typename... Args>
        using TimingOf = Timing<ClockDuration<Clock>, Detail::CompleteType_t<FunctionReturnType<Func,
Args...»>;
    } // namespace Benchmark
} // namespace Catch

// end catch_timing.hpp
#include <utility>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename Clock, typename Fun, typename... Args>
            TimingOf<Clock, Fun, Args...> measure(Fun&& fun, Args&&... args) {
                auto start = Clock::now();
                auto&& r = Detail::complete_invoke(fun, std::forward<Args>(args)...);
                auto end = Clock::now();
                auto delta = end - start;
                return { delta, std::forward<decltype(r)>(r), 1 };
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_measure.hpp
#include <utility>
#include <type_traits>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename Clock, typename Fun>
            TimingOf<Clock, Fun, int> measure_one(Fun&& fun, int iters, std::false_type) {
                return Detail::measure<Clock>(fun, iters);
            }
            template <typename Clock, typename Fun>
            TimingOf<Clock, Fun, Chronometer> measure_one(Fun&& fun, int iters, std::true_type) {
                Detail::ChronometerModel<Clock> meter;
                auto&& result = Detail::complete_invoke(fun, Chronometer(meter, iters));

                return { meter.elapsed(), std::move(result), iters };
            }

            template <typename Clock, typename Fun>
            using run_for_at_least_argument_t = typename
std::conditional<is_callable<Fun(Chronometer)>::value, Chronometer, int>::type;

            struct optimized_away_error : std::exception {
                const char* what() const noexcept override {
                    return "could not measure benchmark, maybe it was optimized away";
                }
            };

            template <typename Clock, typename Fun>
            TimingOf<Clock, Fun, run_for_at_least_argument_t<Clock, Fun»
run_for_at_least(ClockDuration<Clock> how_long, int seed, Fun&& fun) {
                auto iters = seed;
                while (iters < (1 « 30)) {
                    auto&& Timing = measure_one<Clock>(fun, iters, is_callable<Fun(Chronometer)>());

                    if (Timing.elapsed >= how_long) {
                        return { Timing.elapsed, std::move(Timing.result), iters };
                    }
                    iters *= 2;
                }
                Catch::throw_exception(optimized_away_error{});
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_run_for_at_least.hpp
#include <algorithm>
#include <iterator>

namespace Catch {
    namespace Benchmark {
        template <typename Duration>
        struct ExecutionPlan {
            int iterations_per_sample;
            Duration estimated_duration;
            Detail::BenchmarkFunction benchmark;
            Duration warmup_time;
            int warmup_iterations;

            template <typename Duration2>
            operator ExecutionPlan<Duration2>() const {
                return { iterations_per_sample, estimated_duration, benchmark, warmup_time,
warmup_iterations };
            }

            template <typename Clock>
            std::vector<FloatDuration<Clock» run(const IConfig &cfg, Environment<FloatDuration<Clock»
env) const {
                // warmup a bit

Detail::run_for_at_least<Clock>(std::chrono::duration_cast<ClockDuration<Clock»(warmup_time),
warmup_iterations, Detail::repeat(now<Clock>{}));

```

```
                std::vector<FloatDuration<Clock>> times;
                times.reserve(cfg.benchmarkSamples());
                std::generate_n(std::back_inserter(times), cfg.benchmarkSamples(), [this, env] {
                    Detail::ChronometerModel<Clock> model;
                    this->benchmark(Chronometer(model, iterations_per_sample));
                    auto sample_time = model.elapsed() - env.clock_cost.mean;
                    if (sample_time < FloatDuration<Clock>::zero()) sample_time =
FloatDuration<Clock>::zero();
                    return sample_time / iterations_per_sample;
                });
                return times;
            }
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_execution_plan.hpp
// start catch_estimate_clock.hpp

 // Environment measurement


// start catch_stats.hpp

// Statistical analysis tools


#include <algorithm>
#include <functional>
#include <vector>
#include <iterator>
#include <numeric>
#include <tuple>
#include <cmath>
#include <utility>
#include <cstddef>
#include <random>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            using sample = std::vector<double>;

            double weighted_average_quantile(int k, int q, std::vector<double>::iterator first,
std::vector<double>::iterator last);

            template <typename Iterator>
            OutlierClassification classify_outliers(Iterator first, Iterator last) {
                std::vector<double> copy(first, last);

                auto q1 = weighted_average_quantile(1, 4, copy.begin(), copy.end());
                auto q3 = weighted_average_quantile(3, 4, copy.begin(), copy.end());
                auto iqr = q3 - q1;
                auto los = q1 - (iqr * 3.);
                auto lom = q1 - (iqr * 1.5);
                auto him = q3 + (iqr * 1.5);
                auto his = q3 + (iqr * 3.);

                OutlierClassification o;
                for (; first != last; ++first) {
                    auto&& t = *first;
                    if (t < los) ++o.low_severe;
                    else if (t < lom) ++o.low_mild;
                    else if (t > his) ++o.high_severe;
                    else if (t > him) ++o.high_mild;
                    ++o.samples_seen;
                }
                return o;
            }

            template <typename Iterator>
            double mean(Iterator first, Iterator last) {
                auto count = last - first;
                double sum = std::accumulate(first, last, 0.);
                return sum / count;
            }

            template <typename URng, typename Iterator, typename Estimator>
            sample resample(URng& rng, int resamples, Iterator first, Iterator last, Estimator&
estimator) {
                auto n = last - first;
                std::uniform_int_distribution<decltype(n)> dist(0, n - 1);

                sample out;
                out.reserve(resamples);
                std::generate_n(std::back_inserter(out), resamples, [n, first, &estimator, &dist,
&rng] {
```

```
                    std::vector<double> resampled;
                    resampled.reserve(n);
                    std::generate_n(std::back_inserter(resampled), n, [first, &dist, &rng] { return first[dist(rng)]; });
                    return estimator(resampled.begin(), resampled.end());
                });
                std::sort(out.begin(), out.end());
                return out;
            }

            template <typename Estimator, typename Iterator>
            sample jackknife(Estimator&& estimator, Iterator first, Iterator last) {
                auto n = last - first;
                auto second = std::next(first);
                sample results;
                results.reserve(n);

                for (auto it = first; it != last; ++it) {
                    std::iter_swap(it, first);
                    results.push_back(estimator(second, last));
                }

                return results;
            }

            inline double normal_cdf(double x) {
                return std::erfc(-x / std::sqrt(2.0)) / 2.0;
            }

            double erfc_inv(double x);

            double normal_quantile(double p);

            template <typename Iterator, typename Estimator>
            Estimate<double> bootstrap(double confidence_level, Iterator first, Iterator last, sample const& resample, Estimator&& estimator) {
                auto n_samples = last - first;

                double point = estimator(first, last);
                // Degenerate case with a single sample
                if (n_samples == 1) return { point, point, point, confidence_level };

                sample jack = jackknife(estimator, first, last);
                double jack_mean = mean(jack.begin(), jack.end());
                double sum_squares, sum_cubes;
                std::tie(sum_squares, sum_cubes) = std::accumulate(jack.begin(), jack.end(), std::make_pair(0., 0.), [jack_mean](std::pair<double, double> sqcb, double x) -> std::pair<double, double> {
                    auto d = jack_mean - x;
                    auto d2 = d * d;
                    auto d3 = d2 * d;
                    return { sqcb.first + d2, sqcb.second + d3 };
                });

                double accel = sum_cubes / (6 * std::pow(sum_squares, 1.5));
                int n = static_cast<int>(resample.size());
                double prob_n = std::count_if(resample.begin(), resample.end(), [point](double x) { return x < point; }) / (double)n;
                // degenerate case with uniform samples
                if (prob_n == 0) return { point, point, point, confidence_level };

                double bias = normal_quantile(prob_n);
                double z1 = normal_quantile((1. - confidence_level) / 2.);

                auto cumn = [n](double x) -> int {
                    return std::lround(normal_cdf(x) * n); };
                auto a = [bias, accel](double b) { return bias + b / (1. - accel * b); };
                double b1 = bias + z1;
                double b2 = bias - z1;
                double a1 = a(b1);
                double a2 = a(b2);
                auto lo = (std::max)(cumn(a1), 0);
                auto hi = (std::min)(cumn(a2), n - 1);

                return { point, resample[lo], resample[hi], confidence_level };
            }

            double outlier_variance(Estimate<double> mean, Estimate<double> stddev, int n);

            struct bootstrap_analysis {
                Estimate<double> mean;
                Estimate<double> standard_deviation;
                double outlier_variance;
            };

            bootstrap_analysis analyse_samples(double confidence_level, int n_resamples, std::vector<double>::iterator first, std::vector<double>::iterator last);
```

```
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_stats.hpp
#include <algorithm>
#include <iterator>
#include <tuple>
#include <vector>
#include <cmath>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename Clock>
            std::vector<double> resolution(int k) {
                std::vector<TimePoint<Clock>> times;
                times.reserve(k + 1);
                std::generate_n(std::back_inserter(times), k + 1, now<Clock>{});

                std::vector<double> deltas;
                deltas.reserve(k);
                std::transform(std::next(times.begin()), times.end(), times.begin(),
                    std::back_inserter(deltas),
                    [](TimePoint<Clock> a, TimePoint<Clock> b) { return static_cast<double>((a -
b).count()); });

                return deltas;
            }

            const auto warmup_iterations = 10000;
            const auto warmup_time = std::chrono::milliseconds(100);
            const auto minimum_ticks = 1000;
            const auto warmup_seed = 10000;
            const auto clock_resolution_estimation_time = std::chrono::milliseconds(500);
            const auto clock_cost_estimation_time_limit = std::chrono::seconds(1);
            const auto clock_cost_estimation_tick_limit = 100000;
            const auto clock_cost_estimation_time = std::chrono::milliseconds(10);
            const auto clock_cost_estimation_iterations = 10000;

            template <typename Clock>
            int warmup() {
                return
run_for_at_least<Clock>(std::chrono::duration_cast<ClockDuration<Clock>>(warmup_time), warmup_seed,
&resolution<Clock>)
                    .iterations;
            }
            template <typename Clock>
            EnvironmentEstimate<FloatDuration<Clock>> estimate_clock_resolution(int iterations) {
                auto r =
run_for_at_least<Clock>(std::chrono::duration_cast<ClockDuration<Clock>>(clock_resolution_estimation_time),
iterations, &resolution<Clock>)
                    .result;
                return {
                    FloatDuration<Clock>(mean(r.begin(), r.end())),
                    classify_outliers(r.begin(), r.end()),
                };
            }
            template <typename Clock>
            EnvironmentEstimate<FloatDuration<Clock>> estimate_clock_cost(FloatDuration<Clock>
resolution) {
                auto time_limit = (std::min)(
                    resolution * clock_cost_estimation_tick_limit,
                    FloatDuration<Clock>(clock_cost_estimation_time_limit));
                auto time_clock = [](int k) {
                    return Detail::measure<Clock>([k] {
                        for (int i = 0; i < k; ++i) {
                            volatile auto ignored = Clock::now();
                            (void)ignored;
                        }
                    }).elapsed;
                };
                time_clock(1);
                int iters = clock_cost_estimation_iterations;
                auto&& r =
run_for_at_least<Clock>(std::chrono::duration_cast<ClockDuration<Clock>>(clock_cost_estimation_time),
iters, time_clock);
                std::vector<double> times;
                int nsamples = static_cast<int>(std::ceil(time_limit / r.elapsed));
                times.reserve(nsamples);
                std::generate_n(std::back_inserter(times), nsamples, [time_clock, &r] {
                    return static_cast<double>((time_clock(r.iterations) / r.iterations).count());
                });
                return {
                    FloatDuration<Clock>(mean(times.begin(), times.end())),
                    classify_outliers(times.begin(), times.end()),
                };
            }

            template <typename Clock>
            Environment<FloatDuration<Clock>> measure_environment() {
                static Environment<FloatDuration<Clock>>* env = nullptr;
                if (env) {
                    return *env;
                }

                auto iters = Detail::warmup<Clock>();
                auto resolution = Detail::estimate_clock_resolution<Clock>(iters);
                auto cost = Detail::estimate_clock_cost<Clock>(resolution.mean);

                env = new Environment<FloatDuration<Clock>>{ resolution, cost };
                return *env;
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_estimate_clock.hpp
// start catch_analyse.hpp

 // Run and analyse one benchmark


// start catch_sample_analysis.hpp

// Benchmark results


#include <algorithm>
#include <vector>
#include <string>
#include <iterator>

namespace Catch {
    namespace Benchmark {
        template <typename Duration>
        struct SampleAnalysis {
            std::vector<Duration> samples;
            Estimate<Duration> mean;
            Estimate<Duration> standard_deviation;
            OutlierClassification outliers;
            double outlier_variance;

            template <typename Duration2>
            operator SampleAnalysis<Duration2>() const {
                std::vector<Duration2> samples2;
                samples2.reserve(samples.size());
                std::transform(samples.begin(), samples.end(), std::back_inserter(samples2),
[](Duration d) { return Duration2(d); });
                return {
                    std::move(samples2),
                    mean,
                    standard_deviation,
                    outliers,
                    outlier_variance,
                };
            }
        };
    } // namespace Benchmark
} // namespace Catch

// end catch_sample_analysis.hpp
#include <algorithm>
#include <iterator>
#include <vector>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename Duration, typename Iterator>
            SampleAnalysis<Duration> analyse(const IConfig &cfg, Environment<Duration>, Iterator
first, Iterator last) {
                if (!cfg.benchmarkNoAnalysis()) {
                    std::vector<double> samples;
                    samples.reserve(last - first);
                    std::transform(first, last, std::back_inserter(samples), [](Duration d) { return
d.count(); });

                    auto analysis =
Catch::Benchmark::Detail::analyse_samples(cfg.benchmarkConfidenceInterval(), cfg.benchmarkResamples(),
samples.begin(), samples.end());
                    auto outliers = Catch::Benchmark::Detail::classify_outliers(samples.begin(),
samples.end());

```

```
                    auto wrap_estimate = [](Estimate<double> e) {
                        return Estimate<Duration> {
                            Duration(e.point),
                                Duration(e.lower_bound),
                                Duration(e.upper_bound),
                                e.confidence_interval,
                        };
                    };
                    std::vector<Duration> samples2;
                    samples2.reserve(samples.size());
                    std::transform(samples.begin(), samples.end(), std::back_inserter(samples2),
 [](double d) { return Duration(d); });
                    return {
                        std::move(samples2),
                        wrap_estimate(analysis.mean),
                        wrap_estimate(analysis.standard_deviation),
                        outliers,
                        analysis.outlier_variance,
                    };
                } else {
                    std::vector<Duration> samples;
                    samples.reserve(last - first);

                    Duration mean = Duration(0);
                    int i = 0;
                    for (auto it = first; it < last; ++it, ++i) {
                        samples.push_back(Duration(*it));
                        mean += Duration(*it);
                    }
                    mean /= i;

                    return {
                        std::move(samples),
                        Estimate<Duration>{mean, mean, mean, 0.0},
                        Estimate<Duration>{Duration(0), Duration(0), Duration(0), 0.0},
                        OutlierClassification{},
                        0.0
                    };
                }
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

// end catch_analyse.hpp
#include <algorithm>
#include <functional>
#include <string>
#include <vector>
#include <cmath>

namespace Catch {
    namespace Benchmark {
        struct Benchmark {
            Benchmark(std::string &&name)
                : name(std::move(name)) {}

            template <class FUN>
            Benchmark(std::string &&name, FUN &&func)
                : fun(std::move(func)), name(std::move(name)) {}

            template <typename Clock>
            ExecutionPlan<FloatDuration<Clock>> prepare(const IConfig &cfg,
Environment<FloatDuration<Clock>> env) const {
                auto min_time = env.clock_resolution.mean * Detail::minimum_ticks;
                auto run_time = std::max(min_time,
std::chrono::duration_cast<decltype(min_time)>(cfg.benchmarkWarmupTime()));
                auto&& test =
Detail::run_for_at_least<Clock>(std::chrono::duration_cast<ClockDuration<Clock>>(run_time), 1, fun);
                int new_iters = static_cast<int>(std::ceil(min_time * test.iterations /
test.elapsed));
                return { new_iters, test.elapsed / test.iterations * new_iters *
cfg.benchmarkSamples(), fun,
std::chrono::duration_cast<FloatDuration<Clock>>(cfg.benchmarkWarmupTime()), Detail::warmup_iterations
};
            }

            template <typename Clock = default_clock>
            void run() {
                IConfigPtr cfg = getCurrentContext().getConfig();

                auto env = Detail::measure_environment<Clock>();

                getResultCapture().benchmarkPreparing(name);
                CATCH_TRY{
                    auto plan = user_code([&] {
                        return prepare<Clock>(*cfg, env);
                    });

                    BenchmarkInfo info {
                        name,
                        plan.estimated_duration.count(),
                        plan.iterations_per_sample,
                        cfg->benchmarkSamples(),
                        cfg->benchmarkResamples(),
                        env.clock_resolution.mean.count(),
                        env.clock_cost.mean.count()
                    };

                    getResultCapture().benchmarkStarting(info);

                    auto samples = user_code([&] {
                        return plan.template run<Clock>(*cfg, env);
                    });

                    auto analysis = Detail::analyse(*cfg, env, samples.begin(), samples.end());
                    BenchmarkStats<FloatDuration<Clock>> stats{ info, analysis.samples, analysis.mean,
analysis.standard_deviation, analysis.outliers, analysis.outlier_variance };
                    getResultCapture().benchmarkEnded(stats);

                } CATCH_CATCH_ALL{
                    if (translateActiveException() != Detail::benchmarkErrorMsg) // benchmark errors
have been reported, otherwise rethrow.
                        std::rethrow_exception(std::current_exception());
                }
            }

            // sets lambda to be used in fun *and* executes benchmark!
            template <typename Fun,
                typename std::enable_if<!Detail::is_related<Fun, Benchmark>::value, int>::type = 0>
                Benchmark & operator=(Fun func) {
                fun = Detail::BenchmarkFunction(func);
                run();
                return *this;
            }

            explicit operator bool() {
                return true;
            }

        private:
            Detail::BenchmarkFunction fun;
            std::string name;
        };
    }
} // namespace Catch

#define INTERNAL_CATCH_GET_1_ARG(arg1, arg2, ...) arg1
#define INTERNAL_CATCH_GET_2_ARG(arg1, arg2, ...) arg2

#define INTERNAL_CATCH_BENCHMARK(BenchmarkName, name, benchmarkIndex)\
    if( Catch::Benchmark::Benchmark BenchmarkName{name} ) \
        BenchmarkName = [&](int benchmarkIndex)

#define INTERNAL_CATCH_BENCHMARK_ADVANCED(BenchmarkName, name)\
    if( Catch::Benchmark::Benchmark BenchmarkName{name} ) \
        BenchmarkName = [&]

// end catch_benchmark.hpp
// start catch_constructor.hpp

// Constructor and destructor helpers


#include <type_traits>

namespace Catch {
    namespace Benchmark {
        namespace Detail {
            template <typename T, bool Destruct>
            struct ObjectStorage
            {
                using TStorage = typename std::aligned_storage<sizeof(T),
std::alignment_of<T>::value>::type;

                ObjectStorage() : data() {}

                ObjectStorage(const ObjectStorage& other)
                {
                    new(&data) T(other.stored_object());
                }

                ObjectStorage(ObjectStorage&& other)
                {
                    new(&data) T(std::move(other.stored_object()));
                }

                ~ObjectStorage() { destruct_on_exit<T>(); }

                template <typename... Args>
                void construct(Args&&... args)
                {
                    new (&data) T(std::forward<Args>(args)...);
                }

                template <bool AllowManualDestruction = !Destruct>
                typename std::enable_if<AllowManualDestruction>::type destruct()
                {
                    stored_object().~T();
                }

            private:
                // If this is a constructor benchmark, destruct the underlying object
                template <typename U>
                void destruct_on_exit(typename std::enable_if<Destruct, U>::type* = 0) {
destruct<true>(); }
                // Otherwise, don't
                template <typename U>
                void destruct_on_exit(typename std::enable_if<!Destruct, U>::type* = 0) { }

                T& stored_object() {
                    return *static_cast<T*>(static_cast<void*>(&data));
                }

                T const& stored_object() const {
                    return *static_cast<T*>(static_cast<void*>(&data));
                }

                TStorage data;
            };
        }

        template <typename T>
        using storage_for = Detail::ObjectStorage<T, true>;

        template <typename T>
        using destructable_object = Detail::ObjectStorage<T, false>;
    }
}

// end catch_constructor.hpp
// end catch_benchmarking_all.hpp
#endif

#endif // ! CATCH_CONFIG_IMPL_ONLY

#ifdef CATCH_IMPL
// start catch_impl.hpp

#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Wweak-vtables"
#endif

// Keep these here for external reporters
// start catch_test_case_tracker.h

#include <string>
#include <vector>
#include <memory>

namespace Catch {
namespace TestCaseTracking {

    struct NameAndLocation {
        std::string name;
        SourceLineInfo location;

        NameAndLocation( std::string const& _name, SourceLineInfo const& _location );
        friend bool operator==(NameAndLocation const& lhs, NameAndLocation const& rhs) {
            return lhs.name == rhs.name
                && lhs.location == rhs.location;
        }
    };

    class ITracker;

    using ITrackerPtr = std::shared_ptr<ITracker>;

    class  ITracker {
        NameAndLocation m_nameAndLocation;

    public:
        ITracker(NameAndLocation const& nameAndLoc) :
            m_nameAndLocation(nameAndLoc)
        {}

        // static queries
        NameAndLocation const& nameAndLocation() const {
            return m_nameAndLocation;
        }

        virtual ~ITracker();

        // dynamic queries
        virtual bool isComplete() const = 0; // Successfully completed or failed
        virtual bool isSuccessfullyCompleted() const = 0;
        virtual bool isOpen() const = 0; // Started but not complete
        virtual bool hasChildren() const = 0;
        virtual bool hasStarted() const = 0;

        virtual ITracker& parent() = 0;

        // actions
        virtual void close() = 0; // Successfully complete
        virtual void fail() = 0;
        virtual void markAsNeedingAnotherRun() = 0;

        virtual void addChild( ITrackerPtr const& child ) = 0;
        virtual ITrackerPtr findChild( NameAndLocation const& nameAndLocation ) = 0;
        virtual void openChild() = 0;

        // Debug/ checking
        virtual bool isSectionTracker() const = 0;
        virtual bool isGeneratorTracker() const = 0;
    };

    class TrackerContext {

        enum RunState {
            NotStarted,
            Executing,
            CompletedCycle
        };

        ITrackerPtr m_rootTracker;
        ITracker* m_currentTracker = nullptr;
        RunState m_runState = NotStarted;

    public:

        ITracker& startRun();
        void endRun();

        void startCycle();
        void completeCycle();

        bool completedCycle() const;
        ITracker& currentTracker();
        void setCurrentTracker( ITracker* tracker );
    };

    class TrackerBase : public ITracker {
    protected:
        enum CycleState {
            NotStarted,
            Executing,
            ExecutingChildren,
            NeedsAnotherRun,
            CompletedSuccessfully,
            Failed
        };

        using Children = std::vector<ITrackerPtr>;
        TrackerContext& m_ctx;
        ITracker* m_parent;
        Children m_children;
        CycleState m_runState = NotStarted;

    public:
        TrackerBase( NameAndLocation const& nameAndLocation, TrackerContext& ctx, ITracker* parent );

        bool isComplete() const override;
        bool isSuccessfullyCompleted() const override;
        bool isOpen() const override;
        bool hasChildren() const override;
        bool hasStarted() const override {
            return m_runState != NotStarted;
        }

        void addChild( ITrackerPtr const& child ) override;

        ITrackerPtr findChild( NameAndLocation const& nameAndLocation ) override;
        ITracker& parent() override;

        void openChild() override;

        bool isSectionTracker() const override;
        bool isGeneratorTracker() const override;

        void open();

        void close() override;
        void fail() override;
        void markAsNeedingAnotherRun() override;

    private:
        void moveToParent();
        void moveToThis();
    };

    class SectionTracker : public TrackerBase {
        std::vector<std::string> m_filters;
        std::string m_trimmed_name;
    public:
        SectionTracker( NameAndLocation const& nameAndLocation, TrackerContext& ctx, ITracker* parent
);

        bool isSectionTracker() const override;

        bool isComplete() const override;

        static SectionTracker& acquire( TrackerContext& ctx, NameAndLocation const& nameAndLocation );

        void tryOpen();

        void addInitialFilters( std::vector<std::string> const& filters );
        void addNextFilters( std::vector<std::string> const& filters );
        std::vector<std::string> const& getFilters() const;
        std::string const& trimmedName() const;
    };

} // namespace TestCaseTracking

using TestCaseTracking::ITracker;
using TestCaseTracking::TrackerContext;
using TestCaseTracking::SectionTracker;

} // namespace Catch

// end catch_test_case_tracker.h

// start catch_leak_detector.h

namespace Catch {

    struct LeakDetector {
        LeakDetector();
        ~LeakDetector();
    };

}
// end catch_leak_detector.h
// Cpp files will be included in the single-header file here
// start catch_stats.cpp

// Statistical analysis tools

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)

#include <cassert>
#include <random>

#if defined(CATCH_CONFIG_USE_ASYNC)
#include <future>
#endif

namespace {
    double erf_inv(double x) {
        // Code accompanying the article "Approximating the erfinv function" in GPU Computing Gems,
Volume 2
        double w, p;

        w = -log((1.0 - x) * (1.0 + x));

        if (w < 6.250000) {
            w = w - 3.125000;
            p = -3.6444120640178196996e-21;
            p = -1.685059138182016589e-19 + p * w;
            p = 1.2858480715256400167e-18 + p * w;
            p = 1.115787767802518096e-17 + p * w;
            p = -1.333171662854620906e-16 + p * w;
            p = 2.0972767875968561637e-17 + p * w;
            p = 6.6376381343583238325e-15 + p * w;
            p = -4.0545662729752068639e-14 + p * w;
            p = -8.1519341976054721522e-14 + p * w;
            p = 2.6335093153082322977e-12 + p * w;
            p = -1.2975133253453532498e-11 + p * w;
            p = -5.4154120542946279317e-11 + p * w;
            p = 1.051212273321532285e-09 + p * w;
            p = -4.1126339803469836976e-09 + p * w;
            p = -2.9070369957882005086e-08 + p * w;
            p = 4.2347877827932403518e-07 + p * w;
            p = -1.3654692000834678645e-06 + p * w;
            p = -1.3882523362786468719e-05 + p * w;
            p = 0.0001867342080340571352 + p * w;
            p = -0.00074070253416626697512 + p * w;
            p = -0.006033670871430149053 + p * w;
            p = 0.24015818242558961693 + p * w;
            p = 1.6536545626831027356 + p * w;
        } else if (w < 16.000000) {
            w = sqrt(w) - 3.250000;
            p = 2.2137376921775787049e-09;
            p = 9.0756561938885390979e-08 + p * w;
            p = -2.7517406297064545428e-07 + p * w;
            p = 1.8239629214389227755e-08 + p * w;
            p = 1.5027403968909827627e-06 + p * w;
            p = -4.013867526981545969e-06 + p * w;
            p = 2.9234449089955446044e-06 + p * w;
            p = 1.2475304481671778723e-05 + p * w;
            p = -4.7318229009055733981e-05 + p * w;
            p = 6.8284851459573175448e-05 + p * w;
            p = 2.4031110387097893999e-05 + p * w;
            p = -0.0003550375203628474796 + p * w;
            p = 0.00095328937973738049703 + p * w;
            p = -0.0016882755560235047313 + p * w;
            p = 0.0024914420961078508066 + p * w;
            p = -0.0037512085075692412107 + p * w;
            p = 0.005370914553590063617 + p * w;
            p = 1.0052589676941592334 + p * w;
            p = 3.0838856104922207635 + p * w;
        } else {
            w = sqrt(w) - 5.000000;
            p = -2.7109920616438573243e-11;
            p = -2.5556418169965252055e-10 + p * w;
            p = 1.5076572693500548083e-09 + p * w;
            p = -3.7894654401267369937e-09 + p * w;
            p = 7.6157012080783393804e-09 + p * w;
            p = -1.4960026627149240478e-08 + p * w;
            p = 2.9147953450901080826e-08 + p * w;
            p = -6.7711997758452339498e-08 + p * w;
            p = 2.2900482228026654717e-07 + p * w;
            p = -9.9298272942317002539e-07 + p * w;
            p = 4.5260625972231537039e-06 + p * w;
            p = -1.9681778105531670567e-05 + p * w;
            p = 7.5995277030017761139e-05 + p * w;
            p = -0.00021503011930044477347 + p * w;
            p = -0.00013871931833623122026 + p * w;
            p = 1.0103004648645343977 + p * w;
            p = 4.8499064014085844221 + p * w;
        }
        return p * x;
    }

    double standard_deviation(std::vector<double>::iterator first, std::vector<double>::iterator last)
{
        auto m = Catch::Benchmark::Detail::mean(first, last);
        double variance = std::accumulate(first, last, 0., [m](double a, double b) {
            double diff = b - m;
            return a + diff * diff;
            }) / (last - first);
            return std::sqrt(variance);
    }

}

namespace Catch {
    namespace Benchmark {
        namespace Detail {

            double weighted_average_quantile(int k, int q, std::vector<double>::iterator first,
std::vector<double>::iterator last) {
```

```
                auto count = last - first;
                double idx = (count - 1) * k / static_cast<double>(q);
                int j = static_cast<int>(idx);
                double g = idx - j;
                std::nth_element(first, first + j, last);
                auto xj = first[j];
                if (g == 0) return xj;

                auto xj1 = *std::min_element(first + (j + 1), last);
                return xj + g * (xj1 - xj);
            }

            double erfc_inv(double x) {
                return erf_inv(1.0 - x);
            }

            double normal_quantile(double p) {
                static const double ROOT_TWO = std::sqrt(2.0);

                double result = 0.0;
                assert(p >= 0 && p <= 1);
                if (p < 0 || p > 1) {
                    return result;
                }

                result = -erfc_inv(2.0 * p);
                // result *= normal distribution standard deviation (1.0) * sqrt(2)
                result *= /*sd * */ ROOT_TWO;
                // result += normal disttribution mean (0)
                return result;
            }

            double outlier_variance(Estimate<double> mean, Estimate<double> stddev, int n) {
                double sb = stddev.point;
                double mn = mean.point / n;
                double mg_min = mn / 2.;
                double sg = (std::min)(mg_min / 4., sb / std::sqrt(n));
                double sg2 = sg * sg;
                double sb2 = sb * sb;

                auto c_max = [n, mn, sb2, sg2](double x) -> double {
                    double k = mn - x;
                    double d = k * k;
                    double nd = n * d;
                    double k0 = -n * nd;
                    double k1 = sb2 - n * sg2 + nd;
                    double det = k1 * k1 - 4 * sg2 * k0;
                    return (int)(-2. * k0 / (k1 + std::sqrt(det)));
                };

                auto var_out = [n, sb2, sg2](double c) {
                    double nc = n - c;
                    return (nc / n) * (sb2 - nc * sg2);
                };

                return (std::min)(var_out(1), var_out((std::min)(c_max(0.), c_max(mg_min)))) / sb2;
            }

            bootstrap_analysis analyse_samples(double confidence_level, int n_resamples,
std::vector<double>::iterator first, std::vector<double>::iterator last) {
                CATCH_INTERNAL_START_WARNINGS_SUPPRESSION
                CATCH_INTERNAL_SUPPRESS_GLOBALS_WARNINGS
                static std::random_device entropy;
                CATCH_INTERNAL_STOP_WARNINGS_SUPPRESSION

                auto n = static_cast<int>(last - first); // seriously, one can't use integral types
without hell in C++

                auto mean = &Detail::mean<std::vector<double>::iterator>;
                auto stddev = &standard_deviation;

#if defined(CATCH_CONFIG_USE_ASYNC)
                auto Estimate = [=](double(*f)(std::vector<double>::iterator,
std::vector<double>::iterator)) {
                    auto seed = entropy();
                    return std::async(std::launch::async, [=] {
                        std::mt19937 rng(seed);
                        auto resampled = resample(rng, n_resamples, first, last, f);
                        return bootstrap(confidence_level, first, last, resampled, f);
                    });
                };

                auto mean_future = Estimate(mean);
                auto stddev_future = Estimate(stddev);

                auto mean_estimate = mean_future.get();
                auto stddev_estimate = stddev_future.get();
```

```
#else
                auto Estimate = [=](double(*f)(std::vector<double>::iterator, std::vector<double>::iterator)) {
                    auto seed = entropy();
                    std::mt19937 rng(seed);
                    auto resampled = resample(rng, n_resamples, first, last, f);
                    return bootstrap(confidence_level, first, last, resampled, f);
                };

                auto mean_estimate = Estimate(mean);
                auto stddev_estimate = Estimate(stddev);
#endif // CATCH_USE_ASYNC

                double outlier_variance = Detail::outlier_variance(mean_estimate, stddev_estimate, n);

                return { mean_estimate, stddev_estimate, outlier_variance };
            }
        } // namespace Detail
    } // namespace Benchmark
} // namespace Catch

#endif // CATCH_CONFIG_ENABLE_BENCHMARKING
// end catch_stats.cpp
// start catch_approx.cpp

#include <cmath>
#include <limits>

namespace {

// Performs equivalent check of std::fabs(lhs - rhs) <= margin
// But without the subtraction to allow for INFINITY in comparison
bool marginComparison(double lhs, double rhs, double margin) {
    return (lhs + margin >= rhs) && (rhs + margin >= lhs);
}

}

namespace Catch {
namespace Detail {

    Approx::Approx ( double value )
    :   m_epsilon( std::numeric_limits<float>::epsilon()*100 ),
        m_margin( 0.0 ),
        m_scale( 0.0 ),
        m_value( value )
    {}

    Approx Approx::custom() {
        return Approx( 0 );
    }

    Approx Approx::operator-() const {
        auto temp(*this);
        temp.m_value = -temp.m_value;
        return temp;
    }

    std::string Approx::toString() const {
        ReusableStringStream rss;
        rss « "Approx( " « ::Catch::Detail::stringify( m_value ) « " )";
        return rss.str();
    }

    bool Approx::equalityComparisonImpl(const double other) const {
        // First try with fixed margin, then compute margin based on epsilon, scale and Approx's value
        // Thanks to Richard Harris for his help refining the scaled margin value
        return marginComparison(m_value, other, m_margin)
            || marginComparison(m_value, other, m_epsilon * (m_scale + std::fabs(std::isinf(m_value)? 0 : m_value)));
    }

    void Approx::setMargin(double newMargin) {
        CATCH_ENFORCE(newMargin >= 0,
            "Invalid Approx::margin: " « newMargin « '.'
            « " Approx::Margin has to be non-negative.");
        m_margin = newMargin;
    }

    void Approx::setEpsilon(double newEpsilon) {
        CATCH_ENFORCE(newEpsilon >= 0 && newEpsilon <= 1.0,
            "Invalid Approx::epsilon: " « newEpsilon « '.'
            « " Approx::epsilon has to be in [0, 1]");
        m_epsilon = newEpsilon;
    }

} // end namespace Detail
```

```cpp

namespace literals {
    Detail::Approx operator "" _a(long double val) {
        return Detail::Approx(val);
    }
    Detail::Approx operator "" _a(unsigned long long val) {
        return Detail::Approx(val);
    }
} // end namespace literals

std::string StringMaker<Catch::Detail::Approx>::convert(Catch::Detail::Approx const& value) {
    return value.toString();
}

} // end namespace Catch
// end catch_approx.cpp
// start catch_assertionhandler.cpp

// start catch_debugger.h

namespace Catch {
    bool isDebuggerActive();
}

#ifdef CATCH_PLATFORM_MAC

    #if defined(__i386__) || defined(__x86_64__)
        #define CATCH_TRAP() __asm__("int $3\n" : : ) /* NOLINT */
    #elif defined(__aarch64__)
        #define CATCH_TRAP()  __asm__(".inst 0xd4200000")
    #endif

#elif defined(CATCH_PLATFORM_IPHONE)

    // use inline assembler
    #if defined(__i386__) || defined(__x86_64__)
        #define CATCH_TRAP()  __asm__("int $3")
    #elif defined(__aarch64__)
        #define CATCH_TRAP()  __asm__(".inst 0xd4200000")
    #elif defined(__arm__) && !defined(__thumb__)
        #define CATCH_TRAP()  __asm__(".inst 0xe7f001f0")
    #elif defined(__arm__) &&  defined(__thumb__)
        #define CATCH_TRAP()  __asm__(".inst 0xde01")
    #endif

#elif defined(CATCH_PLATFORM_LINUX)
    // If we can use inline assembler, do it because this allows us to break
    // directly at the location of the failing check instead of breaking inside
    // raise() called from it, i.e. one stack frame below.
    #if defined(__GNUC__) && (defined(__i386) || defined(__x86_64))
        #define CATCH_TRAP() asm volatile ("int $3") /* NOLINT */
    #else // Fall back to the generic way.
        #include <signal.h>

        #define CATCH_TRAP() raise(SIGTRAP)
    #endif
#elif defined(_MSC_VER)
    #define CATCH_TRAP() __debugbreak()
#elif defined(__MINGW32__)
    extern "C" __declspec(dllimport) void __stdcall DebugBreak();
    #define CATCH_TRAP() DebugBreak()
#endif

#ifndef CATCH_BREAK_INTO_DEBUGGER
    #ifdef CATCH_TRAP
        #define CATCH_BREAK_INTO_DEBUGGER() []{ if( Catch::isDebuggerActive() ) { CATCH_TRAP(); } }()
    #else
        #define CATCH_BREAK_INTO_DEBUGGER() []{}()
    #endif
#endif

// end catch_debugger.h
// start catch_run_context.h

// start catch_fatal_condition.h

#include <cassert>

namespace Catch {

    // Wrapper for platform-specific fatal error (signals/SEH) handlers
    //
    // Tries to be cooperative with other handlers, and not step over
    // other handlers. This means that unknown structured exceptions
    // are passed on, previous signal handlers are called, and so on.
    //
    // Can only be instantiated once, and assumes that once a signal
    // is caught, the binary will end up terminating. Thus, there
    class FatalConditionHandler {
        bool m_started = false;

        // Install/disengage implementation for specific platform.
        // Should be if-defed to work on current platform, can assume
        // engage-disengage 1:1 pairing.
        void engage_platform();
        void disengage_platform();
    public:
        // Should also have platform-specific implementations as needed
        FatalConditionHandler();
        ~FatalConditionHandler();

        void engage() {
            assert(!m_started && "Handler cannot be installed twice.");
            m_started = true;
            engage_platform();
        }

        void disengage() {
            assert(m_started && "Handler cannot be uninstalled without being installed first");
            m_started = false;
            disengage_platform();
        }
    };

    class FatalConditionHandlerGuard {
        FatalConditionHandler* m_handler;
    public:
        FatalConditionHandlerGuard(FatalConditionHandler* handler):
            m_handler(handler) {
            m_handler->engage();
        }
        ~FatalConditionHandlerGuard() {
            m_handler->disengage();
        }
    };

} // end namespace Catch

// end catch_fatal_condition.h
#include <string>

namespace Catch {

    struct IMutableContext;


    class RunContext : public IResultCapture, public IRunner {

    public:
        RunContext( RunContext const& ) = delete;
        RunContext& operator =( RunContext const& ) = delete;

        explicit RunContext( IConfigPtr const& _config, IStreamingReporterPtr&& reporter );

        ~RunContext() override;

        void testGroupStarting( std::string const& testSpec, std::size_t groupIndex, std::size_t
groupsCount );
        void testGroupEnded( std::string const& testSpec, Totals const& totals, std::size_t
groupIndex, std::size_t groupsCount );

        Totals runTest(TestCase const& testCase);

        IConfigPtr config() const;
        IStreamingReporter& reporter() const;

    public: // IResultCapture

        // Assertion handlers
        void handleExpr
                (   AssertionInfo const& info,
                    ITransientExpression const& expr,
                    AssertionReaction& reaction ) override;
        void handleMessage
                (   AssertionInfo const& info,
                    ResultWas::OfType resultType,
                    StringRef const& message,
                    AssertionReaction& reaction ) override;
        void handleUnexpectedExceptionNotThrown
                (   AssertionInfo const& info,
                    AssertionReaction& reaction ) override;
        void handleUnexpectedInflightException
                (   AssertionInfo const& info,
                    std::string const& message,
                    AssertionReaction& reaction ) override;
        void handleIncomplete
                (   AssertionInfo const& info ) override;
        void handleNonExpr
                (   AssertionInfo const &info,
                    ResultWas::OfType resultType,
                    AssertionReaction &reaction ) override;

        bool sectionStarted( SectionInfo const& sectionInfo, Counts& assertions ) override;

        void sectionEnded( SectionEndInfo const& endInfo ) override;
        void sectionEndedEarly( SectionEndInfo const& endInfo ) override;

        auto acquireGeneratorTracker( StringRef generatorName, SourceLineInfo const& lineInfo ) ->
IGeneratorTracker& override;

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        void benchmarkPreparing( std::string const& name ) override;
        void benchmarkStarting( BenchmarkInfo const& info ) override;
        void benchmarkEnded( BenchmarkStats<> const& stats ) override;
        void benchmarkFailed( std::string const& error ) override;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

        void pushScopedMessage( MessageInfo const& message ) override;
        void popScopedMessage( MessageInfo const& message ) override;

        void emplaceUnscopedMessage( MessageBuilder const& builder ) override;

        std::string getCurrentTestName() const override;

        const AssertionResult* getLastResult() const override;

        void exceptionEarlyReported() override;

        void handleFatalErrorCondition( StringRef message ) override;

        bool lastAssertionPassed() override;

        void assertionPassed() override;

    public:
        // !TBD We need to do this another way!
        bool aborting() const final;

    private:

        void runCurrentTest( std::string& redirectedCout, std::string& redirectedCerr );
        void invokeActiveTestCase();

        void resetAssertionInfo();
        bool testForMissingAssertions( Counts& assertions );

        void assertionEnded( AssertionResult const& result );
        void reportExpr
                (   AssertionInfo const &info,
                    ResultWas::OfType resultType,
                    ITransientExpression const *expr,
                    bool negated );

        void populateReaction( AssertionReaction& reaction );

    private:

        void handleUnfinishedSections();

        TestRunInfo m_runInfo;
        IMutableContext& m_context;
        TestCase const* m_activeTestCase = nullptr;
        ITracker* m_testCaseTracker = nullptr;
        Option<AssertionResult> m_lastResult;

        IConfigPtr m_config;
        Totals m_totals;
        IStreamingReporterPtr m_reporter;
        std::vector<MessageInfo> m_messages;
        std::vector<ScopedMessage> m_messageScopes; /* Keeps owners of so-called unscoped messages. */
        AssertionInfo m_lastAssertionInfo;
        std::vector<SectionEndInfo> m_unfinishedSections;
        std::vector<ITracker*> m_activeSections;
        TrackerContext m_trackerContext;
        FatalConditionHandler m_fatalConditionhandler;
        bool m_lastAssertionPassed = false;
        bool m_shouldReportUnexpected = true;
        bool m_includeSuccessfulResults;
    };

    void seedRng(IConfig const& config);
    unsigned int rngSeed();
} // end namespace Catch

// end catch_run_context.h
namespace Catch {

    namespace {
        auto operator «( std::ostream& os, ITransientExpression const& expr ) -> std::ostream& {
            expr.streamReconstructedExpression( os );
            return os;
        }
    }

    LazyExpression::LazyExpression( bool isNegated )
    :   m_isNegated( isNegated )
    {}

    LazyExpression::LazyExpression( LazyExpression const& other ) : m_isNegated( other.m_isNegated )
{}

    LazyExpression::operator bool() const {
        return m_transientExpression != nullptr;
    }

    auto operator « ( std::ostream& os, LazyExpression const& lazyExpr ) -> std::ostream& {
        if( lazyExpr.m_isNegated )
            os « "!";

        if( lazyExpr ) {
            if( lazyExpr.m_isNegated && lazyExpr.m_transientExpression->isBinaryExpression() )
                os « "(" « *lazyExpr.m_transientExpression « ")";
            else
                os « *lazyExpr.m_transientExpression;
        }
        else {
            os « "{** error - unchecked empty expression requested **}";
        }
        return os;
    }

    AssertionHandler::AssertionHandler
        (   StringRef const& macroName,
            SourceLineInfo const& lineInfo,
            StringRef capturedExpression,
            ResultDisposition::Flags resultDisposition )
    :   m_assertionInfo{ macroName, lineInfo, capturedExpression, resultDisposition },
        m_resultCapture( getResultCapture() )
    {}

    void AssertionHandler::handleExpr( ITransientExpression const& expr ) {
        m_resultCapture.handleExpr( m_assertionInfo, expr, m_reaction );
    }
    void AssertionHandler::handleMessage(ResultWas::OfType resultType, StringRef const& message) {
        m_resultCapture.handleMessage( m_assertionInfo, resultType, message, m_reaction );
    }

    auto AssertionHandler::allowThrows() const -> bool {
        return getCurrentContext().getConfig()->allowThrows();
    }

    void AssertionHandler::complete() {
        setCompleted();
        if( m_reaction.shouldDebugBreak ) {

            // If you find your debugger stopping you here then go one level up on the
            // call-stack for the code that caused it (typically a failed assertion)

            // (To go back to the test and change execution, jump over the throw, next)
            CATCH_BREAK_INTO_DEBUGGER();
        }
        if (m_reaction.shouldThrow) {
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
            throw Catch::TestFailureException();
#else
            CATCH_ERROR( "Test failure requires aborting test!" );
#endif
        }
    }
    void AssertionHandler::setCompleted() {
        m_completed = true;
    }

    void AssertionHandler::handleUnexpectedInflightException() {
        m_resultCapture.handleUnexpectedInflightException( m_assertionInfo,
Catch::translateActiveException(), m_reaction );
    }

    void AssertionHandler::handleExceptionThrownAsExpected() {
        m_resultCapture.handleNonExpr(m_assertionInfo, ResultWas::Ok, m_reaction);
    }
    void AssertionHandler::handleExceptionNotThrownAsExpected() {
        m_resultCapture.handleNonExpr(m_assertionInfo, ResultWas::Ok, m_reaction);
    }

    void AssertionHandler::handleUnexpectedExceptionNotThrown() {
        m_resultCapture.handleUnexpectedExceptionNotThrown( m_assertionInfo, m_reaction );
    }

    void AssertionHandler::handleThrowingCallSkipped() {
        m_resultCapture.handleNonExpr(m_assertionInfo, ResultWas::Ok, m_reaction);
    }

