Mathematica

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Chapter 1

Hierarchical Index

1.1 Class Hierarchy

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

Chapter 2

Class Index

2.1 Class List

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

Chapter 3

File Index

3.1 File List

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

Chapter 4

Class Documentation

4.1 CompareHashable< HashableObject > Struct Template Reference

Public Member Functions

- bool **operator()** (const HashableObject &first, const HashableObject &second) const

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

- Hashable.h

4.2 ExplanationSystem Class Reference

Public Member Functions

- void **Explain** (Ref< MathNode > tree)
- Vector< String > **GetSolution** () const
- void **Flush** ()

Static Public Member Functions

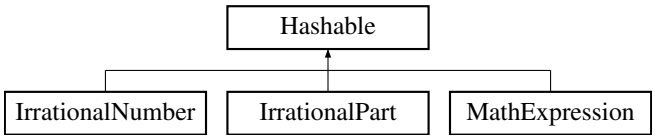
- static ExplanationSystem & **Get** ()

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

- ExplanationSystem.h
- ExplanationSystem.cpp

4.3 Hashable Class Reference

Inheritance diagram for Hashable:



Public Member Functions

- UInt32 **GetHash** () const
- virtual void **Rehash** ()=0
- template<> void **HashField** (UInt32 field)
- template<> void **HashField** (String field)
- template<> void **HashField** (Ref< MathNode > field)
- template<> void **HashField** (RationalNumber field)
- template<> void **HashField** (IrrationalNumber field)

Static Public Member Functions

- static bool **Compare** (const Hashable &first, const Hashable &second)

Protected Member Functions

- template<typename T >
  void **HashField** (T field)
- void **AddChachedHash** (const UInt32 &cached)
- void **ResetHash** ()

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

- Hashable.h
- Hashable.cpp
- Number.h

4.4 HashBinding< HashableObject > Struct Template Reference

Public Member Functions

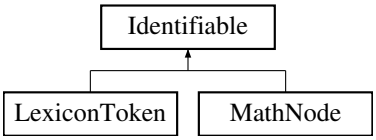
- UInt64 **operator()** (const HashableObject &first) const

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

- Hashable.h

4.5 Identifiable Class Reference

Inheritance diagram for Identifiable:



Public Member Functions

- String **GetUUID** () const
- String **GetShortUUID** () const
- bool **operator==** (Identifiable other)
- bool **operator!=** (Identifiable other)

Protected Attributes

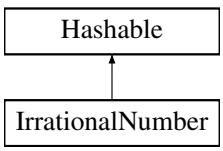
- String **mId**

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

- Identifiable.h
- Identifiable.cpp

4.6 IrrationalNumber Struct Reference

Inheritance diagram for IrrationalNumber:



Public Member Functions

- **IrrationalNumber** (Ref< MathNode > num=Mathematica::MakeRef< MathNode >(), Ref< MathNode > den=Mathematica::MakeRef< MathNode >())
- **IrrationalNumber** (const String &constantName)
- bool **operator==** (const IrrationalNumber &other)
- virtual void Rehash () override
- Float32 **RawNumerical** ()

Public Member Functions inherited from Hashable

- UInt32 **GetHash** () const
- virtual void **Rehash** ()=0
- template<> void **HashField** (UInt32 field)
- template<> void **HashField** (String field)
- template<> void **HashField** (Ref< MathNode > field)
- template<> void **HashField** (RationalNumber field)
- template<> void **HashField** (IrrationalNumber field)

Public Attributes

- Ref< MathNode > **numerator**
- Ref< MathNode > **denominator**

Additional Inherited Members

Static Public Member Functions inherited from Hashable

- static bool **Compare** (const Hashable &first, const Hashable &second)

Protected Member Functions inherited from Hashable

- template<typename T >
  void **HashField** (T field)
- void **AddChachedHash** (const UInt32 &cached)
- void **ResetHash** ()

4.6.1 Member Function Documentation

4.6.1.1 Rehash()

```
void IrrationalNumber::Rehash ( )  [override], [virtual]
```

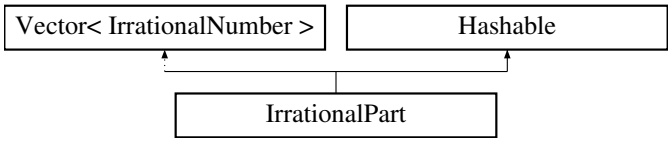
Implements Hashable.