    // This is the overload that takes a string and infers the Equals matcher from it
    // The more general overload, that takes any string matcher, is in catch_capture_matchers.cpp
    void handleExceptionMatchExpr( AssertionHandler& handler, std::string const& str, StringRef const&
matcherString  ) {
        handleExceptionMatchExpr( handler, Matchers::Equals( str ), matcherString );
    }

} // namespace Catch
// end catch_assertionhandler.cpp
// start catch_assertionresult.cpp

namespace Catch {
    AssertionResultData::AssertionResultData(ResultWas::OfType _resultType, LazyExpression const &
_lazyExpression):
        lazyExpression(_lazyExpression),
        resultType(_resultType) {}

    std::string AssertionResultData::reconstructExpression() const {

        if( reconstructedExpression.empty() ) {
            if( lazyExpression ) {
                ReusableStringStream rss;
                rss « lazyExpression;
                reconstructedExpression = rss.str();
            }
        }
        return reconstructedExpression;
    }

    AssertionResult::AssertionResult( AssertionInfo const& info, AssertionResultData const& data )
    :   m_info( info ),
        m_resultData( data )
    {}

    // Result was a success
    bool AssertionResult::succeeded() const {
        return Catch::isOk( m_resultData.resultType );
    }

    // Result was a success, or failure is suppressed
    bool AssertionResult::isOk() const {
        return Catch::isOk( m_resultData.resultType ) || shouldSuppressFailure(
m_info.resultDisposition );
    }

    ResultWas::OfType AssertionResult::getResultType() const {
        return m_resultData.resultType;
    }

    bool AssertionResult::hasExpression() const {
        return !m_info.capturedExpression.empty();
    }

    bool AssertionResult::hasMessage() const {
        return !m_resultData.message.empty();
    }

    std::string AssertionResult::getExpression() const {
        // Possibly overallocating by 3 characters should be basically free
        std::string expr; expr.reserve(m_info.capturedExpression.size() + 3);
        if (isFalseTest(m_info.resultDisposition)) {
            expr += "!(";
        }
        expr += m_info.capturedExpression;
        if (isFalseTest(m_info.resultDisposition)) {
            expr += ’)’;
        }
        return expr;
    }

    std::string AssertionResult::getExpressionInMacro() const {
        std::string expr;
        if( m_info.macroName.empty() )
            expr = static_cast<std::string>(m_info.capturedExpression);
        else {
            expr.reserve( m_info.macroName.size() + m_info.capturedExpression.size() + 4 );
            expr += m_info.macroName;
            expr += "( ";
            expr += m_info.capturedExpression;
            expr += " )";
        }
        return expr;
    }

    bool AssertionResult::hasExpandedExpression() const {
        return hasExpression() && getExpandedExpression() != getExpression();
    }

    std::string AssertionResult::getExpandedExpression() const {
        std::string expr = m_resultData.reconstructExpression();
        return expr.empty()
                ? getExpression()
                : expr;
    }

    std::string AssertionResult::getMessage() const {
        return m_resultData.message;
    }
    SourceLineInfo AssertionResult::getSourceInfo() const {
        return m_info.lineInfo;
    }

    StringRef AssertionResult::getTestMacroName() const {
        return m_info.macroName;
    }

} // end namespace Catch
// end catch_assertionresult.cpp
// start catch_capture_matchers.cpp

namespace Catch {

    using StringMatcher = Matchers::Impl::MatcherBase<std::string>;

    // This is the general overload that takes a any string matcher
    // There is another overload, in catch_assertionhandler.h/.cpp, that only takes a string and
infers
    // the Equals matcher (so the header does not mention matchers)
    void handleExceptionMatchExpr( AssertionHandler& handler, StringMatcher const& matcher, StringRef
const& matcherString  ) {
        std::string exceptionMessage = Catch::translateActiveException();
        MatchExpr<std::string, StringMatcher const&> expr( exceptionMessage, matcher, matcherString );
        handler.handleExpr( expr );
    }

} // namespace Catch
// end catch_capture_matchers.cpp
// start catch_commandline.cpp

// start catch_commandline.h

// start catch_clara.h

// Use Catch's value for console width (store Clara's off to the side, if present)
#ifdef CLARA_CONFIG_CONSOLE_WIDTH
#define CATCH_TEMP_CLARA_CONFIG_CONSOLE_WIDTH CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH
#undef CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH
#endif
#define CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH CATCH_CONFIG_CONSOLE_WIDTH-1

#ifdef __clang__
#pragma clang diagnostic push
#pragma clang diagnostic ignored "-Wweak-vtables"
#pragma clang diagnostic ignored "-Wexit-time-destructors"
#pragma clang diagnostic ignored "-Wshadow"
#endif

// start clara.hpp
// Copyright 2017 Two Blue Cubes Ltd. All rights reserved.
//
// Distributed under the Boost Software License, Version 1.0. (See accompanying
// file LICENSE_1_0.txt or copy at http://www.boost.org/LICENSE_1_0.txt)
//
// See https://github.com/philsquared/Clara for more details

// Clara v1.1.5


#ifndef CATCH_CLARA_CONFIG_CONSOLE_WIDTH
```

```
#define CATCH_CLARA_CONFIG_CONSOLE_WIDTH 80
#endif

#ifndef CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH
#define CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH CATCH_CLARA_CONFIG_CONSOLE_WIDTH
#endif

#ifndef CLARA_CONFIG_OPTIONAL_TYPE
#ifdef __has_include
#if __has_include(<optional>) && __cplusplus >= 201703L
#include <optional>
#define CLARA_CONFIG_OPTIONAL_TYPE std::optional
#endif
#endif
#endif

// ----------- #included from clara_textflow.hpp -----------

// TextFlowCpp
//
// A single-header library for wrapping and laying out basic text, by Phil Nash
//
// Distributed under the Boost Software License, Version 1.0. (See accompanying
// file LICENSE.txt or copy at http://www.boost.org/LICENSE_1_0.txt)
//
// This project is hosted at https://github.com/philsquared/textflowcpp


#include <cassert>
#include <ostream>
#include <sstream>
#include <vector>

#ifndef CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH
#define CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH 80
#endif

namespace Catch {
namespace clara {
namespace TextFlow {

inline auto isWhitespace(char c) -> bool {
    static std::string chars = " \t\n\r";
    return chars.find(c) != std::string::npos;
}
inline auto isBreakableBefore(char c) -> bool {
    static std::string chars = "[({<|";
    return chars.find(c) != std::string::npos;
}
inline auto isBreakableAfter(char c) -> bool {
    static std::string chars = "])}>.,:;*+-=&/\\";
    return chars.find(c) != std::string::npos;
}

class Columns;

class Column {
    std::vector<std::string> m_strings;
    size_t m_width = CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH;
    size_t m_indent = 0;
    size_t m_initialIndent = std::string::npos;

public:
    class iterator {
        friend Column;

        Column const& m_column;
        size_t m_stringIndex = 0;
        size_t m_pos = 0;

        size_t m_len = 0;
        size_t m_end = 0;
        bool m_suffix = false;

        iterator(Column const& column, size_t stringIndex)
            : m_column(column),
            m_stringIndex(stringIndex) {}

        auto line() const -> std::string const& { return m_column.m_strings[m_stringIndex]; }

        auto isBoundary(size_t at) const -> bool {
            assert(at > 0);
            assert(at <= line().size());

            return at == line().size() ||
                (isWhitespace(line()[at]) && !isWhitespace(line()[at - 1])) ||
                isBreakableBefore(line()[at]) ||
                isBreakableAfter(line()[at - 1]);
        }

        void calcLength() {
            assert(m_stringIndex < m_column.m_strings.size());

            m_suffix = false;
            auto width = m_column.m_width - indent();
            m_end = m_pos;
            if (line()[m_pos] == '\n') {
                ++m_end;
            }
            while (m_end < line().size() && line()[m_end] != '\n')
                ++m_end;

            if (m_end < m_pos + width) {
                m_len = m_end - m_pos;
            } else {
                size_t len = width;
                while (len > 0 && !isBoundary(m_pos + len))
                    --len;
                while (len > 0 && isWhitespace(line()[m_pos + len - 1]))
                    --len;

                if (len > 0) {
                    m_len = len;
                } else {
                    m_suffix = true;
                    m_len = width - 1;
                }
            }
        }

        auto indent() const -> size_t {
            auto initial = m_pos == 0 && m_stringIndex == 0 ? m_column.m_initialIndent :
std::string::npos;
            return initial == std::string::npos ? m_column.m_indent : initial;
        }

        auto addIndentAndSuffix(std::string const &plain) const -> std::string {
            return std::string(indent(), ' ') + (m_suffix ? plain + "-" : plain);
        }

    public:
        using difference_type = std::ptrdiff_t;
        using value_type = std::string;
        using pointer = value_type * ;
        using reference = value_type & ;
        using iterator_category = std::forward_iterator_tag;

        explicit iterator(Column const& column) : m_column(column) {
            assert(m_column.m_width > m_column.m_indent);
            assert(m_column.m_initialIndent == std::string::npos || m_column.m_width >
m_column.m_initialIndent);
            calcLength();
            if (m_len == 0)
                m_stringIndex++; // Empty string
        }

        auto operator *() const -> std::string {
            assert(m_stringIndex < m_column.m_strings.size());
            assert(m_pos <= m_end);
            return addIndentAndSuffix(line().substr(m_pos, m_len));
        }

        auto operator ++() -> iterator& {
            m_pos += m_len;
            if (m_pos < line().size() && line()[m_pos] == '\n')
                m_pos += 1;
            else
                while (m_pos < line().size() && isWhitespace(line()[m_pos]))
                    ++m_pos;

            if (m_pos == line().size()) {
                m_pos = 0;
                ++m_stringIndex;
            }
            if (m_stringIndex < m_column.m_strings.size())
                calcLength();
            return *this;
        }
        auto operator ++(int) -> iterator {
            iterator prev(*this);
            operator++();
            return prev;
        }

        auto operator ==(iterator const& other) const -> bool {
            return
                m_pos == other.m_pos &&
                m_stringIndex == other.m_stringIndex &&
                &m_column == &other.m_column;
        }
        auto operator !=(iterator const& other) const -> bool {
            return !operator==(other);
        }
    };
    using const_iterator = iterator;

    explicit Column(std::string const& text) { m_strings.push_back(text); }

    auto width(size_t newWidth) -> Column& {
        assert(newWidth > 0);
        m_width = newWidth;
        return *this;
    }
    auto indent(size_t newIndent) -> Column& {
        m_indent = newIndent;
        return *this;
    }
    auto initialIndent(size_t newIndent) -> Column& {
        m_initialIndent = newIndent;
        return *this;
    }

    auto width() const -> size_t { return m_width; }
    auto begin() const -> iterator { return iterator(*this); }
    auto end() const -> iterator { return { *this, m_strings.size() }; }

    inline friend std::ostream& operator « (std::ostream& os, Column const& col) {
        bool first = true;
        for (auto line : col) {
            if (first)
                first = false;
            else
                os « "\n";
            os « line;
        }
        return os;
    }

    auto operator + (Column const& other)->Columns;

    auto toString() const -> std::string {
        std::ostringstream oss;
        oss « *this;
        return oss.str();
    }
};

class Spacer : public Column {

public:
    explicit Spacer(size_t spaceWidth) : Column("") {
        width(spaceWidth);
    }
};

class Columns {
    std::vector<Column> m_columns;

public:

    class iterator {
        friend Columns;
        struct EndTag {};

        std::vector<Column> const& m_columns;
        std::vector<Column::iterator> m_iterators;
        size_t m_activeIterators;

        iterator(Columns const& columns, EndTag)
            : m_columns(columns.m_columns),
            m_activeIterators(0) {
            m_iterators.reserve(m_columns.size());

            for (auto const& col : m_columns)
                m_iterators.push_back(col.end());
        }

    public:
        using difference_type = std::ptrdiff_t;
        using value_type = std::string;
        using pointer = value_type * ;
        using reference = value_type & ;
        using iterator_category = std::forward_iterator_tag;

        explicit iterator(Columns const& columns)
            : m_columns(columns.m_columns),
            m_activeIterators(m_columns.size()) {
            m_iterators.reserve(m_columns.size());

            for (auto const& col : m_columns)
                m_iterators.push_back(col.begin());
        }

        auto operator ==(iterator const& other) const -> bool {
            return m_iterators == other.m_iterators;
        }
        auto operator !=(iterator const& other) const -> bool {
            return m_iterators != other.m_iterators;
        }
        auto operator *() const -> std::string {
            std::string row, padding;

            for (size_t i = 0; i < m_columns.size(); ++i) {
                auto width = m_columns[i].width();
                if (m_iterators[i] != m_columns[i].end()) {
                    std::string col = *m_iterators[i];
                    row += padding + col;
                    if (col.size() < width)
                        padding = std::string(width - col.size(), ' ');
                    else
                        padding = "";
                } else {
                    padding += std::string(width, ' ');
                }
            }
            return row;
        }
        auto operator ++() -> iterator& {
            for (size_t i = 0; i < m_columns.size(); ++i) {
                if (m_iterators[i] != m_columns[i].end())
                    ++m_iterators[i];
            }
            return *this;
        }
        auto operator ++(int) -> iterator {
            iterator prev(*this);
            operator++();
            return prev;
        }
    };
    using const_iterator = iterator;

    auto begin() const -> iterator { return iterator(*this); }
    auto end() const -> iterator { return { *this, iterator::EndTag() }; }

    auto operator += (Column const& col) -> Columns& {
        m_columns.push_back(col);
        return *this;
    }
    auto operator + (Column const& col) -> Columns {
        Columns combined = *this;
        combined += col;
        return combined;
    }

    inline friend std::ostream& operator « (std::ostream& os, Columns const& cols) {

        bool first = true;
        for (auto line : cols) {
            if (first)
                first = false;
            else
                os « "\n";
            os « line;
        }
        return os;
    }

    auto toString() const -> std::string {
        std::ostringstream oss;
        oss « *this;
        return oss.str();
    }
};

inline auto Column::operator + (Column const& other) -> Columns {
    Columns cols;
    cols += *this;
    cols += other;
    return cols;
}
}

}
}

// ----------- end of #include from clara_textflow.hpp -----------
// ........... back in clara.hpp

#include <cctype>
#include <string>
#include <memory>
#include <set>
#include <algorithm>

#if !defined(CATCH_PLATFORM_WINDOWS) && ( defined(WIN32) || defined(__WIN32__) || defined(_WIN32) ||
defined(_MSC_VER) )
#define CATCH_PLATFORM_WINDOWS
#endif

namespace Catch { namespace clara {
namespace detail {

    // Traits for extracting arg and return type of lambdas (for single argument lambdas)
    template<typename L>
    struct UnaryLambdaTraits : UnaryLambdaTraits<decltype( &L::operator() )> {};

    template<typename ClassT, typename ReturnT, typename... Args>
    struct UnaryLambdaTraits<ReturnT( ClassT::* )( Args... ) const> {
        static const bool isValid = false;
    };

    template<typename ClassT, typename ReturnT, typename ArgT>
    struct UnaryLambdaTraits<ReturnT( ClassT::* )( ArgT ) const> {
        static const bool isValid = true;
        using ArgType = typename std::remove_const<typename std::remove_reference<ArgT>::type>::type;
        using ReturnType = ReturnT;
    };

    class TokenStream;

    // Transport for raw args (copied from main args, or supplied via init list for testing)
    class Args {
        friend TokenStream;
        std::string m_exeName;
        std::vector<std::string> m_args;

    public:
        Args( int argc, char const* const* argv )
            : m_exeName(argv[0]),
              m_args(argv + 1, argv + argc) {}

        Args( std::initializer_list<std::string> args )
        :   m_exeName( *args.begin() ),
            m_args( args.begin()+1, args.end() )
        {}

        auto exeName() const -> std::string {
            return m_exeName;
        }
    };

    // Wraps a token coming from a token stream. These may not directly correspond to strings as a
single string
    // may encode an option + its argument if the : or = form is used
    enum class TokenType {
        Option, Argument
    };
    struct Token {
        TokenType type;
        std::string token;
    };

    inline auto isOptPrefix( char c ) -> bool {
        return c == '-'
#ifdef CATCH_PLATFORM_WINDOWS
            || c == '/'
#endif
        ;
    }

    // Abstracts iterators into args as a stream of tokens, with option arguments uniformly handled
    class TokenStream {
        using Iterator = std::vector<std::string>::const_iterator;
        Iterator it;
        Iterator itEnd;
        std::vector<Token> m_tokenBuffer;

        void loadBuffer() {
            m_tokenBuffer.resize( 0 );

            // Skip any empty strings
            while( it != itEnd && it->empty() )
                ++it;

            if( it != itEnd ) {
                auto const &next = *it;
                if( isOptPrefix( next[0] ) ) {
                    auto delimiterPos = next.find_first_of( " :=" );
                    if( delimiterPos != std::string::npos ) {
                        m_tokenBuffer.push_back( { TokenType::Option, next.substr( 0, delimiterPos ) }
);
                        m_tokenBuffer.push_back( { TokenType::Argument, next.substr( delimiterPos + 1
) } );
                    } else {
                        if( next[1] != '-' && next.size() > 2 ) {
                            std::string opt = "- ";
                            for( size_t i = 1; i < next.size(); ++i ) {
                                opt[1] = next[i];
                                m_tokenBuffer.push_back( { TokenType::Option, opt } );
                            }
                        } else {
                            m_tokenBuffer.push_back( { TokenType::Option, next } );
                        }
                    }
                } else {
                    m_tokenBuffer.push_back( { TokenType::Argument, next } );
                }
            }
        }

    public:
        explicit TokenStream( Args const &args ) : TokenStream( args.m_args.begin(), args.m_args.end()
) {}

        TokenStream( Iterator it, Iterator itEnd ) : it( it ), itEnd( itEnd ) {
            loadBuffer();
        }

        explicit operator bool() const {
            return !m_tokenBuffer.empty() || it != itEnd;
        }

        auto count() const -> size_t { return m_tokenBuffer.size() + (itEnd - it); }

        auto operator*() const -> Token {
            assert( !m_tokenBuffer.empty() );
            return m_tokenBuffer.front();
        }

        auto operator->() const -> Token const * {
            assert( !m_tokenBuffer.empty() );
            return &m_tokenBuffer.front();
        }

        auto operator++() -> TokenStream & {
            if( m_tokenBuffer.size() >= 2 ) {
                m_tokenBuffer.erase( m_tokenBuffer.begin() );
            } else {
                if( it != itEnd )
                    ++it;
                loadBuffer();
            }
            return *this;
        }
    };

    class ResultBase {
    public:
        enum Type {
            Ok, LogicError, RuntimeError
        };

    protected:
        ResultBase( Type type ) : m_type( type ) {}
        virtual ~ResultBase() = default;

        virtual void enforceOk() const = 0;

        Type m_type;
    };

    template<typename T>
    class ResultValueBase : public ResultBase {
    public:
        auto value() const -> T const & {
            enforceOk();
            return m_value;
        }

    protected:
        ResultValueBase( Type type ) : ResultBase( type ) {}

        ResultValueBase( ResultValueBase const &other ) : ResultBase( other ) {
            if( m_type == ResultBase::Ok )
                new( &m_value ) T( other.m_value );
        }

        ResultValueBase( Type, T const &value ) : ResultBase( Ok ) {
            new( &m_value ) T( value );
        }

        auto operator=( ResultValueBase const &other ) -> ResultValueBase & {
            if( m_type == ResultBase::Ok )
                m_value.~T();
            ResultBase::operator=(other);
            if( m_type == ResultBase::Ok )
                new( &m_value ) T( other.m_value );
            return *this;
        }

        ~ResultValueBase() override {
            if( m_type == Ok )
                m_value.~T();
        }

        union {
            T m_value;
        };
    };

    template<>
    class ResultValueBase<void> : public ResultBase {
    protected:
        using ResultBase::ResultBase;
    };

    template<typename T = void>
    class BasicResult : public ResultValueBase<T> {
    public:
        template<typename U>
        explicit BasicResult( BasicResult<U> const &other )
        :   ResultValueBase<T>( other.type() ),
            m_errorMessage( other.errorMessage() )
        {
            assert( type() != ResultBase::Ok );
        }

        template<typename U>
        static auto ok( U const &value ) -> BasicResult { return { ResultBase::Ok, value }; }
        static auto ok() -> BasicResult { return { ResultBase::Ok }; }
        static auto logicError( std::string const &message ) -> BasicResult { return {
ResultBase::LogicError, message }; }
        static auto runtimeError( std::string const &message ) -> BasicResult { return {
ResultBase::RuntimeError, message }; }

        explicit operator bool() const { return m_type == ResultBase::Ok; }
        auto type() const -> ResultBase::Type { return m_type; }
        auto errorMessage() const -> std::string { return m_errorMessage; }

    protected:
        void enforceOk() const override {

            // Errors shouldn't reach this point, but if they do
            // the actual error message will be in m_errorMessage
            assert( m_type != ResultBase::LogicError );
            assert( m_type != ResultBase::RuntimeError );
            if( m_type != ResultBase::Ok )
                std::abort();
        }

        std::string m_errorMessage; // Only populated if resultType is an error

        BasicResult( ResultBase::Type type, std::string const &message )
        :   ResultValueBase<T>(type),
            m_errorMessage(message)
        {
            assert( m_type != ResultBase::Ok );
        }

        using ResultValueBase<T>::ResultValueBase;
        using ResultBase::m_type;
    };

    enum class ParseResultType {
        Matched, NoMatch, ShortCircuitAll, ShortCircuitSame
    };

    class ParseState {
    public:

        ParseState( ParseResultType type, TokenStream const &remainingTokens )
        : m_type(type),
          m_remainingTokens( remainingTokens )
        {}

        auto type() const -> ParseResultType { return m_type; }
        auto remainingTokens() const -> TokenStream { return m_remainingTokens; }

    private:
        ParseResultType m_type;
        TokenStream m_remainingTokens;
    };

    using Result = BasicResult<void>;
    using ParserResult = BasicResult<ParseResultType>;
    using InternalParseResult = BasicResult<ParseState>;

    struct HelpColumns {
        std::string left;
        std::string right;
    };

    template<typename T>
    inline auto convertInto( std::string const &source, T& target ) -> ParserResult {
        std::stringstream ss;
        ss « source;
        ss » target;
        if( ss.fail() )
            return ParserResult::runtimeError( "Unable to convert '" + source + "' to destination
type" );
        else
            return ParserResult::ok( ParseResultType::Matched );
    }
    inline auto convertInto( std::string const &source, std::string& target ) -> ParserResult {
        target = source;
        return ParserResult::ok( ParseResultType::Matched );
    }
    inline auto convertInto( std::string const &source, bool &target ) -> ParserResult {
        std::string srcLC = source;
        std::transform( srcLC.begin(), srcLC.end(), srcLC.begin(), []( unsigned char c ) { return
static_cast<char>( std::tolower(c) ); } );
        if (srcLC == "y" || srcLC == "1" || srcLC == "true" || srcLC == "yes" || srcLC == "on")
            target = true;
        else if (srcLC == "n" || srcLC == "0" || srcLC == "false" || srcLC == "no" || srcLC == "off")
            target = false;
        else
            return ParserResult::runtimeError( "Expected a boolean value but did not recognise: '" +
source + "'" );
        return ParserResult::ok( ParseResultType::Matched );
    }
#ifdef CLARA_CONFIG_OPTIONAL_TYPE
    template<typename T>
    inline auto convertInto( std::string const &source, CLARA_CONFIG_OPTIONAL_TYPE<T>& target ) ->
ParserResult {
        T temp;
        auto result = convertInto( source, temp );
        if( result )
            target = std::move(temp);
        return result;
    }
#endif // CLARA_CONFIG_OPTIONAL_TYPE

    struct NonCopyable {
        NonCopyable() = default;
        NonCopyable( NonCopyable const & ) = delete;
        NonCopyable( NonCopyable && ) = delete;
        NonCopyable &operator=( NonCopyable const & ) = delete;
        NonCopyable &operator=( NonCopyable && ) = delete;
    };

    struct BoundRef : NonCopyable {
        virtual ~BoundRef() = default;
        virtual auto isContainer() const -> bool { return false; }
        virtual auto isFlag() const -> bool { return false; }
    };
    struct BoundValueRefBase : BoundRef {
        virtual auto setValue( std::string const &arg ) -> ParserResult = 0;
    };
    struct BoundFlagRefBase : BoundRef {
        virtual auto setFlag( bool flag ) -> ParserResult = 0;
        virtual auto isFlag() const -> bool { return true; }
    };

    template<typename T>
    struct BoundValueRef : BoundValueRefBase {
        T &m_ref;

        explicit BoundValueRef( T &ref ) : m_ref( ref ) {}

        auto setValue( std::string const &arg ) -> ParserResult override {
            return convertInto( arg, m_ref );
        }
    };

    template<typename T>
    struct BoundValueRef<std::vector<T» : BoundValueRefBase {
        std::vector<T> &m_ref;

        explicit BoundValueRef( std::vector<T> &ref ) : m_ref( ref ) {}

        auto isContainer() const -> bool override { return true; }

        auto setValue( std::string const &arg ) -> ParserResult override {
            T temp;
            auto result = convertInto( arg, temp );
            if( result )
                m_ref.push_back( temp );
            return result;
        }
    };

    struct BoundFlagRef : BoundFlagRefBase {
        bool &m_ref;

        explicit BoundFlagRef( bool &ref ) : m_ref( ref ) {}

        auto setFlag( bool flag ) -> ParserResult override {
            m_ref = flag;
            return ParserResult::ok( ParseResultType::Matched );
        }
    };

    template<typename ReturnType>
    struct LambdaInvoker {
        static_assert( std::is_same<ReturnType, ParserResult>::value, "Lambda must return void or
clara::ParserResult" );

        template<typename L, typename ArgType>
        static auto invoke( L const &lambda, ArgType const &arg ) -> ParserResult {
            return lambda( arg );
        }
    };

    template<>
    struct LambdaInvoker<void> {
        template<typename L, typename ArgType>
        static auto invoke( L const &lambda, ArgType const &arg ) -> ParserResult {
            lambda( arg );
            return ParserResult::ok( ParseResultType::Matched );
        }
    };

    template<typename ArgType, typename L>
    inline auto invokeLambda( L const &lambda, std::string const &arg ) -> ParserResult {
        ArgType temp{};
        auto result = convertInto( arg, temp );
        return !result
           ? result
           : LambdaInvoker<typename UnaryLambdaTraits<L>::ReturnType>::invoke( lambda, temp );
    }

    template<typename L>
    struct BoundLambda : BoundValueRefBase {
        L m_lambda;

        static_assert( UnaryLambdaTraits<L>::isValid, "Supplied lambda must take exactly one argument"
);
        explicit BoundLambda( L const &lambda ) : m_lambda( lambda ) {}

        auto setValue( std::string const &arg ) -> ParserResult override {
            return invokeLambda<typename UnaryLambdaTraits<L>::ArgType>( m_lambda, arg );
        }
    };

    template<typename L>
    struct BoundFlagLambda : BoundFlagRefBase {
        L m_lambda;

        static_assert( UnaryLambdaTraits<L>::isValid, "Supplied lambda must take exactly one argument"
);
        static_assert( std::is_same<typename UnaryLambdaTraits<L>::ArgType, bool>::value, "flags must
be boolean" );

        explicit BoundFlagLambda( L const &lambda ) : m_lambda( lambda ) {}

        auto setFlag( bool flag ) -> ParserResult override {
            return LambdaInvoker<typename UnaryLambdaTraits<L>::ReturnType>::invoke( m_lambda, flag );
        }
    };

    enum class Optionality { Optional, Required };

    struct Parser;

    class ParserBase {
    public:
        virtual ~ParserBase() = default;
        virtual auto validate() const -> Result { return Result::ok(); }
        virtual auto parse( std::string const& exeName, TokenStream const &tokens) const ->
InternalParseResult  = 0;
        virtual auto cardinality() const -> size_t { return 1; }

        auto parse( Args const &args ) const -> InternalParseResult {
            return parse( args.exeName(), TokenStream( args ) );
        }
    };

    template<typename DerivedT>
    class ComposableParserImpl : public ParserBase {
    public:
        template<typename T>
        auto operator|( T const &other ) const -> Parser;

        template<typename T>
        auto operator+( T const &other ) const -> Parser;
    };

    // Common code and state for Args and Opts
    template<typename DerivedT>
    class ParserRefImpl : public ComposableParserImpl<DerivedT> {
    protected:
        Optionality m_optionality = Optionality::Optional;
        std::shared_ptr<BoundRef> m_ref;
        std::string m_hint;
        std::string m_description;

        explicit ParserRefImpl( std::shared_ptr<BoundRef> const &ref ) : m_ref( ref ) {}

    public:
        template<typename T>
        ParserRefImpl( T &ref, std::string const &hint )
        :   m_ref( std::make_shared<BoundValueRef<T>»( ref ) ),
            m_hint( hint )
        {}

        template<typename LambdaT>
        ParserRefImpl( LambdaT const &ref, std::string const &hint )
        :   m_ref( std::make_shared<BoundLambda<LambdaT>»( ref ) ),
            m_hint(hint)
        {}

        auto operator()( std::string const &description ) -> DerivedT & {
            m_description = description;
            return static_cast<DerivedT &>( *this );
        }

        auto optional() -> DerivedT & {
            m_optionality = Optionality::Optional;
            return static_cast<DerivedT &>( *this );
        };

        auto required() -> DerivedT & {
            m_optionality = Optionality::Required;
            return static_cast<DerivedT &>( *this );
        };

        auto isOptional() const -> bool {
            return m_optionality == Optionality::Optional;
        }

        auto cardinality() const -> size_t override {
            if( m_ref->isContainer() )
                return 0;
            else
                return 1;
        }

        auto hint() const -> std::string { return m_hint; }
    };

    class ExeName : public ComposableParserImpl<ExeName> {
        std::shared_ptr<std::string> m_name;
        std::shared_ptr<BoundValueRefBase> m_ref;

        template<typename LambdaT>
        static auto makeRef(LambdaT const &lambda) -> std::shared_ptr<BoundValueRefBase> {
            return std::make_shared<BoundLambda<LambdaT>>( lambda) ;
        }

    public:
        ExeName() : m_name( std::make_shared<std::string>( "<executable>" ) ) {}

        explicit ExeName( std::string &ref ) : ExeName() {
            m_ref = std::make_shared<BoundValueRef<std::string>>( ref );
        }

        template<typename LambdaT>
        explicit ExeName( LambdaT const& lambda ) : ExeName() {
            m_ref = std::make_shared<BoundLambda<LambdaT>>( lambda );
        }

        // The exe name is not parsed out of the normal tokens, but is handled specially
        auto parse( std::string const&, TokenStream const &tokens ) const -> InternalParseResult
override {
            return InternalParseResult::ok( ParseState( ParseResultType::NoMatch, tokens ) );
        }

        auto name() const -> std::string { return *m_name; }
        auto set( std::string const& newName ) -> ParserResult {

            auto lastSlash = newName.find_last_of( "\\/" );
            auto filename = ( lastSlash == std::string::npos )
                    ? newName
                    : newName.substr( lastSlash+1 );

            *m_name = filename;
            if( m_ref )
                return m_ref->setValue( filename );
            else
                return ParserResult::ok( ParseResultType::Matched );
        }
    };

    class Arg : public ParserRefImpl<Arg> {
    public:
        using ParserRefImpl::ParserRefImpl;

        auto parse( std::string const &, TokenStream const &tokens ) const -> InternalParseResult
override {
            auto validationResult = validate();
            if( !validationResult )
                return InternalParseResult( validationResult );

            auto remainingTokens = tokens;
            auto const &token = *remainingTokens;
            if( token.type != TokenType::Argument )
                return InternalParseResult::ok( ParseState( ParseResultType::NoMatch, remainingTokens
) );

            assert( !m_ref->isFlag() );
            auto valueRef = static_cast<detail::BoundValueRefBase*>( m_ref.get() );

            auto result = valueRef->setValue( remainingTokens->token );
            if( !result )
                return InternalParseResult( result );
            else
                return InternalParseResult::ok( ParseState( ParseResultType::Matched,
++remainingTokens ) );
        }
    };

    inline auto normaliseOpt( std::string const &optName ) -> std::string {
#ifdef CATCH_PLATFORM_WINDOWS
        if( optName[0] == '/' )
            return "-" + optName.substr( 1 );
        else
```

```
#endif
            return optName;
    }

    class Opt : public ParserRefImpl<Opt> {
    protected:
        std::vector<std::string> m_optNames;

    public:
        template<typename LambdaT>
        explicit Opt( LambdaT const &ref ) : ParserRefImpl( std::make_shared<BoundFlagLambda<LambdaT»( ref ) ) {}

        explicit Opt( bool &ref ) : ParserRefImpl( std::make_shared<BoundFlagRef>( ref ) ) {}

        template<typename LambdaT>
        Opt( LambdaT const &ref, std::string const &hint ) : ParserRefImpl( ref, hint ) {}

        template<typename T>
        Opt( T &ref, std::string const &hint ) : ParserRefImpl( ref, hint ) {}

        auto operator[]( std::string const &optName ) -> Opt & {
            m_optNames.push_back( optName );
            return *this;
        }

        auto getHelpColumns() const -> std::vector<HelpColumns> {
            std::ostringstream oss;
            bool first = true;
            for( auto const &opt : m_optNames ) {
                if (first)
                    first = false;
                else
                    oss « ", ";
                oss « opt;
            }
            if( !m_hint.empty() )
                oss « " <" « m_hint « ">";
            return { { oss.str(), m_description } };
        }

        auto isMatch( std::string const &optToken ) const -> bool {
            auto normalisedToken = normaliseOpt( optToken );
            for( auto const &name : m_optNames ) {
                if( normaliseOpt( name ) == normalisedToken )
                    return true;
            }
            return false;
        }

        using ParserBase::parse;

        auto parse( std::string const&, TokenStream const &tokens ) const -> InternalParseResult override {
            auto validationResult = validate();
            if( !validationResult )
                return InternalParseResult( validationResult );

            auto remainingTokens = tokens;
            if( remainingTokens && remainingTokens->type == TokenType::Option ) {
                auto const &token = *remainingTokens;
                if( isMatch(token.token ) ) {
                    if( m_ref->isFlag() ) {
                        auto flagRef = static_cast<detail::BoundFlagRefBase*>( m_ref.get() );
                        auto result = flagRef->setFlag( true );
                        if( !result )
                            return InternalParseResult( result );
                        if( result.value() == ParseResultType::ShortCircuitAll )
                            return InternalParseResult::ok( ParseState( result.value(), remainingTokens ) );
                    } else {
                        auto valueRef = static_cast<detail::BoundValueRefBase*>( m_ref.get() );
                        ++remainingTokens;
                        if( !remainingTokens )
                            return InternalParseResult::runtimeError( "Expected argument following " + token.token );
                        auto const &argToken = *remainingTokens;
                        if( argToken.type != TokenType::Argument )
                            return InternalParseResult::runtimeError( "Expected argument following " + token.token );
                        auto result = valueRef->setValue( argToken.token );
                        if( !result )
                            return InternalParseResult( result );
                        if( result.value() == ParseResultType::ShortCircuitAll )
                            return InternalParseResult::ok( ParseState( result.value(), remainingTokens ) );
                    }
                    return InternalParseResult::ok( ParseState( ParseResultType::Matched,
++remainingTokens ) );
                }
            }
            return InternalParseResult::ok( ParseState( ParseResultType::NoMatch, remainingTokens ) );
        }

        auto validate() const -> Result override {
            if( m_optNames.empty() )
                return Result::logicError( "No options supplied to Opt" );
            for( auto const &name : m_optNames ) {
                if( name.empty() )
                    return Result::logicError( "Option name cannot be empty" );
#ifdef CATCH_PLATFORM_WINDOWS
                if( name[0] != '-' && name[0] != '/' )
                    return Result::logicError( "Option name must begin with '-' or '/'" );
#else
                if( name[0] != '-' )
                    return Result::logicError( "Option name must begin with '-'" );
#endif
            }
            return ParserRefImpl::validate();
        }
    };

    struct Help : Opt {
        Help( bool &showHelpFlag )
        :   Opt([&]( bool flag ) {
                showHelpFlag = flag;
                return ParserResult::ok( ParseResultType::ShortCircuitAll );
            })
        {
            static_cast<Opt &>( *this )
                    ("display usage information")
                    ["-?"]["-h"]["--help"]
                    .optional();
        }
    };

    struct Parser : ParserBase {

        mutable ExeName m_exeName;
        std::vector<Opt> m_options;
        std::vector<Arg> m_args;

        auto operator|=( ExeName const &exeName ) -> Parser & {
            m_exeName = exeName;
            return *this;
        }

        auto operator|=( Arg const &arg ) -> Parser & {
            m_args.push_back(arg);
            return *this;
        }

        auto operator|=( Opt const &opt ) -> Parser & {
            m_options.push_back(opt);
            return *this;
        }

        auto operator|=( Parser const &other ) -> Parser & {
            m_options.insert(m_options.end(), other.m_options.begin(), other.m_options.end());
            m_args.insert(m_args.end(), other.m_args.begin(), other.m_args.end());
            return *this;
        }

        template<typename T>
        auto operator|( T const &other ) const -> Parser {
            return Parser( *this ) |= other;
        }

        // Forward deprecated interface with '+' instead of '|'
        template<typename T>
        auto operator+=( T const &other ) -> Parser & { return operator|=( other ); }
        template<typename T>
        auto operator+( T const &other ) const -> Parser { return operator|( other ); }

        auto getHelpColumns() const -> std::vector<HelpColumns> {
            std::vector<HelpColumns> cols;
            for (auto const &o : m_options) {
                auto childCols = o.getHelpColumns();
                cols.insert( cols.end(), childCols.begin(), childCols.end() );
            }
            return cols;
        }

        void writeToStream( std::ostream &os ) const {
            if (!m_exeName.name().empty()) {
                os « "usage:\n" « "  " « m_exeName.name() « " ";
                bool required = true, first = true;
                for( auto const &arg : m_args ) {
                    if (first)
                        first = false;
                    else
                        os « " ";
                    if( arg.isOptional() && required ) {
                        os « "[";
                        required = false;
                    }
                    os « "<" « arg.hint() « ">";
                    if( arg.cardinality() == 0 )
                        os « " ... ";
                }
                if( !required )
                    os « "]";
                if( !m_options.empty() )
                    os « " options";
                os « "\n\nwhere options are:" « std::endl;
            }

            auto rows = getHelpColumns();
            size_t consoleWidth = CATCH_CLARA_CONFIG_CONSOLE_WIDTH;
            size_t optWidth = 0;
            for( auto const &cols : rows )
                optWidth = (std::max)(optWidth, cols.left.size() + 2);

            optWidth = (std::min)(optWidth, consoleWidth/2);

            for( auto const &cols : rows ) {
                auto row =
                        TextFlow::Column( cols.left ).width( optWidth ).indent( 2 ) +
                        TextFlow::Spacer(4) +
                        TextFlow::Column( cols.right ).width( consoleWidth - 7 - optWidth );
                os « row « std::endl;
            }
        }

        friend auto operator«( std::ostream &os, Parser const &parser ) -> std::ostream& {
            parser.writeToStream( os );
            return os;
        }

        auto validate() const -> Result override {
            for( auto const &opt : m_options ) {
                auto result = opt.validate();
                if( !result )
                    return result;
            }
            for( auto const &arg : m_args ) {
                auto result = arg.validate();
                if( !result )
                    return result;
            }
            return Result::ok();
        }

        using ParserBase::parse;

        auto parse( std::string const& exeName, TokenStream const &tokens ) const ->
InternalParseResult override {

            struct ParserInfo {
                ParserBase const* parser = nullptr;
                size_t count = 0;
            };
            const size_t totalParsers = m_options.size() + m_args.size();
            assert( totalParsers < 512 );
            // ParserInfo parseInfos[totalParsers]; // <-- this is what we really want to do
            ParserInfo parseInfos[512];

            {
                size_t i = 0;
                for (auto const &opt : m_options) parseInfos[i++].parser = &opt;
                for (auto const &arg : m_args) parseInfos[i++].parser = &arg;
            }

            m_exeName.set( exeName );

            auto result = InternalParseResult::ok( ParseState( ParseResultType::NoMatch, tokens ) );
            while( result.value().remainingTokens() ) {
                bool tokenParsed = false;

                for( size_t i = 0; i < totalParsers; ++i ) {
                    auto&  parseInfo = parseInfos[i];
                    if( parseInfo.parser->cardinality() == 0 || parseInfo.count <
parseInfo.parser->cardinality() ) {
                        result = parseInfo.parser->parse(exeName, result.value().remainingTokens());
                        if (!result)
                            return result;
                        if (result.value().type() != ParseResultType::NoMatch) {
                            tokenParsed = true;
                            ++parseInfo.count;
                            break;
                        }
                    }
                }

                if( result.value().type() == ParseResultType::ShortCircuitAll )
                    return result;
                if( !tokenParsed )
                    return InternalParseResult::runtimeError( "Unrecognised token: " +
result.value().remainingTokens()->token );
            }
            // !TBD Check missing required options
            return result;
        }
    };

    template<typename DerivedT>
    template<typename T>
    auto ComposableParserImpl<DerivedT>::operator|( T const &other ) const -> Parser {
        return Parser() | static_cast<DerivedT const &>( *this ) | other;
    }
} // namespace detail

// A Combined parser
using detail::Parser;

// A parser for options
using detail::Opt;

// A parser for arguments
using detail::Arg;

// Wrapper for argc, argv from main()
using detail::Args;

// Specifies the name of the executable
using detail::ExeName;

// Convenience wrapper for option parser that specifies the help option
using detail::Help;

// enum of result types from a parse
using detail::ParseResultType;

// Result type for parser operation
using detail::ParserResult;

}} // namespace Catch::clara

// end clara.hpp
#ifdef __clang__
#pragma clang diagnostic pop
#endif

// Restore Clara's value for console width, if present
#ifdef CATCH_TEMP_CLARA_CONFIG_CONSOLE_WIDTH
#define CATCH_CLARA_TEXTFLOW_CONFIG_CONSOLE_WIDTH CATCH_TEMP_CLARA_CONFIG_CONSOLE_WIDTH
#undef CATCH_TEMP_CLARA_CONFIG_CONSOLE_WIDTH
#endif

// end catch_clara.h
namespace Catch {

    clara::Parser makeCommandLineParser( ConfigData& config );