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

- Number.h
- Number.cpp

4.7 IrrationalPart Struct Reference

Inheritance diagram for IrrationalPart:



Public Types

- using **Super** = Vector< IrrationalNumber >
- using **IteratorType** = Super::iterator
- using **ConstIteratorType** = Super::const_iterator

Public Member Functions

- **IrrationalPart** (size_t count, const IrrationalNumber &val)
- template<typename ... Args>
  decltype(auto) **EmplaceBack** (Args &&... args)
- IteratorType **begin** ()
- IteratorType **end** ()
- ConstIteratorType **begin** () const
- ConstIteratorType **end** () const
- IrrationalNumber **operator[ ]** (const UInt64 &where)
- const IrrationalNumber & **operator[ ]** (const UInt64 &where) const
- void **PushBack** (const IrrationalNumber &what)
- void **PushBack** (IrrationalNumber &&what)
- void **PopBack** ()
- UInt64 **Size** () const
- virtual void Rehash () override

Public Member Functions inherited from Hashable

- UInt32 **GetHash** () const
- virtual void **Rehash** ()=0
- template<> void **HashField** (UInt32 field)
- template<> void **HashField** (String field)
- template<> void **HashField** (Ref< MathNode > field)
- template<> void **HashField** (RationalNumber field)
- template<> void **HashField** (IrrationalNumber field)

Additional Inherited Members

Static Public Member Functions inherited from Hashable

- static bool **Compare** (const Hashable &first, const Hashable &second)

Protected Member Functions inherited from Hashable

- template<typename T >
  void **HashField** (T field)
- void **AddChachedHash** (const UInt32 &cached)
- void **ResetHash** ()

4.7.1 Member Function Documentation

4.7.1.1 Rehash()

```
void IrrationalPart::Rehash ( )  [override], [virtual]
```

Implements Hashable.

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

- Number.h
- Number.cpp

4.8 Lexer Class Reference

```
#include <Lexer.h>
```

Public Member Functions

- void **GenerateTokens** (String equation)
- Vector< LexiconToken > **GetTokens** () const
- Map< UInt32, HashMap< EPriority, Vector< UInt32 > > > **GetOperationIndex** () const
- HashMap< UInt32, Pair< UInt32, Vector< Pair< UInt32, UInt32 > > > > **GetScopeCounter** () const

4.8.1 Detailed Description

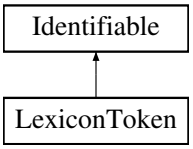
This class is used to generate an array of LexiconToken objects given a user input. It generates also metadata for each array, used during the parsing and solving steps.

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

- Lexer.h
- Lexer.cpp

4.9 LexiconToken Struct Reference

Inheritance diagram for LexiconToken:



Public Member Functions

- **LexiconToken** (String __data, ELexiconTokenType __type)
- String **GetTokenRichInformation** ()

Public Member Functions inherited from Identifiable

- String **GetUUID** () const
- String **GetShortUUID** () const
- bool **operator==** (Identifiable other)
- bool **operator!=** (Identifiable other)

Public Attributes

- String **data**
- ELexiconTokenType **type**

Additional Inherited Members

Protected Attributes inherited from Identifiable

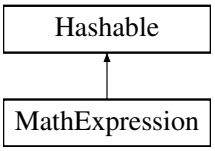
- String **mId**

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

- LexiconToken.h
- LexiconToken.cpp

4.10 MathExpression Struct Reference

Inheritance diagram for MathExpression:



Public Member Functions

- **MathExpression** (Vector< RealNumber > num={}, Vector< RealNumber > den={ {} })
- **MathExpression** (RealNumber real)
- virtual void Rehash () override
- void **CollapseTransformers** ()

Public Member Functions inherited from Hashable

- UInt32 **GetHash** () const
- virtual void **Rehash** ()=0
- template<> void **HashField** (UInt32 field)
- template<> void **HashField** (String field)
- template<> void **HashField** (Ref< MathNode > field)
- template<> void **HashField** (RationalNumber field)
- template<> void **HashField** (IrrationalNumber field)

Public Attributes

- Vector< RealNumber > **numerator**
- Vector< RealNumber > **denominator**
- Vector< Pair< ETransformer, MathExpression > > **transformers**

Additional Inherited Members

Static Public Member Functions inherited from Hashable

- static bool **Compare** (const Hashable &first, const Hashable &second)

Protected Member Functions inherited from Hashable

- template<typename T >
  void **HashField** (T field)
- void **AddChachedHash** (const UInt32 &cached)
- void **ResetHash** ()

4.10.1 Member Function Documentation

4.10.1.1 Rehash()

```
void MathExpression::Rehash ( )  [override], [virtual]
```

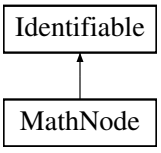
Implements Hashable.

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

- Number.h
- Number.cpp

4.11 MathNode Struct Reference

Inheritance diagram for MathNode:



Public Types

- using **PointerType** = Ref< MathNode >
- using **ChildrenType** = Vector< PointerType >

Public Member Functions

- **MathNode** (PointerType __parent=nullptr, ChildrenType __children={}, Any __data={}, EMathNodeType __type=EMathNodeType::None, Int32 __scope=-1)

Public Member Functions inherited from Identifiable

- String **GetUUID** () const
- String **GetShortUUID** () const
- bool **operator==** (Identifiable other)
- bool **operator!=** (Identifiable other)

Public Attributes

- Int32 **scope**
- PointerType **parent**
- ChildrenType **children**
- Any **data**
- EMathNodeType **type**