} // end namespace Catch

// end catch_commandline.h
#include <fstream>
#include <ctime>

namespace Catch {

    clara::Parser makeCommandLineParser( ConfigData& config ) {

        using namespace clara;

        auto const setWarning = [&]( std::string const& warning ) {
                auto warningSet = [&]() {
                    if( warning == "NoAssertions" )
                        return WarnAbout::NoAssertions;

                    if ( warning == "NoTests" )
                        return WarnAbout::NoTests;

                    return WarnAbout::Nothing;
                }();

                if (warningSet == WarnAbout::Nothing)
                    return ParserResult::runtimeError( "Unrecognised warning: '" + warning + "'" );
                config.warnings = static_cast<WarnAbout::What>( config.warnings | warningSet );
                return ParserResult::ok( ParseResultType::Matched );
            };
        auto const loadTestNamesFromFile = [&]( std::string const& filename ) {
                std::ifstream f( filename.c_str() );
                if( !f.is_open() )
                    return ParserResult::runtimeError( "Unable to load input file: '" + filename + "'" );

                std::string line;
                while( std::getline( f, line ) ) {
                    line = trim(line);
                    if( !line.empty() && !startsWith( line, '#' ) ) {
                        if( !startsWith( line, '"' ) )
                            line = '"' + line + '"';
                        config.testsOrTags.push_back( line );
                        config.testsOrTags.emplace_back( "," );
                    }
                }
                //Remove comma in the end
                if(!config.testsOrTags.empty())
                    config.testsOrTags.erase( config.testsOrTags.end()-1 );

                return ParserResult::ok( ParseResultType::Matched );
            };
        auto const setTestOrder = [&]( std::string const& order ) {
                if( startsWith( "declared", order ) )
                    config.runOrder = RunTests::InDeclarationOrder;
                else if( startsWith( "lexical", order ) )
                    config.runOrder = RunTests::InLexicographicalOrder;
                else if( startsWith( "random", order ) )
                    config.runOrder = RunTests::InRandomOrder;
                else
                    return clara::ParserResult::runtimeError( "Unrecognised ordering: '" + order + "'" );
                return ParserResult::ok( ParseResultType::Matched );
            };
        auto const setRngSeed = [&]( std::string const& seed ) {
                if( seed != "time" )
                    return clara::detail::convertInto( seed, config.rngSeed );
                config.rngSeed = static_cast<unsigned int>( std::time(nullptr) );
                return ParserResult::ok( ParseResultType::Matched );
            };
        auto const setColourUsage = [&]( std::string const& useColour ) {
                    auto mode = toLower( useColour );

                    if( mode == "yes" )
                        config.useColour = UseColour::Yes;
                    else if( mode == "no" )
                        config.useColour = UseColour::No;
                    else if( mode == "auto" )
                        config.useColour = UseColour::Auto;
                    else
                        return ParserResult::runtimeError( "colour mode must be one of: auto, yes or no. '" + useColour + "' not recognised" );
                return ParserResult::ok( ParseResultType::Matched );
            };
        auto const setWaitForKeypress = [&]( std::string const& keypress ) {
                auto keypressLc = toLower( keypress );
                if (keypressLc == "never")
                    config.waitForKeypress = WaitForKeypress::Never;
                else if( keypressLc == "start" )
                    config.waitForKeypress = WaitForKeypress::BeforeStart;
                else if( keypressLc == "exit" )
                    config.waitForKeypress = WaitForKeypress::BeforeExit;
                else if( keypressLc == "both" )
                    config.waitForKeypress = WaitForKeypress::BeforeStartAndExit;
                else
                    return ParserResult::runtimeError( "keypress argument must be one of: never, start, exit or both. '" + keypress + "' not recognised" );
            return ParserResult::ok( ParseResultType::Matched );
            };
        auto const setVerbosity = [&]( std::string const& verbosity ) {
            auto lcVerbosity = toLower( verbosity );
            if( lcVerbosity == "quiet" )
                config.verbosity = Verbosity::Quiet;
            else if( lcVerbosity == "normal" )
                config.verbosity = Verbosity::Normal;
            else if( lcVerbosity == "high" )
                config.verbosity = Verbosity::High;
            else
                return ParserResult::runtimeError( "Unrecognised verbosity, '" + verbosity + "'" );
            return ParserResult::ok( ParseResultType::Matched );
        };
        auto const setReporter = [&]( std::string const& reporter ) {
            IReporterRegistry::FactoryMap const& factories =
getRegistryHub().getReporterRegistry().getFactories();

            auto lcReporter = toLower( reporter );
            auto result = factories.find( lcReporter );

            if( factories.end() != result )
                config.reporterName = lcReporter;
            else
                return ParserResult::runtimeError( "Unrecognized reporter, '" + reporter + "'. Check
available with --list-reporters" );
            return ParserResult::ok( ParseResultType::Matched );
        };

        auto cli
            = ExeName( config.processName )
            | Help( config.showHelp )
            | Opt( config.listTests )
                ["-l"]["--list-tests"]
                ( "list all/matching test cases" )
            | Opt( config.listTags )
                ["-t"]["--list-tags"]
                ( "list all/matching tags" )
            | Opt( config.showSuccessfulTests )
                ["-s"]["--success"]
                ( "include successful tests in output" )
            | Opt( config.shouldDebugBreak )
                ["-b"]["--break"]
                ( "break into debugger on failure" )
            | Opt( config.noThrow )
                ["-e"]["--nothrow"]
                ( "skip exception tests" )
            | Opt( config.showInvisibles )
                ["-i"]["--invisibles"]
                ( "show invisibles (tabs, newlines)" )
            | Opt( config.outputFilename, "filename" )
                ["-o"]["--out"]
                ( "output filename" )
            | Opt( setReporter, "name" )
                ["-r"]["--reporter"]
                ( "reporter to use (defaults to console)" )
            | Opt( config.name, "name" )
                ["-n"]["--name"]
                ( "suite name" )
            | Opt( [&]( bool ){ config.abortAfter = 1; } )
                ["-a"]["--abort"]
                ( "abort at first failure" )
            | Opt( [&]( int x ){ config.abortAfter = x; }, "no. failures" )
                ["-x"]["--abortx"]
                ( "abort after x failures" )
            | Opt( setWarning, "warning name" )
                ["-w"]["--warn"]
                ( "enable warnings" )
            | Opt( [&]( bool flag ) { config.showDurations = flag ? ShowDurations::Always :
ShowDurations::Never; }, "yes|no" )
                ["-d"]["--durations"]
                ( "show test durations" )
            | Opt( config.minDuration, "seconds" )
                ["-D"]["--min-duration"]
                ( "show test durations for tests taking at least the given number of seconds" )
            | Opt( loadTestNamesFromFile, "filename" )
                ["-f"]["--input-file"]
                ( "load test names to run from a file" )
            | Opt( config.filenamesAsTags )
                ["-#"]["--filenames-as-tags"]
                ( "adds a tag for the filename" )
            | Opt( config.sectionsToRun, "section name" )
                ["-c"]["--section"]
                ( "specify section to run" )
            | Opt( setVerbosity, "quiet|normal|high" )
                ["-v"]["--verbosity"]
                ( "set output verbosity" )
            | Opt( config.listTestNamesOnly )
                ["--list-test-names-only"]
                ( "list all/matching test cases names only" )
            | Opt( config.listReporters )
                ["--list-reporters"]
                ( "list all reporters" )
            | Opt( setTestOrder, "decl|lex|rand" )
                ["--order"]
                ( "test case order (defaults to decl)" )
            | Opt( setRngSeed, "'time'|number" )
                ["--rng-seed"]
                ( "set a specific seed for random numbers" )
            | Opt( setColourUsage, "yes|no" )
                ["--use-colour"]
                ( "should output be colourised" )
            | Opt( config.libIdentify )
                ["--libidentify"]
                ( "report name and version according to libidentify standard" )
            | Opt( setWaitForKeypress, "never|start|exit|both" )
                ["--wait-for-keypress"]
                ( "waits for a keypress before exiting" )
            | Opt( config.benchmarkSamples, "samples" )
                ["--benchmark-samples"]
                ( "number of samples to collect (default: 100)" )
            | Opt( config.benchmarkResamples, "resamples" )
                ["--benchmark-resamples"]
                ( "number of resamples for the bootstrap (default: 100000)" )
            | Opt( config.benchmarkConfidenceInterval, "confidence interval" )
                ["--benchmark-confidence-interval"]
                ( "confidence interval for the bootstrap (between 0 and 1, default: 0.95)" )
            | Opt( config.benchmarkNoAnalysis )
                ["--benchmark-no-analysis"]
                ( "perform only measurements; do not perform any analysis" )
            | Opt( config.benchmarkWarmupTime, "benchmarkWarmupTime" )
                ["--benchmark-warmup-time"]
                ( "amount of time in milliseconds spent on warming up each test (default: 100)" )
            | Arg( config.testsOrTags, "test name|pattern|tags" )
                ( "which test or tests to use" );

        return cli;
    }

} // end namespace Catch
// end catch_commandline.cpp
// start catch_common.cpp

#include <cstring>
#include <ostream>

namespace Catch {

    bool SourceLineInfo::operator == ( SourceLineInfo const& other ) const noexcept {
        return line == other.line && (file == other.file || std::strcmp(file, other.file) == 0);
    }
    bool SourceLineInfo::operator < ( SourceLineInfo const& other ) const noexcept {
        // We can assume that the same file will usually have the same pointer.
        // Thus, if the pointers are the same, there is no point in calling the strcmp
        return line < other.line || ( line == other.line && file != other.file && (std::strcmp(file,
other.file) < 0));
    }

    std::ostream& operator « ( std::ostream& os, SourceLineInfo const& info ) {
#ifndef __GNUG__
        os « info.file « '(' « info.line « ')';
#else
        os « info.file « ':' « info.line;
#endif
        return os;
    }

    std::string StreamEndStop::operator+() const {
        return std::string();
    }

    NonCopyable::NonCopyable() = default;
    NonCopyable::~NonCopyable() = default;

}
// end catch_common.cpp
// start catch_config.cpp

namespace Catch {

    Config::Config( ConfigData const& data )
    :   m_data( data ),
        m_stream( openStream() )
    {
        // We need to trim filter specs to avoid trouble with superfluous
        // whitespace (esp. important for bdd macros, as those are manually
        // aligned with whitespace).

        for (auto& elem : m_data.testsOrTags) {
            elem = trim(elem);
        }
        for (auto& elem : m_data.sectionsToRun) {
            elem = trim(elem);
        }

        TestSpecParser parser(ITagAliasRegistry::get());
        if (!m_data.testsOrTags.empty()) {
            m_hasTestFilters = true;
            for (auto const& testOrTags : m_data.testsOrTags) {
                parser.parse(testOrTags);
            }
        }
        m_testSpec = parser.testSpec();
    }

    std::string const& Config::getFilename() const {
        return m_data.outputFilename ;
    }

    bool Config::listTests() const          { return m_data.listTests; }
    bool Config::listTestNamesOnly() const  { return m_data.listTestNamesOnly; }
    bool Config::listTags() const           { return m_data.listTags; }
    bool Config::listReporters() const      { return m_data.listReporters; }

    std::string Config::getProcessName() const { return m_data.processName; }
    std::string const& Config::getReporterName() const { return m_data.reporterName; }

    std::vector<std::string> const& Config::getTestsOrTags() const { return m_data.testsOrTags; }
    std::vector<std::string> const& Config::getSectionsToRun() const { return m_data.sectionsToRun; }

    TestSpec const& Config::testSpec() const { return m_testSpec; }
    bool Config::hasTestFilters() const { return m_hasTestFilters; }

    bool Config::showHelp() const { return m_data.showHelp; }

    // IConfig interface
    bool Config::allowThrows() const                   { return !m_data.noThrow; }
    std::ostream& Config::stream() const               { return m_stream->stream(); }
    std::string Config::name() const                   { return m_data.name.empty() ? m_data.processName : m_data.name; }
    bool Config::includeSuccessfulResults() const      { return m_data.showSuccessfulTests; }
    bool Config::warnAboutMissingAssertions() const    { return !!(m_data.warnings & WarnAbout::NoAssertions); }
    bool Config::warnAboutNoTests() const              { return !!(m_data.warnings & WarnAbout::NoTests); }
    ShowDurations::OrNot Config::showDurations() const { return m_data.showDurations; }
    double Config::minDuration() const                 { return m_data.minDuration; }
    RunTests::InWhatOrder Config::runOrder() const     { return m_data.runOrder; }
    unsigned int Config::rngSeed() const               { return m_data.rngSeed; }
    UseColour::YesOrNo Config::useColour() const       { return m_data.useColour; }
    bool Config::shouldDebugBreak() const              { return m_data.shouldDebugBreak; }
    int Config::abortAfter() const                     { return m_data.abortAfter; }
    bool Config::showInvisibles() const                { return m_data.showInvisibles; }
    Verbosity Config::verbosity() const                { return m_data.verbosity; }

    bool Config::benchmarkNoAnalysis() const                      { return m_data.benchmarkNoAnalysis; }
    int Config::benchmarkSamples() const                          { return m_data.benchmarkSamples; }
    double Config::benchmarkConfidenceInterval() const            { return m_data.benchmarkConfidenceInterval; }
    unsigned int Config::benchmarkResamples() const               { return m_data.benchmarkResamples; }
    std::chrono::milliseconds Config::benchmarkWarmupTime() const { return std::chrono::milliseconds(m_data.benchmarkWarmupTime); }

    IStream const* Config::openStream() {
        return Catch::makeStream(m_data.outputFilename);
    }

} // end namespace Catch
// end catch_config.cpp
// start catch_console_colour.cpp

#if defined(__clang__)
#    pragma clang diagnostic push
#    pragma clang diagnostic ignored "-Wexit-time-destructors"
#endif

// start catch_errno_guard.h

namespace Catch {

    class ErrnoGuard {
    public:
        ErrnoGuard();
        ~ErrnoGuard();
    private:
        int m_oldErrno;
    };

}

// end catch_errno_guard.h
// start catch_windows_h_proxy.h


#if defined(CATCH_PLATFORM_WINDOWS)

#if !defined(NOMINMAX) && !defined(CATCH_CONFIG_NO_NOMINMAX)
#  define CATCH_DEFINED_NOMINMAX
#  define NOMINMAX
#endif
#if !defined(WIN32_LEAN_AND_MEAN) && !defined(CATCH_CONFIG_NO_WIN32_LEAN_AND_MEAN)
#  define CATCH_DEFINED_WIN32_LEAN_AND_MEAN
#  define WIN32_LEAN_AND_MEAN
#endif

#ifdef __AFXDLL
#include <AfxWin.h>
#else
#include <windows.h>
#endif

#ifdef CATCH_DEFINED_NOMINMAX
#  undef NOMINMAX
#endif
#ifdef CATCH_DEFINED_WIN32_LEAN_AND_MEAN
#  undef WIN32_LEAN_AND_MEAN
#endif

#endif // defined(CATCH_PLATFORM_WINDOWS)

// end catch_windows_h_proxy.h
#include <sstream>

namespace Catch {
    namespace {

        struct IColourImpl {
            virtual ~IColourImpl() = default;
            virtual void use( Colour::Code _colourCode ) = 0;
        };

        struct NoColourImpl : IColourImpl {
            void use( Colour::Code ) override {}

            static IColourImpl* instance() {
                static NoColourImpl s_instance;
                return &s_instance;
            }
        };

    } // anon namespace
} // namespace Catch

#if !defined( CATCH_CONFIG_COLOUR_NONE ) && !defined( CATCH_CONFIG_COLOUR_WINDOWS ) && !defined(
CATCH_CONFIG_COLOUR_ANSI )
#   ifdef CATCH_PLATFORM_WINDOWS
#       define CATCH_CONFIG_COLOUR_WINDOWS
#   else
#       define CATCH_CONFIG_COLOUR_ANSI
#   endif
#endif

#if defined ( CATCH_CONFIG_COLOUR_WINDOWS )

namespace Catch {
namespace {

    class Win32ColourImpl : public IColourImpl {
    public:
        Win32ColourImpl() : stdoutHandle( GetStdHandle(STD_OUTPUT_HANDLE) )
        {
            CONSOLE_SCREEN_BUFFER_INFO csbiInfo;
            GetConsoleScreenBufferInfo( stdoutHandle, &csbiInfo );
            originalForegroundAttributes = csbiInfo.wAttributes & ~( BACKGROUND_GREEN | BACKGROUND_RED
| BACKGROUND_BLUE | BACKGROUND_INTENSITY );
            originalBackgroundAttributes = csbiInfo.wAttributes & ~( FOREGROUND_GREEN | FOREGROUND_RED
| FOREGROUND_BLUE | FOREGROUND_INTENSITY );
        }

        void use( Colour::Code _colourCode ) override {
            switch( _colourCode ) {
                case Colour::None:      return setTextAttribute( originalForegroundAttributes );
                case Colour::White:     return setTextAttribute( FOREGROUND_GREEN | FOREGROUND_RED |
FOREGROUND_BLUE );
                case Colour::Red:       return setTextAttribute( FOREGROUND_RED );
                case Colour::Green:     return setTextAttribute( FOREGROUND_GREEN );
                case Colour::Blue:      return setTextAttribute( FOREGROUND_BLUE );
                case Colour::Cyan:      return setTextAttribute( FOREGROUND_BLUE | FOREGROUND_GREEN );
                case Colour::Yellow:    return setTextAttribute( FOREGROUND_RED | FOREGROUND_GREEN );
                case Colour::Grey:      return setTextAttribute( 0 );

                case Colour::LightGrey:     return setTextAttribute( FOREGROUND_INTENSITY );
                case Colour::BrightRed:     return setTextAttribute( FOREGROUND_INTENSITY |
FOREGROUND_RED );
                case Colour::BrightGreen:   return setTextAttribute( FOREGROUND_INTENSITY |
FOREGROUND_GREEN );
                case Colour::BrightWhite:   return setTextAttribute( FOREGROUND_INTENSITY |
FOREGROUND_GREEN | FOREGROUND_RED | FOREGROUND_BLUE );
                case Colour::BrightYellow:  return setTextAttribute( FOREGROUND_INTENSITY |
FOREGROUND_RED | FOREGROUND_GREEN );

                case Colour::Bright: CATCH_INTERNAL_ERROR( "not a colour" );

                default:
                    CATCH_ERROR( "Unknown colour requested" );
            }
        }

    private:
        void setTextAttribute( WORD _textAttribute ) {
            SetConsoleTextAttribute( stdoutHandle, _textAttribute | originalBackgroundAttributes );
        }
        HANDLE stdoutHandle;
        WORD originalForegroundAttributes;
        WORD originalBackgroundAttributes;
    };

    IColourImpl* platformColourInstance() {
        static Win32ColourImpl s_instance;

        IConfigPtr config = getCurrentContext().getConfig();
        UseColour::YesOrNo colourMode = config
            ? config->useColour()
            : UseColour::Auto;
        if( colourMode == UseColour::Auto )
            colourMode = UseColour::Yes;
        return colourMode == UseColour::Yes
            ? &s_instance
            : NoColourImpl::instance();
    }

} // end anon namespace
} // end namespace Catch

#elif defined( CATCH_CONFIG_COLOUR_ANSI )

#include <unistd.h>

namespace Catch {
namespace {

    // use POSIX/ ANSI console terminal codes
    // Thanks to Adam Strzelecki for original contribution
    // (http://github.com/nanoant)
    // https://github.com/philsquared/Catch/pull/131
    class PosixColourImpl : public IColourImpl {
    public:
        void use( Colour::Code _colourCode ) override {
            switch( _colourCode ) {
                case Colour::None:
                case Colour::White:     return setColour( "[0m" );
                case Colour::Red:       return setColour( "[0;31m" );
                case Colour::Green:     return setColour( "[0;32m" );
                case Colour::Blue:      return setColour( "[0;34m" );
                case Colour::Cyan:      return setColour( "[0;36m" );
                case Colour::Yellow:    return setColour( "[0;33m" );
                case Colour::Grey:      return setColour( "[1;30m" );

                case Colour::LightGrey:     return setColour( "[0;37m" );
                case Colour::BrightRed:     return setColour( "[1;31m" );
                case Colour::BrightGreen:   return setColour( "[1;32m" );
                case Colour::BrightWhite:   return setColour( "[1;37m" );
                case Colour::BrightYellow:  return setColour( "[1;33m" );

                case Colour::Bright: CATCH_INTERNAL_ERROR( "not a colour" );
                default: CATCH_INTERNAL_ERROR( "Unknown colour requested" );
            }
        }
        static IColourImpl* instance() {
            static PosixColourImpl s_instance;
            return &s_instance;
        }

    private:
        void setColour( const char* _escapeCode ) {
            getCurrentContext().getConfig()->stream()
                « '\033' « _escapeCode;
        }
    };

    bool useColourOnPlatform() {
        return
#if defined(CATCH_PLATFORM_MAC) || defined(CATCH_PLATFORM_IPHONE)
            !isDebuggerActive() &&
#endif
#if !(defined(__DJGPP__) && defined(__STRICT_ANSI__))
            isatty(STDOUT_FILENO)
#else
            false
#endif
            ;
    }
    IColourImpl* platformColourInstance() {
        ErrnoGuard guard;
        IConfigPtr config = getCurrentContext().getConfig();
        UseColour::YesOrNo colourMode = config
            ? config->useColour()
            : UseColour::Auto;
        if( colourMode == UseColour::Auto )
            colourMode = useColourOnPlatform()
                ? UseColour::Yes
                : UseColour::No;
        return colourMode == UseColour::Yes
            ? PosixColourImpl::instance()
            : NoColourImpl::instance();
    }

} // end anon namespace
} // end namespace Catch

#else  // not Windows or ANSI ///////////////////////////////////////////////

namespace Catch {

    static IColourImpl* platformColourInstance() { return NoColourImpl::instance(); }

} // end namespace Catch

#endif // Windows/ ANSI/ None

namespace Catch {

    Colour::Colour( Code _colourCode ) { use( _colourCode ); }
    Colour::Colour( Colour&& other ) noexcept {
        m_moved = other.m_moved;
        other.m_moved = true;
    }
    Colour& Colour::operator=( Colour&& other ) noexcept {
        m_moved = other.m_moved;
        other.m_moved  = true;
        return *this;
    }

    Colour::~Colour(){ if( !m_moved ) use( None ); }

    void Colour::use( Code _colourCode ) {
        static IColourImpl* impl = platformColourInstance();
        // Strictly speaking, this cannot possibly happen.
        // However, under some conditions it does happen (see #1626),
        // and this change is small enough that we can let practicality
        // triumph over purity in this case.
        if (impl != nullptr) {
            impl->use( _colourCode );
        }
    }

    std::ostream& operator « ( std::ostream& os, Colour const& ) {
        return os;
    }

} // end namespace Catch

#if defined(__clang__)
#    pragma clang diagnostic pop
#endif

```

```
// end catch_console_colour.cpp
// start catch_context.cpp

namespace Catch {

    class Context : public IMutableContext, NonCopyable {

    public: // IContext
        IResultCapture* getResultCapture() override {
            return m_resultCapture;
        }
        IRunner* getRunner() override {
            return m_runner;
        }

        IConfigPtr const& getConfig() const override {
            return m_config;
        }

        ~Context() override;

    public: // IMutableContext
        void setResultCapture( IResultCapture* resultCapture ) override {
            m_resultCapture = resultCapture;
        }
        void setRunner( IRunner* runner ) override {
            m_runner = runner;
        }
        void setConfig( IConfigPtr const& config ) override {
            m_config = config;
        }

        friend IMutableContext& getCurrentMutableContext();

    private:
        IConfigPtr m_config;
        IRunner* m_runner = nullptr;
        IResultCapture* m_resultCapture = nullptr;
    };

    IMutableContext *IMutableContext::currentContext = nullptr;

    void IMutableContext::createContext()
    {
        currentContext = new Context();
    }

    void cleanUpContext() {
        delete IMutableContext::currentContext;
        IMutableContext::currentContext = nullptr;
    }
    IContext::~IContext() = default;
    IMutableContext::~IMutableContext() = default;
    Context::~Context() = default;

    SimplePcg32& rng() {
        static SimplePcg32 s_rng;
        return s_rng;
    }

}
// end catch_context.cpp
// start catch_debug_console.cpp

// start catch_debug_console.h

#include <string>

namespace Catch {
    void writeToDebugConsole( std::string const& text );
}

// end catch_debug_console.h
#if defined(CATCH_CONFIG_ANDROID_LOGWRITE)
#include <android/log.h>

    namespace Catch {
        void writeToDebugConsole( std::string const& text ) {
            __android_log_write( ANDROID_LOG_DEBUG, "Catch", text.c_str() );
        }
    }

#elif defined(CATCH_PLATFORM_WINDOWS)

    namespace Catch {
        void writeToDebugConsole( std::string const& text ) {
            ::OutputDebugStringA( text.c_str() );
        }
    }

#else

    namespace Catch {
        void writeToDebugConsole( std::string const& text ) {
            // !TBD: Need a version for Mac/ XCode and other IDEs
            Catch::cout() « text;
        }
    }

#endif // Platform
// end catch_debug_console.cpp
// start catch_debugger.cpp

#if defined(CATCH_PLATFORM_MAC) || defined(CATCH_PLATFORM_IPHONE)

#  include <cassert>
#  include <sys/types.h>
#  include <unistd.h>
#  include <cstddef>
#  include <ostream>

#ifdef __apple_build_version__
    // These headers will only compile with AppleClang (XCode)
    // For other compilers (Clang, GCC, ... ) we need to exclude them
#  include <sys/sysctl.h>
#endif

    namespace Catch {
        #ifdef __apple_build_version__
        // The following function is taken directly from the following technical note:
        // https://developer.apple.com/library/archive/qa/qa1361/_index.html

        // Returns true if the current process is being debugged (either
        // running under the debugger or has a debugger attached post facto).
        bool isDebuggerActive(){
            int                 mib[4];
            struct kinfo_proc   info;
            std::size_t         size;

            // Initialize the flags so that, if sysctl fails for some bizarre
            // reason, we get a predictable result.

            info.kp_proc.p_flag = 0;

            // Initialize mib, which tells sysctl the info we want, in this case
            // we're looking for information about a specific process ID.

            mib[0] = CTL_KERN;
            mib[1] = KERN_PROC;
            mib[2] = KERN_PROC_PID;
            mib[3] = getpid();

            // Call sysctl.

            size = sizeof(info);
            if( sysctl(mib, sizeof(mib) / sizeof(*mib), &info, &size, nullptr, 0) != 0 ) {
                Catch::cerr() « "\n** Call to sysctl failed - unable to determine if debugger is
active **\n" « std::endl;
                return false;
            }

            // We're being debugged if the P_TRACED flag is set.

            return ( (info.kp_proc.p_flag & P_TRACED) != 0 );
        }
        #else
        bool isDebuggerActive() {
            // We need to find another way to determine this for non-appleclang compilers on macOS
            return false;
        }
        #endif
    } // namespace Catch

#elif defined(CATCH_PLATFORM_LINUX)
    #include <fstream>
    #include <string>

    namespace Catch{
        // The standard POSIX way of detecting a debugger is to attempt to
        // ptrace() the process, but this needs to be done from a child and not
        // this process itself to still allow attaching to this process later
        // if wanted, so is rather heavy. Under Linux we have the PID of the
        // "debugger" (which doesn't need to be gdb, of course, it could also
        // be strace, for example) in /proc/$PID/status, so just get it from
        // there instead.
        bool isDebuggerActive(){
            // Libstdc++ has a bug, where std::ifstream sets errno to 0
            // This way our users can properly assert over errno values
            ErrnoGuard guard;
            std::ifstream in("/proc/self/status");
            for( std::string line; std::getline(in, line); ) {
                static const int PREFIX_LEN = 11;
                if( line.compare(0, PREFIX_LEN, "TracerPid:\t") == 0 ) {
                    // We're traced if the PID is not 0 and no other PID starts
                    // with 0 digit, so it's enough to check for just a single
                    // character.
                    return line.length() > PREFIX_LEN && line[PREFIX_LEN] != '0';
                }
            }

            return false;
        }
    } // namespace Catch
#elif defined(_MSC_VER)
    extern "C" __declspec(dllimport) int __stdcall IsDebuggerPresent();
    namespace Catch {
        bool isDebuggerActive() {
            return IsDebuggerPresent() != 0;
        }
    }
#elif defined(__MINGW32__)
    extern "C" __declspec(dllimport) int __stdcall IsDebuggerPresent();
    namespace Catch {
        bool isDebuggerActive() {
            return IsDebuggerPresent() != 0;
        }
    }
#else
    namespace Catch {
       bool isDebuggerActive() { return false; }
    }
#endif // Platform
// end catch_debugger.cpp
// start catch_decomposer.cpp

namespace Catch {

    ITransientExpression::~ITransientExpression() = default;

    void formatReconstructedExpression( std::ostream &os, std::string const& lhs, StringRef op,
std::string const& rhs ) {
        if( lhs.size() + rhs.size() < 40 &&
                lhs.find('\n') == std::string::npos &&
                rhs.find('\n') == std::string::npos )
            os « lhs « " " « op « " " « rhs;
        else
            os « lhs « "\n" « op « "\n" « rhs;
    }
}
// end catch_decomposer.cpp
// start catch_enforce.cpp

#include <stdexcept>

namespace Catch {
#if defined(CATCH_CONFIG_DISABLE_EXCEPTIONS) &&
!defined(CATCH_CONFIG_DISABLE_EXCEPTIONS_CUSTOM_HANDLER)
    [[noreturn]]
    void throw_exception(std::exception const& e) {
        Catch::cerr() « "Catch will terminate because it needed to throw an exception.\n"
                      « "The message was: " « e.what() « '\n';
        std::terminate();
    }
#endif

    [[noreturn]]
    void throw_logic_error(std::string const& msg) {
        throw_exception(std::logic_error(msg));
    }

    [[noreturn]]
    void throw_domain_error(std::string const& msg) {
        throw_exception(std::domain_error(msg));
    }

    [[noreturn]]
    void throw_runtime_error(std::string const& msg) {
        throw_exception(std::runtime_error(msg));
    }

} // namespace Catch;
```

```
// end catch_enforce.cpp
// start catch_enum_values_registry.cpp
// start catch_enum_values_registry.h

#include <vector>
#include <memory>

namespace Catch {

    namespace Detail {

        std::unique_ptr<EnumInfo> makeEnumInfo( StringRef enumName, StringRef allValueNames,
std::vector<int> const& values );

        class EnumValuesRegistry : public IMutableEnumValuesRegistry {

            std::vector<std::unique_ptr<EnumInfo>> m_enumInfos;

            EnumInfo const& registerEnum( StringRef enumName, StringRef allEnums, std::vector<int>
const& values) override;
        };

        std::vector<StringRef> parseEnums( StringRef enums );

    } // Detail

} // Catch

// end catch_enum_values_registry.h

#include <map>
#include <cassert>

namespace Catch {

    IMutableEnumValuesRegistry::~IMutableEnumValuesRegistry() {}

    namespace Detail {

        namespace {
            // Extracts the actual name part of an enum instance
            // In other words, it returns the Blue part of Bikeshed::Colour::Blue
            StringRef extractInstanceName(StringRef enumInstance) {
                // Find last occurrence of ":"
                size_t name_start = enumInstance.size();
                while (name_start > 0 && enumInstance[name_start - 1] != ':') {
                    --name_start;
                }
                return enumInstance.substr(name_start, enumInstance.size() - name_start);
            }
        }

        std::vector<StringRef> parseEnums( StringRef enums ) {
            auto enumValues = splitStringRef( enums, ',' );
            std::vector<StringRef> parsed;
            parsed.reserve( enumValues.size() );
            for( auto const& enumValue : enumValues ) {
                parsed.push_back(trim(extractInstanceName(enumValue)));
            }
            return parsed;
        }

        EnumInfo::~EnumInfo() {}

        StringRef EnumInfo::lookup( int value ) const {
            for( auto const& valueToName : m_values ) {
                if( valueToName.first == value )
                    return valueToName.second;
            }
            return "{** unexpected enum value **}"_sr;
        }

        std::unique_ptr<EnumInfo> makeEnumInfo( StringRef enumName, StringRef allValueNames,
std::vector<int> const& values ) {
            std::unique_ptr<EnumInfo> enumInfo( new EnumInfo );
            enumInfo->m_name = enumName;
            enumInfo->m_values.reserve( values.size() );

            const auto valueNames = Catch::Detail::parseEnums( allValueNames );
            assert( valueNames.size() == values.size() );
            std::size_t i = 0;
            for( auto value : values )
                enumInfo->m_values.emplace_back(value, valueNames[i++]);

            return enumInfo;
        }

        EnumInfo const& EnumValuesRegistry::registerEnum( StringRef enumName, StringRef allValueNames,
std::vector<int> const& values ) {
            m_enumInfos.push_back(makeEnumInfo(enumName, allValueNames, values));
            return *m_enumInfos.back();
        }

    } // Detail
} // Catch

// end catch_enum_values_registry.cpp
// start catch_errno_guard.cpp

#include <cerrno>

namespace Catch {
        ErrnoGuard::ErrnoGuard():m_oldErrno(errno){}
        ErrnoGuard::~ErrnoGuard() { errno = m_oldErrno; }
}
// end catch_errno_guard.cpp
// start catch_exception_translator_registry.cpp

// start catch_exception_translator_registry.h

#include <vector>
#include <string>
#include <memory>

namespace Catch {

    class ExceptionTranslatorRegistry : public IExceptionTranslatorRegistry {
    public:
        ~ExceptionTranslatorRegistry();
        virtual void registerTranslator( const IExceptionTranslator* translator );
        std::string translateActiveException() const override;
        std::string tryTranslators() const;

    private:
        std::vector<std::unique_ptr<IExceptionTranslator const» m_translators;
    };
}

// end catch_exception_translator_registry.h
#ifdef __OBJC__
#import "Foundation/Foundation.h"
#endif

namespace Catch {

    ExceptionTranslatorRegistry::~ExceptionTranslatorRegistry() {
    }

    void ExceptionTranslatorRegistry::registerTranslator( const IExceptionTranslator* translator ) {
        m_translators.push_back( std::unique_ptr<const IExceptionTranslator>( translator ) );
    }

#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
    std::string ExceptionTranslatorRegistry::translateActiveException() const {
        try {
#ifdef __OBJC__
            // In Objective-C try objective-c exceptions first
            @try {
                return tryTranslators();
            }
            @catch (NSException *exception) {
                return Catch::Detail::stringify( [exception description] );
            }
#else
            // Compiling a mixed mode project with MSVC means that CLR
            // exceptions will be caught in (...) as well. However, these
            // do not fill-in std::current_exception and thus lead to crash
            // when attempting rethrow.
            // /EHa switch also causes structured exceptions to be caught
            // here, but they fill-in current_exception properly, so
            // at worst the output should be a little weird, instead of
            // causing a crash.
            if (std::current_exception() == nullptr) {
                return "Non C++ exception. Possibly a CLR exception.";
            }
            return tryTranslators();
#endif
        }
        catch( TestFailureException& ) {
            std::rethrow_exception(std::current_exception());
        }
        catch( std::exception& ex ) {
            return ex.what();
        }
        catch( std::string& msg ) {
            return msg;
        }
        catch( const char* msg ) {
            return msg;
        }
        catch(...) {
            return "Unknown exception";
        }
    }

    std::string ExceptionTranslatorRegistry::tryTranslators() const {
        if (m_translators.empty()) {
            std::rethrow_exception(std::current_exception());
        } else {
            return m_translators[0]->translate(m_translators.begin() + 1, m_translators.end());
        }
    }

#else // ^^ Exceptions are enabled // Exceptions are disabled vv
    std::string ExceptionTranslatorRegistry::translateActiveException() const {
        CATCH_INTERNAL_ERROR("Attempted to translate active exception under
CATCH_CONFIG_DISABLE_EXCEPTIONS!");
    }

    std::string ExceptionTranslatorRegistry::tryTranslators() const {
        CATCH_INTERNAL_ERROR("Attempted to use exception translators under
CATCH_CONFIG_DISABLE_EXCEPTIONS!");
    }
#endif

}
// end catch_exception_translator_registry.cpp
// start catch_fatal_condition.cpp

#include <algorithm>

#if !defined( CATCH_CONFIG_WINDOWS_SEH ) && !defined( CATCH_CONFIG_POSIX_SIGNALS )

namespace Catch {

    // If neither SEH nor signal handling is required, the handler impls
    // do not have to do anything, and can be empty.
    void FatalConditionHandler::engage_platform() {}
    void FatalConditionHandler::disengage_platform() {}
    FatalConditionHandler::FatalConditionHandler() = default;
    FatalConditionHandler::~FatalConditionHandler() = default;

} // end namespace Catch

#endif // !CATCH_CONFIG_WINDOWS_SEH && !CATCH_CONFIG_POSIX_SIGNALS

#if defined( CATCH_CONFIG_WINDOWS_SEH ) && defined( CATCH_CONFIG_POSIX_SIGNALS )
#error "Inconsistent configuration: Windows' SEH handling and POSIX signals cannot be enabled at the
same time"
#endif // CATCH_CONFIG_WINDOWS_SEH && CATCH_CONFIG_POSIX_SIGNALS

#if defined( CATCH_CONFIG_WINDOWS_SEH ) || defined( CATCH_CONFIG_POSIX_SIGNALS )

namespace {
    void reportFatal( char const * const message ) {
        Catch::getCurrentContext().getResultCapture()->handleFatalErrorCondition( message );
    }

    constexpr std::size_t minStackSizeForErrors = 32 * 1024;
} // end unnamed namespace

#endif // CATCH_CONFIG_WINDOWS_SEH || CATCH_CONFIG_POSIX_SIGNALS

#if defined( CATCH_CONFIG_WINDOWS_SEH )

namespace Catch {

    struct SignalDefs { DWORD id; const char* name; };

    // There is no 1-1 mapping between signals and windows exceptions.
    // Windows can easily distinguish between SO and SigSegV,
    // but SigInt, SigTerm, etc are handled differently.
    static SignalDefs signalDefs[] = {
        { static_cast<DWORD>(EXCEPTION_ILLEGAL_INSTRUCTION),  "SIGILL - Illegal instruction signal" },
        { static_cast<DWORD>(EXCEPTION_STACK_OVERFLOW), "SIGSEGV - Stack overflow" },
        { static_cast<DWORD>(EXCEPTION_ACCESS_VIOLATION), "SIGSEGV - Segmentation violation signal" },
        { static_cast<DWORD>(EXCEPTION_INT_DIVIDE_BY_ZERO), "Divide by zero error" },
    };

    static LONG CALLBACK handleVectoredException(PEXCEPTION_POINTERS ExceptionInfo) {
        for (auto const& def : signalDefs) {
            if (ExceptionInfo->ExceptionRecord->ExceptionCode == def.id) {
                reportFatal(def.name);
            }
        }
        // If its not an exception we care about, pass it along.
        // This stops us from eating debugger breaks etc.
        return EXCEPTION_CONTINUE_SEARCH;
    }

    // Since we do not support multiple instantiations, we put these
    // into global variables and rely on cleaning them up in outlined
    // constructors/destructors
    static PVOID exceptionHandlerHandle = nullptr;

    // For MSVC, we reserve part of the stack memory for handling
    // memory overflow structured exception.
    FatalConditionHandler::FatalConditionHandler() {
        ULONG guaranteeSize = static_cast<ULONG>(minStackSizeForErrors);
        if (!SetThreadStackGuarantee(&guaranteeSize)) {
            // We do not want to fully error out, because needing
            // the stack reserve should be rare enough anyway.
            Catch::cerr()
                « "Failed to reserve piece of stack."
                « " Stack overflows will not be reported successfully.";
        }
    }

    // We do not attempt to unset the stack guarantee, because
    // Windows does not support lowering the stack size guarantee.
    FatalConditionHandler::~FatalConditionHandler() = default;

    void FatalConditionHandler::engage_platform() {
        // Register as first handler in current chain
        exceptionHandlerHandle = AddVectoredExceptionHandler(1, handleVectoredException);
        if (!exceptionHandlerHandle) {
            CATCH_RUNTIME_ERROR("Could not register vectored exception handler");
        }
    }

    void FatalConditionHandler::disengage_platform() {
        if (!RemoveVectoredExceptionHandler(exceptionHandlerHandle)) {
            CATCH_RUNTIME_ERROR("Could not unregister vectored exception handler");
        }
        exceptionHandlerHandle = nullptr;
    }

} // end namespace Catch

#endif // CATCH_CONFIG_WINDOWS_SEH

#if defined( CATCH_CONFIG_POSIX_SIGNALS )

#include <signal.h>

namespace Catch {

    struct SignalDefs {
        int id;
        const char* name;
    };

    static SignalDefs signalDefs[] = {
        { SIGINT,  "SIGINT - Terminal interrupt signal" },
        { SIGILL,  "SIGILL - Illegal instruction signal" },
        { SIGFPE,  "SIGFPE - Floating point error signal" },
        { SIGSEGV, "SIGSEGV - Segmentation violation signal" },
        { SIGTERM, "SIGTERM - Termination request signal" },
        { SIGABRT, "SIGABRT - Abort (abnormal termination) signal" }
    };

// Older GCCs trigger -Wmissing-field-initializers for T foo = {}
// which is zero initialization, but not explicit. We want to avoid
// that.
#if defined(__GNUC__)
#    pragma GCC diagnostic push
#    pragma GCC diagnostic ignored "-Wmissing-field-initializers"
#endif

    static char* altStackMem = nullptr;
    static std::size_t altStackSize = 0;
    static stack_t oldSigStack{};
    static struct sigaction oldSigActions[sizeof(signalDefs) / sizeof(SignalDefs)]{};

    static void restorePreviousSignalHandlers() {
        // We set signal handlers back to the previous ones. Hopefully
        // nobody overwrote them in the meantime, and doesn't expect
        // their signal handlers to live past ours given that they
        // installed them after ours..
        for (std::size_t i = 0; i < sizeof(signalDefs) / sizeof(SignalDefs); ++i) {
            sigaction(signalDefs[i].id, &oldSigActions[i], nullptr);
        }
        // Return the old stack
        sigaltstack(&oldSigStack, nullptr);
    }

    static void handleSignal( int sig ) {
        char const * name = "<unknown signal>";
        for (auto const& def : signalDefs) {
            if (sig == def.id) {
                name = def.name;
                break;
            }
        }
        // We need to restore previous signal handlers and let them do
        // their thing, so that the users can have the debugger break
        // when a signal is raised, and so on.
        restorePreviousSignalHandlers();
        reportFatal( name );
        raise( sig );
    }

    FatalConditionHandler::FatalConditionHandler() {
        assert(!altStackMem && "Cannot initialize POSIX signal handler when one already exists");
        if (altStackSize == 0) {
            altStackSize = std::max(static_cast<size_t>(SIGSTKSZ), minStackSizeForErrors);
        }
        altStackMem = new char[altStackSize]();
    }

    FatalConditionHandler::~FatalConditionHandler() {
        delete[] altStackMem;
        // We signal that another instance can be constructed by zeroing
        // out the pointer.
        altStackMem = nullptr;
    }

    void FatalConditionHandler::engage_platform() {
        stack_t sigStack;
        sigStack.ss_sp = altStackMem;
        sigStack.ss_size = altStackSize;
        sigStack.ss_flags = 0;
        sigaltstack(&sigStack, &oldSigStack);
        struct sigaction sa = { };

        sa.sa_handler = handleSignal;
        sa.sa_flags = SA_ONSTACK;
        for (std::size_t i = 0; i < sizeof(signalDefs)/sizeof(SignalDefs); ++i) {
            sigaction(signalDefs[i].id, &sa, &oldSigActions[i]);
        }
    }

#if defined(__GNUC__)
#    pragma GCC diagnostic pop
#endif

    void FatalConditionHandler::disengage_platform() {
        restorePreviousSignalHandlers();
    }

} // end namespace Catch

#endif // CATCH_CONFIG_POSIX_SIGNALS
// end catch_fatal_condition.cpp
// start catch_generators.cpp

#include <limits>
#include <set>

namespace Catch {

IGeneratorTracker::~IGeneratorTracker() {}

const char* GeneratorException::what() const noexcept {
    return m_msg;
}

namespace Generators {

    GeneratorUntypedBase::~GeneratorUntypedBase() {}

    auto acquireGeneratorTracker( StringRef generatorName, SourceLineInfo const& lineInfo ) ->
IGeneratorTracker& {
        return getResultCapture().acquireGeneratorTracker( generatorName, lineInfo );
    }
```

```

} // namespace Generators
} // namespace Catch
// end catch_generators.cpp
// start catch_interfaces_capture.cpp

namespace Catch {
    IResultCapture::~IResultCapture() = default;
}
// end catch_interfaces_capture.cpp
// start catch_interfaces_config.cpp

namespace Catch {
    IConfig::~IConfig() = default;
}
// end catch_interfaces_config.cpp
// start catch_interfaces_exception.cpp

namespace Catch {
    IExceptionTranslator::~IExceptionTranslator() = default;
    IExceptionTranslatorRegistry::~IExceptionTranslatorRegistry() = default;
}
// end catch_interfaces_exception.cpp
// start catch_interfaces_registry_hub.cpp

namespace Catch {
    IRegistryHub::~IRegistryHub() = default;
    IMutableRegistryHub::~IMutableRegistryHub() = default;
}
// end catch_interfaces_registry_hub.cpp
// start catch_interfaces_reporter.cpp

// start catch_reporter_listening.h

namespace Catch {

    class ListeningReporter : public IStreamingReporter {
        using Reporters = std::vector<IStreamingReporterPtr>;
        Reporters m_listeners;
        IStreamingReporterPtr m_reporter = nullptr;
        ReporterPreferences m_preferences;

    public:
        ListeningReporter();

        void addListener( IStreamingReporterPtr&& listener );
        void addReporter( IStreamingReporterPtr&& reporter );

    public: // IStreamingReporter

        ReporterPreferences getPreferences() const override;

        void noMatchingTestCases( std::string const& spec ) override;

        void reportInvalidArguments(std::string const&arg) override;

        static std::set<Verbosity> getSupportedVerbosities();

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
        void benchmarkPreparing(std::string const& name) override;
        void benchmarkStarting( BenchmarkInfo const& benchmarkInfo ) override;
        void benchmarkEnded( BenchmarkStats<> const& benchmarkStats ) override;
        void benchmarkFailed(std::string const&) override;
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

        void testRunStarting( TestRunInfo const& testRunInfo ) override;
        void testGroupStarting( GroupInfo const& groupInfo ) override;
        void testCaseStarting( TestCaseInfo const& testInfo ) override;
        void sectionStarting( SectionInfo const& sectionInfo ) override;
        void assertionStarting( AssertionInfo const& assertionInfo ) override;

        // The return value indicates if the messages buffer should be cleared:
        bool assertionEnded( AssertionStats const& assertionStats ) override;
        void sectionEnded( SectionStats const& sectionStats ) override;
        void testCaseEnded( TestCaseStats const& testCaseStats ) override;
        void testGroupEnded( TestGroupStats const& testGroupStats ) override;
        void testRunEnded( TestRunStats const& testRunStats ) override;

        void skipTest( TestCaseInfo const& testInfo ) override;
        bool isMulti() const override;

    };

} // end namespace Catch

// end catch_reporter_listening.h
namespace Catch {

    ReporterConfig::ReporterConfig( IConfigPtr const& _fullConfig )
    :   m_stream( &_fullConfig->stream() ), m_fullConfig( _fullConfig ) {}

    ReporterConfig::ReporterConfig( IConfigPtr const& _fullConfig, std::ostream& _stream )
    :   m_stream( &_stream ), m_fullConfig( _fullConfig ) {}

    std::ostream& ReporterConfig::stream() const { return *m_stream; }
    IConfigPtr ReporterConfig::fullConfig() const { return m_fullConfig; }

    TestRunInfo::TestRunInfo( std::string const& _name ) : name( _name ) {}

    GroupInfo::GroupInfo(  std::string const& _name,
                           std::size_t _groupIndex,
                           std::size_t _groupsCount )
    :   name( _name ),
        groupIndex( _groupIndex ),
        groupsCounts( _groupsCount )
    {}

     AssertionStats::AssertionStats( AssertionResult const& _assertionResult,
                                     std::vector<MessageInfo> const& _infoMessages,
                                     Totals const& _totals )
    :   assertionResult( _assertionResult ),
        infoMessages( _infoMessages ),
        totals( _totals )
    {
        assertionResult.m_resultData.lazyExpression.m_transientExpression =
_assertionResult.m_resultData.lazyExpression.m_transientExpression;

        if( assertionResult.hasMessage() ) {
            // Copy message into messages list.
            // !TBD This should have been done earlier, somewhere
            MessageBuilder builder( assertionResult.getTestMacroName(),
assertionResult.getSourceInfo(), assertionResult.getResultType() );
            builder « assertionResult.getMessage();
            builder.m_info.message = builder.m_stream.str();

            infoMessages.push_back( builder.m_info );
        }
    }

     AssertionStats::~AssertionStats() = default;

    SectionStats::SectionStats(  SectionInfo const& _sectionInfo,
                                 Counts const& _assertions,
                                 double _durationInSeconds,
                                 bool _missingAssertions )
    :   sectionInfo( _sectionInfo ),
        assertions( _assertions ),
        durationInSeconds( _durationInSeconds ),
        missingAssertions( _missingAssertions )
    {}

    SectionStats::~SectionStats() = default;

    TestCaseStats::TestCaseStats(  TestCaseInfo const& _testInfo,
                                   Totals const& _totals,
                                   std::string const& _stdOut,
                                   std::string const& _stdErr,
                                   bool _aborting )
    : testInfo( _testInfo ),
        totals( _totals ),
        stdOut( _stdOut ),
        stdErr( _stdErr ),
        aborting( _aborting )
    {}

    TestCaseStats::~TestCaseStats() = default;

    TestGroupStats::TestGroupStats( GroupInfo const& _groupInfo,
                                    Totals const& _totals,
                                    bool _aborting )
    :   groupInfo( _groupInfo ),
        totals( _totals ),
        aborting( _aborting )
    {}

    TestGroupStats::TestGroupStats( GroupInfo const& _groupInfo )
    :   groupInfo( _groupInfo ),
        aborting( false )
    {}

    TestGroupStats::~TestGroupStats() = default;

    TestRunStats::TestRunStats(   TestRunInfo const& _runInfo,
                    Totals const& _totals,
                      bool _aborting )
    :   runInfo( _runInfo ),
        totals( _totals ),
        aborting( _aborting )
    {}

    TestRunStats::~TestRunStats() = default;

    void IStreamingReporter::fatalErrorEncountered( StringRef ) {}
    bool IStreamingReporter::isMulti() const { return false; }

    IReporterFactory::~IReporterFactory() = default;
    IReporterRegistry::~IReporterRegistry() = default;

} // end namespace Catch
// end catch_interfaces_reporter.cpp
// start catch_interfaces_runner.cpp

namespace Catch {
    IRunner::~IRunner() = default;
}
// end catch_interfaces_runner.cpp
// start catch_interfaces_testcase.cpp

namespace Catch {
    ITestInvoker::~ITestInvoker() = default;
    ITestCaseRegistry::~ITestCaseRegistry() = default;
}
// end catch_interfaces_testcase.cpp
// start catch_leak_detector.cpp

#ifdef CATCH_CONFIG_WINDOWS_CRTDBG
#include <crtdbg.h>

namespace Catch {

    LeakDetector::LeakDetector() {
        int flag = _CrtSetDbgFlag(_CRTDBG_REPORT_FLAG);
        flag |= _CRTDBG_LEAK_CHECK_DF;
        flag |= _CRTDBG_ALLOC_MEM_DF;
        _CrtSetDbgFlag(flag);
        _CrtSetReportMode(_CRT_WARN, _CRTDBG_MODE_FILE | _CRTDBG_MODE_DEBUG);
        _CrtSetReportFile(_CRT_WARN, _CRTDBG_FILE_STDERR);
        // Change this to leaking allocation's number to break there
        _CrtSetBreakAlloc(-1);
    }
}

#else

    Catch::LeakDetector::LeakDetector() {}

#endif

Catch::LeakDetector::~LeakDetector() {
    Catch::cleanUp();
}
// end catch_leak_detector.cpp
// start catch_list.cpp

// start catch_list.h

#include <set>

namespace Catch {

    std::size_t listTests( Config const& config );

    std::size_t listTestsNamesOnly( Config const& config );

    struct TagInfo {
        void add( std::string const& spelling );
        std::string all() const;

        std::set<std::string> spellings;
        std::size_t count = 0;
    };

    std::size_t listTags( Config const& config );

    std::size_t listReporters();

    Option<std::size_t> list( std::shared_ptr<Config> const& config );

} // end namespace Catch

// end catch_list.h
// start catch_text.h

namespace Catch {
    using namespace clara::TextFlow;
}

// end catch_text.h
#include <limits>
#include <algorithm>
#include <iomanip>

namespace Catch {

    std::size_t listTests( Config const& config ) {
        TestSpec const& testSpec = config.testSpec();
        if( config.hasTestFilters() )
            Catch::cout() « "Matching test cases:\n";
        else {
            Catch::cout() « "All available test cases:\n";
        }

        auto matchedTestCases = filterTests( getAllTestCasesSorted( config ), testSpec, config );
        for( auto const& testCaseInfo : matchedTestCases ) {
            Colour::Code colour = testCaseInfo.isHidden()
                ? Colour::SecondaryText
                : Colour::None;
            Colour colourGuard( colour );

            Catch::cout() « Column( testCaseInfo.name ).initialIndent( 2 ).indent( 4 ) « "\n";
            if( config.verbosity() >= Verbosity::High ) {
                Catch::cout() « Column( Catch::Detail::stringify( testCaseInfo.lineInfo ) ).indent(4)
« std::endl;
                std::string description = testCaseInfo.description;
                if( description.empty() )
                    description = "(NO DESCRIPTION)";
                Catch::cout() « Column( description ).indent(4) « std::endl;
            }
            if( !testCaseInfo.tags.empty() )
                Catch::cout() « Column( testCaseInfo.tagsAsString() ).indent( 6 ) « "\n";
        }

        if( !config.hasTestFilters() )
            Catch::cout() « pluralise( matchedTestCases.size(), "test case" ) « '\n' « std::endl;
        else
            Catch::cout() « pluralise( matchedTestCases.size(), "matching test case" ) « '\n' «
std::endl;
        return matchedTestCases.size();
    }

    std::size_t listTestsNamesOnly( Config const& config ) {
        TestSpec const& testSpec = config.testSpec();
        std::size_t matchedTests = 0;
        std::vector<TestCase> matchedTestCases = filterTests( getAllTestCasesSorted( config ),
testSpec, config );
        for( auto const& testCaseInfo : matchedTestCases ) {
            matchedTests++;
            if( startsWith( testCaseInfo.name, '#' ) )
               Catch::cout() « '"' « testCaseInfo.name « '"';
            else
               Catch::cout() « testCaseInfo.name;
            if ( config.verbosity() >= Verbosity::High )
                Catch::cout() « "\t@" « testCaseInfo.lineInfo;
            Catch::cout() « std::endl;
        }
        return matchedTests;
    }

    void TagInfo::add( std::string const& spelling ) {
        ++count;
        spellings.insert( spelling );
    }

    std::string TagInfo::all() const {
        size_t size = 0;
        for (auto const& spelling : spellings) {
            // Add 2 for the brackes
            size += spelling.size() + 2;
        }

        std::string out; out.reserve(size);
        for (auto const& spelling : spellings) {
            out += '[';
            out += spelling;
            out += ']';
        }
        return out;
    }

    std::size_t listTags( Config const& config ) {
        TestSpec const& testSpec = config.testSpec();
        if( config.hasTestFilters() )
            Catch::cout() « "Tags for matching test cases:\n";
        else {
            Catch::cout() « "All available tags:\n";
        }

        std::map<std::string, TagInfo> tagCounts;

        std::vector<TestCase> matchedTestCases = filterTests( getAllTestCasesSorted( config ),
testSpec, config );
        for( auto const& testCase : matchedTestCases ) {
            for( auto const& tagName : testCase.getTestCaseInfo().tags ) {
                std::string lcaseTagName = toLower( tagName );
                auto countIt = tagCounts.find( lcaseTagName );
                if( countIt == tagCounts.end() )
                    countIt = tagCounts.insert( std::make_pair( lcaseTagName, TagInfo() ) ).first;
                countIt->second.add( tagName );
            }
        }

        for( auto const& tagCount : tagCounts ) {
            ReusableStringStream rss;
            rss « "  " « std::setw(2) « tagCount.second.count « "  ";
            auto str = rss.str();
            auto wrapper = Column( tagCount.second.all() )
                                                    .initialIndent( 0 )
                                                    .indent( str.size() )
                                                    .width( CATCH_CONFIG_CONSOLE_WIDTH-10 );
            Catch::cout() « str « wrapper « '\n';
        }
        Catch::cout() « pluralise( tagCounts.size(), "tag" ) « '\n' « std::endl;
        return tagCounts.size();
    }

    std::size_t listReporters() {
        Catch::cout() « "Available reporters:\n";
        IReporterRegistry::FactoryMap const& factories =
getRegistryHub().getReporterRegistry().getFactories();
        std::size_t maxNameLen = 0;
        for( auto const& factoryKvp : factories )
            maxNameLen = (std::max)( maxNameLen, factoryKvp.first.size() );

        for( auto const& factoryKvp : factories ) {
            Catch::cout()
                    « Column( factoryKvp.first + ":" )
                            .indent(2)
                            .width( 5+maxNameLen )
                    +  Column( factoryKvp.second->getDescription() )
                            .initialIndent(0)
                            .indent(2)
                            .width( CATCH_CONFIG_CONSOLE_WIDTH - maxNameLen-8 )
                    « "\n";
        }
        Catch::cout() « std::endl;
        return factories.size();
    }

    Option<std::size_t> list( std::shared_ptr<Config> const& config ) {
        Option<std::size_t> listedCount;
        getCurrentMutableContext().setConfig( config );
        if( config->listTests() )
            listedCount = listedCount.valueOr(0) + listTests( *config );
        if( config->listTestNamesOnly() )
            listedCount = listedCount.valueOr(0) + listTestsNamesOnly( *config );
        if( config->listTags() )
            listedCount = listedCount.valueOr(0) + listTags( *config );
        if( config->listReporters() )
            listedCount = listedCount.valueOr(0) + listReporters();
        return listedCount;
    }

} // end namespace Catch
// end catch_list.cpp
// start catch_matchers.cpp

namespace Catch {
namespace Matchers {
    namespace Impl {

        std::string MatcherUntypedBase::toString() const {
            if( m_cachedToString.empty() )
                m_cachedToString = describe();
            return m_cachedToString;
        }

        MatcherUntypedBase::~MatcherUntypedBase() = default;

    } // namespace Impl
} // namespace Matchers

using namespace Matchers;
using Matchers::Impl::MatcherBase;

} // namespace Catch
// end catch_matchers.cpp
// start catch_matchers_exception.cpp

namespace Catch {
namespace Matchers {
namespace Exception {

bool ExceptionMessageMatcher::match(std::exception const& ex) const {
    return ex.what() == m_message;
}

std::string ExceptionMessageMatcher::describe() const {
    return "exception message matches \"" + m_message + "\"";
}

}
Exception::ExceptionMessageMatcher Message(std::string const& message) {
    return Exception::ExceptionMessageMatcher(message);
}

// namespace Exception
} // namespace Matchers
} // namespace Catch
// end catch_matchers_exception.cpp
// start catch_matchers_floating.cpp

// start catch_polyfills.hpp

namespace Catch {
    bool isnan(float f);
    bool isnan(double d);
}

// end catch_polyfills.hpp
// start catch_to_string.hpp

#include <string>

namespace Catch {
    template <typename T>
    std::string to_string(T const& t) {
#if defined(CATCH_CONFIG_CPP11_TO_STRING)
        return std::to_string(t);
#else
        ReusableStringStream rss;
        rss « t;
        return rss.str();
#endif
    }
} // end namespace Catch

// end catch_to_string.hpp
#include <algorithm>
#include <cmath>
#include <cstdlib>
#include <cstdint>
#include <cstring>
#include <sstream>
#include <type_traits>
#include <iomanip>
#include <limits>

namespace Catch {
namespace {

    int32_t convert(float f) {
        static_assert(sizeof(float) == sizeof(int32_t), "Important ULP matcher assumption violated");
        int32_t i;
        std::memcpy(&i, &f, sizeof(f));
        return i;
    }

    int64_t convert(double d) {
        static_assert(sizeof(double) == sizeof(int64_t), "Important ULP matcher assumption violated");
        int64_t i;
        std::memcpy(&i, &d, sizeof(d));
        return i;
    }

    template <typename FP>
    bool almostEqualUlps(FP lhs, FP rhs, uint64_t maxUlpDiff) {
        // Comparison with NaN should always be false.
        // This way we can rule it out before getting into the ugly details
        if (Catch::isnan(lhs) || Catch::isnan(rhs)) {
            return false;
        }

        auto lc = convert(lhs);
        auto rc = convert(rhs);

        if ((lc < 0) != (rc < 0)) {
            // Potentially we can have +0 and -0
            return lhs == rhs;
        }

        // static cast as a workaround for IBM XLC
        auto ulpDiff = std::abs(static_cast<FP>(lc - rc));
        return static_cast<uint64_t>(ulpDiff) <= maxUlpDiff;
    }

#if defined(CATCH_CONFIG_GLOBAL_NEXTAFTER)

    float nextafter(float x, float y) {
        return ::nextafterf(x, y);
    }

    double nextafter(double x, double y) {
        return ::nextafter(x, y);
    }

#endif // ^^^ CATCH_CONFIG_GLOBAL_NEXTAFTER ^^^

template <typename FP>
FP step(FP start, FP direction, uint64_t steps) {
    for (uint64_t i = 0; i < steps; ++i) {
#if defined(CATCH_CONFIG_GLOBAL_NEXTAFTER)
        start = Catch::nextafter(start, direction);
#else
        start = std::nextafter(start, direction);
#endif
    }
    return start;
}

// Performs equivalent check of std::fabs(lhs - rhs) <= margin
// But without the subtraction to allow for INFINITY in comparison
bool marginComparison(double lhs, double rhs, double margin) {
    return (lhs + margin >= rhs) && (rhs + margin >= lhs);
}

template <typename FloatingPoint>
void write(std::ostream& out, FloatingPoint num) {
    out « std::scientific
        « std::setprecision(std::numeric_limits<FloatingPoint>::max_digits10 - 1)
        « num;
}

} // end anonymous namespace

namespace Matchers {
namespace Floating {

    enum class FloatingPointKind : uint8_t {
        Float,
        Double
    };

    WithinAbsMatcher::WithinAbsMatcher(double target, double margin)
        :m_target{ target }, m_margin{ margin } {
        CATCH_ENFORCE(margin >= 0, "Invalid margin: " « margin « '.'
            « " Margin has to be non-negative.");
    }

    // Performs equivalent check of std::fabs(lhs - rhs) <= margin
    // But without the subtraction to allow for INFINITY in comparison
    bool WithinAbsMatcher::match(double const& matchee) const {
        return (matchee + m_margin >= m_target) && (m_target + m_margin >= matchee);
    }

    std::string WithinAbsMatcher::describe() const {
        return "is within " + ::Catch::Detail::stringify(m_margin) + " of " +
::Catch::Detail::stringify(m_target);
    }

    WithinUlpsMatcher::WithinUlpsMatcher(double target, uint64_t ulps, FloatingPointKind baseType)
        :m_target{ target }, m_ulps{ ulps }, m_type{ baseType } {
        CATCH_ENFORCE(m_type == FloatingPointKind::Double
                   || m_ulps < (std::numeric_limits<uint32_t>::max)(),
            "Provided ULP is impossibly large for a float comparison.");
    }

#if defined(__clang__)
#pragma clang diagnostic push
// Clang <3.5 reports on the default branch in the switch below
#pragma clang diagnostic ignored "-Wunreachable-code"
#endif

    bool WithinUlpsMatcher::match(double const& matchee) const {
        switch (m_type) {
        case FloatingPointKind::Float:
            return almostEqualUlps<float>(static_cast<float>(matchee), static_cast<float>(m_target),
m_ulps);
        case FloatingPointKind::Double:
            return almostEqualUlps<double>(matchee, m_target, m_ulps);
        default:
            CATCH_INTERNAL_ERROR( "Unknown FloatingPointKind value" );
        }
    }

#if defined(__clang__)
#pragma clang diagnostic pop
#endif

    std::string WithinUlpsMatcher::describe() const {
        std::stringstream ret;

        ret « "is within " « m_ulps « " ULPs of ";

        if (m_type == FloatingPointKind::Float) {
            write(ret, static_cast<float>(m_target));
            ret « 'f';
        } else {
            write(ret, m_target);
        }

        ret « " ([";
        if (m_type == FloatingPointKind::Double) {
            write(ret, step(m_target, static_cast<double>(-INFINITY), m_ulps));
            ret « ", ";
            write(ret, step(m_target, static_cast<double>( INFINITY), m_ulps));
        } else {
            // We have to cast INFINITY to float because of MinGW, see #1782
            write(ret, step(static_cast<float>(m_target), static_cast<float>(-INFINITY), m_ulps));
            ret « ", ";
            write(ret, step(static_cast<float>(m_target), static_cast<float>( INFINITY), m_ulps));
        }
        ret « "])";

        return ret.str();
    }

    WithinRelMatcher::WithinRelMatcher(double target, double epsilon):
        m_target(target),
        m_epsilon(epsilon){
        CATCH_ENFORCE(m_epsilon >= 0., "Relative comparison with epsilon <  0 does not make sense.");
        CATCH_ENFORCE(m_epsilon  < 1., "Relative comparison with epsilon >= 1 does not make sense.");
    }

    bool WithinRelMatcher::match(double const& matchee) const {
        const auto relMargin = m_epsilon * (std::max)(std::fabs(matchee), std::fabs(m_target));
        return marginComparison(matchee, m_target,
                                std::isinf(relMargin)? 0 : relMargin);
    }

    std::string WithinRelMatcher::describe() const {
        Catch::ReusableStringStream sstr;
        sstr « "and " « m_target « " are within " « m_epsilon * 100. « "% of each other";
        return sstr.str();
    }

}// namespace Floating

Floating::WithinUlpsMatcher WithinULP(double target, uint64_t maxUlpDiff) {
    return Floating::WithinUlpsMatcher(target, maxUlpDiff, Floating::FloatingPointKind::Double);
}

Floating::WithinUlpsMatcher WithinULP(float target, uint64_t maxUlpDiff) {
    return Floating::WithinUlpsMatcher(target, maxUlpDiff, Floating::FloatingPointKind::Float);
}

Floating::WithinAbsMatcher WithinAbs(double target, double margin) {
    return Floating::WithinAbsMatcher(target, margin);
}

Floating::WithinRelMatcher WithinRel(double target, double eps) {
    return Floating::WithinRelMatcher(target, eps);
}

Floating::WithinRelMatcher WithinRel(double target) {
    return Floating::WithinRelMatcher(target, std::numeric_limits<double>::epsilon() * 100);
}

Floating::WithinRelMatcher WithinRel(float target, float eps) {
    return Floating::WithinRelMatcher(target, eps);
}

Floating::WithinRelMatcher WithinRel(float target) {
    return Floating::WithinRelMatcher(target, std::numeric_limits<float>::epsilon() * 100);
}

} // namespace Matchers
} // namespace Catch
// end catch_matchers_floating.cpp
// start catch_matchers_generic.cpp

std::string Catch::Matchers::Generic::Detail::finalizeDescription(const std::string& desc) {
    if (desc.empty()) {
        return "matches undescribed predicate";
    } else {
        return "matches predicate: \"" + desc + '"';
    }
}
// end catch_matchers_generic.cpp
// start catch_matchers_string.cpp

#include <regex>

namespace Catch {
namespace Matchers {

    namespace StdString {

        CasedString::CasedString( std::string const& str, CaseSensitive::Choice caseSensitivity )
        :   m_caseSensitivity( caseSensitivity ),
            m_str( adjustString( str ) )
        {}
        std::string CasedString::adjustString( std::string const& str ) const {
            return m_caseSensitivity == CaseSensitive::No
                   ? toLower( str )
                   : str;
        }
        std::string CasedString::caseSensitivitySuffix() const {
            return m_caseSensitivity == CaseSensitive::No
                   ? " (case insensitive)"
                   : std::string();
        }

        StringMatcherBase::StringMatcherBase( std::string const& operation, CasedString const&
comparator )
        : m_comparator( comparator ),
          m_operation( operation ) {
        }

        std::string StringMatcherBase::describe() const {
            std::string description;
            description.reserve(5 + m_operation.size() + m_comparator.m_str.size() +
                                        m_comparator.caseSensitivitySuffix().size());
            description += m_operation;
            description += ": \"";
            description += m_comparator.m_str;
            description += "\"";
            description += m_comparator.caseSensitivitySuffix();
            return description;
        }

        EqualsMatcher::EqualsMatcher( CasedString const& comparator ) : StringMatcherBase( "equals",
comparator ) {}

        bool EqualsMatcher::match( std::string const& source ) const {
            return m_comparator.adjustString( source ) == m_comparator.m_str;
        }

        ContainsMatcher::ContainsMatcher( CasedString const& comparator ) : StringMatcherBase(
"contains", comparator ) {}

        bool ContainsMatcher::match( std::string const& source ) const {
            return contains( m_comparator.adjustString( source ), m_comparator.m_str );
        }

        StartsWithMatcher::StartsWithMatcher( CasedString const& comparator ) : StringMatcherBase(
"starts with", comparator ) {}

        bool StartsWithMatcher::match( std::string const& source ) const {
            return startsWith( m_comparator.adjustString( source ), m_comparator.m_str );
        }

        EndsWithMatcher::EndsWithMatcher( CasedString const& comparator ) : StringMatcherBase( "ends
with", comparator ) {}

        bool EndsWithMatcher::match( std::string const& source ) const {
            return endsWith( m_comparator.adjustString( source ), m_comparator.m_str );
        }

        RegexMatcher::RegexMatcher(std::string regex, CaseSensitive::Choice caseSensitivity):
m_regex(std::move(regex)), m_caseSensitivity(caseSensitivity) {}

        bool RegexMatcher::match(std::string const& matchee) const {
            auto flags = std::regex::ECMAScript; // ECMAScript is the default syntax option anyway
            if (m_caseSensitivity == CaseSensitive::Choice::No) {
                flags |= std::regex::icase;
            }
            auto reg = std::regex(m_regex, flags);
            return std::regex_match(matchee, reg);
        }

        std::string RegexMatcher::describe() const {
            return "matches " + ::Catch::Detail::stringify(m_regex) + ((m_caseSensitivity ==
CaseSensitive::Choice::Yes)? " case sensitively" : " case insensitively");
        }

    } // namespace StdString

    StdString::EqualsMatcher Equals( std::string const& str, CaseSensitive::Choice caseSensitivity ) {
        return StdString::EqualsMatcher( StdString::CasedString( str, caseSensitivity) );
    }
    StdString::ContainsMatcher Contains( std::string const& str, CaseSensitive::Choice caseSensitivity
) {
        return StdString::ContainsMatcher( StdString::CasedString( str, caseSensitivity) );
    }
    StdString::EndsWithMatcher EndsWith( std::string const& str, CaseSensitive::Choice caseSensitivity
) {
        return StdString::EndsWithMatcher( StdString::CasedString( str, caseSensitivity) );
    }
    StdString::StartsWithMatcher StartsWith( std::string const& str, CaseSensitive::Choice
caseSensitivity ) {
        return StdString::StartsWithMatcher( StdString::CasedString( str, caseSensitivity) );
    }

    StdString::RegexMatcher Matches(std::string const& regex, CaseSensitive::Choice caseSensitivity) {
        return StdString::RegexMatcher(regex, caseSensitivity);
    }

} // namespace Matchers
} // namespace Catch
// end catch_matchers_string.cpp
// start catch_message.cpp

// start catch_uncaught_exceptions.h

namespace Catch {
    bool uncaught_exceptions();
} // end namespace Catch

// end catch_uncaught_exceptions.h
#include <cassert>
#include <stack>

namespace Catch {

    MessageInfo::MessageInfo(   StringRef const& _macroName,
                                SourceLineInfo const& _lineInfo,
                                ResultWas::OfType _type )
    :   macroName( _macroName ),
        lineInfo( _lineInfo ),
        type( _type ),
        sequence( ++globalCount )
    {}

    bool MessageInfo::operator==( MessageInfo const& other ) const {
        return sequence == other.sequence;
    }

    bool MessageInfo::operator<( MessageInfo const& other ) const {
        return sequence < other.sequence;
    }

    // This may need protecting if threading support is added
    unsigned int MessageInfo::globalCount = 0;


    Catch::MessageBuilder::MessageBuilder( StringRef const& macroName,
                                           SourceLineInfo const& lineInfo,
                                           ResultWas::OfType type )
        :m_info(macroName, lineInfo, type) {}


    ScopedMessage::ScopedMessage( MessageBuilder const& builder )
    : m_info( builder.m_info ), m_moved()
    {
        m_info.message = builder.m_stream.str();
        getResultCapture().pushScopedMessage( m_info );
    }

    ScopedMessage::ScopedMessage( ScopedMessage&& old )
    : m_info( old.m_info ), m_moved()
    {
        old.m_moved = true;
    }

    ScopedMessage::~ScopedMessage() {
        if ( !uncaught_exceptions() && !m_moved ){
            getResultCapture().popScopedMessage(m_info);
        }
    }

    Capturer::Capturer( StringRef macroName, SourceLineInfo const& lineInfo, ResultWas::OfType
resultType, StringRef names ) {
        auto trimmed = [&] (size_t start, size_t end) {
            while (names[start] == ',' || isspace(static_cast<unsigned char>(names[start]))) {
                ++start;
            }
            while (names[end] == ',' || isspace(static_cast<unsigned char>(names[end]))) {
                --end;
            }
            return names.substr(start, end - start + 1);
        };
        auto skipq = [&] (size_t start, char quote) {
            for (auto i = start + 1; i < names.size() ; ++i) {
                if (names[i] == quote)
                    return i;
                if (names[i] == '\\')
                    ++i;
            }
            CATCH_INTERNAL_ERROR("CAPTURE parsing encountered unmatched quote");
        };

        size_t start = 0;
        std::stack<char> openings;
        for (size_t pos = 0; pos < names.size(); ++pos) {
            char c = names[pos];
            switch (c) {
            case '[':
            case '{':
            case '(':
            // It is basically impossible to disambiguate between
            // comparison and start of template args in this context
//            case '<':
                openings.push(c);
                break;
            case ']':
            case '}':
            case ')':
//           case '>':
                openings.pop();
                break;
            case '"':
            case '\'':
                pos = skipq(pos, c);
                break;
            case ',':
                if (start != pos && openings.empty()) {
                    m_messages.emplace_back(macroName, lineInfo, resultType);
                    m_messages.back().message = static_cast<std::string>(trimmed(start, pos));
                    m_messages.back().message += " := ";
                    start = pos;
                }
            }
        }
        assert(openings.empty() && "Mismatched openings");
        m_messages.emplace_back(macroName, lineInfo, resultType);
        m_messages.back().message = static_cast<std::string>(trimmed(start, names.size() - 1));
        m_messages.back().message += " := ";
    }
    Capturer::~Capturer() {
        if ( !uncaught_exceptions() ){
            assert( m_captured == m_messages.size() );
            for( size_t i = 0; i < m_captured; ++i  )
                m_resultCapture.popScopedMessage( m_messages[i] );
        }
    }

    void Capturer::captureValue( size_t index, std::string const& value ) {
        assert( index < m_messages.size() );
        m_messages[index].message += value;
        m_resultCapture.pushScopedMessage( m_messages[index] );
        m_captured++;
    }

} // end namespace Catch
// end catch_message.cpp
// start catch_output_redirect.cpp

// start catch_output_redirect.h
#ifndef TWOBLUECUBES_CATCH_OUTPUT_REDIRECT_H
#define TWOBLUECUBES_CATCH_OUTPUT_REDIRECT_H

#include <cstdio>
#include <iosfwd>
#include <string>

namespace Catch {

    class RedirectedStream {
        std::ostream& m_originalStream;
        std::ostream& m_redirectionStream;
        std::streambuf* m_prevBuf;

    public:
        RedirectedStream( std::ostream& originalStream, std::ostream& redirectionStream );
        ~RedirectedStream();
    };

    class RedirectedStdOut {
        ReusableStringStream m_rss;
        RedirectedStream m_cout;
    public:
        RedirectedStdOut();
        auto str() const -> std::string;
    };

    // StdErr has two constituent streams in C++, std::cerr and std::clog
    // This means that we need to redirect 2 streams into 1 to keep proper
    // order of writes
    class RedirectedStdErr {
        ReusableStringStream m_rss;
        RedirectedStream m_cerr;
        RedirectedStream m_clog;
    public:
        RedirectedStdErr();
        auto str() const -> std::string;
    };

    class RedirectedStreams {
    public:
        RedirectedStreams(RedirectedStreams const&) = delete;
        RedirectedStreams& operator=(RedirectedStreams const&) = delete;
        RedirectedStreams(RedirectedStreams&&) = delete;
        RedirectedStreams& operator=(RedirectedStreams&&) = delete;

        RedirectedStreams(std::string& redirectedCout, std::string& redirectedCerr);
        ~RedirectedStreams();
    private:
        std::string& m_redirectedCout;
        std::string& m_redirectedCerr;
        RedirectedStdOut m_redirectedStdOut;
        RedirectedStdErr m_redirectedStdErr;
    };

#if defined(CATCH_CONFIG_NEW_CAPTURE)

    // Windows's implementation of std::tmpfile is terrible (it tries
    // to create a file inside system folder, thus requiring elevated
    // privileges for the binary), so we have to use tmpnam(_s) and
    // create the file ourselves there.
    class TempFile {
    public:
        TempFile(TempFile const&) = delete;
        TempFile& operator=(TempFile const&) = delete;
        TempFile(TempFile&&) = delete;
        TempFile& operator=(TempFile&&) = delete;

        TempFile();
        ~TempFile();

        std::FILE* getFile();
        std::string getContents();

    private:
        std::FILE* m_file = nullptr;
    #if defined(_MSC_VER)
        char m_buffer[L_tmpnam] = { 0 };
    #endif
    };

    class OutputRedirect {
    public:
        OutputRedirect(OutputRedirect const&) = delete;
        OutputRedirect& operator=(OutputRedirect const&) = delete;
        OutputRedirect(OutputRedirect&&) = delete;
        OutputRedirect& operator=(OutputRedirect&&) = delete;

        OutputRedirect(std::string& stdout_dest, std::string& stderr_dest);
        ~OutputRedirect();

    private:
        int m_originalStdout = -1;
        int m_originalStderr = -1;
        TempFile m_stdoutFile;
        TempFile m_stderrFile;
        std::string& m_stdoutDest;
        std::string& m_stderrDest;
    };

#endif

} // end namespace Catch

#endif // TWOBLUECUBES_CATCH_OUTPUT_REDIRECT_H
// end catch_output_redirect.h
#include <cstdio>
#include <cstring>
#include <fstream>
#include <sstream>
#include <stdexcept>

#if defined(CATCH_CONFIG_NEW_CAPTURE)
    #if defined(_MSC_VER)
    #include <io.h>      //_dup and _dup2
    #define dup _dup
    #define dup2 _dup2
    #define fileno _fileno
    #else
    #include <unistd.h>  // dup and dup2
    #endif
#endif

namespace Catch {

    RedirectedStream::RedirectedStream( std::ostream& originalStream, std::ostream& redirectionStream
)
    :   m_originalStream( originalStream ),
        m_redirectionStream( redirectionStream ),
        m_prevBuf( m_originalStream.rdbuf() )
    {
        m_originalStream.rdbuf( m_redirectionStream.rdbuf() );
    }

    RedirectedStream::~RedirectedStream() {
        m_originalStream.rdbuf( m_prevBuf );
    }

    RedirectedStdOut::RedirectedStdOut() : m_cout( Catch::cout(), m_rss.get() ) {}
    auto RedirectedStdOut::str() const -> std::string { return m_rss.str(); }

    RedirectedStdErr::RedirectedStdErr()
    :   m_cerr( Catch::cerr(), m_rss.get() ),
        m_clog( Catch::clog(), m_rss.get() )
    {}
    auto RedirectedStdErr::str() const -> std::string { return m_rss.str(); }

    RedirectedStreams::RedirectedStreams(std::string& redirectedCout, std::string& redirectedCerr)
    :   m_redirectedCout(redirectedCout),
        m_redirectedCerr(redirectedCerr)
    {}

    RedirectedStreams::~RedirectedStreams() {
        m_redirectedCout += m_redirectedStdOut.str();
        m_redirectedCerr += m_redirectedStdErr.str();
    }

#if defined(CATCH_CONFIG_NEW_CAPTURE)

#if defined(_MSC_VER)
    TempFile::TempFile() {
        if (tmpnam_s(m_buffer)) {
            CATCH_RUNTIME_ERROR("Could not get a temp filename");
        }
        if (fopen_s(&m_file, m_buffer, "w+")) {
            char buffer[100];
            if (strerror_s(buffer, errno)) {
                CATCH_RUNTIME_ERROR("Could not translate errno to a string");
            }
            CATCH_RUNTIME_ERROR("Could not open the temp file: '" « m_buffer « "' because: " «
buffer);
        }
    }
#else
    TempFile::TempFile() {
        m_file = std::tmpfile();
        if (!m_file) {
            CATCH_RUNTIME_ERROR("Could not create a temp file.");
        }
    }

#endif

    TempFile::~TempFile() {
         // TBD: What to do about errors here?
         std::fclose(m_file);
         // We manually create the file on Windows only, on Linux
         // it will be autodeleted
#if defined(_MSC_VER)
         std::remove(m_buffer);
#endif
    }

    FILE* TempFile::getFile() {
        return m_file;
    }

    std::string TempFile::getContents() {
        std::stringstream sstr;
        char buffer[100] = {};
        std::rewind(m_file);
        while (std::fgets(buffer, sizeof(buffer), m_file)) {
            sstr « buffer;
        }
        return sstr.str();
    }

    OutputRedirect::OutputRedirect(std::string& stdout_dest, std::string& stderr_dest) :
        m_originalStdout(dup(1)),
        m_originalStderr(dup(2)),
        m_stdoutDest(stdout_dest),
        m_stderrDest(stderr_dest) {
        dup2(fileno(m_stdoutFile.getFile()), 1);
        dup2(fileno(m_stderrFile.getFile()), 2);
    }

    OutputRedirect::~OutputRedirect() {
        Catch::cout() « std::flush;
        fflush(stdout);
        // Since we support overriding these streams, we flush cerr
        // even though std::cerr is unbuffered
        Catch::cerr() « std::flush;
        Catch::clog() « std::flush;
        fflush(stderr);

        dup2(m_originalStdout, 1);
        dup2(m_originalStderr, 2);

        m_stdoutDest += m_stdoutFile.getContents();
        m_stderrDest += m_stderrFile.getContents();
    }

#endif // CATCH_CONFIG_NEW_CAPTURE

} // namespace Catch

#if defined(CATCH_CONFIG_NEW_CAPTURE)
    #if defined(_MSC_VER)
    #undef dup
    #undef dup2
    #undef fileno
    #endif
#endif
// end catch_output_redirect.cpp
// start catch_polyfills.cpp

#include <cmath>

namespace Catch {

#if !defined(CATCH_CONFIG_POLYFILL_ISNAN)
    bool isnan(float f) {
        return std::isnan(f);
    }
    bool isnan(double d) {
        return std::isnan(d);
    }
#else
    // For now we only use this for embarcadero
    bool isnan(float f) {
        return std::_isnan(f);
    }
    bool isnan(double d) {
        return std::_isnan(d);
    }
#endif

} // end namespace Catch
// end catch_polyfills.cpp
// start catch_random_number_generator.cpp

namespace Catch {

namespace {

#if defined(_MSC_VER)
#pragma warning(push)
#pragma warning(disable:4146) // we negate uint32 during the rotate
#endif
        // Safe rotr implementation thanks to John Regehr
        uint32_t rotate_right(uint32_t val, uint32_t count) {
            const uint32_t mask = 31;
            count &= mask;
            return (val » count) | (val « (-count & mask));
        }

#if defined(_MSC_VER)
#pragma warning(pop)
#endif

}

    SimplePcg32::SimplePcg32(result_type seed_) {
        seed(seed_);
    }

    void SimplePcg32::seed(result_type seed_) {
        m_state = 0;
        (*this)();
        m_state += seed_;
        (*this)();
    }

    void SimplePcg32::discard(uint64_t skip) {
        // We could implement this to run in O(log n) steps, but this
        // should suffice for our use case.
        for (uint64_t s = 0; s < skip; ++s) {
            static_cast<void>((*this)());
        }
    }

    SimplePcg32::result_type SimplePcg32::operator()() {
        // prepare the output value
        const uint32_t xorshifted = static_cast<uint32_t>(((m_state » 18u) ^ m_state) » 27u);
        const auto output = rotate_right(xorshifted, m_state » 59u);

        // advance state
        m_state = m_state * 6364136223846793005ULL + s_inc;

        return output;
    }

    bool operator==(SimplePcg32 const& lhs, SimplePcg32 const& rhs) {
        return lhs.m_state == rhs.m_state;
    }

    bool operator!=(SimplePcg32 const& lhs, SimplePcg32 const& rhs) {
        return lhs.m_state != rhs.m_state;
    }
}
// end catch_random_number_generator.cpp
// start catch_registry_hub.cpp

// start catch_test_case_registry_impl.h

#include <vector>
#include <set>
#include <algorithm>
#include <ios>

namespace Catch {

    class TestCase;
    struct IConfig;

    std::vector<TestCase> sortTests( IConfig const& config, std::vector<TestCase> const&
unsortedTestCases );

    bool isThrowSafe( TestCase const& testCase, IConfig const& config );
    bool matchTest( TestCase const& testCase, TestSpec const& testSpec, IConfig const& config );

    void enforceNoDuplicateTestCases( std::vector<TestCase> const& functions );

    std::vector<TestCase> filterTests( std::vector<TestCase> const& testCases, TestSpec const&
testSpec, IConfig const& config );
    std::vector<TestCase> const& getAllTestCasesSorted( IConfig const& config );

    class TestRegistry : public ITestCaseRegistry {
    public:
        virtual ~TestRegistry() = default;

        virtual void registerTest( TestCase const& testCase );

        std::vector<TestCase> const& getAllTests() const override;
        std::vector<TestCase> const& getAllTestsSorted( IConfig const& config ) const override;

    private:
        std::vector<TestCase> m_functions;
        mutable RunTests::InWhatOrder m_currentSortOrder = RunTests::InDeclarationOrder;
        mutable std::vector<TestCase> m_sortedFunctions;
        std::size_t m_unnamedCount = 0;
        std::ios_base::Init m_ostreamInit; // Forces cout/ cerr to be initialised
    };


    class TestInvokerAsFunction : public ITestInvoker {
        void(*m_testAsFunction)();
    public:
        TestInvokerAsFunction( void(*testAsFunction)() ) noexcept;

        void invoke() const override;
    };

    std::string extractClassName( StringRef const& classOrQualifiedMethodName );


} // end namespace Catch

// end catch_test_case_registry_impl.h
// start catch_reporter_registry.h

#include <map>

namespace Catch {

    class ReporterRegistry : public IReporterRegistry {

    public:

        ~ReporterRegistry() override;

        IStreamingReporterPtr create( std::string const& name, IConfigPtr const& config ) const
override;

        void registerReporter( std::string const& name, IReporterFactoryPtr const& factory );
        void registerListener( IReporterFactoryPtr const& factory );

        FactoryMap const& getFactories() const override;
        Listeners const& getListeners() const override;

    private:
        FactoryMap m_factories;
        Listeners m_listeners;
    };
```

```cpp
}

// end catch_reporter_registry.h
// start catch_tag_alias_registry.h

// start catch_tag_alias.h

#include <string>

namespace Catch {

    struct TagAlias {
        TagAlias(std::string const& _tag, SourceLineInfo _lineInfo);

        std::string tag;
        SourceLineInfo lineInfo;
    };

} // end namespace Catch

// end catch_tag_alias.h
#include <map>

namespace Catch {

    class TagAliasRegistry : public ITagAliasRegistry {
    public:
        ~TagAliasRegistry() override;
        TagAlias const* find( std::string const& alias ) const override;
        std::string expandAliases( std::string const& unexpandedTestSpec ) const override;
        void add( std::string const& alias, std::string const& tag, SourceLineInfo const& lineInfo );

    private:
        std::map<std::string, TagAlias> m_registry;
    };

} // end namespace Catch

// end catch_tag_alias_registry.h
// start catch_startup_exception_registry.h

#include <vector>
#include <exception>

namespace Catch {

    class StartupExceptionRegistry {
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
    public:
        void add(std::exception_ptr const& exception) noexcept;
        std::vector<std::exception_ptr> const& getExceptions() const noexcept;
    private:
        std::vector<std::exception_ptr> m_exceptions;
#endif
    };

} // end namespace Catch

// end catch_startup_exception_registry.h
// start catch_singletons.hpp

namespace Catch {

    struct ISingleton {
        virtual ~ISingleton();
    };

    void addSingleton( ISingleton* singleton );
    void cleanupSingletons();

    template<typename SingletonImplT, typename InterfaceT = SingletonImplT, typename MutableInterfaceT
= InterfaceT>
    class Singleton : SingletonImplT, public ISingleton {

        static auto getInternal() -> Singleton* {
            static Singleton* s_instance = nullptr;
            if( !s_instance ) {
                s_instance = new Singleton;
                addSingleton( s_instance );
            }
            return s_instance;
        }

    public:
        static auto get() -> InterfaceT const& {
            return *getInternal();
        }
        static auto getMutable() -> MutableInterfaceT& {
            return *getInternal();
        }
    };

} // namespace Catch

// end catch_singletons.hpp
namespace Catch {

    namespace {

        class RegistryHub : public IRegistryHub, public IMutableRegistryHub,
                            private NonCopyable {

        public: // IRegistryHub
            RegistryHub() = default;
            IReporterRegistry const& getReporterRegistry() const override {
                return m_reporterRegistry;
            }
            ITestCaseRegistry const& getTestCaseRegistry() const override {
                return m_testCaseRegistry;
            }
            IExceptionTranslatorRegistry const& getExceptionTranslatorRegistry() const override {
                return m_exceptionTranslatorRegistry;
            }
            ITagAliasRegistry const& getTagAliasRegistry() const override {
                return m_tagAliasRegistry;
            }
            StartupExceptionRegistry const& getStartupExceptionRegistry() const override {
                return m_exceptionRegistry;
            }

        public: // IMutableRegistryHub
            void registerReporter( std::string const& name, IReporterFactoryPtr const& factory )
override {
                m_reporterRegistry.registerReporter( name, factory );
            }
            void registerListener( IReporterFactoryPtr const& factory ) override {
                m_reporterRegistry.registerListener( factory );
            }
            void registerTest( TestCase const& testInfo ) override {
                m_testCaseRegistry.registerTest( testInfo );
            }
            void registerTranslator( const IExceptionTranslator* translator ) override {
                m_exceptionTranslatorRegistry.registerTranslator( translator );
            }
            void registerTagAlias( std::string const& alias, std::string const& tag, SourceLineInfo
const& lineInfo ) override {
                m_tagAliasRegistry.add( alias, tag, lineInfo );
            }
            void registerStartupException() noexcept override {
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
                m_exceptionRegistry.add(std::current_exception());
#else
                CATCH_INTERNAL_ERROR("Attempted to register active exception under
CATCH_CONFIG_DISABLE_EXCEPTIONS!");
#endif
            }
            IMutableEnumValuesRegistry& getMutableEnumValuesRegistry() override {
                return m_enumValuesRegistry;
            }

        private:
            TestRegistry m_testCaseRegistry;
            ReporterRegistry m_reporterRegistry;
            ExceptionTranslatorRegistry m_exceptionTranslatorRegistry;
            TagAliasRegistry m_tagAliasRegistry;
            StartupExceptionRegistry m_exceptionRegistry;
            Detail::EnumValuesRegistry m_enumValuesRegistry;
        };
    }

    using RegistryHubSingleton = Singleton<RegistryHub, IRegistryHub, IMutableRegistryHub>;

    IRegistryHub const& getRegistryHub() {
        return RegistryHubSingleton::get();
    }
    IMutableRegistryHub& getMutableRegistryHub() {
        return RegistryHubSingleton::getMutable();
    }
    void cleanUp() {
        cleanupSingletons();
        cleanUpContext();
    }
    std::string translateActiveException() {
        return getRegistryHub().getExceptionTranslatorRegistry().translateActiveException();
    }

} // end namespace Catch
// end catch_registry_hub.cpp
// start catch_reporter_registry.cpp

namespace Catch {

    ReporterRegistry::~ReporterRegistry() = default;

    IStreamingReporterPtr ReporterRegistry::create( std::string const& name, IConfigPtr const& config ) const {
        auto it =  m_factories.find( name );
        if( it == m_factories.end() )
            return nullptr;
        return it->second->create( ReporterConfig( config ) );
    }

    void ReporterRegistry::registerReporter( std::string const& name, IReporterFactoryPtr const& factory ) {
        m_factories.emplace(name, factory);
    }
    void ReporterRegistry::registerListener( IReporterFactoryPtr const& factory ) {
        m_listeners.push_back( factory );
    }

    IReporterRegistry::FactoryMap const& ReporterRegistry::getFactories() const {
        return m_factories;
    }
    IReporterRegistry::Listeners const& ReporterRegistry::getListeners() const {
        return m_listeners;
    }

}
// end catch_reporter_registry.cpp
// start catch_result_type.cpp

namespace Catch {

    bool isOk( ResultWas::OfType resultType ) {
        return ( resultType & ResultWas::FailureBit ) == 0;
    }
    bool isJustInfo( int flags ) {
        return flags == ResultWas::Info;
    }

    ResultDisposition::Flags operator | ( ResultDisposition::Flags lhs, ResultDisposition::Flags rhs ) {
        return static_cast<ResultDisposition::Flags>( static_cast<int>( lhs ) | static_cast<int>( rhs ) );
    }

    bool shouldContinueOnFailure( int flags )    { return ( flags & ResultDisposition::ContinueOnFailure ) != 0; }
    bool shouldSuppressFailure( int flags )      { return ( flags & ResultDisposition::SuppressFail ) != 0; }

} // end namespace Catch
// end catch_result_type.cpp
// start catch_run_context.cpp

#include <cassert>
#include <algorithm>
#include <sstream>

namespace Catch {

    namespace Generators {
        struct GeneratorTracker : TestCaseTracking::TrackerBase, IGeneratorTracker {
            GeneratorBasePtr m_generator;

            GeneratorTracker( TestCaseTracking::NameAndLocation const& nameAndLocation, TrackerContext& ctx, ITracker* parent )
            :   TrackerBase( nameAndLocation, ctx, parent )
            {}
            ~GeneratorTracker();

            static GeneratorTracker& acquire( TrackerContext& ctx, TestCaseTracking::NameAndLocation const& nameAndLocation ) {
                std::shared_ptr<GeneratorTracker> tracker;

                ITracker& currentTracker = ctx.currentTracker();
                // Under specific circumstances, the generator we want
                // to acquire is also the current tracker. If this is
                // the case, we have to avoid looking through current
                // tracker's children, and instead return the current
                // tracker.
                // A case where this check is important is e.g.
                //     for (int i = 0; i < 5; ++i) {
                //         int n = GENERATE(1, 2);
                //     }
                //
                // without it, the code above creates 5 nested generators.
                if (currentTracker.nameAndLocation() == nameAndLocation) {
                    auto thisTracker = currentTracker.parent().findChild(nameAndLocation);
                    assert(thisTracker);
                    assert(thisTracker->isGeneratorTracker());
                    tracker = std::static_pointer_cast<GeneratorTracker>(thisTracker);
                } else if ( TestCaseTracking::ITrackerPtr childTracker = currentTracker.findChild( nameAndLocation ) ) {
                    assert( childTracker );
                    assert( childTracker->isGeneratorTracker() );
                    tracker = std::static_pointer_cast<GeneratorTracker>( childTracker );
                } else {
                    tracker = std::make_shared<GeneratorTracker>( nameAndLocation, ctx, &currentTracker );
                    currentTracker.addChild( tracker );
                }

                if( !tracker->isComplete() ) {
                    tracker->open();
                }

                return *tracker;
            }

            // TrackerBase interface
            bool isGeneratorTracker() const override { return true; }
            auto hasGenerator() const -> bool override {
                return !!m_generator;
            }
            void close() override {
                TrackerBase::close();
                // If a generator has a child (it is followed by a section)
                // and none of its children have started, then we must wait
                // until later to start consuming its values.
                // This catches cases where `GENERATE` is placed between two
                // `SECTION`s.
                // **The check for m_children.empty cannot be removed**.
                // doing so would break `GENERATE` _not_ followed by `SECTION`s.
                const bool should_wait_for_child = [&]() {
                    // No children -> nobody to wait for
                    if ( m_children.empty() ) {
                        return false;
                    }
                    // If at least one child started executing, don't wait
                    if ( std::find_if(
                             m_children.begin(),
                             m_children.end(),
                             []( TestCaseTracking::ITrackerPtr tracker ) {
                                 return tracker->hasStarted();
                             } ) != m_children.end() ) {
                        return false;
                    }