Additional Inherited Members

Protected Attributes inherited from Identifiable

- String **mId**

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

- MathNode.h
- MathNode.cpp

4.12 Parser Class Reference

Public Member Functions

- void **InitParser** (const Vector< LexiconToken > &tokens, const Map< UInt32, HashMap< EPriority, Vector< UInt32 > > > &opIndexes, const HashMap< UInt32, Pair< UInt32, Vector< Pair< UInt32, UInt32 > > > > &scopeCounter)
- Map< UInt32, Vector< Ref< MathNode > > > **GetExecutionFlow** () const
- Ref< MathNode > **GenerateTree** ()

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

- Parser.h
- Parser.cpp

4.13 ProfileInformation Struct Reference

Public Attributes

- String **name**
- Int32 **start**
- Int32 **end**
- Int32 **duration**
- Int32 **processId**
- Int32 **threadId**

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

- Profiler.h

4.14 Profiler Class Reference

Public Member Functions

- void **BeginProfile** (const String &name, String outFilePath="")
- void **WriteProfile** (const ProfileInformation &information)
- void **EndProfile** ()

Static Public Member Functions

- static Profiler & **Get** ()

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

- Profiler.h
- Profiler.cpp

4.15 ProfilerSession Struct Reference

Public Attributes

- String **name**

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

- Profiler.h

4.16 RandomEngine Class Reference

Static Public Member Functions

- static void **Init** ()
- static Int32 **Int** (Int32 minRange=0, Int32 maxRange=0x7fffffff)
- static UInt32 **UnsignedInt** (UInt32 minRange=0, UInt32 maxRange=0xffffffff)
- static Float32 **Float** (Float32 minRange=0.0, Float32 maxRange=1.0)
- static Float64 **Double** (Float64 minRange=0.0, Float64 maxRange=1.0)

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

- Random.h
- Random.cpp

4.17 RationalNumber Struct Reference

Public Member Functions

- **RationalNumber** (Int32 num=1, Int32 den=1)
- **RationalNumber** (const String &strNumber)
- RationalNumber **operator+** (RationalNumber other)
- RationalNumber **operator-** (RationalNumber other)
- RationalNumber **operator*** (RationalNumber other)
- RationalNumber **operator/** (RationalNumber other)
- RationalNumber **operator-** ()
- const RationalNumber & **operator+** (RationalNumber other) const
- const RationalNumber & **operator-** (RationalNumber other) const
- const RationalNumber & **operator*** (RationalNumber other) const
- const RationalNumber & **operator/** (RationalNumber other) const
- void **operator+=** (RationalNumber other)
- void **operator-=** (RationalNumber other)
- void **operator*=** (RationalNumber other)
- void **operator/=** (RationalNumber other)
- bool **operator==** (RationalNumber other)
- bool **operator!=** (RationalNumber other)
- bool **operator>=** (RationalNumber other)
- bool **operator<=** (RationalNumber other)
- bool **operator>** (RationalNumber other)
- bool **operator<** (RationalNumber other)
- Float32 **RawNumerical** ()
- RationalNumber **LowestTerms** (Int32 num, Int32 den)
- void **LowestTerms** ()

Public Attributes

- Int32 **numerator**
- Int32 **denominator**
- ENumberType **type**

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

- Number.h
- Number.cpp

4.18 RealNumber Struct Reference

Public Member Functions

- **RealNumber** (RationalNumber rational={}, IrrationalPart irrational={})
- **RealNumber** (const String &strNumber)
- RealNumber **operator-** ()
- Float32 **RawNumerical** ()

Public Attributes

- RationalNumber **rational**
- IrrationalPart **irrational**
- ESubset **type**

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

- Number.h
- Number.cpp

4.19 Solver Class Reference

Public Member Functions

- void **InitSolver** (const Ref< MathNode > &tree)
- void **InitSolver** (const Ref< MathNode > &tree, const Map< UInt32, Vector< Ref< MathNode > > > &executionFlow)
- RationalNumber **SolveTree** ()

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

- Solver.h
- Solver.cpp

4.20 Timer Class Reference

Public Member Functions

- **Timer** (const String &name)
- void **Start** ()
- void **Stop** ()

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

- Timer.h
- Timer.cpp

Chapter 5

File Documentation

5.1 ExplanationSystem.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 #include "Core/MathNode.h"
00006
00007 class ExplanationSystem
00008 {
00009 public:
00010     void Explain(Ref<MathNode> tree);
00011
00012     Vector<String> GetSolution() const { return mSolution; }
00013
00014     static ExplanationSystem& Get();
00015     void Flush();
00016
00017 private:
00018     void RecursiveExplain(Ref<MathNode> node);
00019
00020     String mCurrentStep;
00021     Vector<String> mSolution;
00022 };
```

5.2 Hashable.h