                    // No children have started. We need to check if they _can_
                    // start, and thus we should wait for them, or they cannot
                    // start (due to filters), and we shouldn't wait for them
                    auto* parent = m_parent;
                    // This is safe: there is always at least one section
                    // tracker in a test case tracking tree
                    while ( !parent->isSectionTracker() ) {
                        parent = &( parent->parent() );
                    }
                    assert( parent &&
                            "Missing root (test case) level section" );

                    auto const& parentSection =
                        static_cast<SectionTracker&>( *parent );
                    auto const& filters = parentSection.getFilters();
                    // No filters -> no restrictions on running sections
                    if ( filters.empty() ) {
                        return true;
                    }

                    for ( auto const& child : m_children ) {
                        if ( child->isSectionTracker() &&
                             std::find( filters.begin(),
                                        filters.end(),
                                        static_cast<SectionTracker&>( *child )
                                            .trimmedName() ) !=
                                 filters.end() ) {
                            return true;
                        }
                    }
                    return false;
                }();

                // This check is a bit tricky, because m_generator->next()
                // has a side-effect, where it consumes generator's current
                // value, but we do not want to invoke the side-effect if
                // this generator is still waiting for any child to start.
                if ( should_wait_for_child ||
                     ( m_runState == CompletedSuccessfully &&
                       m_generator->next() ) ) {
                    m_children.clear();
                    m_runState = Executing;
                }
            }

            // IGeneratorTracker interface
            auto getGenerator() const -> GeneratorBasePtr const& override {
                return m_generator;
            }
            void setGenerator( GeneratorBasePtr&& generator ) override {
                m_generator = std::move( generator );
            }
        };
        GeneratorTracker::~GeneratorTracker() {}
    }

    RunContext::RunContext(IConfigPtr const& _config, IStreamingReporterPtr&& reporter)
    :   m_runInfo(_config->name()),
        m_context(getCurrentMutableContext()),
        m_config(_config),
        m_reporter(std::move(reporter)),
        m_lastAssertionInfo{ StringRef(), SourceLineInfo("",0), StringRef(), ResultDisposition::Normal
},
        m_includeSuccessfulResults( m_config->includeSuccessfulResults() ||
m_reporter->getPreferences().shouldReportAllAssertions )
    {
        m_context.setRunner(this);
        m_context.setConfig(m_config);
        m_context.setResultCapture(this);
        m_reporter->testRunStarting(m_runInfo);
    }

    RunContext::~RunContext() {
        m_reporter->testRunEnded(TestRunStats(m_runInfo, m_totals, aborting()));
    }

    void RunContext::testGroupStarting(std::string const& testSpec, std::size_t groupIndex,
std::size_t groupsCount) {
        m_reporter->testGroupStarting(GroupInfo(testSpec, groupIndex, groupsCount));
    }

    void RunContext::testGroupEnded(std::string const& testSpec, Totals const& totals, std::size_t
groupIndex, std::size_t groupsCount) {
        m_reporter->testGroupEnded(TestGroupStats(GroupInfo(testSpec, groupIndex, groupsCount),
totals, aborting()));
    }

    Totals RunContext::runTest(TestCase const& testCase) {
        Totals prevTotals = m_totals;

        std::string redirectedCout;
        std::string redirectedCerr;

        auto const& testInfo = testCase.getTestCaseInfo();

        m_reporter->testCaseStarting(testInfo);

        m_activeTestCase = &testCase;

        ITracker& rootTracker = m_trackerContext.startRun();
        assert(rootTracker.isSectionTracker());
        static_cast<SectionTracker&>(rootTracker).addInitialFilters(m_config->getSectionsToRun());
        do {
            m_trackerContext.startCycle();
            m_testCaseTracker = &SectionTracker::acquire(m_trackerContext,
TestCaseTracking::NameAndLocation(testInfo.name, testInfo.lineInfo));
            runCurrentTest(redirectedCout, redirectedCerr);
        } while (!m_testCaseTracker->isSuccessfullyCompleted() && !aborting());

        Totals deltaTotals = m_totals.delta(prevTotals);
        if (testInfo.expectedToFail() && deltaTotals.testCases.passed > 0) {
            deltaTotals.assertions.failed++;
            deltaTotals.testCases.passed--;
            deltaTotals.testCases.failed++;
        }
        m_totals.testCases += deltaTotals.testCases;
        m_reporter->testCaseEnded(TestCaseStats(testInfo,
                                  deltaTotals,
                                  redirectedCout,
                                  redirectedCerr,
                                  aborting()));

        m_activeTestCase = nullptr;
        m_testCaseTracker = nullptr;

        return deltaTotals;
    }

    IConfigPtr RunContext::config() const {
        return m_config;
    }

    IStreamingReporter& RunContext::reporter() const {
        return *m_reporter;
    }

    void RunContext::assertionEnded(AssertionResult const & result) {
        if (result.getResultType() == ResultWas::Ok) {
            m_totals.assertions.passed++;
            m_lastAssertionPassed = true;
        } else if (!result.isOk()) {
            m_lastAssertionPassed = false;
            if( m_activeTestCase->getTestCaseInfo().okToFail() )
                m_totals.assertions.failedButOk++;
            else
                m_totals.assertions.failed++;
        }
        else {
            m_lastAssertionPassed = true;
        }

        // We have no use for the return value (whether messages should be cleared), because messages
were made scoped
        // and should be let to clear themselves out.
        static_cast<void>(m_reporter->assertionEnded(AssertionStats(result, m_messages, m_totals)));

        if (result.getResultType() != ResultWas::Warning)
            m_messageScopes.clear();

        // Reset working state
        resetAssertionInfo();
        m_lastResult = result;
    }
    void RunContext::resetAssertionInfo() {
        m_lastAssertionInfo.macroName = StringRef();
        m_lastAssertionInfo.capturedExpression = "{Unknown expression after the reported line}"_sr;
    }

    bool RunContext::sectionStarted(SectionInfo const & sectionInfo, Counts & assertions) {
        ITracker& sectionTracker = SectionTracker::acquire(m_trackerContext,
TestCaseTracking::NameAndLocation(sectionInfo.name, sectionInfo.lineInfo));
        if (!sectionTracker.isOpen())
            return false;
        m_activeSections.push_back(&sectionTracker);

        m_lastAssertionInfo.lineInfo = sectionInfo.lineInfo;

        m_reporter->sectionStarting(sectionInfo);

        assertions = m_totals.assertions;

        return true;
    }
    auto RunContext::acquireGeneratorTracker( StringRef generatorName, SourceLineInfo const& lineInfo
) -> IGeneratorTracker& {
        using namespace Generators;
        GeneratorTracker& tracker = GeneratorTracker::acquire(m_trackerContext,
                                                              TestCaseTracking::NameAndLocation(
static_cast<std::string>(generatorName), lineInfo ) );
        m_lastAssertionInfo.lineInfo = lineInfo;
        return tracker;
    }

    bool RunContext::testForMissingAssertions(Counts& assertions) {
        if (assertions.total() != 0)
            return false;
        if (!m_config->warnAboutMissingAssertions())
            return false;
        if (m_trackerContext.currentTracker().hasChildren())
            return false;
        m_totals.assertions.failed++;
        assertions.failed++;
        return true;
    }

    void RunContext::sectionEnded(SectionEndInfo const & endInfo) {
        Counts assertions = m_totals.assertions - endInfo.prevAssertions;
        bool missingAssertions = testForMissingAssertions(assertions);

        if (!m_activeSections.empty()) {
            m_activeSections.back()->close();
            m_activeSections.pop_back();
        }

        m_reporter->sectionEnded(SectionStats(endInfo.sectionInfo, assertions,
endInfo.durationInSeconds, missingAssertions));
        m_messages.clear();
        m_messageScopes.clear();
    }

    void RunContext::sectionEndedEarly(SectionEndInfo const & endInfo) {
        if (m_unfinishedSections.empty())
            m_activeSections.back()->fail();
        else
            m_activeSections.back()->close();
        m_activeSections.pop_back();

        m_unfinishedSections.push_back(endInfo);
    }

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
    void RunContext::benchmarkPreparing(std::string const& name) {
        m_reporter->benchmarkPreparing(name);
    }
    void RunContext::benchmarkStarting( BenchmarkInfo const& info ) {
        m_reporter->benchmarkStarting( info );
    }
    void RunContext::benchmarkEnded( BenchmarkStats<> const& stats ) {
        m_reporter->benchmarkEnded( stats );
    }
    void RunContext::benchmarkFailed(std::string const & error) {
        m_reporter->benchmarkFailed(error);
    }
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

    void RunContext::pushScopedMessage(MessageInfo const & message) {
        m_messages.push_back(message);
    }

    void RunContext::popScopedMessage(MessageInfo const & message) {
        m_messages.erase(std::remove(m_messages.begin(), m_messages.end(), message),
m_messages.end());
    }

    void RunContext::emplaceUnscopedMessage( MessageBuilder const& builder ) {
        m_messageScopes.emplace_back( builder );
    }

    std::string RunContext::getCurrentTestName() const {
        return m_activeTestCase
            ? m_activeTestCase->getTestCaseInfo().name
            : std::string();
    }

    const AssertionResult * RunContext::getLastResult() const {
        return &(*m_lastResult);
    }

    void RunContext::exceptionEarlyReported() {
        m_shouldReportUnexpected = false;
    }

    void RunContext::handleFatalErrorCondition( StringRef message ) {
        // First notify reporter that bad things happened
        m_reporter->fatalErrorEncountered(message);

        // Don't rebuild the result -- the stringification itself can cause more fatal errors
        // Instead, fake a result data.
        AssertionResultData tempResult( ResultWas::FatalErrorCondition, { false } );
        tempResult.message = static_cast<std::string>(message);
        AssertionResult result(m_lastAssertionInfo, tempResult);

        assertionEnded(result);

        handleUnfinishedSections();

        // Recreate section for test case (as we will lose the one that was in scope)
        auto const& testCaseInfo = m_activeTestCase->getTestCaseInfo();
        SectionInfo testCaseSection(testCaseInfo.lineInfo, testCaseInfo.name);

        Counts assertions;
        assertions.failed = 1;
        SectionStats testCaseSectionStats(testCaseSection, assertions, 0, false);
        m_reporter->sectionEnded(testCaseSectionStats);

        auto const& testInfo = m_activeTestCase->getTestCaseInfo();

        Totals deltaTotals;
        deltaTotals.testCases.failed = 1;
        deltaTotals.assertions.failed = 1;
        m_reporter->testCaseEnded(TestCaseStats(testInfo,
                                  deltaTotals,
                                  std::string(),
                                  std::string(),
                                  false));
        m_totals.testCases.failed++;
        testGroupEnded(std::string(), m_totals, 1, 1);
        m_reporter->testRunEnded(TestRunStats(m_runInfo, m_totals, false));
    }

    bool RunContext::lastAssertionPassed() {
         return m_lastAssertionPassed;
    }

    void RunContext::assertionPassed() {
        m_lastAssertionPassed = true;
        ++m_totals.assertions.passed;
        resetAssertionInfo();
        m_messageScopes.clear();
    }

    bool RunContext::aborting() const {
        return m_totals.assertions.failed >= static_cast<std::size_t>(m_config->abortAfter());
    }

    void RunContext::runCurrentTest(std::string & redirectedCout, std::string & redirectedCerr) {
        auto const& testCaseInfo = m_activeTestCase->getTestCaseInfo();
        SectionInfo testCaseSection(testCaseInfo.lineInfo, testCaseInfo.name);
        m_reporter->sectionStarting(testCaseSection);
        Counts prevAssertions = m_totals.assertions;
        double duration = 0;
        m_shouldReportUnexpected = true;
        m_lastAssertionInfo = { "TEST_CASE"_sr, testCaseInfo.lineInfo, StringRef(),
ResultDisposition::Normal };

        seedRng(*m_config);

        Timer timer;
        CATCH_TRY {
            if (m_reporter->getPreferences().shouldRedirectStdOut) {
#if !defined(CATCH_CONFIG_EXPERIMENTAL_REDIRECT)
                RedirectedStreams redirectedStreams(redirectedCout, redirectedCerr);

                timer.start();
                invokeActiveTestCase();
#else
                OutputRedirect r(redirectedCout, redirectedCerr);
                timer.start();
                invokeActiveTestCase();
#endif
            } else {
                timer.start();
                invokeActiveTestCase();
            }
            duration = timer.getElapsedSeconds();
        } CATCH_CATCH_ANON (TestFailureException&) {
            // This just means the test was aborted due to failure
        } CATCH_CATCH_ALL {
            // Under CATCH_CONFIG_FAST_COMPILE, unexpected exceptions under REQUIRE assertions
            // are reported without translation at the point of origin.
            if( m_shouldReportUnexpected ) {
                AssertionReaction dummyReaction;
                handleUnexpectedInflightException( m_lastAssertionInfo, translateActiveException(),
dummyReaction );
            }
        }
        Counts assertions = m_totals.assertions - prevAssertions;
        bool missingAssertions = testForMissingAssertions(assertions);

        m_testCaseTracker->close();
        handleUnfinishedSections();
        m_messages.clear();
        m_messageScopes.clear();

        SectionStats testCaseSectionStats(testCaseSection, assertions, duration, missingAssertions);
        m_reporter->sectionEnded(testCaseSectionStats);
    }

    void RunContext::invokeActiveTestCase() {
        FatalConditionHandlerGuard _(&m_fatalConditionhandler);
        m_activeTestCase->invoke();
    }

    void RunContext::handleUnfinishedSections() {
        // If sections ended prematurely due to an exception we stored their
        // infos here so we can tear them down outside the unwind process.
        for (auto it = m_unfinishedSections.rbegin(),
             itEnd = m_unfinishedSections.rend();
             it != itEnd;
             ++it)
            sectionEnded(*it);
        m_unfinishedSections.clear();
    }

    void RunContext::handleExpr(
        AssertionInfo const& info,
        ITransientExpression const& expr,
        AssertionReaction& reaction
    ) {
        m_reporter->assertionStarting( info );

        bool negated = isFalseTest( info.resultDisposition );
        bool result = expr.getResult() != negated;

        if( result ) {
            if (!m_includeSuccessfulResults) {
                assertionPassed();
            }
            else {
                reportExpr(info, ResultWas::Ok, &expr, negated);
            }
        }
        else {
            reportExpr(info, ResultWas::ExpressionFailed, &expr, negated );
            populateReaction( reaction );
        }
    }
    void RunContext::reportExpr(
            AssertionInfo const &info,
            ResultWas::OfType resultType,
            ITransientExpression const *expr,
            bool negated ) {

        m_lastAssertionInfo = info;
        AssertionResultData data( resultType, LazyExpression( negated ) );

        AssertionResult assertionResult{ info, data };
        assertionResult.m_resultData.lazyExpression.m_transientExpression = expr;

        assertionEnded( assertionResult );
    }

    void RunContext::handleMessage(
            AssertionInfo const& info,
            ResultWas::OfType resultType,
            StringRef const& message,
            AssertionReaction& reaction
    ) {
        m_reporter->assertionStarting( info );

        m_lastAssertionInfo = info;

        AssertionResultData data( resultType, LazyExpression( false ) );
        data.message = static_cast<std::string>(message);
        AssertionResult assertionResult{ m_lastAssertionInfo, data };
        assertionEnded( assertionResult );
        if( !assertionResult.isOk() )
            populateReaction( reaction );
    }
    void RunContext::handleUnexpectedExceptionNotThrown(
            AssertionInfo const& info,
            AssertionReaction& reaction
    ) {
        handleNonExpr(info, Catch::ResultWas::DidntThrowException, reaction);
    }

    void RunContext::handleUnexpectedInflightException(
            AssertionInfo const& info,
            std::string const& message,
            AssertionReaction& reaction
    ) {
        m_lastAssertionInfo = info;

        AssertionResultData data( ResultWas::ThrewException, LazyExpression( false ) );
        data.message = message;
        AssertionResult assertionResult{ info, data };
        assertionEnded( assertionResult );
        populateReaction( reaction );
    }

    void RunContext::populateReaction( AssertionReaction& reaction ) {
        reaction.shouldDebugBreak = m_config->shouldDebugBreak();
        reaction.shouldThrow = aborting() || (m_lastAssertionInfo.resultDisposition &
ResultDisposition::Normal);
    }

    void RunContext::handleIncomplete(
            AssertionInfo const& info
    ) {
        m_lastAssertionInfo = info;

        AssertionResultData data( ResultWas::ThrewException, LazyExpression( false ) );
        data.message = "Exception translation was disabled by CATCH_CONFIG_FAST_COMPILE";
        AssertionResult assertionResult{ info, data };
        assertionEnded( assertionResult );
    }
    void RunContext::handleNonExpr(
            AssertionInfo const &info,
            ResultWas::OfType resultType,
            AssertionReaction &reaction
    ) {
        m_lastAssertionInfo = info;

        AssertionResultData data( resultType, LazyExpression( false ) );
        AssertionResult assertionResult{ info, data };
        assertionEnded( assertionResult );

        if( !assertionResult.isOk() )
            populateReaction( reaction );
    }

    IResultCapture& getResultCapture() {
        if (auto* capture = getCurrentContext().getResultCapture())
            return *capture;
        else
            CATCH_INTERNAL_ERROR("No result capture instance");
    }

    void seedRng(IConfig const& config) {
        if (config.rngSeed() != 0) {
            std::srand(config.rngSeed());
            rng().seed(config.rngSeed());
        }
    }

    unsigned int rngSeed() {
        return getCurrentContext().getConfig()->rngSeed();
    }

}
// end catch_run_context.cpp
// start catch_section.cpp

namespace Catch {

    Section::Section( SectionInfo const& info )
    :   m_info( info ),
        m_sectionIncluded( getResultCapture().sectionStarted( m_info, m_assertions ) )
    {
        m_timer.start();
    }

    Section::~Section() {
        if( m_sectionIncluded ) {
            SectionEndInfo endInfo{ m_info, m_assertions, m_timer.getElapsedSeconds() };
            if( uncaught_exceptions() )
                getResultCapture().sectionEndedEarly( endInfo );
            else
                getResultCapture().sectionEnded( endInfo );
        }
    }

    // This indicates whether the section should be executed or not
    Section::operator bool() const {
        return m_sectionIncluded;
    }

} // end namespace Catch
// end catch_section.cpp
// start catch_section_info.cpp

```

```
namespace Catch {

    SectionInfo::SectionInfo
        (   SourceLineInfo const& _lineInfo,
            std::string const& _name )
    :   name( _name ),
        lineInfo( _lineInfo )
    {}

} // end namespace Catch
// end catch_section_info.cpp
// start catch_session.cpp

// start catch_session.h

#include <memory>

namespace Catch {

    class Session : NonCopyable {
    public:

        Session();
        ~Session() override;

        void showHelp() const;
        void libIdentify();

        int applyCommandLine( int argc, char const * const * argv );
    #if defined(CATCH_CONFIG_WCHAR) && defined(_WIN32) && defined(UNICODE)
        int applyCommandLine( int argc, wchar_t const * const * argv );
    #endif

        void useConfigData( ConfigData const& configData );

        template<typename CharT>
        int run(int argc, CharT const * const argv[]) {
            if (m_startupExceptions)
                return 1;
            int returnCode = applyCommandLine(argc, argv);
            if (returnCode == 0)
                returnCode = run();
            return returnCode;
        }

        int run();

        clara::Parser const& cli() const;
        void cli( clara::Parser const& newParser );
        ConfigData& configData();
        Config& config();
    private:
        int runInternal();

        clara::Parser m_cli;
        ConfigData m_configData;
        std::shared_ptr<Config> m_config;
        bool m_startupExceptions = false;
    };

} // end namespace Catch

// end catch_session.h
// start catch_version.h

#include <iosfwd>

namespace Catch {

    // Versioning information
    struct Version {
        Version( Version const& ) = delete;
        Version& operator=( Version const& ) = delete;
        Version(    unsigned int _majorVersion,
                    unsigned int _minorVersion,
                    unsigned int _patchNumber,
                    char const * const _branchName,
                    unsigned int _buildNumber );

        unsigned int const majorVersion;
        unsigned int const minorVersion;
        unsigned int const patchNumber;

        // buildNumber is only used if branchName is not null
        char const * const branchName;
        unsigned int const buildNumber;

        friend std::ostream& operator « ( std::ostream& os, Version const& version );
    };

    Version const& libraryVersion();
}

// end catch_version.h
#include <cstdlib>
#include <iomanip>
#include <set>
#include <iterator>

namespace Catch {

    namespace {
        const int MaxExitCode = 255;

        IStreamingReporterPtr createReporter(std::string const& reporterName, IConfigPtr const&
config) {
            auto reporter = Catch::getRegistryHub().getReporterRegistry().create(reporterName,
config);
            CATCH_ENFORCE(reporter, "No reporter registered with name: '" « reporterName « "'");

            return reporter;
        }

        IStreamingReporterPtr makeReporter(std::shared_ptr<Config> const& config) {
            if (Catch::getRegistryHub().getReporterRegistry().getListeners().empty()) {
                return createReporter(config->getReporterName(), config);
            }

            // On older platforms, returning std::unique_ptr<ListeningReporter>
            // when the return type is std::unique_ptr<IStreamingReporter>
            // doesn't compile without a std::move call. However, this causes
            // a warning on newer platforms. Thus, we have to work around
            // it a bit and downcast the pointer manually.
            auto ret = std::unique_ptr<IStreamingReporter>(new ListeningReporter);
            auto& multi = static_cast<ListeningReporter&>(*ret);
            auto const& listeners = Catch::getRegistryHub().getReporterRegistry().getListeners();
            for (auto const& listener : listeners) {
                multi.addListener(listener->create(Catch::ReporterConfig(config)));
            }
            multi.addReporter(createReporter(config->getReporterName(), config));
            return ret;
        }

        class TestGroup {
        public:
            explicit TestGroup(std::shared_ptr<Config> const& config)
            : m_config{config}
            , m_context{config, makeReporter(config)}
            {
                auto const& allTestCases = getAllTestCasesSorted(*m_config);
                m_matches = m_config->testSpec().matchesByFilter(allTestCases, *m_config);
                auto const& invalidArgs = m_config->testSpec().getInvalidArgs();

                if (m_matches.empty() && invalidArgs.empty()) {
                    for (auto const& test : allTestCases)
                        if (!test.isHidden())
                            m_tests.emplace(&test);
                } else {
                    for (auto const& match : m_matches)
                        m_tests.insert(match.tests.begin(), match.tests.end());
                }
            }

            Totals execute() {
                auto const& invalidArgs = m_config->testSpec().getInvalidArgs();
                Totals totals;
                m_context.testGroupStarting(m_config->name(), 1, 1);
                for (auto const& testCase : m_tests) {
                    if (!m_context.aborting())
                        totals += m_context.runTest(*testCase);
                    else
                        m_context.reporter().skipTest(*testCase);
                }

                for (auto const& match : m_matches) {
                    if (match.tests.empty()) {
                        m_context.reporter().noMatchingTestCases(match.name);
                        totals.error = -1;
                    }
                }

                if (!invalidArgs.empty()) {
                    for (auto const& invalidArg: invalidArgs)
                         m_context.reporter().reportInvalidArguments(invalidArg);
                }

                m_context.testGroupEnded(m_config->name(), totals, 1, 1);
                return totals;
            }

        private:
            using Tests = std::set<TestCase const*>;

            std::shared_ptr<Config> m_config;
            RunContext m_context;
            Tests m_tests;
            TestSpec::Matches m_matches;
        };

        void applyFilenamesAsTags(Catch::IConfig const& config) {
            auto& tests = const_cast<std::vector<TestCase>&>(getAllTestCasesSorted(config));
            for (auto& testCase : tests) {
                auto tags = testCase.tags;

                std::string filename = testCase.lineInfo.file;
                auto lastSlash = filename.find_last_of("\\/");
                if (lastSlash != std::string::npos) {
                    filename.erase(0, lastSlash);
                    filename[0] = '#';
                }

                auto lastDot = filename.find_last_of('.');
                if (lastDot != std::string::npos) {
                    filename.erase(lastDot);
                }

                tags.push_back(std::move(filename));
                setTags(testCase, tags);
            }
        }

    } // anon namespace

    Session::Session() {
        static bool alreadyInstantiated = false;
        if( alreadyInstantiated ) {
            CATCH_TRY { CATCH_INTERNAL_ERROR( "Only one instance of Catch::Session can ever be used"
); }
            CATCH_CATCH_ALL { getMutableRegistryHub().registerStartupException(); }
        }

        // There cannot be exceptions at startup in no-exception mode.
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
        const auto& exceptions = getRegistryHub().getStartupExceptionRegistry().getExceptions();
        if ( !exceptions.empty() ) {
            config();
            getCurrentMutableContext().setConfig(m_config);

            m_startupExceptions = true;
            Colour colourGuard( Colour::Red );
            Catch::cerr() « "Errors occurred during startup!" « '\n';
            // iterate over all exceptions and notify user
            for ( const auto& ex_ptr : exceptions ) {
                try {
                    std::rethrow_exception(ex_ptr);
                } catch ( std::exception const& ex ) {
                    Catch::cerr() « Column( ex.what() ).indent(2) « '\n';
                }
            }
        }
#endif

        alreadyInstantiated = true;
        m_cli = makeCommandLineParser( m_configData );
    }
    Session::~Session() {
        Catch::cleanUp();
    }

    void Session::showHelp() const {
        Catch::cout()
                « "\nCatch v" « libraryVersion() « "\n"
                « m_cli « std::endl
                « "For more detailed usage please see the project docs\n" « std::endl;
    }
    void Session::libIdentify() {
        Catch::cout()
                « std::left « std::setw(16) « "description: " « "A Catch2 test executable\n"
                « std::left « std::setw(16) « "category: " « "testframework\n"
                « std::left « std::setw(16) « "framework: " « "Catch Test\n"
                « std::left « std::setw(16) « "version: " « libraryVersion() « std::endl;
    }

    int Session::applyCommandLine( int argc, char const * const * argv ) {
        if( m_startupExceptions )
            return 1;

        auto result = m_cli.parse( clara::Args( argc, argv ) );
        if( !result ) {
            config();
            getCurrentMutableContext().setConfig(m_config);
            Catch::cerr()
                « Colour( Colour::Red )
                « "\nError(s) in input:\n"
                « Column( result.errorMessage() ).indent( 2 )
                « "\n\n";
            Catch::cerr() « "Run with -? for usage\n" « std::endl;
            return MaxExitCode;
        }

        if( m_configData.showHelp )
            showHelp();
        if( m_configData.libIdentify )
            libIdentify();
        m_config.reset();
        return 0;
    }

#if defined(CATCH_CONFIG_WCHAR) && defined(_WIN32) && defined(UNICODE)
    int Session::applyCommandLine( int argc, wchar_t const * const * argv ) {

        char **utf8Argv = new char *[ argc ];

        for ( int i = 0; i < argc; ++i ) {
            int bufSize = WideCharToMultiByte( CP_UTF8, 0, argv[i], -1, nullptr, 0, nullptr, nullptr
);

            utf8Argv[ i ] = new char[ bufSize ];

            WideCharToMultiByte( CP_UTF8, 0, argv[i], -1, utf8Argv[i], bufSize, nullptr, nullptr );
        }

        int returnCode = applyCommandLine( argc, utf8Argv );

        for ( int i = 0; i < argc; ++i )
            delete [] utf8Argv[ i ];

        delete [] utf8Argv;

        return returnCode;
    }
#endif

    void Session::useConfigData( ConfigData const& configData ) {
        m_configData = configData;
        m_config.reset();
    }

    int Session::run() {
        if( ( m_configData.waitForKeypress & WaitForKeypress::BeforeStart ) != 0 ) {
            Catch::cout() « "...waiting for enter/ return before starting" « std::endl;
            static_cast<void>(std::getchar());
        }
        int exitCode = runInternal();
        if( ( m_configData.waitForKeypress & WaitForKeypress::BeforeExit ) != 0 ) {
            Catch::cout() « "...waiting for enter/ return before exiting, with code: " « exitCode «
std::endl;
            static_cast<void>(std::getchar());
        }
        return exitCode;
    }

    clara::Parser const& Session::cli() const {
        return m_cli;
    }
    void Session::cli( clara::Parser const& newParser ) {
        m_cli = newParser;
    }
    ConfigData& Session::configData() {
        return m_configData;
    }
    Config& Session::config() {
        if( !m_config )
            m_config = std::make_shared<Config>( m_configData );
        return *m_config;
    }

    int Session::runInternal() {
        if( m_startupExceptions )
            return 1;

        if (m_configData.showHelp || m_configData.libIdentify) {
            return 0;
        }

        CATCH_TRY {
            config(); // Force config to be constructed

            seedRng( *m_config );

            if( m_configData.filenamesAsTags )
                applyFilenamesAsTags( *m_config );

            // Handle list request
            if( Option<std::size_t> listed = list( m_config ) )
                return static_cast<int>( *listed );

            TestGroup tests { m_config };
            auto const totals = tests.execute();

            if( m_config->warnAboutNoTests() && totals.error == -1 )
                return 2;

            // Note that on unices only the lower 8 bits are usually used, clamping
            // the return value to 255 prevents false negative when some multiple
            // of 256 tests has failed
            return (std::min) (MaxExitCode, (std::max) (totals.error,
static_cast<int>(totals.assertions.failed)));
        }
#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
        catch( std::exception& ex ) {
            Catch::cerr() « ex.what() « std::endl;
            return MaxExitCode;
        }
#endif
    }

} // end namespace Catch
// end catch_session.cpp
// start catch_singletons.cpp

#include <vector>

namespace Catch {

    namespace {
        static auto getSingletons() -> std::vector<ISingleton*>*& {
            static std::vector<ISingleton*>* g_singletons = nullptr;
            if( !g_singletons )
                g_singletons = new std::vector<ISingleton*>();
            return g_singletons;
        }
    }

    ISingleton::~ISingleton() {}

    void addSingleton(ISingleton* singleton ) {
        getSingletons()->push_back( singleton );
    }
    void cleanupSingletons() {
        auto& singletons = getSingletons();
        for( auto singleton : *singletons )
            delete singleton;
        delete singletons;
        singletons = nullptr;
    }

} // namespace Catch
// end catch_singletons.cpp
// start catch_startup_exception_registry.cpp

#if !defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
namespace Catch {
void StartupExceptionRegistry::add( std::exception_ptr const& exception ) noexcept {
        CATCH_TRY {
            m_exceptions.push_back(exception);
        } CATCH_CATCH_ALL {
            // If we run out of memory during start-up there's really not a lot more we can do about
it
            std::terminate();
        }
    }

    std::vector<std::exception_ptr> const& StartupExceptionRegistry::getExceptions() const noexcept {
        return m_exceptions;
    }

} // end namespace Catch
#endif
// end catch_startup_exception_registry.cpp
// start catch_stream.cpp

#include <cstdio>
#include <iostream>
#include <fstream>
#include <sstream>
#include <vector>
#include <memory>

namespace Catch {

    Catch::IStream::~IStream() = default;

    namespace Detail { namespace {
        template<typename WriterF, std::size_t bufferSize=256>
        class StreamBufImpl : public std::streambuf {
            char data[bufferSize];
            WriterF m_writer;

        public:
            StreamBufImpl() {
                setp( data, data + sizeof(data) );
            }

            ~StreamBufImpl() noexcept {
                StreamBufImpl::sync();
            }

        private:
            int overflow( int c ) override {
                sync();

                if( c != EOF ) {
                    if( pbase() == epptr() )
                        m_writer( std::string( 1, static_cast<char>( c ) ) );
                    else
                        sputc( static_cast<char>( c ) );
                }
                return 0;
            }

            int sync() override {
                if( pbase() != pptr() ) {
                    m_writer( std::string( pbase(), static_cast<std::string::size_type>( pptr() -
pbase() ) ) );
                    setp( pbase(), epptr() );
                }
                return 0;
            }
        };


        struct OutputDebugWriter {

            void operator()( std::string const&str ) {
                writeToDebugConsole( str );
            }
        };


        class FileStream : public IStream {
            mutable std::ofstream m_ofs;
        public:
            FileStream( StringRef filename ) {
                m_ofs.open( filename.c_str() );
                CATCH_ENFORCE( !m_ofs.fail(), "Unable to open file: '" « filename « "'" );
            }
            ~FileStream() override = default;
        public: // IStream
            std::ostream& stream() const override {
                return m_ofs;
            }
        };


        class CoutStream : public IStream {
            mutable std::ostream m_os;
        public:
            // Store the streambuf from cout up-front because
            // cout may get redirected when running tests
            CoutStream() : m_os( Catch::cout().rdbuf() ) {}
            ~CoutStream() override = default;

        public: // IStream
            std::ostream& stream() const override { return m_os; }
        };


        class DebugOutStream : public IStream {
            std::unique_ptr<StreamBufImpl<OutputDebugWriter» m_streamBuf;
            mutable std::ostream m_os;
        public:
            DebugOutStream()
            :   m_streamBuf( new StreamBufImpl<OutputDebugWriter>() ),
                m_os( m_streamBuf.get() )
            {}

            ~DebugOutStream() override = default;

        public: // IStream
            std::ostream& stream() const override { return m_os; }
        };

    }} // namespace anon::detail


    auto makeStream( StringRef const &filename ) -> IStream const* {
        if( filename.empty() )
            return new Detail::CoutStream();
        else if( filename[0] == '%' ) {
            if( filename == "%debug" )
                return new Detail::DebugOutStream();
            else
                CATCH_ERROR( "Unrecognised stream: '" « filename « "'" );
        }
        else
            return new Detail::FileStream( filename );
    }

    // This class encapsulates the idea of a pool of ostringstreams that can be reused.
    struct StringStreams {
        std::vector<std::unique_ptr<std::ostringstream» m_streams;
        std::vector<std::size_t> m_unused;
        std::ostringstream m_referenceStream; // Used for copy state/ flags from

        auto add() -> std::size_t {
            if( m_unused.empty() ) {
                m_streams.push_back( std::unique_ptr<std::ostringstream>( new std::ostringstream ) );
                return m_streams.size()-1;
            }
            else {
                auto index = m_unused.back();
                m_unused.pop_back();
                return index;
            }
        }

        void release( std::size_t index ) {
            m_streams[index]->copyfmt( m_referenceStream ); // Restore initial flags and other state
            m_unused.push_back(index);
        }
    };

    ReusableStringStream::ReusableStringStream()
    :   m_index( Singleton<StringStreams>::getMutable().add() ),
        m_oss( Singleton<StringStreams>::getMutable().m_streams[m_index].get() )
    {}

    ReusableStringStream::~ReusableStringStream() {
        static_cast<std::ostringstream*>( m_oss )->str("");
        m_oss->clear();
        Singleton<StringStreams>::getMutable().release( m_index );
    }

    auto ReusableStringStream::str() const -> std::string {
        return static_cast<std::ostringstream*>( m_oss )->str();
    }


#ifndef CATCH_CONFIG_NOSTDOUT // If you #define this you must implement these functions
    std::ostream& cout() { return std::cout; }
    std::ostream& cerr() { return std::cerr; }
    std::ostream& clog() { return std::clog; }
#endif
}
// end catch_stream.cpp
// start catch_string_manip.cpp

#include <algorithm>
```

```
#include <ostream>
#include <cstring>
#include <cctype>
#include <vector>

namespace Catch {

    namespace {
        char toLowerCh(char c) {
            return static_cast<char>( std::tolower( static_cast<unsigned char>(c) ) );
        }
    }

    bool startsWith( std::string const& s, std::string const& prefix ) {
        return s.size() >= prefix.size() && std::equal(prefix.begin(), prefix.end(), s.begin());
    }
    bool startsWith( std::string const& s, char prefix ) {
        return !s.empty() && s[0] == prefix;
    }
    bool endsWith( std::string const& s, std::string const& suffix ) {
        return s.size() >= suffix.size() && std::equal(suffix.rbegin(), suffix.rend(), s.rbegin());
    }
    bool endsWith( std::string const& s, char suffix ) {
        return !s.empty() && s[s.size()-1] == suffix;
    }
    bool contains( std::string const& s, std::string const& infix ) {
        return s.find( infix ) != std::string::npos;
    }
    void toLowerInPlace( std::string& s ) {
        std::transform( s.begin(), s.end(), s.begin(), toLowerCh );
    }
    std::string toLower( std::string const& s ) {
        std::string lc = s;
        toLowerInPlace( lc );
        return lc;
    }
    std::string trim( std::string const& str ) {
        static char const* whitespaceChars = "\n\r\t ";
        std::string::size_type start = str.find_first_not_of( whitespaceChars );
        std::string::size_type end = str.find_last_not_of( whitespaceChars );

        return start != std::string::npos ? str.substr( start, 1+end-start ) : std::string();
    }

    StringRef trim(StringRef ref) {
        const auto is_ws = [](char c) {
            return c == ' ' || c == '\t' || c == '\n' || c == '\r';
        };
        size_t real_begin = 0;
        while (real_begin < ref.size() && is_ws(ref[real_begin])) { ++real_begin; }
        size_t real_end = ref.size();
        while (real_end > real_begin && is_ws(ref[real_end - 1])) { --real_end; }

        return ref.substr(real_begin, real_end - real_begin);
    }

    bool replaceInPlace( std::string& str, std::string const& replaceThis, std::string const& withThis
) {
        bool replaced = false;
        std::size_t i = str.find( replaceThis );
        while( i != std::string::npos ) {
            replaced = true;
            str = str.substr( 0, i ) + withThis + str.substr( i+replaceThis.size() );
            if( i < str.size()-withThis.size() )
                i = str.find( replaceThis, i+withThis.size() );
            else
                i = std::string::npos;
        }
        return replaced;
    }

    std::vector<StringRef> splitStringRef( StringRef str, char delimiter ) {
        std::vector<StringRef> subStrings;
        std::size_t start = 0;
        for(std::size_t pos = 0; pos < str.size(); ++pos ) {
            if( str[pos] == delimiter ) {
                if( pos - start > 1 )
                    subStrings.push_back( str.substr( start, pos-start ) );
                start = pos+1;
            }
        }
        if( start < str.size() )
            subStrings.push_back( str.substr( start, str.size()-start ) );
        return subStrings;
    }

    pluralise::pluralise( std::size_t count, std::string const& label )
    :   m_count( count ),
        m_label( label )
    {}

    std::ostream& operator « ( std::ostream& os, pluralise const& pluraliser ) {
        os « pluraliser.m_count « ' ' « pluraliser.m_label;
        if( pluraliser.m_count != 1 )
            os « 's';
        return os;
    }

}
// end catch_string_manip.cpp
// start catch_stringref.cpp

#include <algorithm>
#include <ostream>
#include <cstring>
#include <cstdint>

namespace Catch {
    StringRef::StringRef( char const* rawChars ) noexcept
    : StringRef( rawChars, static_cast<StringRef::size_type>(std::strlen(rawChars) ) )
    {}

    auto StringRef::c_str() const -> char const* {
        CATCH_ENFORCE(isNullTerminated(), "Called StringRef::c_str() on a non-null-terminated
instance");
        return m_start;
    }
    auto StringRef::data() const noexcept -> char const* {
        return m_start;
    }

    auto StringRef::substr( size_type start, size_type size ) const noexcept -> StringRef {
        if (start < m_size) {
            return StringRef(m_start + start, (std::min)(m_size - start, size));
        } else {
            return StringRef();
        }
    }
    auto StringRef::operator == ( StringRef const& other ) const noexcept -> bool {
        return m_size == other.m_size
            && (std::memcmp( m_start, other.m_start, m_size ) == 0);
    }

    auto operator « ( std::ostream& os, StringRef const& str ) -> std::ostream& {
        return os.write(str.data(), str.size());
    }

    auto operator+=( std::string& lhs, StringRef const& rhs ) -> std::string& {
        lhs.append(rhs.data(), rhs.size());
        return lhs;
    }

} // namespace Catch
// end catch_stringref.cpp
// start catch_tag_alias.cpp

namespace Catch {
    TagAlias::TagAlias(std::string const & _tag, SourceLineInfo _lineInfo): tag(_tag),
lineInfo(_lineInfo) {}
}
// end catch_tag_alias.cpp
// start catch_tag_alias_autoregistrar.cpp

namespace Catch {

    RegistrarForTagAliases::RegistrarForTagAliases(char const* alias, char const* tag, SourceLineInfo
const& lineInfo) {
        CATCH_TRY {
            getMutableRegistryHub().registerTagAlias(alias, tag, lineInfo);
        } CATCH_CATCH_ALL {
            // Do not throw when constructing global objects, instead register the exception to be
processed later
            getMutableRegistryHub().registerStartupException();
        }
    }

}
// end catch_tag_alias_autoregistrar.cpp
// start catch_tag_alias_registry.cpp

#include <sstream>

namespace Catch {

    TagAliasRegistry::~TagAliasRegistry() {}

    TagAlias const* TagAliasRegistry::find( std::string const& alias ) const {
        auto it = m_registry.find( alias );
        if( it != m_registry.end() )
            return &(it->second);
        else
            return nullptr;
    }

    std::string TagAliasRegistry::expandAliases( std::string const& unexpandedTestSpec ) const {
        std::string expandedTestSpec = unexpandedTestSpec;
        for( auto const& registryKvp : m_registry ) {
            std::size_t pos = expandedTestSpec.find( registryKvp.first );
            if( pos != std::string::npos ) {
                expandedTestSpec =  expandedTestSpec.substr( 0, pos ) +
                                    registryKvp.second.tag +
                                    expandedTestSpec.substr( pos + registryKvp.first.size() );
            }
        }
        return expandedTestSpec;
    }

    void TagAliasRegistry::add( std::string const& alias, std::string const& tag, SourceLineInfo const& lineInfo ) {
        CATCH_ENFORCE( startsWith(alias, "[@") && endsWith(alias, ’]’),
                      "error: tag alias, ’" « alias « "’ is not of the form [@alias name].\n" « lineInfo );

        CATCH_ENFORCE( m_registry.insert(std::make_pair(alias, TagAlias(tag, lineInfo))).second,
                      "error: tag alias, ’" « alias « "’ already registered.\n"
                      « "\tFirst seen at: " « find(alias)->lineInfo « "\n"
                      « "\tRedefined at: " « lineInfo );
    }

    ITagAliasRegistry::~ITagAliasRegistry() {}

    ITagAliasRegistry const& ITagAliasRegistry::get() {
        return getRegistryHub().getTagAliasRegistry();
    }

} // end namespace Catch
// end catch_tag_alias_registry.cpp
// start catch_test_case_info.cpp

#include <cctype>
#include <exception>
#include <algorithm>
#include <sstream>

namespace Catch {

    namespace {
        TestCaseInfo::SpecialProperties parseSpecialTag( std::string const& tag ) {
            if( startsWith( tag, ’.’ ) ||
                tag == "!hide" )
                return TestCaseInfo::IsHidden;
            else if( tag == "!throws" )
                return TestCaseInfo::Throws;
            else if( tag == "!shouldfail" )
                return TestCaseInfo::ShouldFail;
            else if( tag == "!mayfail" )
                return TestCaseInfo::MayFail;
            else if( tag == "!nonportable" )
                return TestCaseInfo::NonPortable;
            else if( tag == "!benchmark" )
                return static_cast<TestCaseInfo::SpecialProperties>( TestCaseInfo::Benchmark | TestCaseInfo::IsHidden );
            else
                return TestCaseInfo::None;
        }
        bool isReservedTag( std::string const& tag ) {
            return parseSpecialTag( tag ) == TestCaseInfo::None && tag.size() > 0 && !std::isalnum( static_cast<unsigned char>(tag[0]) );
        }
        void enforceNotReservedTag( std::string const& tag, SourceLineInfo const& _lineInfo ) {
            CATCH_ENFORCE( !isReservedTag(tag),
                          "Tag name: [" « tag « "] is not allowed.\n"
                          « "Tag names starting with non alphanumeric characters are reserved\n"
                          « _lineInfo );
        }
    }

    TestCase makeTestCase(  ITestInvoker* _testCase,
                            std::string const& _className,
                            NameAndTags const& nameAndTags,
                            SourceLineInfo const& _lineInfo )
    {
        bool isHidden = false;

        // Parse out tags
        std::vector<std::string> tags;
        std::string desc, tag;
        bool inTag = false;
        for (char c : nameAndTags.tags) {
            if( !inTag ) {
                if( c == '[' )
                    inTag = true;
                else
                    desc += c;
            }
            else {
                if( c == ']' ) {
                    TestCaseInfo::SpecialProperties prop = parseSpecialTag( tag );
                    if( ( prop & TestCaseInfo::IsHidden ) != 0 )
                        isHidden = true;
                    else if( prop == TestCaseInfo::None )
                        enforceNotReservedTag( tag, _lineInfo );

                    // Merged hide tags like `[.approvals]` should be added as
                    // `[.][approvals]`. The `[.]` is added at later point, so
                    // we only strip the prefix
                    if (startsWith(tag, '.') && tag.size() > 1) {
                        tag.erase(0, 1);
                    }
                    tags.push_back( tag );
                    tag.clear();
                    inTag = false;
                }
                else
                    tag += c;
            }
        }
        if( isHidden ) {
            // Add all "hidden" tags to make them behave identically
            tags.insert( tags.end(), { ".", "!hide" } );
        }

        TestCaseInfo info( static_cast<std::string>(nameAndTags.name), _className, desc, tags,
 _lineInfo );
        return TestCase( _testCase, std::move(info) );
    }

    void setTags( TestCaseInfo& testCaseInfo, std::vector<std::string> tags ) {
        std::sort(begin(tags), end(tags));
        tags.erase(std::unique(begin(tags), end(tags)), end(tags));
        testCaseInfo.lcaseTags.clear();

        for( auto const& tag : tags ) {
            std::string lcaseTag = toLower( tag );
            testCaseInfo.properties = static_cast<TestCaseInfo::SpecialProperties>(
 testCaseInfo.properties | parseSpecialTag( lcaseTag ) );
            testCaseInfo.lcaseTags.push_back( lcaseTag );
        }
        testCaseInfo.tags = std::move(tags);
    }

    TestCaseInfo::TestCaseInfo( std::string const& _name,
                                std::string const& _className,
                                std::string const& _description,
                                std::vector<std::string> const& _tags,
                                SourceLineInfo const& _lineInfo )
    :   name( _name ),
        className( _className ),
        description( _description ),
        lineInfo( _lineInfo ),
        properties( None )
    {
        setTags( *this, _tags );
    }

    bool TestCaseInfo::isHidden() const {
        return ( properties & IsHidden ) != 0;
    }
    bool TestCaseInfo::throws() const {
        return ( properties & Throws ) != 0;
    }
    bool TestCaseInfo::okToFail() const {
        return ( properties & (ShouldFail | MayFail ) ) != 0;
    }
    bool TestCaseInfo::expectedToFail() const {
        return ( properties & (ShouldFail ) ) != 0;
    }

    std::string TestCaseInfo::tagsAsString() const {
        std::string ret;
        // '[' and ']' per tag
        std::size_t full_size = 2 * tags.size();
        for (const auto& tag : tags) {
            full_size += tag.size();
        }
        ret.reserve(full_size);
        for (const auto& tag : tags) {
            ret.push_back('[');
            ret.append(tag);
            ret.push_back(']');
        }

        return ret;
    }

    TestCase::TestCase( ITestInvoker* testCase, TestCaseInfo&& info ) : TestCaseInfo( std::move(info)
), test( testCase ) {}

    TestCase TestCase::withName( std::string const& _newName ) const {
        TestCase other( *this );
        other.name = _newName;
        return other;
    }

    void TestCase::invoke() const {
        test->invoke();
    }

    bool TestCase::operator == ( TestCase const& other ) const {
        return  test.get() == other.test.get() &&
                name == other.name &&
                className == other.className;
    }

    bool TestCase::operator < ( TestCase const& other ) const {
        return name < other.name;
    }

    TestCaseInfo const& TestCase::getTestCaseInfo() const
    {
        return *this;
    }

} // end namespace Catch
// end catch_test_case_info.cpp
// start catch_test_case_registry_impl.cpp

#include <algorithm>
#include <sstream>

namespace Catch {

    namespace {
        struct TestHasher {
            using hash_t = uint64_t;

            explicit TestHasher( hash_t hashSuffix ):
                m_hashSuffix{ hashSuffix } {}

            uint32_t operator()( TestCase const& t ) const {
                // FNV-1a hash with multiplication fold.
                const hash_t prime = 1099511628211u;
                hash_t hash = 14695981039346656037u;
                for ( const char c : t.name ) {
                    hash ^= c;
                    hash *= prime;
                }
                hash ^= m_hashSuffix;
                hash *= prime;
                const uint32_t low{ static_cast<uint32_t>( hash ) };
                const uint32_t high{ static_cast<uint32_t>( hash » 32 ) };
                return low * high;
            }

        private:
            hash_t m_hashSuffix;
        };
    } // end unnamed namespace

    std::vector<TestCase> sortTests( IConfig const& config, std::vector<TestCase> const&
unsortedTestCases ) {
        switch( config.runOrder() ) {
            case RunTests::InDeclarationOrder:
                // already in declaration order
                break;

            case RunTests::InLexicographicalOrder: {
                std::vector<TestCase> sorted = unsortedTestCases;
                std::sort( sorted.begin(), sorted.end() );
                return sorted;
            }

            case RunTests::InRandomOrder: {
                seedRng( config );
                TestHasher h{ config.rngSeed() };

                using hashedTest = std::pair<TestHasher::hash_t, TestCase const*>;
                std::vector<hashedTest> indexed_tests;
                indexed_tests.reserve( unsortedTestCases.size() );

                for (auto const& testCase : unsortedTestCases) {
                    indexed_tests.emplace_back(h(testCase), &testCase);
                }

                std::sort(indexed_tests.begin(), indexed_tests.end(),
                          [](hashedTest const& lhs, hashedTest const& rhs) {
                          if (lhs.first == rhs.first) {
                              return lhs.second->name < rhs.second->name;
                          }
                          return lhs.first < rhs.first;
                });

                std::vector<TestCase> sorted;
                sorted.reserve( indexed_tests.size() );

                for (auto const& hashed : indexed_tests) {
                    sorted.emplace_back(*hashed.second);
                }

                return sorted;
            }
        }
        return unsortedTestCases;
    }

    bool isThrowSafe( TestCase const& testCase, IConfig const& config ) {
        return !testCase.throws() || config.allowThrows();
    }

    bool matchTest( TestCase const& testCase, TestSpec const& testSpec, IConfig const& config ) {
        return testSpec.matches( testCase ) && isThrowSafe( testCase, config );
    }

    void enforceNoDuplicateTestCases( std::vector<TestCase> const& functions ) {
        std::set<TestCase> seenFunctions;
        for( auto const& function : functions ) {
            auto prev = seenFunctions.insert( function );
            CATCH_ENFORCE( prev.second,
                    "error: TEST_CASE( \"" « function.name « "\" ) already defined.\n"
                    « "\tFirst seen at " « prev.first->getTestCaseInfo().lineInfo « "\n"
                    « "\tRedefined at " « function.getTestCaseInfo().lineInfo );
        }
    }

    std::vector<TestCase> filterTests( std::vector<TestCase> const& testCases, TestSpec const&
testSpec, IConfig const& config ) {
        std::vector<TestCase> filtered;
        filtered.reserve( testCases.size() );
        for (auto const& testCase : testCases) {
            if ((!testSpec.hasFilters() && !testCase.isHidden()) ||
                (testSpec.hasFilters() && matchTest(testCase, testSpec, config))) {
                filtered.push_back(testCase);
            }
        }
        return filtered;
    }
    std::vector<TestCase> const& getAllTestCasesSorted( IConfig const& config ) {
        return getRegistryHub().getTestCaseRegistry().getAllTestsSorted( config );
    }

    void TestRegistry::registerTest( TestCase const& testCase ) {
        std::string name = testCase.getTestCaseInfo().name;
        if( name.empty() ) {
            ReusableStringStream rss;
            rss « "Anonymous test case " « ++m_unnamedCount;
            return registerTest( testCase.withName( rss.str() ) );
        }
        m_functions.push_back( testCase );
    }

    std::vector<TestCase> const& TestRegistry::getAllTests() const {
        return m_functions;
    }
    std::vector<TestCase> const& TestRegistry::getAllTestsSorted( IConfig const& config ) const {
        if( m_sortedFunctions.empty() )
            enforceNoDuplicateTestCases( m_functions );

        if(  m_currentSortOrder != config.runOrder() || m_sortedFunctions.empty() ) {
            m_sortedFunctions = sortTests( config, m_functions );
            m_currentSortOrder = config.runOrder();
        }
        return m_sortedFunctions;
    }

    TestInvokerAsFunction::TestInvokerAsFunction( void(*testAsFunction)() ) noexcept :
m_testAsFunction( testAsFunction ) {}

    void TestInvokerAsFunction::invoke() const {
        m_testAsFunction();
    }

    std::string extractClassName( StringRef const& classOrQualifiedMethodName ) {
        std::string className(classOrQualifiedMethodName);
        if( startsWith( className, '&' ) )
        {
            std::size_t lastColons = className.rfind( "::" );
            std::size_t penultimateColons = className.rfind( "::", lastColons-1 );
            if( penultimateColons == std::string::npos )
                penultimateColons = 1;
            className = className.substr( penultimateColons, lastColons-penultimateColons );
        }
        return className;
    }

} // end namespace Catch
// end catch_test_case_registry_impl.cpp
// start catch_test_case_tracker.cpp

#include <algorithm>
#include <cassert>
#include <stdexcept>
#include <memory>
#include <sstream>

#if defined(__clang__)
#    pragma clang diagnostic push
#    pragma clang diagnostic ignored "-Wexit-time-destructors"
#endif

namespace Catch {
namespace TestCaseTracking {

    NameAndLocation::NameAndLocation( std::string const& _name, SourceLineInfo const& _location )
    :   name( _name ),
        location( _location )
    {}

    ITracker::~ITracker() = default;

    ITracker& TrackerContext::startRun() {
        m_rootTracker = std::make_shared<SectionTracker>( NameAndLocation( "{root}",
CATCH_INTERNAL_LINEINFO ), *this, nullptr );
        m_currentTracker = nullptr;
        m_runState = Executing;
        return *m_rootTracker;
    }

    void TrackerContext::endRun() {
        m_rootTracker.reset();
        m_currentTracker = nullptr;
        m_runState = NotStarted;
    }

    void TrackerContext::startCycle() {
        m_currentTracker = m_rootTracker.get();
        m_runState = Executing;
    }
    void TrackerContext::completeCycle() {
        m_runState = CompletedCycle;
    }

    bool TrackerContext::completedCycle() const {
        return m_runState == CompletedCycle;
    }
    ITracker& TrackerContext::currentTracker() {
        return *m_currentTracker;
    }
    void TrackerContext::setCurrentTracker( ITracker* tracker ) {
        m_currentTracker = tracker;
    }

    TrackerBase::TrackerBase( NameAndLocation const& nameAndLocation, TrackerContext& ctx, ITracker* parent ):
        ITracker(nameAndLocation),
        m_ctx( ctx ),
        m_parent( parent )
    {}

    bool TrackerBase::isComplete() const {
        return m_runState == CompletedSuccessfully || m_runState == Failed;
    }
    bool TrackerBase::isSuccessfullyCompleted() const {
        return m_runState == CompletedSuccessfully;
    }
    bool TrackerBase::isOpen() const {
        return m_runState != NotStarted && !isComplete();
    }
    bool TrackerBase::hasChildren() const {
        return !m_children.empty();
    }

    void TrackerBase::addChild( ITrackerPtr const& child ) {
        m_children.push_back( child );
    }

    ITrackerPtr TrackerBase::findChild( NameAndLocation const& nameAndLocation ) {
        auto it = std::find_if( m_children.begin(), m_children.end(),
            [&nameAndLocation]( ITrackerPtr const& tracker ){
                return
                    tracker->nameAndLocation().location == nameAndLocation.location &&
                    tracker->nameAndLocation().name == nameAndLocation.name;
            } );
        return( it != m_children.end() )
            ? *it
            : nullptr;
    }
    ITracker& TrackerBase::parent() {
        assert( m_parent ); // Should always be non-null except for root
        return *m_parent;
    }

    void TrackerBase::openChild() {
        if( m_runState != ExecutingChildren ) {
            m_runState = ExecutingChildren;
            if( m_parent )
                m_parent->openChild();
        }
    }

    bool TrackerBase::isSectionTracker() const { return false; }
    bool TrackerBase::isGeneratorTracker() const { return false; }

    void TrackerBase::open() {
        m_runState = Executing;
        moveToThis();
        if( m_parent )
            m_parent->openChild();
    }

    void TrackerBase::close() {

        // Close any still open children (e.g. generators)
        while( &m_ctx.currentTracker() != this )
            m_ctx.currentTracker().close();

        switch( m_runState ) {
            case NeedsAnotherRun:
                break;

            case Executing:
                m_runState = CompletedSuccessfully;
                break;
            case ExecutingChildren:
                if( std::all_of(m_children.begin(), m_children.end(), [](ITrackerPtr const& t){ return t->isComplete(); }) )
                    m_runState = CompletedSuccessfully;
                break;

            case NotStarted:
            case CompletedSuccessfully:
            case Failed:
                CATCH_INTERNAL_ERROR( "Illogical state: " « m_runState );

            default:
                CATCH_INTERNAL_ERROR( "Unknown state: " « m_runState );
        }
        moveToParent();
        m_ctx.completeCycle();
    }
    void TrackerBase::fail() {
        m_runState = Failed;
        if( m_parent )
            m_parent->markAsNeedingAnotherRun();
        moveToParent();
        m_ctx.completeCycle();
    }
    void TrackerBase::markAsNeedingAnotherRun() {
        m_runState = NeedsAnotherRun;
    }

    void TrackerBase::moveToParent() {
        assert( m_parent );
        m_ctx.setCurrentTracker( m_parent );
    }
    void TrackerBase::moveToThis() {
        m_ctx.setCurrentTracker( this );
    }

    SectionTracker::SectionTracker( NameAndLocation const& nameAndLocation, TrackerContext& ctx,
ITracker* parent )
    :   TrackerBase( nameAndLocation, ctx, parent ),
        m_trimmed_name(trim(nameAndLocation.name))
    {
        if( parent ) {
            while( !parent->isSectionTracker() )
                parent = &parent->parent();

            SectionTracker& parentSection = static_cast<SectionTracker&>( *parent );
            addNextFilters( parentSection.m_filters );
        }
    }

    bool SectionTracker::isComplete() const {
        bool complete = true;

        if (m_filters.empty()
            || m_filters[0] == ""
            || std::find(m_filters.begin(), m_filters.end(), m_trimmed_name) != m_filters.end()) {
            complete = TrackerBase::isComplete();
        }
        return complete;
    }

    bool SectionTracker::isSectionTracker() const { return true; }

    SectionTracker& SectionTracker::acquire( TrackerContext& ctx, NameAndLocation const&
nameAndLocation ) {
        std::shared_ptr<SectionTracker> section;

        ITracker& currentTracker = ctx.currentTracker();
        if( ITrackerPtr childTracker = currentTracker.findChild( nameAndLocation ) ) {
            assert( childTracker );
            assert( childTracker->isSectionTracker() );
            section = std::static_pointer_cast<SectionTracker>( childTracker );
        }
        else {
            section = std::make_shared<SectionTracker>( nameAndLocation, ctx, &currentTracker );
            currentTracker.addChild( section );
        }
        if( !ctx.completedCycle() )
            section->tryOpen();
        return *section;
    }

    void SectionTracker::tryOpen() {
        if( !isComplete() )
            open();
    }

    void SectionTracker::addInitialFilters( std::vector<std::string> const& filters ) {
        if( !filters.empty() ) {
            m_filters.reserve( m_filters.size() + filters.size() + 2 );
            m_filters.emplace_back(""); // Root - should never be consulted
            m_filters.emplace_back(""); // Test Case - not a section filter
            m_filters.insert( m_filters.end(), filters.begin(), filters.end() );
        }
    }
    void SectionTracker::addNextFilters( std::vector<std::string> const& filters ) {
        if( filters.size() > 1 )
            m_filters.insert( m_filters.end(), filters.begin()+1, filters.end() );
    }

    std::vector<std::string> const& SectionTracker::getFilters() const {
        return m_filters;
    }

    std::string const& SectionTracker::trimmedName() const {
        return m_trimmed_name;
    }

} // namespace TestCaseTracking

using TestCaseTracking::ITracker;
using TestCaseTracking::TrackerContext;
using TestCaseTracking::SectionTracker;

} // namespace Catch

#if defined(__clang__)
#    pragma clang diagnostic pop
#endif
// end catch_test_case_tracker.cpp
// start catch_test_registry.cpp

namespace Catch {

    auto makeTestInvoker( void(*testAsFunction)() ) noexcept -> ITestInvoker* {
        return new(std::nothrow) TestInvokerAsFunction( testAsFunction );
    }

    NameAndTags::NameAndTags( StringRef const& name_ , StringRef const& tags_ ) noexcept : name( name_
), tags( tags_ ) {}

    AutoReg::AutoReg( ITestInvoker* invoker, SourceLineInfo const& lineInfo, StringRef const&
classOrMethod, NameAndTags const& nameAndTags ) noexcept {
        CATCH_TRY {
            getMutableRegistryHub()
                    .registerTest(
                        makeTestCase(
                            invoker,
                            extractClassName( classOrMethod ),
                            nameAndTags,
                            lineInfo));
        } CATCH_CATCH_ALL {
            // Do not throw when constructing global objects, instead register the exception to be
processed later
            getMutableRegistryHub().registerStartupException();
        }
    }

    AutoReg::~AutoReg() = default;
}
// end catch_test_registry.cpp
// start catch_test_spec.cpp

#include <algorithm>
#include <string>
#include <vector>
#include <memory>

namespace Catch {

    TestSpec::Pattern::Pattern( std::string const& name )
    : m_name( name )
    {}

    TestSpec::Pattern::~Pattern() = default;

    std::string const& TestSpec::Pattern::name() const {
        return m_name;
    }

    TestSpec::NamePattern::NamePattern( std::string const& name, std::string const& filterString )
    : Pattern( filterString )
    , m_wildcardPattern( toLower( name ), CaseSensitive::No )
    {}

    bool TestSpec::NamePattern::matches( TestCaseInfo const& testCase ) const {
        return m_wildcardPattern.matches( testCase.name );
    }

    TestSpec::TagPattern::TagPattern( std::string const& tag, std::string const& filterString )
    : Pattern( filterString )
    , m_tag( toLower( tag ) )
    {}

    bool TestSpec::TagPattern::matches( TestCaseInfo const& testCase ) const {
        return std::find(begin(testCase.lcaseTags),
                         end(testCase.lcaseTags),
                         m_tag) != end(testCase.lcaseTags);
    }

    TestSpec::ExcludedPattern::ExcludedPattern( PatternPtr const& underlyingPattern )
    : Pattern( underlyingPattern->name() )
    , m_underlyingPattern( underlyingPattern )
    {}

    bool TestSpec::ExcludedPattern::matches( TestCaseInfo const& testCase ) const {
        return !m_underlyingPattern->matches( testCase );
    }

    bool TestSpec::Filter::matches( TestCaseInfo const& testCase ) const {
        return std::all_of( m_patterns.begin(), m_patterns.end(), [&]( PatternPtr const& p ){ return
p->matches( testCase ); } );
    }

    std::string TestSpec::Filter::name() const {
        std::string name;
        for( auto const& p : m_patterns )
            name += p->name();
        return name;
    }

    bool TestSpec::hasFilters() const {
        return !m_filters.empty();
    }

    bool TestSpec::matches( TestCaseInfo const& testCase ) const {
        return std::any_of( m_filters.begin(), m_filters.end(), [&]( Filter const& f ){ return
f.matches( testCase ); } );
    }

    TestSpec::Matches TestSpec::matchesByFilter( std::vector<TestCase> const& testCases, IConfig
const& config ) const
    {
        Matches matches( m_filters.size() );
        std::transform( m_filters.begin(), m_filters.end(), matches.begin(), [&]( Filter const& filter
){
            std::vector<TestCase const*> currentMatches;
            for( auto const& test : testCases )
                if( isThrowSafe( test, config ) && filter.matches( test ) )
                    currentMatches.emplace_back( &test );
            return FilterMatch{ filter.name(), currentMatches };
        } );
        return matches;
    }

    const TestSpec::vectorStrings& TestSpec::getInvalidArgs() const{
        return  (m_invalidArgs);
    }

}
// end catch_test_spec.cpp
// start catch_test_spec_parser.cpp

namespace Catch {

    TestSpecParser::TestSpecParser( ITagAliasRegistry const& tagAliases ) : m_tagAliases( &tagAliases
) {}

    TestSpecParser& TestSpecParser::parse( std::string const& arg ) {
        m_mode = None;
        m_exclusion = false;
        m_arg = m_tagAliases->expandAliases( arg );
        m_escapeChars.clear();
        m_substring.reserve(m_arg.size());
        m_patternName.reserve(m_arg.size());
        m_realPatternPos = 0;

        for( m_pos = 0; m_pos < m_arg.size(); ++m_pos )
          //if visitChar fails
           if( !visitChar( m_arg[m_pos] ) ){
               m_testSpec.m_invalidArgs.push_back(arg);
               break;
           }
        endMode();
        return *this;
    }
    TestSpec TestSpecParser::testSpec() {
        addFilter();
        return m_testSpec;
    }
    bool TestSpecParser::visitChar( char c ) {
        if( (m_mode != EscapedName) && (c == '\\') ) {
            escape();
            addCharToPattern(c);
            return true;
        }else if((m_mode != EscapedName) && (c == ',') )  {
            return separate();
        }

        switch( m_mode ) {
        case None:
            if( processNoneChar( c ) )
                return true;
            break;
        case Name:
            processNameChar( c );
            break;
        case EscapedName:
            endMode();
            addCharToPattern(c);
            return true;
        default:
        case Tag:
        case QuotedName:
            if( processOtherChar( c ) )
                return true;
            break;
        }

        m_substring += c;
        if( !isControlChar( c ) ) {
            m_patternName += c;
            m_realPatternPos++;
        }
        return true;
    }
    // Two of the processing methods return true to signal the caller to return
    // without adding the given character to the current pattern strings
    bool TestSpecParser::processNoneChar( char c ) {
        switch( c ) {
        case ' ':
            return true;
        case '~':
            m_exclusion = true;
            return false;
        case '[':
            startNewMode( Tag );
            return false;
        case '"':
            startNewMode( QuotedName );
            return false;
        default:
            startNewMode( Name );
            return false;
        }
    }
    void TestSpecParser::processNameChar( char c ) {
        if( c == '[' ) {
            if( m_substring == "exclude:" )
                m_exclusion = true;
            else
                endMode();
            startNewMode( Tag );
        }
    }
    bool TestSpecParser::processOtherChar( char c ) {
        if( !isControlChar( c ) )
            return false;
        m_substring += c;
        endMode();
        return true;
    }
    void TestSpecParser::startNewMode( Mode mode ) {
        m_mode = mode;
    }
    void TestSpecParser::endMode() {
        switch( m_mode ) {
        case Name:
        case QuotedName:
            return addNamePattern();
        case Tag:
            return addTagPattern();
        case EscapedName:
            revertBackToLastMode();
            return;
        case None:
        default:
            return startNewMode( None );
        }
    }
    void TestSpecParser::escape() {
        saveLastMode();
        m_mode = EscapedName;
        m_escapeChars.push_back(m_realPatternPos);
    }
    bool TestSpecParser::isControlChar( char c ) const {
        switch( m_mode ) {
            default:
                return false;
            case None:
                return c == '~';
            case Name:
                return c == '[';
            case EscapedName:
                return true;
            case QuotedName:
                return c == '"';
            case Tag:
                return c == '[' || c == ']';
        }
    }

    void TestSpecParser::addFilter() {
        if( !m_currentFilter.m_patterns.empty() ) {
            m_testSpec.m_filters.push_back( m_currentFilter );
            m_currentFilter = TestSpec::Filter();
        }
    }

    void TestSpecParser::saveLastMode() {
      lastMode = m_mode;
    }

    void TestSpecParser::revertBackToLastMode() {
      m_mode = lastMode;
    }

    bool TestSpecParser::separate() {
      if( (m_mode==QuotedName) || (m_mode==Tag) ){
         //invalid argument, signal failure to previous scope.
         m_mode = None;
         m_pos = m_arg.size();
         m_substring.clear();
         m_patternName.clear();
         m_realPatternPos = 0;
         return false;
      }
      endMode();
      addFilter();
      return true; //success
    }

    std::string TestSpecParser::preprocessPattern() {
        std::string token = m_patternName;
        for (std::size_t i = 0; i < m_escapeChars.size(); ++i)
            token = token.substr(0, m_escapeChars[i] - i) + token.substr(m_escapeChars[i] - i + 1);
        m_escapeChars.clear();
        if (startsWith(token, "exclude:")) {
            m_exclusion = true;
            token = token.substr(8);
        }

        m_patternName.clear();
        m_realPatternPos = 0;

        return token;
    }

    void TestSpecParser::addNamePattern() {
        auto token = preprocessPattern();

        if (!token.empty()) {
            TestSpec::PatternPtr pattern = std::make_shared<TestSpec::NamePattern>(token,
m_substring);
            if (m_exclusion)
                pattern = std::make_shared<TestSpec::ExcludedPattern>(pattern);
            m_currentFilter.m_patterns.push_back(pattern);
        }
        m_substring.clear();
        m_exclusion = false;
        m_mode = None;
    }

    void TestSpecParser::addTagPattern() {
        auto token = preprocessPattern();

        if (!token.empty()) {
            // If the tag pattern is the "hide and tag" shorthand (e.g. [.foo])
            // we have to create a separate hide tag and shorten the real one
            if (token.size() > 1 && token[0] == '.') {
                token.erase(token.begin());
                TestSpec::PatternPtr pattern = std::make_shared<TestSpec::TagPattern>(".",
m_substring);
                if (m_exclusion) {
                    pattern = std::make_shared<TestSpec::ExcludedPattern>(pattern);
                }
                m_currentFilter.m_patterns.push_back(pattern);
            }

            TestSpec::PatternPtr pattern = std::make_shared<TestSpec::TagPattern>(token, m_substring);

            if (m_exclusion) {
                pattern = std::make_shared<TestSpec::ExcludedPattern>(pattern);
            }
            m_currentFilter.m_patterns.push_back(pattern);
        }
        m_substring.clear();
        m_exclusion = false;
        m_mode = None;
    }

    TestSpec parseTestSpec( std::string const& arg ) {
        return TestSpecParser( ITagAliasRegistry::get() ).parse( arg ).testSpec();
    }

} // namespace Catch
// end catch_test_spec_parser.cpp
// start catch_timer.cpp

#include <chrono>

static const uint64_t nanosecondsInSecond = 1000000000;

namespace Catch {

    auto getCurrentNanosecondsSinceEpoch() -> uint64_t {
        return std::chrono::duration_cast<std::chrono::nanoseconds>(
std::chrono::high_resolution_clock::now().time_since_epoch() ).count();
    }

    namespace {
        auto estimateClockResolution() -> uint64_t {
            uint64_t sum = 0;
            static const uint64_t iterations = 1000000;

            auto startTime = getCurrentNanosecondsSinceEpoch();

            for( std::size_t i = 0; i < iterations; ++i ) {

                uint64_t ticks;
                uint64_t baseTicks = getCurrentNanosecondsSinceEpoch();
                do {
                    ticks = getCurrentNanosecondsSinceEpoch();
                } while( ticks == baseTicks );

                auto delta = ticks - baseTicks;
                sum += delta;

                // If we have been calibrating for over 3 seconds -- the clock
                // is terrible and we should move on.
                // TBD: How to signal that the measured resolution is probably wrong?
                if (ticks > startTime + 3 * nanosecondsInSecond) {
                    return sum / ( i + 1u );
                }
            }

            // We're just taking the mean, here. To do better we could take the std. dev and exclude
outliers
            // - and potentially do more iterations if there's a high variance.
            return sum/iterations;
        }
    }
    auto getEstimatedClockResolution() -> uint64_t {
        static auto s_resolution = estimateClockResolution();
        return s_resolution;
    }

    void Timer::start() {
       m_nanoseconds = getCurrentNanosecondsSinceEpoch();
    }
    auto Timer::getElapsedNanoseconds() const -> uint64_t {
        return getCurrentNanosecondsSinceEpoch() - m_nanoseconds;
    }
    auto Timer::getElapsedMicroseconds() const -> uint64_t {
        return getElapsedNanoseconds()/1000;
    }
    auto Timer::getElapsedMilliseconds() const -> unsigned int {
        return static_cast<unsigned int>(getElapsedMicroseconds()/1000);
    }
    auto Timer::getElapsedSeconds() const -> double {
        return getElapsedMicroseconds()/1000000.0;
    }

} // namespace Catch
// end catch_timer.cpp
// start catch_tostring.cpp

#if defined(__clang__)
#    pragma clang diagnostic push
#    pragma clang diagnostic ignored "-Wexit-time-destructors"
#    pragma clang diagnostic ignored "-Wglobal-constructors"
#endif

// Enable specific decls locally
#if !defined(CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER)
#define CATCH_CONFIG_ENABLE_CHRONO_STRINGMAKER
#endif

#include <cmath>
#include <iomanip>

namespace Catch {

namespace Detail {

    const std::string unprintableString = "{?}";

    namespace {
        const int hexThreshold = 255;

        struct Endianness {
            enum Arch { Big, Little };

            static Arch which() {
                int one = 1;
                // If the lowest byte we read is non-zero, we can assume
                // that little endian format is used.
                auto value = *reinterpret_cast<char*>(&one);
                return value ? Little : Big;
            }
        };
    }

    std::string rawMemoryToString( const void *object, std::size_t size ) {
        // Reverse order for little endian architectures
        int i = 0, end = static_cast<int>( size ), inc = 1;
        if( Endianness::which() == Endianness::Little ) {
            i = end-1;
            end = inc = -1;
        }

        unsigned char const *bytes = static_cast<unsigned char const *>(object);
        ReusableStringStream rss;
        rss « "0x" « std::setfill('0') « std::hex;
        for( ; i != end; i += inc )
             rss « std::setw(2) « static_cast<unsigned>(bytes[i]);
       return rss.str();
    }
}

template<typename T>
std::string fpToString( T value, int precision ) {
    if (Catch::isnan(value)) {
        return "nan";
    }

    ReusableStringStream rss;
    rss « std::setprecision( precision )
        « std::fixed
        « value;
    std::string d = rss.str();
    std::size_t i = d.find_last_not_of( '0' );
    if( i != std::string::npos && i != d.size()-1 ) {
        if( d[i] == '.' )
            i++;
        d = d.substr( 0, i+1 );
    }
    return d;
}

//
//   Out-of-line defs for full specialization of StringMaker
//
```

```

std::string StringMaker<std::string>::convert(const std::string& str) {
    if (!getCurrentContext().getConfig()->showInvisibles()) {
        return '"' + str + '"';
    }

    std::string s("\"");
    for (char c : str) {
        switch (c) {
        case '\n':
            s.append("\\n");
            break;
        case '\t':
            s.append("\\t");
            break;
        default:
            s.push_back(c);
            break;
        }
    }
    s.append("\"");
    return s;
}

#ifdef CATCH_CONFIG_CPP17_STRING_VIEW
std::string StringMaker<std::string_view>::convert(std::string_view str) {
    return ::Catch::Detail::stringify(std::string{ str });
}
#endif

std::string StringMaker<char const*>::convert(char const* str) {
    if (str) {
        return ::Catch::Detail::stringify(std::string{ str });
    } else {
        return{ "{null string}" };
    }
}
std::string StringMaker<char*>::convert(char* str) {
    if (str) {
        return ::Catch::Detail::stringify(std::string{ str });
    } else {
        return{ "{null string}" };
    }
}

#ifdef CATCH_CONFIG_WCHAR
std::string StringMaker<std::wstring>::convert(const std::wstring& wstr) {
    std::string s;
    s.reserve(wstr.size());
    for (auto c : wstr) {
        s += (c <= 0xff) ? static_cast<char>(c) : '?';
    }
    return ::Catch::Detail::stringify(s);
}

# ifdef CATCH_CONFIG_CPP17_STRING_VIEW
std::string StringMaker<std::wstring_view>::convert(std::wstring_view str) {
    return StringMaker<std::wstring>::convert(std::wstring(str));
}
# endif

std::string StringMaker<wchar_t const*>::convert(wchar_t const * str) {
    if (str) {
        return ::Catch::Detail::stringify(std::wstring{ str });
    } else {
        return{ "{null string}" };
    }
}
std::string StringMaker<wchar_t *>::convert(wchar_t * str) {
    if (str) {
        return ::Catch::Detail::stringify(std::wstring{ str });
    } else {
        return{ "{null string}" };
    }
}
#endif

#if defined(CATCH_CONFIG_CPP17_BYTE)
#include <cstddef>
std::string StringMaker<std::byte>::convert(std::byte value) {
    return ::Catch::Detail::stringify(std::to_integer<unsigned long long>(value));
}
#endif // defined(CATCH_CONFIG_CPP17_BYTE)

std::string StringMaker<int>::convert(int value) {
    return ::Catch::Detail::stringify(static_cast<long long>(value));
}
```

```
std::string StringMaker<long>::convert(long value) {
    return ::Catch::Detail::stringify(static_cast<long long>(value));
}
std::string StringMaker<long long>::convert(long long value) {
    ReusableStringStream rss;
    rss « value;
    if (value > Detail::hexThreshold) {
        rss « " (0x" « std::hex « value « ')';
    }
    return rss.str();
}

std::string StringMaker<unsigned int>::convert(unsigned int value) {
    return ::Catch::Detail::stringify(static_cast<unsigned long long>(value));
}
std::string StringMaker<unsigned long>::convert(unsigned long value) {
    return ::Catch::Detail::stringify(static_cast<unsigned long long>(value));
}
std::string StringMaker<unsigned long long>::convert(unsigned long long value) {
    ReusableStringStream rss;
    rss « value;
    if (value > Detail::hexThreshold) {
        rss « " (0x" « std::hex « value « ')';
    }
    return rss.str();
}

std::string StringMaker<bool>::convert(bool b) {
    return b ? "true" : "false";
}

std::string StringMaker<signed char>::convert(signed char value) {
    if (value == '\r') {
        return "'\\r'";
    } else if (value == '\f') {
        return "'\\f'";
    } else if (value == '\n') {
        return "'\\n'";
    } else if (value == '\t') {
        return "'\\t'";
    } else if ('\0' <= value && value < ' ') {
        return ::Catch::Detail::stringify(static_cast<unsigned int>(value));
    } else {
        char chstr[] = "' '";
        chstr[1] = value;
        return chstr;
    }
}
std::string StringMaker<char>::convert(char c) {
    return ::Catch::Detail::stringify(static_cast<signed char>(c));
}
std::string StringMaker<unsigned char>::convert(unsigned char c) {
    return ::Catch::Detail::stringify(static_cast<char>(c));
}

std::string StringMaker<std::nullptr_t>::convert(std::nullptr_t) {
    return "nullptr";
}

int StringMaker<float>::precision = 5;

std::string StringMaker<float>::convert(float value) {
    return fpToString(value, precision) + 'f';
}

int StringMaker<double>::precision = 10;

std::string StringMaker<double>::convert(double value) {
    return fpToString(value, precision);
}

std::string ratio_string<std::atto>::symbol() { return "a"; }
std::string ratio_string<std::femto>::symbol() { return "f"; }
std::string ratio_string<std::pico>::symbol() { return "p"; }
std::string ratio_string<std::nano>::symbol() { return "n"; }
std::string ratio_string<std::micro>::symbol() { return "u"; }
std::string ratio_string<std::milli>::symbol() { return "m"; }

} // end namespace Catch

#if defined(__clang__)
#    pragma clang diagnostic pop
#endif

// end catch_tostring.cpp
// start catch_totals.cpp

```

```
namespace Catch {

    Counts Counts::operator - ( Counts const& other ) const {
        Counts diff;
        diff.passed = passed - other.passed;
        diff.failed = failed - other.failed;
        diff.failedButOk = failedButOk - other.failedButOk;
        return diff;
    }

    Counts& Counts::operator += ( Counts const& other ) {
        passed += other.passed;
        failed += other.failed;
        failedButOk += other.failedButOk;
        return *this;
    }

    std::size_t Counts::total() const {
        return passed + failed + failedButOk;
    }
    bool Counts::allPassed() const {
        return failed == 0 && failedButOk == 0;
    }
    bool Counts::allOk() const {
        return failed == 0;
    }

    Totals Totals::operator - ( Totals const& other ) const {
        Totals diff;
        diff.assertions = assertions - other.assertions;
        diff.testCases = testCases - other.testCases;
        return diff;
    }

    Totals& Totals::operator += ( Totals const& other ) {
        assertions += other.assertions;
        testCases += other.testCases;
        return *this;
    }

    Totals Totals::delta( Totals const& prevTotals ) const {
        Totals diff = *this - prevTotals;
        if( diff.assertions.failed > 0 )
            ++diff.testCases.failed;
        else if( diff.assertions.failedButOk > 0 )
            ++diff.testCases.failedButOk;
        else
            ++diff.testCases.passed;
        return diff;
    }

}
// end catch_totals.cpp
// start catch_uncaught_exceptions.cpp

// start catch_config_uncaught_exceptions.hpp

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//        https://www.boost.org/LICENSE_1_0.txt)

// SPDX-License-Identifier: BSL-1.0

#ifndef CATCH_CONFIG_UNCAUGHT_EXCEPTIONS_HPP
#define CATCH_CONFIG_UNCAUGHT_EXCEPTIONS_HPP

#if defined(_MSC_VER)
#  if _MSC_VER >= 1900 // Visual Studio 2015 or newer
#    define CATCH_INTERNAL_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS
#  endif
#endif

#include <exception>

#if defined(__cpp_lib_uncaught_exceptions) \
    && !defined(CATCH_INTERNAL_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS)

#  define CATCH_INTERNAL_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS
#endif // __cpp_lib_uncaught_exceptions

#if defined(CATCH_INTERNAL_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS) \
    && !defined(CATCH_CONFIG_NO_CPP17_UNCAUGHT_EXCEPTIONS) \
    && !defined(CATCH_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS)

#  define CATCH_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS
#endif
```

```

#endif // CATCH_CONFIG_UNCAUGHT_EXCEPTIONS_HPP
// end catch_config_uncaught_exceptions.hpp
#include <exception>

namespace Catch {
    bool uncaught_exceptions() {
#if defined(CATCH_CONFIG_DISABLE_EXCEPTIONS)
        return false;
#elif defined(CATCH_CONFIG_CPP17_UNCAUGHT_EXCEPTIONS)
        return std::uncaught_exceptions() > 0;
#else
        return std::uncaught_exception();
#endif
  }
} // end namespace Catch
// end catch_uncaught_exceptions.cpp
// start catch_version.cpp

#include <ostream>

namespace Catch {

    Version::Version
        (   unsigned int _majorVersion,
            unsigned int _minorVersion,
            unsigned int _patchNumber,
            char const * const _branchName,
            unsigned int _buildNumber )
    :   majorVersion( _majorVersion ),
        minorVersion( _minorVersion ),
        patchNumber( _patchNumber ),
        branchName( _branchName ),
        buildNumber( _buildNumber )
    {}

    std::ostream& operator « ( std::ostream& os, Version const& version ) {
        os  « version.majorVersion « '.'
            « version.minorVersion « '.'
            « version.patchNumber;
        // branchName is never null -> 0th char is \0 if it is empty
        if (version.branchName[0]) {
            os « '-' « version.branchName
               « '.' « version.buildNumber;
        }
        return os;
    }

    Version const& libraryVersion() {
        static Version version( 2, 13, 7, "", 0 );
        return version;
    }

}
// end catch_version.cpp
// start catch_wildcard_pattern.cpp

namespace Catch {

    WildcardPattern::WildcardPattern( std::string const& pattern,
                                      CaseSensitive::Choice caseSensitivity )
    :   m_caseSensitivity( caseSensitivity ),
        m_pattern( normaliseString( pattern ) )
    {
        if( startsWith( m_pattern, '*' ) ) {
            m_pattern = m_pattern.substr( 1 );
            m_wildcard = WildcardAtStart;
        }
        if( endsWith( m_pattern, '*' ) ) {
            m_pattern = m_pattern.substr( 0, m_pattern.size()-1 );
            m_wildcard = static_cast<WildcardPosition>( m_wildcard | WildcardAtEnd );
        }
    }

    bool WildcardPattern::matches( std::string const& str ) const {
        switch( m_wildcard ) {
            case NoWildcard:
                return m_pattern == normaliseString( str );
            case WildcardAtStart:
                return endsWith( normaliseString( str ), m_pattern );
            case WildcardAtEnd:
                return startsWith( normaliseString( str ), m_pattern );
            case WildcardAtBothEnds:
                return contains( normaliseString( str ), m_pattern );
            default:
                CATCH_INTERNAL_ERROR( "Unknown enum" );
        }
    }

    std::string WildcardPattern::normaliseString( std::string const& str ) const {
        return trim( m_caseSensitivity == CaseSensitive::No ? toLower( str ) : str );
    }
}
// end catch_wildcard_pattern.cpp
// start catch_xmlwriter.cpp

#include <iomanip>
#include <type_traits>

namespace Catch {

namespace {

    size_t trailingBytes(unsigned char c) {
        if ((c & 0xE0) == 0xC0) {
            return 2;
        }
        if ((c & 0xF0) == 0xE0) {
            return 3;
        }
        if ((c & 0xF8) == 0xF0) {
            return 4;
        }
        CATCH_INTERNAL_ERROR("Invalid multibyte utf-8 start byte encountered");
    }

    uint32_t headerValue(unsigned char c) {
        if ((c & 0xE0) == 0xC0) {
            return c & 0x1F;
        }
        if ((c & 0xF0) == 0xE0) {
            return c & 0x0F;
        }
        if ((c & 0xF8) == 0xF0) {
            return c & 0x07;
        }
        CATCH_INTERNAL_ERROR("Invalid multibyte utf-8 start byte encountered");
    }

    void hexEscapeChar(std::ostream& os, unsigned char c) {
        std::ios_base::fmtflags f(os.flags());
        os « "\\x"
            « std::uppercase « std::hex « std::setfill('0') « std::setw(2)
            « static_cast<int>(c);
        os.flags(f);
    }

    bool shouldNewline(XmlFormatting fmt) {
        return !!(static_cast<std::underlying_type<XmlFormatting>::type>(fmt &
XmlFormatting::Newline));
    }

    bool shouldIndent(XmlFormatting fmt) {
        return !!(static_cast<std::underlying_type<XmlFormatting>::type>(fmt &
XmlFormatting::Indent));
    }

} // anonymous namespace

    XmlFormatting operator | (XmlFormatting lhs, XmlFormatting rhs) {
        return static_cast<XmlFormatting>(
            static_cast<std::underlying_type<XmlFormatting>::type>(lhs) |
            static_cast<std::underlying_type<XmlFormatting>::type>(rhs)
        );
    }

    XmlFormatting operator & (XmlFormatting lhs, XmlFormatting rhs) {
        return static_cast<XmlFormatting>(
            static_cast<std::underlying_type<XmlFormatting>::type>(lhs) &
            static_cast<std::underlying_type<XmlFormatting>::type>(rhs)
        );
    }

    XmlEncode::XmlEncode( std::string const& str, ForWhat forWhat )
    :   m_str( str ),
        m_forWhat( forWhat )
    {}

    void XmlEncode::encodeTo( std::ostream& os ) const {
        // Apostrophe escaping not necessary if we always use " to write attributes
        // (see: http://www.w3.org/TR/xml/#syntax)

        for( std::size_t idx = 0; idx < m_str.size(); ++ idx ) {
            unsigned char c = m_str[idx];
            switch (c) {
            case ’<’:   os « "&lt;"; break;
            case ’&’:   os « "&amp;"; break;

            case ’>’:
                // See: http://www.w3.org/TR/xml/#syntax
                if (idx > 2 && m_str[idx - 1] == ’]’ && m_str[idx - 2] == ’]’)
                    os « "&gt;";
                else
                    os « c;
                break;

            case ’\"’:
                if (m_forWhat == ForAttributes)
                    os « "&quot;";
                else
                    os « c;
                break;

            default:
                // Check for control characters and invalid utf-8

                // Escape control characters in standard ascii
                // see http://stackoverflow.com/questions/404107/why-are-control-characters-illegal-in-xml-1-0
                if (c < 0x09 || (c > 0x0D && c < 0x20) || c == 0x7F) {
                    hexEscapeChar(os, c);
                    break;
                }

                // Plain ASCII: Write it to stream
                if (c < 0x7F) {
                    os « c;
                    break;
                }

                // UTF-8 territory
                // Check if the encoding is valid and if it is not, hex escape bytes.
                // Important: We do not check the exact decoded values for validity, only the encoding format
                // First check that this bytes is a valid lead byte:
                // This means that it is not encoded as 1111 1XXX
                // Or as 10XX XXXX
                if (c <  0xC0 ||
                    c >= 0xF8) {
                    hexEscapeChar(os, c);
                    break;
                }

                auto encBytes = trailingBytes(c);
                // Are there enough bytes left to avoid accessing out-of-bounds memory?
                if (idx + encBytes - 1 >= m_str.size()) {
                    hexEscapeChar(os, c);
                    break;
                }
                // The header is valid, check data
                // The next encBytes bytes must together be a valid utf-8
                // This means: bitpattern 10XX XXXX and the extracted value is sane (ish)
                bool valid = true;
                uint32_t value = headerValue(c);
                for (std::size_t n = 1; n < encBytes; ++n) {
                    unsigned char nc = m_str[idx + n];
                    valid &= ((nc & 0xC0) == 0x80);
                    value = (value « 6) | (nc & 0x3F);
                }

                if (
                    // Wrong bit pattern of following bytes
                    (!valid) ||
                    // Overlong encodings
                    (value < 0x80) ||
                    (0x80 <= value && value < 0x800   && encBytes > 2) ||
                    (0x800 < value && value < 0x10000 && encBytes > 3) ||
                    // Encoded value out of range
                    (value >= 0x110000)
                    ) {
                    hexEscapeChar(os, c);
                    break;
                }

                // If we got here, this is in fact a valid(ish) utf-8 sequence
                for (std::size_t n = 0; n < encBytes; ++n) {
                    os « m_str[idx + n];
                }
                idx += encBytes - 1;
                break;
            }
```

```
        }
    }

    std::ostream& operator « ( std::ostream& os, XmlEncode const& xmlEncode ) {
        xmlEncode.encodeTo( os );
        return os;
    }

    XmlWriter::ScopedElement::ScopedElement( XmlWriter* writer, XmlFormatting fmt )
    :   m_writer( writer ),
        m_fmt(fmt)
    {}

    XmlWriter::ScopedElement::ScopedElement( ScopedElement&& other ) noexcept
    :   m_writer( other.m_writer ),
        m_fmt(other.m_fmt)
    {
        other.m_writer = nullptr;
        other.m_fmt = XmlFormatting::None;
    }
    XmlWriter::ScopedElement& XmlWriter::ScopedElement::operator=( ScopedElement&& other ) noexcept {
        if ( m_writer ) {
            m_writer->endElement();
        }
        m_writer = other.m_writer;
        other.m_writer = nullptr;
        m_fmt = other.m_fmt;
        other.m_fmt = XmlFormatting::None;
        return *this;
    }

    XmlWriter::ScopedElement::~ScopedElement() {
        if (m_writer) {
            m_writer->endElement(m_fmt);
        }
    }

    XmlWriter::ScopedElement& XmlWriter::ScopedElement::writeText( std::string const& text,
  XmlFormatting fmt ) {
        m_writer->writeText( text, fmt );
        return *this;
    }

    XmlWriter::XmlWriter( std::ostream& os ) : m_os( os )
    {
        writeDeclaration();
    }

    XmlWriter::~XmlWriter() {
        while (!m_tags.empty()) {
            endElement();
        }
        newlineIfNecessary();
    }

    XmlWriter& XmlWriter::startElement( std::string const& name, XmlFormatting fmt ) {
        ensureTagClosed();
        newlineIfNecessary();
        if (shouldIndent(fmt)) {
            m_os « m_indent;
            m_indent += "  ";
        }
        m_os « '<' « name;
        m_tags.push_back( name );
        m_tagIsOpen = true;
        applyFormatting(fmt);
        return *this;
    }

    XmlWriter::ScopedElement XmlWriter::scopedElement( std::string const& name, XmlFormatting fmt ) {
        ScopedElement scoped( this, fmt );
        startElement( name, fmt );
        return scoped;
    }

    XmlWriter& XmlWriter::endElement(XmlFormatting fmt) {
        m_indent = m_indent.substr(0, m_indent.size() - 2);

        if( m_tagIsOpen ) {
            m_os « "/>";
            m_tagIsOpen = false;
        } else {
            newlineIfNecessary();
            if (shouldIndent(fmt)) {
                m_os « m_indent;
            }
            m_os « "</" « m_tags.back() « ">";
        }
        m_os « std::flush;
        applyFormatting(fmt);
        m_tags.pop_back();
        return *this;
    }

    XmlWriter& XmlWriter::writeAttribute( std::string const& name, std::string const& attribute ) {
        if( !name.empty() && !attribute.empty() )
            m_os « ' ' « name « "=\"" « XmlEncode( attribute, XmlEncode::ForAttributes ) « '"';
        return *this;
    }

    XmlWriter& XmlWriter::writeAttribute( std::string const& name, bool attribute ) {
        m_os « ' ' « name « "=\"" « ( attribute ? "true" : "false" ) « '"';
        return *this;
    }