```
00001 #pragma once
00002
00003 #include "Core/MathNode.h"
00004
00005 #include "Core/Utility/Utils.h"
00006 #include "Core/Utility/Types.h"
00007
00008 class Hashable
00009 {
00010 public:
00011     Hashable();
00012     UInt32 GetHash() const { return mHash; }
00013
00014     virtual void Rehash() = 0;
00015
00016     static bool Compare(const Hashable& first, const Hashable& second);
00017
00018 protected:
00019     template<typename T>
00020     void HashField(T field);
00021
00022     void AddChachedHash(const UInt32& cached) { mHash *= cached; }
00023     void ResetHash() { mHash = 1; }
00024
00025 private:
00026     void Hash(UInt32 seed);
00027
00028     UInt32 mHash;
00029 };
```

```
00030
00031 template<typename HashableObject>
00032 struct HashBinding
00033 {
00034     UInt64 operator()(const HashableObject& first) const
00035     {
00036         return Mathematica::Cast<UInt64>(first.GetHash());
00037     }
00038 };
00039
00040 template<typename HashableObject>
00041 struct CompareHashable
00042 {
00043     bool operator()(const HashableObject& first, const HashableObject& second) const
00044     {
00045         return Hashable::Compare(first, second);
00046     }
00047 };
00048
00049 template<typename T>
00050 inline void Hashable::HashField(T field)
00051 {
00052     MTH_ASSERT(false, "HashError: To use Hashable with this type, you have to implement your own hash
    function!");
00053 }
00054
00055 template<>
00056 inline void Hashable::HashField(UInt32 field)
00057 {
00058     Hash(field);
00059 }
00060
00061 template<>
00062 inline void Hashable::HashField(String field)
00063 {
00064     UInt32 hashNumber = 0;
00065
00066     const UInt16 magicHigh = 0xaf13;
00067     const UInt16 magicLow = 0x4b71;
00068
00069     for (auto c : field) hashNumber += c * magicHigh - magicLow / c;
00070
00071     Hash(hashNumber);
00072 }
00073
00074 template<>
00075 inline void Hashable::HashField(Ref<MathNode> field)
00076 {
00077     Hash(*MTH_UINT_ADDRESS_OF(field->data));
00078
00079     for (Ref<MathNode> child : field->children) HashField(child);
00080 }
```

5.3 Identifiable.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 class Identifiable
00006 {
00007 public:
00008     Identifiable();
00009     String GetUUID() const { return mId; }
00010     String GetShortUUID() const { return String(mId.begin(), mId.begin() + 7); }
00011
00012     bool operator==(Identifiable other);
00013     bool operator!=(Identifiable other);
00014
00015 protected:
00016     String mId;
00017
00018 private:
00019     String GenerateUUID();
00020 };
```

5.4 Lexer.h

```
00001 #pragma once
```

```
00002
00003 #include "Core/LexiconToken.h"
00004
00005 #include "Core/Utility/Types.h"
00006
00007 enum class EPriority : Int32
00008 {
00009     Low,
00010     Medium,
00011     High,
00012     Macro
00013 };
00014
00023 class Lexer
00024 {
00025 public:
00026     Lexer();
00027
00028     void GenerateTokens(String equation);
00029
00030     Vector<LexiconToken> GetTokens() const { return mTokens; }
00031     Map<UInt32, HashMap<EPriority, Vector<UInt32>> GetOperationIndex() const { return
      mOperationIndexes; }
00032     HashMap<UInt32, Pair<UInt32, Vector<Pair<UInt32, UInt32>>> GetScopeCounter() const { return
      mScopeCounter; }
00033
00034 private:
00035     String StringifyNumberToken(String string, bool invertSign);
00036     String PreliminaryProcess(String equation);
00037
00038     Vector<LexiconToken> mTokens;
00039
00040     // Token Metadata
00041     Map<UInt32, HashMap<EPriority, Vector<UInt32>> mOperationIndexes;
00042     HashMap<UInt32, Pair<UInt32, Vector<Pair<UInt32, UInt32>>> mScopeCounter;
00043     Map<UInt32, Pair<UInt32, String> mFunctionMacros;
00044 };
00045
00046 // NOTE : Making Lexer and Parser friends is potentially useful. Maybe in the future I'll change that.
```

5.5 LexiconToken.h

```
00001 #pragma once
00002
00003 #include "Core/Identifiable.h"
00004
00005 #include "Core/Utility/Utils.h"
00006
00007 enum class ELexiconTokenType : Int32
00008 {
00009     Number,
00010     BinaryFunction,
00011     WrapperStart,
00012     WrapperEnd,
00013     Macro,
00014
00015     Unknown
00016 };
00017
00018 struct LexiconToken : public Identifiable
00019 {
00020     String data;
00021     ELexiconTokenType type;
00022
00023     LexiconToken(String __data, ELexiconTokenType __type);
00024     String GetTokenRichInformation();
00025 };
```

5.6 Integer.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Utils.h"
00004
00005 namespace Mathematica
00006 {
00007     namespace Integer
00008     {
00009         // Integer functions
```