    XmlWriter& XmlWriter::writeText( std::string const& text, XmlFormatting fmt) {
        if( !text.empty() ){
            bool tagWasOpen = m_tagIsOpen;
            ensureTagClosed();
            if (tagWasOpen && shouldIndent(fmt)) {
                m_os « m_indent;
            }
            m_os « XmlEncode( text );
            applyFormatting(fmt);
        }
        return *this;
    }

    XmlWriter& XmlWriter::writeComment( std::string const& text, XmlFormatting fmt) {
        ensureTagClosed();
        if (shouldIndent(fmt)) {
            m_os « m_indent;
        }
        m_os « "<!--" « text « "-->";
        applyFormatting(fmt);
        return *this;
    }

    void XmlWriter::writeStylesheetRef( std::string const& url ) {
        m_os « "<?xml-stylesheet type=\"text/xsl\" href=\"" « url « "\"?>\n";
    }

    XmlWriter& XmlWriter::writeBlankLine() {
        ensureTagClosed();
        m_os « '\n';
        return *this;
    }

    void XmlWriter::ensureTagClosed() {
        if( m_tagIsOpen ) {
            m_os « '>' « std::flush;
            newlineIfNecessary();
            m_tagIsOpen = false;
        }
    }

    void XmlWriter::applyFormatting(XmlFormatting fmt) {
        m_needsNewline = shouldNewline(fmt);
    }

    void XmlWriter::writeDeclaration() {
        m_os « "<?xml version=\"1.0\" encoding=\"UTF-8\"?>\n";
    }

    void XmlWriter::newlineIfNecessary() {
        if( m_needsNewline ) {
            m_os « std::endl;
            m_needsNewline = false;
        }
    }
}
// end catch_xmlwriter.cpp
// start catch_reporter_bases.cpp

#include <cstring>
#include <cfloat>
#include <cstdio>
#include <cassert>
#include <memory>

namespace Catch {
    void prepareExpandedExpression(AssertionResult& result) {
        result.getExpandedExpression();
    }

    // Because formatting using c++ streams is stateful, drop down to C is required
    // Alternatively we could use stringstream, but its performance is... not good.
    std::string getFormattedDuration( double duration ) {
        // Max exponent + 1 is required to represent the whole part
        // + 1 for decimal point
        // + 3 for the 3 decimal places
        // + 1 for null terminator
        const std::size_t maxDoubleSize = DBL_MAX_10_EXP + 1 + 1 + 3 + 1;
        char buffer[maxDoubleSize];

        // Save previous errno, to prevent sprintf from overwriting it
        ErrnoGuard guard;
#ifdef _MSC_VER
        sprintf_s(buffer, "%.3f", duration);
#else
        std::sprintf(buffer, "%.3f", duration);
#endif
        return std::string(buffer);
    }

    bool shouldShowDuration( IConfig const& config, double duration ) {
        if ( config.showDurations() == ShowDurations::Always ) {
            return true;
        }
        if ( config.showDurations() == ShowDurations::Never ) {
            return false;
        }
        const double min = config.minDuration();
        return min >= 0 && duration >= min;
    }

    std::string serializeFilters( std::vector<std::string> const& container ) {
        ReusableStringStream oss;
        bool first = true;
        for (auto&& filter : container)
        {
            if (!first)
                oss « ' ';
            else
                first = false;

            oss « filter;
        }
        return oss.str();
    }

    TestEventListenerBase::TestEventListenerBase(ReporterConfig const & _config)
        :StreamingReporterBase(_config) {}

    std::set<Verbosity> TestEventListenerBase::getSupportedVerbosities() {
        return { Verbosity::Quiet, Verbosity::Normal, Verbosity::High };
    }

    void TestEventListenerBase::assertionStarting(AssertionInfo const &) {}

    bool TestEventListenerBase::assertionEnded(AssertionStats const &) {
        return false;
    }

} // end namespace Catch
// end catch_reporter_bases.cpp
// start catch_reporter_compact.cpp

namespace {

#ifdef CATCH_PLATFORM_MAC
    const char* failedString() { return "FAILED"; }
    const char* passedString() { return "PASSED"; }
#else
    const char* failedString() { return "failed"; }
    const char* passedString() { return "passed"; }
#endif

    // Colour::LightGrey
    Catch::Colour::Code dimColour() { return Catch::Colour::FileName; }

    std::string bothOrAll( std::size_t count ) {
        return count == 1 ? std::string() :
               count == 2 ? "both " : "all " ;
    }

} // anon namespace

namespace Catch {
namespace {
// Colour, message variants:
```

```
// - white: No tests ran.
// -   red: Failed [both/all] N test cases, failed [both/all] M assertions.
// - white: Passed [both/all] N test cases (no assertions).
// -   red: Failed N tests cases, failed M assertions.
// - green: Passed [both/all] N tests cases with M assertions.
void printTotals(std::ostream& out, const Totals& totals) {
    if (totals.testCases.total() == 0) {
        out « "No tests ran.";
    } else if (totals.testCases.failed == totals.testCases.total()) {
        Colour colour(Colour::ResultError);
        const std::string qualify_assertions_failed =
            totals.assertions.failed == totals.assertions.total() ?
            bothOrAll(totals.assertions.failed) : std::string();
        out «
            "Failed " « bothOrAll(totals.testCases.failed)
            « pluralise(totals.testCases.failed, "test case") « ", "
            "failed " « qualify_assertions_failed «
            pluralise(totals.assertions.failed, "assertion") « '.';
    } else if (totals.assertions.total() == 0) {
        out «
            "Passed " « bothOrAll(totals.testCases.total())
            « pluralise(totals.testCases.total(), "test case")
            « " (no assertions).";
    } else if (totals.assertions.failed) {
        Colour colour(Colour::ResultError);
        out «
            "Failed " « pluralise(totals.testCases.failed, "test case") « ", "
            "failed " « pluralise(totals.assertions.failed, "assertion") « '.';
    } else {
        Colour colour(Colour::ResultSuccess);
        out «
            "Passed " « bothOrAll(totals.testCases.passed)
            « pluralise(totals.testCases.passed, "test case") «
            " with " « pluralise(totals.assertions.passed, "assertion") « '.';
    }
}

// Implementation of CompactReporter formatting
class AssertionPrinter {
public:
    AssertionPrinter& operator= (AssertionPrinter const&) = delete;
    AssertionPrinter(AssertionPrinter const&) = delete;
    AssertionPrinter(std::ostream& _stream, AssertionStats const& _stats, bool _printInfoMessages)
        : stream(_stream)
        , result(_stats.assertionResult)
        , messages(_stats.infoMessages)
        , itMessage(_stats.infoMessages.begin())
        , printInfoMessages(_printInfoMessages) {}

    void print() {
        printSourceInfo();

        itMessage = messages.begin();

        switch (result.getResultType()) {
        case ResultWas::Ok:
            printResultType(Colour::ResultSuccess, passedString());
            printOriginalExpression();
            printReconstructedExpression();
            if (!result.hasExpression())
                printRemainingMessages(Colour::None);
            else
                printRemainingMessages();
            break;
        case ResultWas::ExpressionFailed:
            if (result.isOk())
                printResultType(Colour::ResultSuccess, failedString() + std::string(" - but was ok"));
            else
                printResultType(Colour::Error, failedString());
            printOriginalExpression();
            printReconstructedExpression();
            printRemainingMessages();
            break;
        case ResultWas::ThrewException:
            printResultType(Colour::Error, failedString());
            printIssue("unexpected exception with message:");
            printMessage();
            printExpressionWas();
            printRemainingMessages();
            break;
        case ResultWas::FatalErrorCondition:
            printResultType(Colour::Error, failedString());
            printIssue("fatal error condition with message:");
            printMessage();
            printExpressionWas();
            printRemainingMessages();
            break;
        case ResultWas::DidntThrowException:
            printResultType(Colour::Error, failedString());
            printIssue("expected exception, got none");
            printExpressionWas();
            printRemainingMessages();
            break;
        case ResultWas::Info:
            printResultType(Colour::None, "info");
            printMessage();
            printRemainingMessages();
            break;
        case ResultWas::Warning:
            printResultType(Colour::None, "warning");
            printMessage();
            printRemainingMessages();
            break;
        case ResultWas::ExplicitFailure:
            printResultType(Colour::Error, failedString());
            printIssue("explicitly");
            printRemainingMessages(Colour::None);
            break;
            // These cases are here to prevent compiler warnings
        case ResultWas::Unknown:
        case ResultWas::FailureBit:
        case ResultWas::Exception:
            printResultType(Colour::Error, "** internal error **");
            break;
        }
    }

private:
    void printSourceInfo() const {
        Colour colourGuard(Colour::FileName);
        stream « result.getSourceInfo() « ':';
    }

    void printResultType(Colour::Code colour, std::string const& passOrFail) const {
        if (!passOrFail.empty()) {
            {
                Colour colourGuard(colour);
                stream « ' ' « passOrFail;
            }
            stream « ':';
        }
    }

    void printIssue(std::string const& issue) const {
        stream « ' ' « issue;
    }

    void printExpressionWas() {
        if (result.hasExpression()) {
            stream « ';';
            {
                Colour colour(dimColour());
                stream « " expression was:";
            }
            printOriginalExpression();
        }
    }

    void printOriginalExpression() const {
        if (result.hasExpression()) {
            stream « ' ' « result.getExpression();
        }
    }

    void printReconstructedExpression() const {
        if (result.hasExpandedExpression()) {
            {
                Colour colour(dimColour());
                stream « " for: ";
            }
            stream « result.getExpandedExpression();
        }
    }

    void printMessage() {
        if (itMessage != messages.end()) {
            stream « " '" « itMessage->message « '\'';
            ++itMessage;
        }
    }

    void printRemainingMessages(Colour::Code colour = dimColour()) {
        if (itMessage == messages.end())
            return;

        const auto itEnd = messages.cend();
        const auto N = static_cast<std::size_t>(std::distance(itMessage, itEnd));

        {
            Colour colourGuard(colour);
            stream « " with " « pluralise(N, "message") « ':';
        }

        while (itMessage != itEnd) {
            // If this assertion is a warning ignore any INFO messages
            if (printInfoMessages || itMessage->type != ResultWas::Info) {
                printMessage();
                if (itMessage != itEnd) {
                    Colour colourGuard(dimColour());
                    stream « " and";
                }
                continue;
            }
            ++itMessage;
        }
    }

private:
    std::ostream& stream;
    AssertionResult const& result;
    std::vector<MessageInfo> messages;
    std::vector<MessageInfo>::const_iterator itMessage;
    bool printInfoMessages;
};

} // anon namespace

        std::string CompactReporter::getDescription() {
            return "Reports test results on a single line, suitable for IDEs";
        }

        void CompactReporter::noMatchingTestCases( std::string const& spec ) {
            stream « "No test cases matched '" « spec « '\'' « std::endl;
        }

        void CompactReporter::assertionStarting( AssertionInfo const& ) {}

        bool CompactReporter::assertionEnded( AssertionStats const& _assertionStats ) {
            AssertionResult const& result = _assertionStats.assertionResult;

            bool printInfoMessages = true;

            // Drop out if result was successful and we're not printing those
            if( !m_config->includeSuccessfulResults() && result.isOk() ) {
                if( result.getResultType() != ResultWas::Warning )
                    return false;
                printInfoMessages = false;
            }

            AssertionPrinter printer( stream, _assertionStats, printInfoMessages );
            printer.print();

            stream « std::endl;
            return true;
        }

        void CompactReporter::sectionEnded(SectionStats const& _sectionStats) {
            double dur = _sectionStats.durationInSeconds;
            if ( shouldShowDuration( *m_config, dur ) ) {
                stream « getFormattedDuration( dur ) « " s: " « _sectionStats.sectionInfo.name «
std::endl;
            }
        }

        void CompactReporter::testRunEnded( TestRunStats const& _testRunStats ) {
            printTotals( stream, _testRunStats.totals );
            stream « '\n' « std::endl;
            StreamingReporterBase::testRunEnded( _testRunStats );
        }

        CompactReporter::~CompactReporter() {}

    CATCH_REGISTER_REPORTER( "compact", CompactReporter )

} // end namespace Catch
// end catch_reporter_compact.cpp
// start catch_reporter_console.cpp

#include <cfloat>
#include <cstdio>

```

```
#if defined(_MSC_VER)
#pragma warning(push)
#pragma warning(disable:4061) // Not all labels are EXPLICITLY handled in switch
 // Note that 4062 (not all labels are handled and default is missing) is enabled
#endif

#if defined(__clang__)
#  pragma clang diagnostic push
// For simplicity, benchmarking-only helpers are always enabled
#  pragma clang diagnostic ignored "-Wunused-function"
#endif

namespace Catch {

namespace {

// Formatter impl for ConsoleReporter
class ConsoleAssertionPrinter {
public:
    ConsoleAssertionPrinter& operator= (ConsoleAssertionPrinter const&) = delete;
    ConsoleAssertionPrinter(ConsoleAssertionPrinter const&) = delete;
    ConsoleAssertionPrinter(std::ostream& _stream, AssertionStats const& _stats, bool
_printInfoMessages)
        : stream(_stream),
        stats(_stats),
        result(_stats.assertionResult),
        colour(Colour::None),
        message(result.getMessage()),
        messages(_stats.infoMessages),
        printInfoMessages(_printInfoMessages) {
        switch (result.getResultType()) {
        case ResultWas::Ok:
            colour = Colour::Success;
            passOrFail = "PASSED";
            //if( result.hasMessage() )
            if (_stats.infoMessages.size() == 1)
                messageLabel = "with message";
            if (_stats.infoMessages.size() > 1)
                messageLabel = "with messages";
            break;
        case ResultWas::ExpressionFailed:
            if (result.isOk()) {
                colour = Colour::Success;
                passOrFail = "FAILED - but was ok";
            } else {
                colour = Colour::Error;
                passOrFail = "FAILED";
            }
            if (_stats.infoMessages.size() == 1)
                messageLabel = "with message";
            if (_stats.infoMessages.size() > 1)
                messageLabel = "with messages";
            break;
        case ResultWas::ThrewException:
            colour = Colour::Error;
            passOrFail = "FAILED";
            messageLabel = "due to unexpected exception with ";
            if (_stats.infoMessages.size() == 1)
                messageLabel += "message";
            if (_stats.infoMessages.size() > 1)
                messageLabel += "messages";
            break;
        case ResultWas::FatalErrorCondition:
            colour = Colour::Error;
            passOrFail = "FAILED";
            messageLabel = "due to a fatal error condition";
            break;
        case ResultWas::DidntThrowException:
            colour = Colour::Error;
            passOrFail = "FAILED";
            messageLabel = "because no exception was thrown where one was expected";
            break;
        case ResultWas::Info:
            messageLabel = "info";
            break;
        case ResultWas::Warning:
            messageLabel = "warning";
            break;
        case ResultWas::ExplicitFailure:
            passOrFail = "FAILED";
            colour = Colour::Error;
            if (_stats.infoMessages.size() == 1)
                messageLabel = "explicitly with message";
            if (_stats.infoMessages.size() > 1)
                messageLabel = "explicitly with messages";
            break;
            // These cases are here to prevent compiler warnings
        case ResultWas::Unknown:
        case ResultWas::FailureBit:
        case ResultWas::Exception:
            passOrFail = "** internal error **";
            colour = Colour::Error;
            break;
        }
    }

    void print() const {
        printSourceInfo();
        if (stats.totals.assertions.total() > 0) {
            printResultType();
            printOriginalExpression();
            printReconstructedExpression();
        } else {
            stream « '\n';
        }
        printMessage();
    }

private:
    void printResultType() const {
        if (!passOrFail.empty()) {
            Colour colourGuard(colour);
            stream « passOrFail « ":\n";
        }
    }
    void printOriginalExpression() const {
        if (result.hasExpression()) {
            Colour colourGuard(Colour::OriginalExpression);
            stream « "  ";
            stream « result.getExpressionInMacro();
            stream « '\n';
        }
    }
    void printReconstructedExpression() const {
        if (result.hasExpandedExpression()) {
            stream « "with expansion:\n";
            Colour colourGuard(Colour::ReconstructedExpression);
            stream « Column(result.getExpandedExpression()).indent(2) « '\n';
        }
    }
    void printMessage() const {
        if (!messageLabel.empty())
            stream « messageLabel « ':' « '\n';
        for (auto const& msg : messages) {
            // If this assertion is a warning ignore any INFO messages
            if (printInfoMessages || msg.type != ResultWas::Info)
                stream « Column(msg.message).indent(2) « '\n';
        }
    }
    void printSourceInfo() const {
        Colour colourGuard(Colour::FileName);
        stream « result.getSourceInfo() « ": ";
    }

    std::ostream& stream;
    AssertionStats const& stats;
    AssertionResult const& result;
    Colour::Code colour;
    std::string passOrFail;
    std::string messageLabel;
    std::string message;
    std::vector<MessageInfo> messages;
    bool printInfoMessages;
};

std::size_t makeRatio(std::size_t number, std::size_t total) {
    std::size_t ratio = total > 0 ? CATCH_CONFIG_CONSOLE_WIDTH * number / total : 0;
    return (ratio == 0 && number > 0) ? 1 : ratio;
}

std::size_t& findMax(std::size_t& i, std::size_t& j, std::size_t& k) {
    if (i > j && i > k)
        return i;
    else if (j > k)
        return j;
    else
        return k;
}

struct ColumnInfo {
    enum Justification { Left, Right };
    std::string name;
    int width;
    Justification justification;
```

```
};
struct ColumnBreak {};
struct RowBreak {};

class Duration {
    enum class Unit {
        Auto,
        Nanoseconds,
        Microseconds,
        Milliseconds,
        Seconds,
        Minutes
    };
    static const uint64_t s_nanosecondsInAMicrosecond = 1000;
    static const uint64_t s_nanosecondsInAMillisecond = 1000 * s_nanosecondsInAMicrosecond;
    static const uint64_t s_nanosecondsInASecond = 1000 * s_nanosecondsInAMillisecond;
    static const uint64_t s_nanosecondsInAMinute = 60 * s_nanosecondsInASecond;

    double m_inNanoseconds;
    Unit m_units;

public:
    explicit Duration(double inNanoseconds, Unit units = Unit::Auto)
        : m_inNanoseconds(inNanoseconds),
        m_units(units) {
        if (m_units == Unit::Auto) {
            if (m_inNanoseconds < s_nanosecondsInAMicrosecond)
                m_units = Unit::Nanoseconds;
            else if (m_inNanoseconds < s_nanosecondsInAMillisecond)
                m_units = Unit::Microseconds;
            else if (m_inNanoseconds < s_nanosecondsInASecond)
                m_units = Unit::Milliseconds;
            else if (m_inNanoseconds < s_nanosecondsInAMinute)
                m_units = Unit::Seconds;
            else
                m_units = Unit::Minutes;
        }

    }

    auto value() const -> double {
        switch (m_units) {
        case Unit::Microseconds:
            return m_inNanoseconds / static_cast<double>(s_nanosecondsInAMicrosecond);
        case Unit::Milliseconds:
            return m_inNanoseconds / static_cast<double>(s_nanosecondsInAMillisecond);
        case Unit::Seconds:
            return m_inNanoseconds / static_cast<double>(s_nanosecondsInASecond);
        case Unit::Minutes:
            return m_inNanoseconds / static_cast<double>(s_nanosecondsInAMinute);
        default:
            return m_inNanoseconds;
        }
    }
    auto unitsAsString() const -> std::string {
        switch (m_units) {
        case Unit::Nanoseconds:
            return "ns";
        case Unit::Microseconds:
            return "us";
        case Unit::Milliseconds:
            return "ms";
        case Unit::Seconds:
            return "s";
        case Unit::Minutes:
            return "m";
        default:
            return "** internal error **";
        }

    }
    friend auto operator « (std::ostream& os, Duration const& duration) -> std::ostream& {
        return os « duration.value() « ' ' « duration.unitsAsString();
    }
};
} // end anon namespace

class TablePrinter {
    std::ostream& m_os;
    std::vector<ColumnInfo> m_columnInfos;
    std::ostringstream m_oss;
    int m_currentColumn = -1;
    bool m_isOpen = false;

public:
    TablePrinter( std::ostream& os, std::vector<ColumnInfo> columnInfos )
    :   m_os( os ),
        m_columnInfos( std::move( columnInfos ) ) {}

    auto columnInfos() const -> std::vector<ColumnInfo> const& {
        return m_columnInfos;
    }

    void open() {
        if (!m_isOpen) {
            m_isOpen = true;
            *this « RowBreak();

            Columns headerCols;
            Spacer spacer(2);
            for (auto const& info : m_columnInfos) {
                headerCols += Column(info.name).width(static_cast<std::size_t>(info.width - 2));
                headerCols += spacer;
            }
            m_os « headerCols « '\n';

            m_os « Catch::getLineOfChars<'-'>() « '\n';
        }
    }
    void close() {
        if (m_isOpen) {
            *this « RowBreak();
            m_os « std::endl;
            m_isOpen = false;
        }
    }

    template<typename T>
    friend TablePrinter& operator « (TablePrinter& tp, T const& value) {
        tp.m_oss « value;
        return tp;
    }

    friend TablePrinter& operator « (TablePrinter& tp, ColumnBreak) {
        auto colStr = tp.m_oss.str();
        const auto strSize = colStr.size();
        tp.m_oss.str("");
        tp.open();
        if (tp.m_currentColumn == static_cast<int>(tp.m_columnInfos.size() - 1)) {
            tp.m_currentColumn = -1;
            tp.m_os « '\n';
        }
        tp.m_currentColumn++;

        auto colInfo = tp.m_columnInfos[tp.m_currentColumn];
        auto padding = (strSize + 1 < static_cast<std::size_t>(colInfo.width))
            ? std::string(colInfo.width - (strSize + 1), ' ')
            : std::string();
        if (colInfo.justification == ColumnInfo::Left)
            tp.m_os « colStr « padding « ' ';
        else
            tp.m_os « padding « colStr « ' ';
        return tp;
    }

    friend TablePrinter& operator « (TablePrinter& tp, RowBreak) {
        if (tp.m_currentColumn > 0) {
            tp.m_os « '\n';
            tp.m_currentColumn = -1;
        }
        return tp;
    }
};

ConsoleReporter::ConsoleReporter(ReporterConfig const& config)
    : StreamingReporterBase(config),
    m_tablePrinter(new TablePrinter(config.stream(),
        [&config]() -> std::vector<ColumnInfo> {
        if (config.fullConfig()->benchmarkNoAnalysis())
        {
            return{
                { "benchmark name", CATCH_CONFIG_CONSOLE_WIDTH - 43, ColumnInfo::Left },
                { "     samples", 14, ColumnInfo::Right },
                { "  iterations", 14, ColumnInfo::Right },
                { "        mean", 14, ColumnInfo::Right }
            };
        }
        else
        {
            return{
                { "benchmark name", CATCH_CONFIG_CONSOLE_WIDTH - 43, ColumnInfo::Left },
                { "samples      mean       std dev", 14, ColumnInfo::Right },
                { "iterations   low mean   low std dev", 14, ColumnInfo::Right },
                { "estimated    high mean  high std dev", 14, ColumnInfo::Right }
            };
        }
    }())) {}
ConsoleReporter::~ConsoleReporter() = default;

std::string ConsoleReporter::getDescription() {
    return "Reports test results as plain lines of text";
}

void ConsoleReporter::noMatchingTestCases(std::string const& spec) {
    stream « "No test cases matched '" « spec « '\'' « std::endl;
}

void ConsoleReporter::reportInvalidArguments(std::string const&arg){
    stream « "Invalid Filter: " « arg « std::endl;
}

void ConsoleReporter::assertionStarting(AssertionInfo const&) {}

bool ConsoleReporter::assertionEnded(AssertionStats const& _assertionStats) {
    AssertionResult const& result = _assertionStats.assertionResult;

    bool includeResults = m_config->includeSuccessfulResults() || !result.isOk();

    // Drop out if result was successful but we're not printing them.
    if (!includeResults && result.getResultType() != ResultWas::Warning)
        return false;

    lazyPrint();

    ConsoleAssertionPrinter printer(stream, _assertionStats, includeResults);
    printer.print();
    stream « std::endl;
    return true;
}

void ConsoleReporter::sectionStarting(SectionInfo const& _sectionInfo) {
    m_tablePrinter->close();
    m_headerPrinted = false;
    StreamingReporterBase::sectionStarting(_sectionInfo);
}
void ConsoleReporter::sectionEnded(SectionStats const& _sectionStats) {
    m_tablePrinter->close();
    if (_sectionStats.missingAssertions) {
        lazyPrint();
        Colour colour(Colour::ResultError);
        if (m_sectionStack.size() > 1)
            stream « "\nNo assertions in section";
        else
            stream « "\nNo assertions in test case";
        stream « " '" « _sectionStats.sectionInfo.name « "'\n" « std::endl;
    }
    double dur = _sectionStats.durationInSeconds;
    if (shouldShowDuration(*m_config, dur)) {
        stream « getFormattedDuration(dur) « " s: " « _sectionStats.sectionInfo.name « std::endl;
    }
    if (m_headerPrinted) {
        m_headerPrinted = false;
    }
    StreamingReporterBase::sectionEnded(_sectionStats);
}

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
void ConsoleReporter::benchmarkPreparing(std::string const& name) {
    lazyPrintWithoutClosingBenchmarkTable();

    auto nameCol = Column(name).width(static_cast<std::size_t>(m_tablePrinter->columnInfos()[0].width
- 2));

    bool firstLine = true;
    for (auto line : nameCol) {
        if (!firstLine)
            (*m_tablePrinter) « ColumnBreak() « ColumnBreak() « ColumnBreak();
        else
            firstLine = false;

        (*m_tablePrinter) « line « ColumnBreak();
    }
}

void ConsoleReporter::benchmarkStarting(BenchmarkInfo const& info) {
    (*m_tablePrinter) « info.samples « ColumnBreak()
        « info.iterations « ColumnBreak();
    if (!m_config->benchmarkNoAnalysis())
        (*m_tablePrinter) « Duration(info.estimatedDuration) « ColumnBreak();
}
void ConsoleReporter::benchmarkEnded(BenchmarkStats<> const& stats) {
    if (m_config->benchmarkNoAnalysis())
    {
        (*m_tablePrinter) « Duration(stats.mean.point.count()) « ColumnBreak();
    }
    else
    {
        (*m_tablePrinter) « ColumnBreak()
            « Duration(stats.mean.point.count()) « ColumnBreak()
            « Duration(stats.mean.lower_bound.count()) « ColumnBreak()
            « Duration(stats.mean.upper_bound.count()) « ColumnBreak() « ColumnBreak()
            « Duration(stats.standardDeviation.point.count()) « ColumnBreak()
            « Duration(stats.standardDeviation.lower_bound.count()) « ColumnBreak()
            « Duration(stats.standardDeviation.upper_bound.count()) « ColumnBreak() « ColumnBreak() «
ColumnBreak() « ColumnBreak() « ColumnBreak();
    }
}

void ConsoleReporter::benchmarkFailed(std::string const& error) {
    Colour colour(Colour::Red);
    (*m_tablePrinter)
        « "Benchmark failed (" « error « ')'
        « ColumnBreak() « RowBreak();
}
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

void ConsoleReporter::testCaseEnded(TestCaseStats const& _testCaseStats) {
    m_tablePrinter->close();
    StreamingReporterBase::testCaseEnded(_testCaseStats);
    m_headerPrinted = false;
}
void ConsoleReporter::testGroupEnded(TestGroupStats const& _testGroupStats) {
    if (currentGroupInfo.used) {
        printSummaryDivider();
        stream « "Summary for group '" « _testGroupStats.groupInfo.name « "':\n";
        printTotals(_testGroupStats.totals);
        stream « '\n' « std::endl;
    }
    StreamingReporterBase::testGroupEnded(_testGroupStats);
}
void ConsoleReporter::testRunEnded(TestRunStats const& _testRunStats) {
    printTotalsDivider(_testRunStats.totals);
    printTotals(_testRunStats.totals);
    stream « std::endl;
    StreamingReporterBase::testRunEnded(_testRunStats);
}
void ConsoleReporter::testRunStarting(TestRunInfo const& _testInfo) {
    StreamingReporterBase::testRunStarting(_testInfo);
    printTestFilters();
}

void ConsoleReporter::lazyPrint() {

    m_tablePrinter->close();
    lazyPrintWithoutClosingBenchmarkTable();
}

void ConsoleReporter::lazyPrintWithoutClosingBenchmarkTable() {

    if (!currentTestRunInfo.used)
        lazyPrintRunInfo();
    if (!currentGroupInfo.used)
        lazyPrintGroupInfo();

    if (!m_headerPrinted) {
        printTestCaseAndSectionHeader();
        m_headerPrinted = true;
    }
}
void ConsoleReporter::lazyPrintRunInfo() {
    stream « '\n' « getLineOfChars<'~'>() « '\n';
    Colour colour(Colour::SecondaryText);
    stream « currentTestRunInfo->name
        « " is a Catch v" « libraryVersion() « " host application.\n"
        « "Run with -? for options\n\n";

    if (m_config->rngSeed() != 0)
        stream « "Randomness seeded to: " « m_config->rngSeed() « "\n\n";

    currentTestRunInfo.used = true;
}
void ConsoleReporter::lazyPrintGroupInfo() {
    if (!currentGroupInfo->name.empty() && currentGroupInfo->groupsCounts > 1) {
        printClosedHeader("Group: " + currentGroupInfo->name);
        currentGroupInfo.used = true;
    }
}
void ConsoleReporter::printTestCaseAndSectionHeader() {
    assert(!m_sectionStack.empty());
    printOpenHeader(currentTestCaseInfo->name);

    if (m_sectionStack.size() > 1) {
        Colour colourGuard(Colour::Headers);

        auto
            it = m_sectionStack.begin() + 1, // Skip first section (test case)
            itEnd = m_sectionStack.end();
        for (; it != itEnd; ++it)
            printHeaderString(it->name, 2);
    }

    SourceLineInfo lineInfo = m_sectionStack.back().lineInfo;

    stream « getLineOfChars<'-'>() « '\n';
    Colour colourGuard(Colour::FileName);
    stream « lineInfo « '\n';
    stream « getLineOfChars<'.'>() « '\n' « std::endl;
}

void ConsoleReporter::printClosedHeader(std::string const& _name) {
    printOpenHeader(_name);
    stream « getLineOfChars<'.'>() « '\n';
}
void ConsoleReporter::printOpenHeader(std::string const& _name) {
    stream « getLineOfChars<'-'>() « '\n';
    {
        Colour colourGuard(Colour::Headers);
        printHeaderString(_name);
    }
}

// if string has a : in first line will set indent to follow it on
// subsequent lines
void ConsoleReporter::printHeaderString(std::string const& _string, std::size_t indent) {
    std::size_t i = _string.find(": ");
    if (i != std::string::npos)
        i += 2;
    else
        i = 0;
    stream « Column(_string).indent(indent + i).initialIndent(indent) « '\n';
}

struct SummaryColumn {

    SummaryColumn( std::string _label, Colour::Code _colour )
    :   label( std::move( _label ) ),
        colour( _colour ) {}
    SummaryColumn addRow( std::size_t count ) {
        ReusableStringStream rss;
        rss « count;
        std::string row = rss.str();
        for (auto& oldRow : rows) {
            while (oldRow.size() < row.size())
                oldRow = ' ' + oldRow;
            while (oldRow.size() > row.size())
                row = ' ' + row;
        }
        rows.push_back(row);
        return *this;
    }

    std::string label;
    Colour::Code colour;
    std::vector<std::string> rows;

};

void ConsoleReporter::printTotals( Totals const& totals ) {
    if (totals.testCases.total() == 0) {
        stream « Colour(Colour::Warning) « "No tests ran\n";
    } else if (totals.assertions.total() > 0 && totals.testCases.allPassed()) {
        stream « Colour(Colour::ResultSuccess) « "All tests passed";
        stream « " ("
            « pluralise(totals.assertions.passed, "assertion") « " in "
            « pluralise(totals.testCases.passed, "test case") « ')'
            « '\n';
    } else {

        std::vector<SummaryColumn> columns;
        columns.push_back(SummaryColumn("", Colour::None)
                              .addRow(totals.testCases.total())
                              .addRow(totals.assertions.total()));
        columns.push_back(SummaryColumn("passed", Colour::Success)
                              .addRow(totals.testCases.passed)
                              .addRow(totals.assertions.passed));
        columns.push_back(SummaryColumn("failed", Colour::ResultError)
                          .addRow(totals.testCases.failed)
                          .addRow(totals.assertions.failed));
        columns.push_back(SummaryColumn("failed as expected", Colour::ResultExpectedFailure)
                          .addRow(totals.testCases.failedButOk)
                          .addRow(totals.assertions.failedButOk));

        printSummaryRow("test cases", columns, 0);
        printSummaryRow("assertions", columns, 1);
    }
}
void ConsoleReporter::printSummaryRow(std::string const& label, std::vector<SummaryColumn> const&
cols, std::size_t row) {
    for (auto col : cols) {
        std::string value = col.rows[row];
        if (col.label.empty()) {
            stream « label « ": ";
            if (value != "0")
                stream « value;
            else
                stream « Colour(Colour::Warning) « "- none -";
        } else if (value != "0") {
            stream « Colour(Colour::LightGrey) « " | ";
            stream « Colour(col.colour)
                « value « ' ' « col.label;
        }
    }
    stream « '\n';
}

void ConsoleReporter::printTotalsDivider(Totals const& totals) {
    if (totals.testCases.total() > 0) {
        std::size_t failedRatio = makeRatio(totals.testCases.failed, totals.testCases.total());
        std::size_t failedButOkRatio = makeRatio(totals.testCases.failedButOk,
totals.testCases.total());
        std::size_t passedRatio = makeRatio(totals.testCases.passed, totals.testCases.total());
        while (failedRatio + failedButOkRatio + passedRatio < CATCH_CONFIG_CONSOLE_WIDTH - 1)
            findMax(failedRatio, failedButOkRatio, passedRatio)++;
        while (failedRatio + failedButOkRatio + passedRatio > CATCH_CONFIG_CONSOLE_WIDTH - 1)
            findMax(failedRatio, failedButOkRatio, passedRatio)--;

        stream « Colour(Colour::Error) « std::string(failedRatio, '=');
        stream « Colour(Colour::ResultExpectedFailure) « std::string(failedButOkRatio, '=');
        if (totals.testCases.allPassed())
            stream « Colour(Colour::ResultSuccess) « std::string(passedRatio, '=');
        else
            stream « Colour(Colour::Success) « std::string(passedRatio, '=');
    } else {
        stream « Colour(Colour::Warning) « std::string(CATCH_CONFIG_CONSOLE_WIDTH - 1, '=');
    }
    stream « '\n';
}
void ConsoleReporter::printSummaryDivider() {
    stream « getLineOfChars<'-'>() « '\n';
}

void ConsoleReporter::printTestFilters() {
    if (m_config->testSpec().hasFilters()) {
        Colour guard(Colour::BrightYellow);
        stream « "Filters: " « serializeFilters(m_config->getTestsOrTags()) « '\n';
    }
}

CATCH_REGISTER_REPORTER("console", ConsoleReporter)

} // end namespace Catch

#if defined(_MSC_VER)
#pragma warning(pop)
#endif

#if defined(__clang__)
#  pragma clang diagnostic pop
#endif
// end catch_reporter_console.cpp
// start catch_reporter_junit.cpp

#include <cassert>
#include <sstream>
#include <ctime>
#include <algorithm>
#include <iomanip>

namespace Catch {

    namespace {
        std::string getCurrentTimestamp() {
            // Beware, this is not reentrant because of backward compatibility issues
            // Also, UTC only, again because of backward compatibility (%z is C++11)
            time_t rawtime;
            std::time(&rawtime);
            auto const timeStampSize = sizeof("2017-01-16T17:06:45Z");

#ifdef _MSC_VER
            std::tm timeInfo = {};
            gmtime_s(&timeInfo, &rawtime);
#else
            std::tm* timeInfo;
            timeInfo = std::gmtime(&rawtime);
#endif

            char timeStamp[timeStampSize];
            const char * const fmt = "%Y-%m-%dT%H:%M:%SZ";

#ifdef _MSC_VER
            std::strftime(timeStamp, timeStampSize, fmt, &timeInfo);
#else
            std::strftime(timeStamp, timeStampSize, fmt, timeInfo);
#endif
            return std::string(timeStamp, timeStampSize-1);
        }

        std::string fileNameTag(const std::vector<std::string> &tags) {
            auto it = std::find_if(begin(tags),
                                   end(tags),
                                   [] (std::string const& tag) {return tag.front() == '#'; });
            if (it != tags.end())
                return it->substr(1);
            return std::string();
        }

        // Formats the duration in seconds to 3 decimal places.
        // This is done because some genius defined Maven Surefire schema
        // in a way that only accepts 3 decimal places, and tools like
        // Jenkins use that schema for validation JUnit reporter output.
        std::string formatDuration( double seconds ) {
            ReusableStringStream rss;
            rss « std::fixed « std::setprecision( 3 ) « seconds;
            return rss.str();
        }

    } // anonymous namespace

    JunitReporter::JunitReporter( ReporterConfig const& _config )
        :   CumulativeReporterBase( _config ),
            xml( _config.stream() )
        {
            m_reporterPrefs.shouldRedirectStdOut = true;
            m_reporterPrefs.shouldReportAllAssertions = true;
        }

    JunitReporter::~JunitReporter() {}

    std::string JunitReporter::getDescription() {
        return "Reports test results in an XML format that looks like Ant's junitreport target";
    }

    void JunitReporter::noMatchingTestCases( std::string const& /*spec*/ ) {}

    void JunitReporter::testRunStarting( TestRunInfo const& runInfo )  {
        CumulativeReporterBase::testRunStarting( runInfo );
        xml.startElement( "testsuites" );
    }

    void JunitReporter::testGroupStarting( GroupInfo const& groupInfo ) {
        suiteTimer.start();
        stdOutForSuite.clear();
        stdErrForSuite.clear();
        unexpectedExceptions = 0;
        CumulativeReporterBase::testGroupStarting( groupInfo );
    }

    void JunitReporter::testCaseStarting( TestCaseInfo const& testCaseInfo ) {
        m_okToFail = testCaseInfo.okToFail();
    }

    bool JunitReporter::assertionEnded( AssertionStats const& assertionStats ) {
        if( assertionStats.assertionResult.getResultType() == ResultWas::ThrewException && !m_okToFail
)
            unexpectedExceptions++;
        return CumulativeReporterBase::assertionEnded( assertionStats );
    }

    void JunitReporter::testCaseEnded( TestCaseStats const& testCaseStats ) {
        stdOutForSuite += testCaseStats.stdOut;
        stdErrForSuite += testCaseStats.stdErr;
        CumulativeReporterBase::testCaseEnded( testCaseStats );
    }

    void JunitReporter::testGroupEnded( TestGroupStats const& testGroupStats ) {
        double suiteTime = suiteTimer.getElapsedSeconds();
        CumulativeReporterBase::testGroupEnded( testGroupStats );
        writeGroup( *m_testGroups.back(), suiteTime );
    }

    void JunitReporter::testRunEndedCumulative() {
        xml.endElement();
    }

    void JunitReporter::writeGroup( TestGroupNode const& groupNode, double suiteTime ) {
        XmlWriter::ScopedElement e = xml.scopedElement( "testsuite" );

        TestGroupStats const& stats = groupNode.value;
        xml.writeAttribute( "name", stats.groupInfo.name );
        xml.writeAttribute( "errors", unexpectedExceptions );
        xml.writeAttribute( "failures", stats.totals.assertions.failed-unexpectedExceptions );
        xml.writeAttribute( "tests", stats.totals.assertions.total() );
        xml.writeAttribute( "hostname", "tbd" ); // !TBD
        if( m_config->showDurations() == ShowDurations::Never )
            xml.writeAttribute( "time", "" );
        else
            xml.writeAttribute( "time", formatDuration( suiteTime ) );
        xml.writeAttribute( "timestamp", getCurrentTimestamp() );

        // Write properties if there are any
        if (m_config->hasTestFilters() || m_config->rngSeed() != 0) {
            auto properties = xml.scopedElement("properties");
            if (m_config->hasTestFilters()) {
                xml.scopedElement("property")
                    .writeAttribute("name", "filters")
                    .writeAttribute("value", serializeFilters(m_config->getTestsOrTags()));
            }
            if (m_config->rngSeed() != 0) {
                xml.scopedElement("property")
                    .writeAttribute("name", "random-seed")
                    .writeAttribute("value", m_config->rngSeed());
            }
        }

        // Write test cases
        for( auto const& child : groupNode.children )
            writeTestCase( *child );

        xml.scopedElement( "system-out" ).writeText( trim( stdOutForSuite ), XmlFormatting::Newline );
        xml.scopedElement( "system-err" ).writeText( trim( stdErrForSuite ), XmlFormatting::Newline );
    }

    void JunitReporter::writeTestCase( TestCaseNode const& testCaseNode ) {
        TestCaseStats const& stats = testCaseNode.value;

        // All test cases have exactly one section - which represents the
        // test case itself. That section may have 0-n nested sections
        assert( testCaseNode.children.size() == 1 );
        SectionNode const& rootSection = *testCaseNode.children.front();

        std::string className = stats.testInfo.className;

        if( className.empty() ) {
            className = fileNameTag(stats.testInfo.tags);
            if ( className.empty() )
                className = "global";
        }

        if ( !m_config->name().empty() )
            className = m_config->name() + "." + className;

        writeSection( className, "", rootSection, stats.testInfo.okToFail() );
    }

    void JunitReporter::writeSection( std::string const& className,
                                      std::string const& rootName,
                                      SectionNode const& sectionNode,
                                      bool testOkToFail) {
        std::string name = trim( sectionNode.stats.sectionInfo.name );
        if( !rootName.empty() )
            name = rootName + '/' + name;

        if( !sectionNode.assertions.empty() ||
            !sectionNode.stdOut.empty() ||
            !sectionNode.stdErr.empty() ) {
            XmlWriter::ScopedElement e = xml.scopedElement( "testcase" );
            if( className.empty() ) {
                xml.writeAttribute( "classname", name );
                xml.writeAttribute( "name", "root" );
            }
            else {
                xml.writeAttribute( "classname", className );
                xml.writeAttribute( "name", name );
            }
            xml.writeAttribute( "time", formatDuration( sectionNode.stats.durationInSeconds ) );
            // This is not ideal, but it should be enough to mimic gtest’s
            // junit output.
            // Ideally the JUnit reporter would also handle `skipTest‘
            // events and write those out appropriately.
            xml.writeAttribute( "status", "run" );

            if (sectionNode.stats.assertions.failedButOk) {
                xml.scopedElement("skipped")
                    .writeAttribute("message", "TEST_CASE tagged with !mayfail");
            }

            writeAssertions( sectionNode );

            if( !sectionNode.stdOut.empty() )
                xml.scopedElement( "system-out" ).writeText( trim( sectionNode.stdOut ), XmlFormatting::Newline );
            if( !sectionNode.stdErr.empty() )
                xml.scopedElement( "system-err" ).writeText( trim( sectionNode.stdErr ), XmlFormatting::Newline );
        }
        for( auto const& childNode : sectionNode.childSections )
            if( className.empty() )
                writeSection( name, "", *childNode, testOkToFail );
            else
                writeSection( className, name, *childNode, testOkToFail );
    }

    void JunitReporter::writeAssertions( SectionNode const& sectionNode ) {
        for( auto const& assertion : sectionNode.assertions )
            writeAssertion( assertion );
    }

    void JunitReporter::writeAssertion( AssertionStats const& stats ) {
        AssertionResult const& result = stats.assertionResult;
        if( !result.isOk() ) {
            std::string elementName;
            switch( result.getResultType() ) {
                case ResultWas::ThrewException:
                case ResultWas::FatalErrorCondition:
                    elementName = "error";
                    break;
                case ResultWas::ExplicitFailure:
                case ResultWas::ExpressionFailed:
                case ResultWas::DidntThrowException:
                    elementName = "failure";
                    break;

                // We should never see these here:
                case ResultWas::Info:
                case ResultWas::Warning:
                case ResultWas::Ok:
                case ResultWas::Unknown:
                case ResultWas::FailureBit:
                case ResultWas::Exception:
                    elementName = "internalError";
                    break;
            }

            XmlWriter::ScopedElement e = xml.scopedElement( elementName );

            xml.writeAttribute( "message", result.getExpression() );
            xml.writeAttribute( "type", result.getTestMacroName() );

            ReusableStringStream rss;
            if (stats.totals.assertions.total() > 0) {
                rss « "FAILED" « ":\n";
                if (result.hasExpression()) {
                    rss « "  ";
                    rss « result.getExpressionInMacro();
                    rss « ’\n’;
                }
                if (result.hasExpandedExpression()) {
                    rss « "with expansion:\n";
                    rss « Column(result.getExpandedExpression()).indent(2) « ’\n’;
                }
            } else {
                rss « ’\n’;
            }

            if( !result.getMessage().empty() )
                rss « result.getMessage() « '\n';
            for( auto const& msg : stats.infoMessages )
                if( msg.type == ResultWas::Info )
                    rss « msg.message « '\n';

            rss « "at " « result.getSourceInfo();
            xml.writeText( rss.str(), XmlFormatting::Newline );
        }
    }

    CATCH_REGISTER_REPORTER( "junit", JunitReporter )

} // end namespace Catch
// end catch_reporter_junit.cpp
// start catch_reporter_listening.cpp

#include <cassert>

namespace Catch {

    ListeningReporter::ListeningReporter() {
        // We will assume that listeners will always want all assertions
        m_preferences.shouldReportAllAssertions = true;
    }

    void ListeningReporter::addListener( IStreamingReporterPtr&& listener ) {
        m_listeners.push_back( std::move( listener ) );
    }

    void ListeningReporter::addReporter(IStreamingReporterPtr&& reporter) {
        assert(!m_reporter && "Listening reporter can wrap only 1 real reporter");
        m_reporter = std::move( reporter );
        m_preferences.shouldRedirectStdOut = m_reporter->getPreferences().shouldRedirectStdOut;
    }

    ReporterPreferences ListeningReporter::getPreferences() const {
        return m_preferences;
    }

    std::set<Verbosity> ListeningReporter::getSupportedVerbosities() {
        return std::set<Verbosity>{ };
    }

    void ListeningReporter::noMatchingTestCases( std::string const& spec ) {
        for ( auto const& listener : m_listeners ) {
            listener->noMatchingTestCases( spec );
        }
        m_reporter->noMatchingTestCases( spec );
    }

    void ListeningReporter::reportInvalidArguments(std::string const&arg){
        for ( auto const& listener : m_listeners ) {
            listener->reportInvalidArguments( arg );
        }
        m_reporter->reportInvalidArguments( arg );
    }