```
00010         Int32 LeastCommonMultiple(Int32 a, Int32 b);
00011         Int32 GreatestCommonDivisor(Int32 a, Int32 b);
00012
00013         // Prime numbers
00014         Map<Int32, Int32> Factorize(Int32 n);
00015         Map<Int32, Int32> Factorize(RationalNumber n);
00016
00017         bool IsPrime(Int32 n);
00018         bool IsPrime(RationalNumber n);
00019
00020         Int32 Prime(Int32 n);
00021         Int32 Prime(RationalNumber n);
00022
00023         // Sieve of Erathosthenes
00024         Vector<Int32> SoE (Int32 max);
00025     }
00026 }
```

5.7 Number.h

```
00001 #pragma once
00002
00003 #include "Core/Identifiable.h"
00004 #include "Core/Hashable.h"
00005 #include "Core/MathNode.h"
00006
00007 #include "Core/Utility/Utils.h"
00008
00009 // NOTE : This definition might vary.
00010 enum class ENumberType : Int32
00011 {
00012     Integer,
00013     Rational,
00014 };
00015
00016 enum class ESubset : Int32
00017 {
00018     Rational,
00019     Irrational,
00020     Real,
00021 };
00022
00023 enum class ETransformer : UInt32
00024 {
00025     Exponentiate
00026 };
00027
00028 struct RationalNumber
00029 {
00030     Int32 numerator;
00031     Int32 denominator;
00032     ENumberType type;
00033
00034     RationalNumber(Int32 num = 1, Int32 den = 1);
00035     RationalNumber(const String& strNumber);
00036
00037     RationalNumber operator+(RationalNumber other);
00038     RationalNumber operator-(RationalNumber other);
00039     RationalNumber operator*(RationalNumber other);
00040     RationalNumber operator/(RationalNumber other);
00041
00042     RationalNumber operator-();
00043
00044     const RationalNumber& operator+(RationalNumber other) const;
00045     const RationalNumber& operator-(RationalNumber other) const;
00046     const RationalNumber& operator*(RationalNumber other) const;
00047     const RationalNumber& operator/(RationalNumber other) const;
00048
00049     void operator+=(RationalNumber other);
00050     void operator-=(RationalNumber other);
00051     void operator*=(RationalNumber other);
00052     void operator/=(RationalNumber other);
00053
00054     bool operator==(RationalNumber other);
00055     bool operator!=(RationalNumber other);
00056     bool operator>=(RationalNumber other);
00057     bool operator<=(RationalNumber other);
00058     bool operator> (RationalNumber other);
00059     bool operator< (RationalNumber other);
00060
00061     Float32 RawNumerical();
00062
00063     RationalNumber LowestTerms(Int32 num, Int32 den);
```

```
00064     void LowestTerms();
00065 };
00066
00067 struct IrrationalNumber : public Hashable
00068 {
00069     Ref<MathNode> numerator;
00070     Ref<MathNode> denominator;
00071
00072     IrrationalNumber(Ref<MathNode> num = Mathematica::MakeRef<MathNode>(), Ref<MathNode> den =
      Mathematica::MakeRef<MathNode>());
00073     IrrationalNumber(const String& constantName);
00074
00075     bool operator==(const IrrationalNumber& other);
00076
00077     virtual void Rehash() override;
00078
00079     Float32 RawNumerical();
00080 };
00081
00082 // REFACTOR : Create HashableVector Data Structure
00083 struct IrrationalPart : private Vector<IrrationalNumber>, public Hashable
00084 {
00085     using Super = Vector<IrrationalNumber>;
00086     using IteratorType = Super::iterator;
00087     using ConstIteratorType = Super::const_iterator;
00088
00089     IrrationalPart() {}
00090     IrrationalPart(size_t count, const IrrationalNumber& val) : Vector<IrrationalNumber>(count, val) {
      Rehash(); }
00091
00092     template<typename ...Args>
00093     inline decltype(auto) EmplaceBack(Args&&... args)
00094     {
00095         Super::emplace_back(std::forward<Args>(args)...);
00096         Rehash();
00097     }
00098
00099     IteratorType begin() { return Super::begin(); }
00100     IteratorType end()   { return Super::end(); }
00101
00102     ConstIteratorType begin() const { return Super::begin(); }
00103     ConstIteratorType end() const   { return Super::end(); }
00104
00105     IrrationalNumber operator[](const UInt64& where) { return Super::operator[](where); }
00106     const IrrationalNumber& operator[](const UInt64& where) const { return Super::operator[](where); }
00107
00108     void PushBack(const IrrationalNumber& what);
00109     void PushBack(IrrationalNumber&& what);
00110
00111     void PopBack();
00112     UInt64 Size() const { return Super::size(); }
00113
00114     virtual void Rehash() override;
00115 };
00116
00117 struct RealNumber
00118 {
00119     RationalNumber rational;
00120     IrrationalPart irrational;
00121     ESubset type;
00122
00123     RealNumber(RationalNumber rational = {}, IrrationalPart irrational = {});
00124     RealNumber(const String& strNumber);
00125
00126     RealNumber operator-();
00127
00128     Float32 RawNumerical();
00129 };
00130
00131 struct MathExpression : public Hashable
00132 {
00133     Vector<RealNumber> numerator;
00134     Vector<RealNumber> denominator;
00135
00136     Vector<Pair<ETransformer, MathExpression» transformers;
00137
00138     MathExpression(Vector<RealNumber> num = {}, Vector<RealNumber> den = { {} });
00139     MathExpression(RealNumber real);
00140
00141     virtual void Rehash() override;
00142
00143     void CollapseTransformers();
00144 };
00145
00146 // TODO : Move these functions somewhere else.
00147 namespace Mathematica
00148 {
```

```
00149     RationalNumber Absolute(RationalNumber number);
00150     Int32 Sign(RationalNumber number);
00151 }
00152
00153 template<>
00154 inline void Hashable::HashField(RationalNumber field)
00155 {
00156     Hash(field.numerator);
00157     Hash(field.denominator);
00158 }
00159
00160 template<>
00161 inline void Hashable::HashField(IrrationalNumber field)
00162 {
00163     HashField(field.numerator);
00164     HashField(field.denominator);
00165 }
```

5.8 Operations.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 namespace Mathematica
00006 {
00007     namespace Operation
00008     {
00009         RationalNumber Add          (const RationalNumber& a, const RationalNumber& b);
00010         RationalNumber Subtract     (const RationalNumber& a, const RationalNumber& b);
00011         RationalNumber Multiply     (const RationalNumber& a, const RationalNumber& b);
00012         RationalNumber Divide       (const RationalNumber& a, const RationalNumber& b);
00013         RealNumber     Exponentiate (const RationalNumber& a, RationalNumber b);
00014
00015         RationalNumber Raise        (const RationalNumber& a, const Int32& b);
00016
00017         RationalNumber Mod          (const RationalNumber& a, const RationalNumber& b);
00018     }
00019 }
```

5.9 Rational.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 namespace Mathematica
00006 {
00007     namespace Rational
00008     {
00009         RationalNumber Average(Vector<RationalNumber> numbers);
00010         RationalNumber Average(RationalNumber first, RationalNumber second);
00011
00012         RationalNumber Between(RationalNumber first, RationalNumber second);
00013
00014         // TODO : Move this function somewhere else.
00015         Int32 Sign(Float32 number);
00016
00017         RationalNumber Farey(Float32 number);
00018
00019         // Rationality
00020         bool IsRootRational(RationalNumber arg, Int32 index);
00021     }
00022 }
```

5.10 Real.h

```
00001 #pragma once
00002
00003 #include "Core/Math/Number.h"
00004
00005 namespace Mathematica
00006 {
00007     namespace Real
00008     {
```

```
00009         namespace Operation
00010         {
00011             MathExpression Add(const MathExpression& first, const MathExpression& second);
00012             MathExpression Subtract(const MathExpression& first, const MathExpression& second);
00013             MathExpression Multiply(const MathExpression& first, const MathExpression& second);
00014             MathExpression Divide(const MathExpression& first, const MathExpression& second);
00015         }
00016 
00017         Vector<RealNumber> ExecuteSimplify(const Vector<RealNumber>& expression);
00018         Vector<RealNumber> ExecuteMultiply(const Vector<RealNumber>& first, const Vector<RealNumber>&
      second);
00019     }
00020 
00021     namespace Irrational
00022     {
00023         RealNumber ProcessIrrationalSubTree(const Ref<MathNode>& subTree, const UInt32& counter);
00024     }
00025 }
```

5.11 MathNode.h

```
00001 #pragma once
00002 
00003 #include "Core/Identifiable.h"
00004 
00005 #include "Core/Utility/Types.h"
00006 
00007 enum class EMathNodeType : Int32
00008 {
00009     Number,
00010     BinaryFunction,
00011     NamedFunction,
00012 
00013     WrapStart,
00014     WrapEnd,
00015 
00016     Wrapper,
00017 
00018     Macro,
00019 
00020     None
00021 };
00022 
00023 // This struct behaves like a node of a tree.
00024 struct MathNode : public Identifiable
00025 {
00026     using PointerType = Ref<MathNode>;
00027     using ChildrenType = Vector<PointerType>;
00028 
00029     Int32 scope;
00030 
00031     PointerType parent;
00032     ChildrenType children;
00033 
00034     Any data;
00035     EMathNodeType type;
00036 
00037     MathNode(
00038         PointerType __parent = nullptr,
00039         ChildrenType __children = {},
00040         Any __data = {},
00041         EMathNodeType __type = EMathNodeType::None,
00042         Int32 __scope = -1
00043     );
00044 };
```

5.12 Parser.h

```
00001 #pragma once
00002 
00003 #include "Core/LexiconToken.h"
00004 #include "Core/MathNode.h"
00005 #include "Core/Lexer.h"
00006 
00007 #include "Core/Utility/Types.h"
00008 
00009 class Parser
00010 {
00011 public:
```