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
    void ListeningReporter::benchmarkPreparing( std::string const& name ) {
        for (auto const& listener : m_listeners) {
            listener->benchmarkPreparing(name);
        }
        m_reporter->benchmarkPreparing(name);
    }
    void ListeningReporter::benchmarkStarting( BenchmarkInfo const& benchmarkInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->benchmarkStarting( benchmarkInfo );
        }
        m_reporter->benchmarkStarting( benchmarkInfo );
    }
    void ListeningReporter::benchmarkEnded( BenchmarkStats<> const& benchmarkStats ) {
        for ( auto const& listener : m_listeners ) {
            listener->benchmarkEnded( benchmarkStats );
        }
        m_reporter->benchmarkEnded( benchmarkStats );
    }

    void ListeningReporter::benchmarkFailed( std::string const& error ) {
        for (auto const& listener : m_listeners) {
            listener->benchmarkFailed(error);
        }
        m_reporter->benchmarkFailed(error);
    }
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

```

```
    void ListeningReporter::testRunStarting( TestRunInfo const& testRunInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->testRunStarting( testRunInfo );
        }
        m_reporter->testRunStarting( testRunInfo );
    }

    void ListeningReporter::testGroupStarting( GroupInfo const& groupInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->testGroupStarting( groupInfo );
        }
        m_reporter->testGroupStarting( groupInfo );
    }

    void ListeningReporter::testCaseStarting( TestCaseInfo const& testInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->testCaseStarting( testInfo );
        }
        m_reporter->testCaseStarting( testInfo );
    }

    void ListeningReporter::sectionStarting( SectionInfo const& sectionInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->sectionStarting( sectionInfo );
        }
        m_reporter->sectionStarting( sectionInfo );
    }

    void ListeningReporter::assertionStarting( AssertionInfo const& assertionInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->assertionStarting( assertionInfo );
        }
        m_reporter->assertionStarting( assertionInfo );
    }

    // The return value indicates if the messages buffer should be cleared:
    bool ListeningReporter::assertionEnded( AssertionStats const& assertionStats ) {
        for( auto const& listener : m_listeners ) {
            static_cast<void>( listener->assertionEnded( assertionStats ) );
        }
        return m_reporter->assertionEnded( assertionStats );
    }

    void ListeningReporter::sectionEnded( SectionStats const& sectionStats ) {
        for ( auto const& listener : m_listeners ) {
            listener->sectionEnded( sectionStats );
        }
        m_reporter->sectionEnded( sectionStats );
    }

    void ListeningReporter::testCaseEnded( TestCaseStats const& testCaseStats ) {
        for ( auto const& listener : m_listeners ) {
            listener->testCaseEnded( testCaseStats );
        }
        m_reporter->testCaseEnded( testCaseStats );
    }

    void ListeningReporter::testGroupEnded( TestGroupStats const& testGroupStats ) {
        for ( auto const& listener : m_listeners ) {
            listener->testGroupEnded( testGroupStats );
        }
        m_reporter->testGroupEnded( testGroupStats );
    }

    void ListeningReporter::testRunEnded( TestRunStats const& testRunStats ) {
        for ( auto const& listener : m_listeners ) {
            listener->testRunEnded( testRunStats );
        }
        m_reporter->testRunEnded( testRunStats );
    }

    void ListeningReporter::skipTest( TestCaseInfo const& testInfo ) {
        for ( auto const& listener : m_listeners ) {
            listener->skipTest( testInfo );
        }
        m_reporter->skipTest( testInfo );
    }

    bool ListeningReporter::isMulti() const {
        return true;
    }

} // end namespace Catch
// end catch_reporter_listening.cpp
// start catch_reporter_xml.cpp

#if defined(_MSC_VER)
```

```
#pragma warning(push)
#pragma warning(disable:4061) // Not all labels are EXPLICITLY handled in switch
                              // Note that 4062 (not all labels are handled
                              // and default is missing) is enabled
#endif

namespace Catch {
    XmlReporter::XmlReporter( ReporterConfig const& _config )
    :   StreamingReporterBase( _config ),
        m_xml(_config.stream())
    {
        m_reporterPrefs.shouldRedirectStdOut = true;
        m_reporterPrefs.shouldReportAllAssertions = true;
    }

    XmlReporter::~XmlReporter() = default;

    std::string XmlReporter::getDescription() {
        return "Reports test results as an XML document";
    }

    std::string XmlReporter::getStylesheetRef() const {
        return std::string();
    }

    void XmlReporter::writeSourceInfo( SourceLineInfo const& sourceInfo ) {
        m_xml
            .writeAttribute( "filename", sourceInfo.file )
            .writeAttribute( "line", sourceInfo.line );
    }

    void XmlReporter::noMatchingTestCases( std::string const& s ) {
        StreamingReporterBase::noMatchingTestCases( s );
    }

    void XmlReporter::testRunStarting( TestRunInfo const& testInfo ) {
        StreamingReporterBase::testRunStarting( testInfo );
        std::string stylesheetRef = getStylesheetRef();
        if( !stylesheetRef.empty() )
            m_xml.writeStylesheetRef( stylesheetRef );
        m_xml.startElement( "Catch" );
        if( !m_config->name().empty() )
            m_xml.writeAttribute( "name", m_config->name() );
        if (m_config->testSpec().hasFilters())
            m_xml.writeAttribute( "filters", serializeFilters( m_config->getTestsOrTags() ) );
        if( m_config->rngSeed() != 0 )
            m_xml.scopedElement( "Randomness" )
                .writeAttribute( "seed", m_config->rngSeed() );
    }

    void XmlReporter::testGroupStarting( GroupInfo const& groupInfo ) {
        StreamingReporterBase::testGroupStarting( groupInfo );
        m_xml.startElement( "Group" )
            .writeAttribute( "name", groupInfo.name );
    }

    void XmlReporter::testCaseStarting( TestCaseInfo const& testInfo ) {
        StreamingReporterBase::testCaseStarting(testInfo);
        m_xml.startElement( "TestCase" )
            .writeAttribute( "name", trim( testInfo.name ) )
            .writeAttribute( "description", testInfo.description )
            .writeAttribute( "tags", testInfo.tagsAsString() );

        writeSourceInfo( testInfo.lineInfo );

        if ( m_config->showDurations() == ShowDurations::Always )
            m_testCaseTimer.start();
        m_xml.ensureTagClosed();
    }

    void XmlReporter::sectionStarting( SectionInfo const& sectionInfo ) {
        StreamingReporterBase::sectionStarting( sectionInfo );
        if( m_sectionDepth++ > 0 ) {
            m_xml.startElement( "Section" )
                .writeAttribute( "name", trim( sectionInfo.name ) );
            writeSourceInfo( sectionInfo.lineInfo );
            m_xml.ensureTagClosed();
        }
    }

    void XmlReporter::assertionStarting( AssertionInfo const& ) { }

    bool XmlReporter::assertionEnded( AssertionStats const& assertionStats ) {

        AssertionResult const& result = assertionStats.assertionResult;

        bool includeResults = m_config->includeSuccessfulResults() || !result.isOk();

        if( includeResults || result.getResultType() == ResultWas::Warning ) {
            // Print any info messages in <Info> tags.
            for( auto const& msg : assertionStats.infoMessages ) {
                if( msg.type == ResultWas::Info && includeResults ) {
                    m_xml.scopedElement( "Info" )
                            .writeText( msg.message );
                } else if ( msg.type == ResultWas::Warning ) {
                    m_xml.scopedElement( "Warning" )
                            .writeText( msg.message );
                }
            }
        }

        // Drop out if result was successful but we're not printing them.
        if( !includeResults && result.getResultType() != ResultWas::Warning )
            return true;

        // Print the expression if there is one.
        if( result.hasExpression() ) {
            m_xml.startElement( "Expression" )
                .writeAttribute( "success", result.succeeded() )
                .writeAttribute( "type", result.getTestMacroName() );

            writeSourceInfo( result.getSourceInfo() );

            m_xml.scopedElement( "Original" )
                .writeText( result.getExpression() );
            m_xml.scopedElement( "Expanded" )
                .writeText( result.getExpandedExpression() );
        }

        // And... Print a result applicable to each result type.
        switch( result.getResultType() ) {
            case ResultWas::ThrewException:
                m_xml.startElement( "Exception" );
                writeSourceInfo( result.getSourceInfo() );
                m_xml.writeText( result.getMessage() );
                m_xml.endElement();
                break;
            case ResultWas::FatalErrorCondition:
                m_xml.startElement( "FatalErrorCondition" );
                writeSourceInfo( result.getSourceInfo() );
                m_xml.writeText( result.getMessage() );
                m_xml.endElement();
                break;
            case ResultWas::Info:
                m_xml.scopedElement( "Info" )
                    .writeText( result.getMessage() );
                break;
            case ResultWas::Warning:
                // Warning will already have been written
                break;
            case ResultWas::ExplicitFailure:
                m_xml.startElement( "Failure" );
                writeSourceInfo( result.getSourceInfo() );
                m_xml.writeText( result.getMessage() );
                m_xml.endElement();
                break;
            default:
                break;
        }

        if( result.hasExpression() )
            m_xml.endElement();

        return true;
    }

    void XmlReporter::sectionEnded( SectionStats const& sectionStats ) {
        StreamingReporterBase::sectionEnded( sectionStats );
        if( --m_sectionDepth > 0 ) {
            XmlWriter::ScopedElement e = m_xml.scopedElement( "OverallResults" );
            e.writeAttribute( "successes", sectionStats.assertions.passed );
            e.writeAttribute( "failures", sectionStats.assertions.failed );
            e.writeAttribute( "expectedFailures", sectionStats.assertions.failedButOk );

            if ( m_config->showDurations() == ShowDurations::Always )
                e.writeAttribute( "durationInSeconds", sectionStats.durationInSeconds );

            m_xml.endElement();
        }
    }

    void XmlReporter::testCaseEnded( TestCaseStats const& testCaseStats ) {
        StreamingReporterBase::testCaseEnded( testCaseStats );
        XmlWriter::ScopedElement e = m_xml.scopedElement( "OverallResult" );
        e.writeAttribute( "success", testCaseStats.totals.assertions.allOk() );

        if ( m_config->showDurations() == ShowDurations::Always )
            e.writeAttribute( "durationInSeconds", m_testCaseTimer.getElapsedSeconds() );

        if( !testCaseStats.stdOut.empty() )
            m_xml.scopedElement( "StdOut" ).writeText( trim( testCaseStats.stdOut ),
XmlFormatting::Newline );
        if( !testCaseStats.stdErr.empty() )
            m_xml.scopedElement( "StdErr" ).writeText( trim( testCaseStats.stdErr ),
XmlFormatting::Newline );

        m_xml.endElement();
    }

    void XmlReporter::testGroupEnded( TestGroupStats const& testGroupStats ) {
        StreamingReporterBase::testGroupEnded( testGroupStats );
        // TODO: Check testGroupStats.aborting and act accordingly.
        m_xml.scopedElement( "OverallResults" )
            .writeAttribute( "successes", testGroupStats.totals.assertions.passed )
            .writeAttribute( "failures", testGroupStats.totals.assertions.failed )
            .writeAttribute( "expectedFailures", testGroupStats.totals.assertions.failedButOk );
        m_xml.scopedElement( "OverallResultsCases")
            .writeAttribute( "successes", testGroupStats.totals.testCases.passed )
            .writeAttribute( "failures", testGroupStats.totals.testCases.failed )
            .writeAttribute( "expectedFailures", testGroupStats.totals.testCases.failedButOk );
        m_xml.endElement();
    }

    void XmlReporter::testRunEnded( TestRunStats const& testRunStats ) {
        StreamingReporterBase::testRunEnded( testRunStats );
        m_xml.scopedElement( "OverallResults" )
            .writeAttribute( "successes", testRunStats.totals.assertions.passed )
            .writeAttribute( "failures", testRunStats.totals.assertions.failed )
            .writeAttribute( "expectedFailures", testRunStats.totals.assertions.failedButOk );
        m_xml.scopedElement( "OverallResultsCases")
            .writeAttribute( "successes", testRunStats.totals.testCases.passed )
            .writeAttribute( "failures", testRunStats.totals.testCases.failed )
            .writeAttribute( "expectedFailures", testRunStats.totals.testCases.failedButOk );
        m_xml.endElement();
    }

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
    void XmlReporter::benchmarkPreparing(std::string const& name) {
        m_xml.startElement("BenchmarkResults")
            .writeAttribute("name", name);
    }

    void XmlReporter::benchmarkStarting(BenchmarkInfo const &info) {
        m_xml.writeAttribute("samples", info.samples)
            .writeAttribute("resamples", info.resamples)
            .writeAttribute("iterations", info.iterations)
            .writeAttribute("clockResolution", info.clockResolution)
            .writeAttribute("estimatedDuration", info.estimatedDuration)
            .writeComment("All values in nano seconds");
    }

    void XmlReporter::benchmarkEnded(BenchmarkStats<> const& benchmarkStats) {
        m_xml.startElement("mean")
            .writeAttribute("value", benchmarkStats.mean.point.count())
            .writeAttribute("lowerBound", benchmarkStats.mean.lower_bound.count())
            .writeAttribute("upperBound", benchmarkStats.mean.upper_bound.count())
            .writeAttribute("ci", benchmarkStats.mean.confidence_interval);
        m_xml.endElement();
        m_xml.startElement("standardDeviation")
            .writeAttribute("value", benchmarkStats.standardDeviation.point.count())
            .writeAttribute("lowerBound", benchmarkStats.standardDeviation.lower_bound.count())
            .writeAttribute("upperBound", benchmarkStats.standardDeviation.upper_bound.count())
            .writeAttribute("ci", benchmarkStats.standardDeviation.confidence_interval);
        m_xml.endElement();
        m_xml.startElement("outliers")
            .writeAttribute("variance", benchmarkStats.outlierVariance)
            .writeAttribute("lowMild", benchmarkStats.outliers.low_mild)
            .writeAttribute("lowSevere", benchmarkStats.outliers.low_severe)
            .writeAttribute("highMild", benchmarkStats.outliers.high_mild)
            .writeAttribute("highSevere", benchmarkStats.outliers.high_severe);
        m_xml.endElement();
        m_xml.endElement();
    }

    void XmlReporter::benchmarkFailed(std::string const &error) {
        m_xml.scopedElement("failed").
            writeAttribute("message", error);
        m_xml.endElement();
    }
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

```

```
    CATCH_REGISTER_REPORTER( "xml", XmlReporter )

} // end namespace Catch

#if defined(_MSC_VER)
#pragma warning(pop)
#endif
// end catch_reporter_xml.cpp

namespace Catch {
    LeakDetector leakDetector;
}

#ifdef __clang__
#pragma clang diagnostic pop
#endif

// end catch_impl.hpp
#endif

#ifdef CATCH_CONFIG_MAIN
// start catch_default_main.hpp

#ifndef __OBJC__

#if defined(CATCH_CONFIG_WCHAR) && defined(CATCH_PLATFORM_WINDOWS) && defined(_UNICODE) &&
!defined(DO_NOT_USE_WMAIN)
// Standard C/C++ Win32 Unicode wmain entry point
extern "C" int wmain (int argc, wchar_t * argv[], wchar_t * []) {
#else
// Standard C/C++ main entry point
int main (int argc, char * argv[]) {
#endif

    return Catch::Session().run( argc, argv );
}

#else // __OBJC__

// Objective-C entry point
int main (int argc, char * const argv[]) {
#if !CATCH_ARC_ENABLED
    NSAutoreleasePool * pool = [[NSAutoreleasePool alloc] init];
#endif

    Catch::registerTestMethods();
    int result = Catch::Session().run( argc, (char**)argv );

#if !CATCH_ARC_ENABLED
    [pool drain];
#endif

    return result;
}

#endif // __OBJC__

// end catch_default_main.hpp
#endif

#if !defined(CATCH_CONFIG_IMPL_ONLY)

#ifdef CLARA_CONFIG_MAIN_NOT_DEFINED
#  undef CLARA_CONFIG_MAIN
#endif

#if !defined(CATCH_CONFIG_DISABLE)
// If this config identifier is defined then all CATCH macros are prefixed with CATCH_
#ifdef CATCH_CONFIG_PREFIX_ALL

#define CATCH_REQUIRE( ... ) INTERNAL_CATCH_TEST( "CATCH_REQUIRE", Catch::ResultDisposition::Normal,
__VA_ARGS__ )
#define CATCH_REQUIRE_FALSE( ... ) INTERNAL_CATCH_TEST( "CATCH_REQUIRE_FALSE",
Catch::ResultDisposition::Normal | Catch::ResultDisposition::FalseTest, __VA_ARGS__ )

#define CATCH_REQUIRE_THROWS( ... ) INTERNAL_CATCH_THROWS( "CATCH_REQUIRE_THROWS",
Catch::ResultDisposition::Normal, __VA_ARGS__ )
#define CATCH_REQUIRE_THROWS_AS( expr, exceptionType ) INTERNAL_CATCH_THROWS_AS(
"CATCH_REQUIRE_THROWS_AS", exceptionType, Catch::ResultDisposition::Normal, expr )
#define CATCH_REQUIRE_THROWS_WITH( expr, matcher ) INTERNAL_CATCH_THROWS_STR_MATCHES(
"CATCH_REQUIRE_THROWS_WITH", Catch::ResultDisposition::Normal, matcher, expr )
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_REQUIRE_THROWS_MATCHES( expr, exceptionType, matcher ) INTERNAL_CATCH_THROWS_MATCHES(
"CATCH_REQUIRE_THROWS_MATCHES", exceptionType, Catch::ResultDisposition::Normal, matcher, expr )
#endif// CATCH_CONFIG_DISABLE_MATCHERS
#define CATCH_REQUIRE_NOTHROW( ... ) INTERNAL_CATCH_NO_THROW( "CATCH_REQUIRE_NOTHROW",
Catch::ResultDisposition::Normal, __VA_ARGS__ )
```

```

#define CATCH_CHECK( ... ) INTERNAL_CATCH_TEST( "CATCH_CHECK", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CATCH_CHECK_FALSE( ... ) INTERNAL_CATCH_TEST( "CATCH_CHECK_FALSE", Catch::ResultDisposition::ContinueOnFailure | Catch::ResultDisposition::FalseTest, __VA_ARGS__ )
#define CATCH_CHECKED_IF( ... ) INTERNAL_CATCH_IF( "CATCH_CHECKED_IF", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CATCH_CHECKED_ELSE( ... ) INTERNAL_CATCH_ELSE( "CATCH_CHECKED_ELSE", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CATCH_CHECK_NOFAIL( ... ) INTERNAL_CATCH_TEST( "CATCH_CHECK_NOFAIL", Catch::ResultDisposition::ContinueOnFailure | Catch::ResultDisposition::SuppressFail, __VA_ARGS__ )

#define CATCH_CHECK_THROWS( ... )  INTERNAL_CATCH_THROWS( "CATCH_CHECK_THROWS", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CATCH_CHECK_THROWS_AS( expr, exceptionType ) INTERNAL_CATCH_THROWS_AS( "CATCH_CHECK_THROWS_AS", exceptionType, Catch::ResultDisposition::ContinueOnFailure, expr )
#define CATCH_CHECK_THROWS_WITH( expr, matcher ) INTERNAL_CATCH_THROWS_STR_MATCHES( "CATCH_CHECK_THROWS_WITH", Catch::ResultDisposition::ContinueOnFailure, matcher, expr )
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_CHECK_THROWS_MATCHES( expr, exceptionType, matcher ) INTERNAL_CATCH_THROWS_MATCHES( "CATCH_CHECK_THROWS_MATCHES", exceptionType, Catch::ResultDisposition::ContinueOnFailure, matcher, expr )
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define CATCH_CHECK_NOTHROW( ... ) INTERNAL_CATCH_NO_THROW( "CATCH_CHECK_NOTHROW", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )

#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_CHECK_THAT( arg, matcher ) INTERNAL_CHECK_THAT( "CATCH_CHECK_THAT", matcher, Catch::ResultDisposition::ContinueOnFailure, arg )

#define CATCH_REQUIRE_THAT( arg, matcher ) INTERNAL_CHECK_THAT( "CATCH_REQUIRE_THAT", matcher, Catch::ResultDisposition::Normal, arg )
#endif // CATCH_CONFIG_DISABLE_MATCHERS

#define CATCH_INFO( msg ) INTERNAL_CATCH_INFO( "CATCH_INFO", msg )
#define CATCH_UNSCOPED_INFO( msg ) INTERNAL_CATCH_UNSCOPED_INFO( "CATCH_UNSCOPED_INFO", msg )
#define CATCH_WARN( msg ) INTERNAL_CATCH_MSG( "CATCH_WARN", Catch::ResultWas::Warning, Catch::ResultDisposition::ContinueOnFailure, msg )
#define CATCH_CAPTURE( ... ) INTERNAL_CATCH_CAPTURE( INTERNAL_CATCH_UNIQUE_NAME(capturer), "CATCH_CAPTURE",__VA_ARGS__ )

#define CATCH_TEST_CASE( ... ) INTERNAL_CATCH_TESTCASE( __VA_ARGS__ )
#define CATCH_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define CATCH_METHOD_AS_TEST_CASE( method, ... ) INTERNAL_CATCH_METHOD_AS_TEST_CASE( method, __VA_ARGS__ )
#define CATCH_REGISTER_TEST_CASE( Function, ... ) INTERNAL_CATCH_REGISTER_TESTCASE( Function, __VA_ARGS__ )
#define CATCH_SECTION( ... ) INTERNAL_CATCH_SECTION( __VA_ARGS__ )
#define CATCH_DYNAMIC_SECTION( ... ) INTERNAL_CATCH_DYNAMIC_SECTION( __VA_ARGS__ )
#define CATCH_FAIL( ... ) INTERNAL_CATCH_MSG( "CATCH_FAIL", Catch::ResultWas::ExplicitFailure, Catch::ResultDisposition::Normal, __VA_ARGS__ )
#define CATCH_FAIL_CHECK( ... ) INTERNAL_CATCH_MSG( "CATCH_FAIL_CHECK", Catch::ResultWas::ExplicitFailure, Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CATCH_SUCCEED( ... ) INTERNAL_CATCH_MSG( "CATCH_SUCCEED", Catch::ResultWas::Ok, Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )

#define CATCH_ANON_TEST_CASE() INTERNAL_CATCH_TESTCASE()

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define CATCH_TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG( __VA_ARGS__ )
#define CATCH_TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ )
#else
#define CATCH_TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ ) )
#define CATCH_TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG( __VA_ARGS__ ) )
#define CATCH_TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( className, __VA_ARGS__ ) )
#define CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ ) )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE( __VA_ARGS__ ) )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( __VA_ARGS__ ) )
```

```
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, __VA_ARGS__ ) )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ ) )
#endif

#if !defined(CATCH_CONFIG_RUNTIME_STATIC_REQUIRE)
#define CATCH_STATIC_REQUIRE( ... )       static_assert(   __VA_ARGS__ ,      #__VA_ARGS__ ); CATCH_SUCCEED( #__VA_ARGS__ )
#define CATCH_STATIC_REQUIRE_FALSE( ... ) static_assert( !(__VA_ARGS__), "!(" #__VA_ARGS__ ")" ); CATCH_SUCCEED( #__VA_ARGS__ )
#else
#define CATCH_STATIC_REQUIRE( ... )       CATCH_REQUIRE( __VA_ARGS__ )
#define CATCH_STATIC_REQUIRE_FALSE( ... ) CATCH_REQUIRE_FALSE( __VA_ARGS__ )
#endif

// "BDD-style" convenience wrappers
#define CATCH_SCENARIO( ... ) CATCH_TEST_CASE( "Scenario: " __VA_ARGS__ )
#define CATCH_SCENARIO_METHOD( className, ... ) INTERNAL_CATCH_TEST_CASE_METHOD( className, "Scenario: " __VA_ARGS__ )
#define CATCH_GIVEN( desc )     INTERNAL_CATCH_DYNAMIC_SECTION( "    Given: " « desc )
#define CATCH_AND_GIVEN( desc ) INTERNAL_CATCH_DYNAMIC_SECTION( "And given: " « desc )
#define CATCH_WHEN( desc )      INTERNAL_CATCH_DYNAMIC_SECTION( "     When: " « desc )
#define CATCH_AND_WHEN( desc )  INTERNAL_CATCH_DYNAMIC_SECTION( " And when: " « desc )
#define CATCH_THEN( desc )      INTERNAL_CATCH_DYNAMIC_SECTION( "     Then: " « desc )
#define CATCH_AND_THEN( desc )  INTERNAL_CATCH_DYNAMIC_SECTION( "      And: " « desc )

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
#define CATCH_BENCHMARK(...) \
    INTERNAL_CATCH_BENCHMARK(INTERNAL_CATCH_UNIQUE_NAME(____C_A_T_C_H____B_E_N_C_H____), INTERNAL_CATCH_GET_1_ARG(__VA_ARGS__„), INTERNAL_CATCH_GET_2_ARG(__VA_ARGS__„))
#define CATCH_BENCHMARK_ADVANCED(name) \
    INTERNAL_CATCH_BENCHMARK_ADVANCED(INTERNAL_CATCH_UNIQUE_NAME(____C_A_T_C_H____B_E_N_C_H____), name)
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

// If CATCH_CONFIG_PREFIX_ALL is not defined then the CATCH_ prefix is not required
#else

#define REQUIRE( ... ) INTERNAL_CATCH_TEST( "REQUIRE", Catch::ResultDisposition::Normal, __VA_ARGS__ )
#define REQUIRE_FALSE( ... ) INTERNAL_CATCH_TEST( "REQUIRE_FALSE", Catch::ResultDisposition::Normal | Catch::ResultDisposition::FalseTest, __VA_ARGS__ )

#define REQUIRE_THROWS( ... ) INTERNAL_CATCH_THROWS( "REQUIRE_THROWS", Catch::ResultDisposition::Normal, __VA_ARGS__ )
#define REQUIRE_THROWS_AS( expr, exceptionType ) INTERNAL_CATCH_THROWS_AS( "REQUIRE_THROWS_AS", exceptionType, Catch::ResultDisposition::Normal, expr )
#define REQUIRE_THROWS_WITH( expr, matcher ) INTERNAL_CATCH_THROWS_STR_MATCHES( "REQUIRE_THROWS_WITH", Catch::ResultDisposition::Normal, matcher, expr )
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define REQUIRE_THROWS_MATCHES( expr, exceptionType, matcher ) INTERNAL_CATCH_THROWS_MATCHES( "REQUIRE_THROWS_MATCHES", exceptionType, Catch::ResultDisposition::Normal, matcher, expr )
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define REQUIRE_NOTHROW( ... ) INTERNAL_CATCH_NO_THROW( "REQUIRE_NOTHROW", Catch::ResultDisposition::Normal, __VA_ARGS__ )

#define CHECK( ... ) INTERNAL_CATCH_TEST( "CHECK", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CHECK_FALSE( ... ) INTERNAL_CATCH_TEST( "CHECK_FALSE", Catch::ResultDisposition::ContinueOnFailure | Catch::ResultDisposition::FalseTest, __VA_ARGS__ )
#define CHECKED_IF( ... ) INTERNAL_CATCH_IF( "CHECKED_IF", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CHECKED_ELSE( ... ) INTERNAL_CATCH_ELSE( "CHECKED_ELSE", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CHECK_NOFAIL( ... ) INTERNAL_CATCH_TEST( "CHECK_NOFAIL", Catch::ResultDisposition::ContinueOnFailure | Catch::ResultDisposition::SuppressFail, __VA_ARGS__ )

#define CHECK_THROWS( ... )  INTERNAL_CATCH_THROWS( "CHECK_THROWS", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define CHECK_THROWS_AS( expr, exceptionType ) INTERNAL_CATCH_THROWS_AS( "CHECK_THROWS_AS", exceptionType, Catch::ResultDisposition::ContinueOnFailure, expr )
#define CHECK_THROWS_WITH( expr, matcher ) INTERNAL_CATCH_THROWS_STR_MATCHES( "CHECK_THROWS_WITH", Catch::ResultDisposition::ContinueOnFailure, matcher, expr )
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CHECK_THROWS_MATCHES( expr, exceptionType, matcher ) INTERNAL_CATCH_THROWS_MATCHES( "CHECK_THROWS_MATCHES", exceptionType, Catch::ResultDisposition::ContinueOnFailure, matcher, expr )
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define CHECK_NOTHROW( ... ) INTERNAL_CATCH_NO_THROW( "CHECK_NOTHROW", Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )

#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CHECK_THAT( arg, matcher ) INTERNAL_CHECK_THAT( "CHECK_THAT", matcher, Catch::ResultDisposition::ContinueOnFailure, arg )

#define REQUIRE_THAT( arg, matcher ) INTERNAL_CHECK_THAT( "REQUIRE_THAT", matcher, Catch::ResultDisposition::Normal, arg )
```

```
#endif // CATCH_CONFIG_DISABLE_MATCHERS

#define INFO( msg ) INTERNAL_CATCH_INFO( "INFO", msg )
#define UNSCOPED_INFO( msg ) INTERNAL_CATCH_UNSCOPED_INFO( "UNSCOPED_INFO", msg )
#define WARN( msg ) INTERNAL_CATCH_MSG( "WARN", Catch::ResultWas::Warning, Catch::ResultDisposition::ContinueOnFailure, msg )
#define CAPTURE( ... ) INTERNAL_CATCH_CAPTURE( INTERNAL_CATCH_UNIQUE_NAME(capturer), "CAPTURE",__VA_ARGS__ )

#define TEST_CASE( ... ) INTERNAL_CATCH_TESTCASE( __VA_ARGS__ )
#define TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define METHOD_AS_TEST_CASE( method, ... ) INTERNAL_CATCH_METHOD_AS_TEST_CASE( method, __VA_ARGS__ )
#define REGISTER_TEST_CASE( Function, ... ) INTERNAL_CATCH_REGISTER_TESTCASE( Function, __VA_ARGS__ )
#define SECTION( ... ) INTERNAL_CATCH_SECTION( __VA_ARGS__ )
#define DYNAMIC_SECTION( ... ) INTERNAL_CATCH_DYNAMIC_SECTION( __VA_ARGS__ )
#define FAIL( ... ) INTERNAL_CATCH_MSG( "FAIL", Catch::ResultWas::ExplicitFailure, Catch::ResultDisposition::Normal, __VA_ARGS__ )
#define FAIL_CHECK( ... ) INTERNAL_CATCH_MSG( "FAIL_CHECK", Catch::ResultWas::ExplicitFailure, Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define SUCCEED( ... ) INTERNAL_CATCH_MSG( "SUCCEED", Catch::ResultWas::Ok, Catch::ResultDisposition::ContinueOnFailure, __VA_ARGS__ )
#define ANON_TEST_CASE() INTERNAL_CATCH_TESTCASE()

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG( __VA_ARGS__ )
#define TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ )
#define TEMPLATE_LIST_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE(__VA_ARGS__)
#define TEMPLATE_LIST_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_METHOD( className, __VA_ARGS__ )
#else
#define TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ ) )
#define TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG( __VA_ARGS__ ) )
#define TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD( className, __VA_ARGS__ ) )
#define TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ ) )
#define TEMPLATE_PRODUCT_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE( __VA_ARGS__ ) )
#define TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( __VA_ARGS__ ) )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, __VA_ARGS__ ) )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, __VA_ARGS__ ) )
#define TEMPLATE_LIST_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE( __VA_ARGS__ ) )
#define TEMPLATE_LIST_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS( INTERNAL_CATCH_TEMPLATE_LIST_TEST_CASE_METHOD( className, __VA_ARGS__ ) )
#endif

#if !defined(CATCH_CONFIG_RUNTIME_STATIC_REQUIRE)
#define STATIC_REQUIRE( ... )       static_assert(   __VA_ARGS__,  #__VA_ARGS__ ); SUCCEED( #__VA_ARGS__ )
#define STATIC_REQUIRE_FALSE( ... ) static_assert( !(__VA_ARGS__), "!(" #__VA_ARGS__ ")" ); SUCCEED( "!(" #__VA_ARGS__ ")" )
#else
#define STATIC_REQUIRE( ... )       REQUIRE( __VA_ARGS__ )
#define STATIC_REQUIRE_FALSE( ... ) REQUIRE_FALSE( __VA_ARGS__ )
#endif

#endif

#define CATCH_TRANSLATE_EXCEPTION( signature ) INTERNAL_CATCH_TRANSLATE_EXCEPTION( signature )

// "BDD-style" convenience wrappers
#define SCENARIO( ... ) TEST_CASE( "Scenario: " __VA_ARGS__ )
#define SCENARIO_METHOD( className, ... ) INTERNAL_CATCH_TEST_CASE_METHOD( className, "Scenario: " __VA_ARGS__ )

#define GIVEN( desc )     INTERNAL_CATCH_DYNAMIC_SECTION( "    Given: " « desc )
#define AND_GIVEN( desc ) INTERNAL_CATCH_DYNAMIC_SECTION( "And given: " « desc )
#define WHEN( desc )      INTERNAL_CATCH_DYNAMIC_SECTION( "     When: " « desc )
#define AND_WHEN( desc )  INTERNAL_CATCH_DYNAMIC_SECTION( " And when: " « desc )
#define THEN( desc )      INTERNAL_CATCH_DYNAMIC_SECTION( "     Then: " « desc )
```

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#define AND_THEN( desc )  INTERNAL_CATCH_DYNAMIC_SECTION( "      And: " « desc )

#if defined(CATCH_CONFIG_ENABLE_BENCHMARKING)
#define BENCHMARK(...) \
    INTERNAL_CATCH_BENCHMARK(INTERNAL_CATCH_UNIQUE_NAME(____C_A_T_C_H____B_E_N_C_H____),
INTERNAL_CATCH_GET_1_ARG(__VA_ARGS__„), INTERNAL_CATCH_GET_2_ARG(__VA_ARGS__„))
#define BENCHMARK_ADVANCED(name) \
    INTERNAL_CATCH_BENCHMARK_ADVANCED(INTERNAL_CATCH_UNIQUE_NAME(____C_A_T_C_H____B_E_N_C_H____),
name)
#endif // CATCH_CONFIG_ENABLE_BENCHMARKING

using Catch::Detail::Approx;

#else // CATCH_CONFIG_DISABLE

// If this config identifier is defined then all CATCH macros are prefixed with CATCH_
#ifdef CATCH_CONFIG_PREFIX_ALL

#define CATCH_REQUIRE( ... )        (void)(0)
#define CATCH_REQUIRE_FALSE( ... )  (void)(0)

#define CATCH_REQUIRE_THROWS( ... ) (void)(0)
#define CATCH_REQUIRE_THROWS_AS( expr, exceptionType ) (void)(0)
#define CATCH_REQUIRE_THROWS_WITH( expr, matcher )     (void)(0)
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_REQUIRE_THROWS_MATCHES( expr, exceptionType, matcher ) (void)(0)
#endif// CATCH_CONFIG_DISABLE_MATCHERS
#define CATCH_REQUIRE_NOTHROW( ... ) (void)(0)

#define CATCH_CHECK( ... )         (void)(0)
#define CATCH_CHECK_FALSE( ... )   (void)(0)
#define CATCH_CHECKED_IF( ... )    if (__VA_ARGS__)
#define CATCH_CHECKED_ELSE( ... )  if (!(__VA_ARGS__))
#define CATCH_CHECK_NOFAIL( ... )  (void)(0)

#define CATCH_CHECK_THROWS( ... )  (void)(0)
#define CATCH_CHECK_THROWS_AS( expr, exceptionType ) (void)(0)
#define CATCH_CHECK_THROWS_WITH( expr, matcher )     (void)(0)
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_CHECK_THROWS_MATCHES( expr, exceptionType, matcher ) (void)(0)
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define CATCH_CHECK_NOTHROW( ... ) (void)(0)

#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CATCH_CHECK_THAT( arg, matcher )   (void)(0)

#define CATCH_REQUIRE_THAT( arg, matcher ) (void)(0)
#endif // CATCH_CONFIG_DISABLE_MATCHERS

#define CATCH_INFO( msg )          (void)(0)
#define CATCH_UNSCOPED_INFO( msg ) (void)(0)
#define CATCH_WARN( msg )          (void)(0)
#define CATCH_CAPTURE( msg )       (void)(0)

#define CATCH_TEST_CASE( ... ) INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ))
#define CATCH_TEST_CASE_METHOD( className, ... )
INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_S_T____ ))
#define CATCH_METHOD_AS_TEST_CASE( method, ... )
#define CATCH_REGISTER_TEST_CASE( Function, ... ) (void)(0)
#define CATCH_SECTION( ... )
#define CATCH_DYNAMIC_SECTION( ... )
#define CATCH_FAIL( ... ) (void)(0)
#define CATCH_FAIL_CHECK( ... ) (void)(0)
#define CATCH_SUCCEED( ... ) (void)(0)

#define CATCH_ANON_TEST_CASE() INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ))

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define CATCH_TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(__VA_ARGS__)
#define CATCH_TEMPLATE_TEST_CASE_SIG( ... )
INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(__VA_ARGS__)
#define CATCH_TEMPLATE_TEST_CASE_METHOD( className, ... )
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION(className, __VA_ARGS__)
#define CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, ... )
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION(className, __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE( ... ) CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) CATCH_TEMPLATE_TEST_CASE_METHOD(
className, __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) CATCH_TEMPLATE_TEST_CASE_METHOD(
className, __VA_ARGS__ )
#else
#define CATCH_TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(__VA_ARGS__) )
#define CATCH_TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(__VA_ARGS__) )
#define CATCH_TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION(className, __VA_ARGS__ ) )
#define CATCH_TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION(className, __VA_ARGS__ ) )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE( ... ) CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) CATCH_TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) CATCH_TEMPLATE_TEST_CASE_METHOD(
className, __VA_ARGS__ )
#define CATCH_TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) CATCH_TEMPLATE_TEST_CASE_METHOD(
className, __VA_ARGS__ )
#endif

// "BDD-style" convenience wrappers
#define CATCH_SCENARIO( ... ) INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ))
#define CATCH_SCENARIO_METHOD( className, ... )
INTERNAL_CATCH_TESTCASE_METHOD_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ), className )
#define CATCH_GIVEN( desc )
#define CATCH_AND_GIVEN( desc )
#define CATCH_WHEN( desc )
#define CATCH_AND_WHEN( desc )
#define CATCH_THEN( desc )
#define CATCH_AND_THEN( desc )

#define CATCH_STATIC_REQUIRE( ... )       (void)(0)
#define CATCH_STATIC_REQUIRE_FALSE( ... ) (void)(0)

// If CATCH_CONFIG_PREFIX_ALL is not defined then the CATCH_ prefix is not required
#else

#define REQUIRE( ... )       (void)(0)
#define REQUIRE_FALSE( ... ) (void)(0)

#define REQUIRE_THROWS( ... ) (void)(0)
#define REQUIRE_THROWS_AS( expr, exceptionType ) (void)(0)
#define REQUIRE_THROWS_WITH( expr, matcher ) (void)(0)
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define REQUIRE_THROWS_MATCHES( expr, exceptionType, matcher ) (void)(0)
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define REQUIRE_NOTHROW( ... ) (void)(0)

#define CHECK( ... ) (void)(0)
#define CHECK_FALSE( ... ) (void)(0)
#define CHECKED_IF( ... ) if (__VA_ARGS__)
#define CHECKED_ELSE( ... ) if (!(__VA_ARGS__))
#define CHECK_NOFAIL( ... ) (void)(0)

#define CHECK_THROWS( ... )  (void)(0)
#define CHECK_THROWS_AS( expr, exceptionType ) (void)(0)
#define CHECK_THROWS_WITH( expr, matcher ) (void)(0)
#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CHECK_THROWS_MATCHES( expr, exceptionType, matcher ) (void)(0)
#endif // CATCH_CONFIG_DISABLE_MATCHERS
#define CHECK_NOTHROW( ... ) (void)(0)

#if !defined(CATCH_CONFIG_DISABLE_MATCHERS)
#define CHECK_THAT( arg, matcher ) (void)(0)

#define REQUIRE_THAT( arg, matcher ) (void)(0)
#endif // CATCH_CONFIG_DISABLE_MATCHERS

#define INFO( msg ) (void)(0)
#define UNSCOPED_INFO( msg ) (void)(0)
#define WARN( msg ) (void)(0)
#define CAPTURE( msg ) (void)(0)

#define TEST_CASE( ... )  INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ))
#define TEST_CASE_METHOD( className, ... )
INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME( ____C_A_T_C_H____T_E_S_T____ ))
#define METHOD_AS_TEST_CASE( method, ... )
#define REGISTER_TEST_CASE( Function, ... ) (void)(0)
#define SECTION( ... )
#define DYNAMIC_SECTION( ... )
#define FAIL( ... ) (void)(0)
#define FAIL_CHECK( ... ) (void)(0)
#define SUCCEED( ... ) (void)(0)
#define ANON_TEST_CASE() INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ))

#ifndef CATCH_CONFIG_TRADITIONAL_MSVC_PREPROCESSOR
#define TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(__VA_ARGS__)
#define TEMPLATE_TEST_CASE_SIG( ... )
INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(__VA_ARGS__)
#define TEMPLATE_TEST_CASE_METHOD( className, ... )
```

```
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION(className, __VA_ARGS__)
#define TEMPLATE_TEST_CASE_METHOD_SIG( className, ... )
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION(className, __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE( ... ) TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) TEMPLATE_TEST_CASE_METHOD( className,
__VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) TEMPLATE_TEST_CASE_METHOD( className,
__VA_ARGS__ )
#else
#define TEMPLATE_TEST_CASE( ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_NO_REGISTRATION(__VA_ARGS__) )
#define TEMPLATE_TEST_CASE_SIG( ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_SIG_NO_REGISTRATION(__VA_ARGS__) )
#define TEMPLATE_TEST_CASE_METHOD( className, ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_NO_REGISTRATION(className, __VA_ARGS__ ) )
#define TEMPLATE_TEST_CASE_METHOD_SIG( className, ... ) INTERNAL_CATCH_EXPAND_VARGS(
INTERNAL_CATCH_TEMPLATE_TEST_CASE_METHOD_SIG_NO_REGISTRATION(className, __VA_ARGS__ ) )
#define TEMPLATE_PRODUCT_TEST_CASE( ... ) TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_SIG( ... ) TEMPLATE_TEST_CASE( __VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD( className, ... ) TEMPLATE_TEST_CASE_METHOD( className,
__VA_ARGS__ )
#define TEMPLATE_PRODUCT_TEST_CASE_METHOD_SIG( className, ... ) TEMPLATE_TEST_CASE_METHOD( className,
__VA_ARGS__ )
#endif

#define STATIC_REQUIRE( ... )       (void)(0)
#define STATIC_REQUIRE_FALSE( ... ) (void)(0)

#endif

#define CATCH_TRANSLATE_EXCEPTION( signature ) INTERNAL_CATCH_TRANSLATE_EXCEPTION_NO_REG(
INTERNAL_CATCH_UNIQUE_NAME( catch_internal_ExceptionTranslator ), signature )

// "BDD-style" convenience wrappers
#define SCENARIO( ... ) INTERNAL_CATCH_TESTCASE_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ) )
#define SCENARIO_METHOD( className, ... )
INTERNAL_CATCH_TESTCASE_METHOD_NO_REGISTRATION(INTERNAL_CATCH_UNIQUE_NAME(
____C_A_T_C_H____T_E_S_T____ ), className )

#define GIVEN( desc )
#define AND_GIVEN( desc )
#define WHEN( desc )
#define AND_WHEN( desc )
#define THEN( desc )
#define AND_THEN( desc )

using Catch::Detail::Approx;

#endif

#endif // ! CATCH_CONFIG_IMPL_ONLY

// start catch_reenable_warnings.h


#ifdef __clang__
#    ifdef __ICC // icpc defines the __clang__ macro
#        pragma warning(pop)
#    else
#        pragma clang diagnostic pop
#    endif
#elif defined __GNUC__
#    pragma GCC diagnostic pop
#endif

// end catch_reenable_warnings.h
// end catch.hpp
#endif // TWOBLUECUBES_SINGLE_INCLUDE_CATCH_HPP_INCLUDED

```

6.2 /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/cmdline.h

```
#ifndef CMDLINE_H
#define CMDLINE_H

void use_arguments(int argc, char* argv[]);

#endif //UNTITLED_CMDLINE_H
```

6.3 /Users/tailangcao/myGithubRepo/CS6015/Assignment/Assignment 4/Expr.h

```
#ifndef EXPR_EXPR_H
#define EXPR_EXPR_H

#include <string>
#include <sstream>
#include "catch.hpp"
#include "iostream"


typedef enum {
    prec_none,  // = 0
    prec_add,   // = 1
    prec_mult   // = 2
} precedence_t;


class Expr {
public:
    virtual bool equals(Expr *e) = 0;
    virtual int interp() = 0;
    virtual bool has_variable() = 0;
    virtual Expr *subst(std::string,Expr *s) = 0;
    virtual void print(std::ostream &ot) = 0;
    virtual void pretty_print(std::ostream &ot, precedence_t prec) = 0;
    std::string to_string(){
        std::stringstream st("");
        this ->print(st);
        return st.str();
    }
    virtual void pretty_print_dr(std::ostream &ot) = 0;
    std::string to_pretty_string(){
        std::stringstream st("");
        this ->pretty_print(st, prec_none);
        return st.str();
    }

};

class Var:public Expr{
public:
    std::string val;
    Var(std::string val);
    bool equals(Expr *e) ;
    int interp () ;
    bool has_variable();
    Expr *subst(std::string,Expr *s)   ;
    void print(std::ostream &ot) ;
    void pretty_print_dr(std::ostream &ot);
    void pretty_print(std::ostream &ot, precedence_t prec);
};

class Num:public Expr{
public:
    int val;
    Num(int val);
    bool equals(Expr *e);
    int interp ();
    bool has_variable();
    Expr *subst(std::string,Expr *s);
    void print(std::ostream &ot) ;
    void pretty_print_dr(std::ostream &ot);
    void pretty_print(std::ostream &ot, precedence_t prec);
};

class  Add:public Expr{
public:
    Expr *lhs;
    Expr *rhs;
    Add(Expr *lhs,Expr *rhs);
    bool equals(Expr *e);
    int interp () ;
    bool has_variable() ;
    Expr *subst(std::string,Expr *s);
    void print(std::ostream &ot);
    void pretty_print_dr(std::ostream &ot);
    void pretty_print(std::ostream &ot, precedence_t prec);
};

class Mult:public Expr{
public:
    Expr *lhs;
    Expr *rhs;
    Mult(Expr *lhs, Expr *rhs);
    bool equals(Expr *e) ;
    int interp () ;
    bool has_variable() ;
    Expr *subst(std::string,Expr *s) ;
    void print(std::ostream &ot) ;
    void pretty_print_dr(std::ostream &ot);
    void pretty_print(std::ostream &ot, precedence_t prec);
};


#endif //EXPR_EXPR_H
```

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