```
00012     Parser();
00013
00014     void InitParser(const Vector<LexiconToken>& tokens, const Map<UInt32, HashMap<EPriority,
      Vector<UInt32»>& opIndexes, const HashMap<UInt32, Pair<UInt32, Vector<Pair<UInt32, UInt32»»&
      scopeCounter);
00015
00016     Map<UInt32, Vector<Ref<MathNode»> GetExecutionFlow() const { return mExecutionFlow; }
00017
00018     Ref<MathNode> GenerateTree();
00019
00020 private:
00021     void GenerateWrappedNodes(HashMap<EPriority, Vector<UInt32»& scopeData, EPriority priority);
00022     void WrapMacros(HashMap<EPriority, Vector<UInt32»& scopeData);
00023     void GenerateNodes(const Vector<LexiconToken>& tokens);
00024
00025     HashMap<UInt32, Pair<UInt32, Vector<Pair<UInt32, UInt32»» mScopeCounter;
00026     Map<UInt32, HashMap<EPriority, Vector<UInt32»> mOperationIndexes;
00027     Vector<Ref<MathNode» mNodes;
00028
00029     Map<UInt32, Vector<Ref<MathNode»> mExecutionFlow;
00030
00031     Ref<MathNode> mTree;
00032
00033     UInt32 mFirstIndex;
00034     UInt32 mCurrentScope;
00035     UInt32 mExecutionIndex;
00036 };
```

5.13 Solver.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 #include "Core/Math/Number.h"
00006
00007 #include "Core/ExplanationSystem.h"
00008 #include "Core/MathNode.h"
00009
00010 class Solver
00011 {
00012 public:
00013     Solver();
00014     void InitSolver(const Ref<MathNode>& tree);
00015     void InitSolver(const Ref<MathNode>& tree, const Map<UInt32, Vector<Ref<MathNode»>&
      executionFlow);
00016
00017     RationalNumber SolveTree();
00018
00019 private:
00020     RationalNumber RecursiveSolve(const Ref<MathNode>& node);
00021     RationalNumber ExecutionSolve();
00022
00023     Map<UInt32, Vector<Ref<MathNode»> mExecutionFlow;
00024     ExplanationSystem& mExplanationSystem;
00025     Ref<MathNode> mTree;
00026 };
```

5.14 Conversions.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 namespace Mathematica
00006 {
00007     // TODO : Add more conversions.
00008     namespace Convert
00009     {
00010         String Uint32ToHexString(UInt32 number, UInt32 length);
00011         String Uint32ToOctString(UInt32 number, UInt32 length);
00012
00013         String Uint32ToBaseString(UInt32 number, UInt32 base, UInt32 length);
00014
00015         Int32 StringToInt32(String string);
00016
00017         String Int32ToString(Int32 number);
00018
00019         Float32 StringToFloat32(String string);
```

```
00020         Float64 StringToFloat64(String string);
00021
00022         String Float32ToString(Float32 number);
00023         String Float64ToString(Float64 number);
00024     }
00025 }
```

5.15 Profiler.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004 #include "Core/Utility/Timer.h"
00005
00006 #ifdef MTH_ENABLE_PROFILER
00007 #define MTH_PROFILE_SCOPE(name) Timer timer##__LINE__(name)
00008 #define MTH_PROFILE_FUNCTION() MTH_PROFILE_SCOPE(__FUNCSIG__)
00009 #define MTH_PROFILE_BEGIN(...) Profiler::Get().BeginProfile(__VA_ARGS__);
00010 #define MTH_PROFILE_END() Profiler::Get().EndProfile();
00011 #else
00012 #define MTH_PROFILE_SCOPE(name)
00013 #define MTH_PROFILE_FUNCTION()
00014 #define MTH_PROFILE_BEGIN(...)
00015 #define MTH_PROFILE_END()
00016 #endif
00017
00018 struct ProfileInformation
00019 {
00020     String name;
00021     Int32 start;
00022     Int32 end;
00023     Int32 duration;
00024
00025     Int32 processId;
00026     Int32 threadId;
00027 };
00028
00029 struct ProfilerSession
00030 {
00031     String name;
00032 };
00033
00034 class Profiler
00035 {
00036 public:
00037     Profiler();
00038     void BeginProfile(const String& name, String outFilePath = "");
00039     void WriteProfile(const ProfileInformation& information);
00040     void EndProfile();
00041
00042     static Profiler& Get();
00043
00044 private:
00045     void WriteHeader();
00046     void WriteFooter();
00047
00048     Scope<ProfilerSession> mCurrentSession;
00049     OutFile mOutputFile;
00050     Int32 mProfileCount;
00051 };
```

5.16 Random.h

```
00001 #pragma once
00002
00003 class RandomEngine
00004 {
00005 public:
00006     static void Init();
00007
00008     static Int32 Int(Int32 minRange = 0, Int32 maxRange = 0x7fffffff);
00009     static UInt32 UnsignedInt(UInt32 minRange = 0, UInt32 maxRange = 0xffffffff);
00010     static Float32 Float(Float32 minRange = 0.0, Float32 maxRange = 1.0);
00011     static Float64 Double(Float64 minRange = 0.0, Float64 maxRange = 1.0);
00012
00013     ~RandomEngine() = default;
00014
00015 private:
00016
```

```
00017     RandomEngine();
00018
00019     static RandomDevice mRandomDevice;
00020     static MersenneTwister mMersenneTwister;
00021     static RandomEngine* sInstance;
00022 };
```

5.17 Timer.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 class Timer
00006 {
00007 public:
00008     Timer(const String& name);
00009     ~Timer();
00010
00011     void Start();
00012     void Stop();
00013
00014 private:
00015     String mName;
00016     TimePoint<SteadyClock> mStartTimepoint;
00017     bool mRunning;
00018 };
```

5.18 Types.h

```
00001 #pragma once
00002
00003 // Forward declarations
00004 struct RationalNumber;
00005 struct RealNumber;
00006
00007 // Data structures
00008 using String = std::string;
00009 using StringStream = std::stringstream;
00010 using Any = std::any;
00011
00012 template<typename T>
00013 using Vector = std::vector<T>;
00014
00015 template<typename T, size_t S>
00016 using Array = std::array<T, S>;
00017
00018 template<typename... Args>
00019 using HashMap = std::unordered_map<Args...>;
00020
00021 template<typename K, typename V>
00022 using Map = std::map<K, V>;
00023
00024 template<typename F, typename S>
00025 using Pair = std::pair<F, S>;
00026
00027 // Files
00028 using OutFile = std::ofstream;
00029 using InFile = std::ifstream;
00030 using File = std::fstream;
00031
00032 // Chrono
00033 template<typename D>
00034 using TimePoint = std::chrono::time_point<D>;
00035
00036 using SteadyClock = std::chrono::steady_clock;
00037
00038 using Nanoseconds  = std::chrono::nanoseconds;
00039 using Milliseconds = std::chrono::milliseconds;
00040 using Microseconds = std::chrono::microseconds;
00041
00042 // Miscellaneous
00043 using MersenneTwister = std::mt19937;
00044 using RandomDevice = std::random_device;
00045
00046 // Functions
00047 typedef RationalNumber(*FRationalBinaryRational)(const RationalNumber&, const RationalNumber&);
00048 typedef RealNumber(*FRealBinaryRational)(const RationalNumber&, const RationalNumber&);
00049
```

```
00050 // Primitive types
00051 using UInt64  = unsigned long long int;
00052 using UInt32  = unsigned int;
00053 using UInt16  = unsigned short;
00054 using UInt8   = unsigned char;
00055 using Int64   = long long int;
00056 using Int32   = int;
00057 using Int16   = short;
00058 using Int8    = char;
00059 using Float32 = float;
00060 using Float64 = double;
00061
00062 // Smart pointers
00063 template<typename T>
00064 using Ref = std::shared_ptr<T>;
00065 template<typename T>
00066 using Scope = std::unique_ptr<T>;
```

5.19 Utils.h

```
00001 #pragma once
00002
00003 #include "Core/Utility/Types.h"
00004
00005 #ifdef MTH_DEBUG
00006 #define MTH_ASSERT(expression, message) if(!(expression)) Mathematica::Assert(#expression,
      Mathematica::RelativeToBuildPath(__FILE__).c_str(), __FUNCTION__, __LINE__, message)
00007 #define MTH_DEBUG_INFO(function) DisplayFunctionInfo(#function, __FUNCTION__); function
00008 #else
00009 #define MTH_ASSERT(expression, message)
00010 #define MTH_DEBUG_INFO(function) function;
00011 #endif
00012
00013 #ifdef MTH_WIN
00014 constexpr auto MTH_PROJECT_PATH = "MathematicaCLI\\";
00015 #else
00016 constexpr auto MTH_PROJECT_PATH = "MathematicaCLI/";
00017
00018 #ifndef __FUNCSIG__
00019 #define __FUNCSIG__ __FUNCTION__
00020 #endif
00021
00022 #endif
00023
00024 #define MTH_UNUSED(x)           Mathematica::Cast<void>(x)
00025 #define MTH_ADDRESS_OF(x)       Mathematica::Cast<void*>(&x)
00026 #define MTH_UINT_ADDRESS_OF(x)  Mathematica::Cast<UInt32*>(MTH_ADDRESS_OF(x))
00027
00028 #define MTH_HIGH_WORD(x)    Mathematica::Cast<UInt8>((x » 8) & MTH_WORD_MASK)
00029 #define MTH_LOW_WORD(x)     Mathematica::Cast<UInt8>(x & MTH_WORD_MASK)
00030 #define MTH_HIGH_DWORD(x)   Mathematica::Cast<UInt16>((x » 16) & MTH_DWORD_MASK)
00031 #define MTH_LOW_DWORD(x)    Mathematica::Cast<UInt16>(x & MTH_DWORD_MASK)
00032 #define MTH_HIGH_QWORD(x)   Mathematica::Cast<UInt32>((x » 32) & MTH_QWORD_MASK)
00033 #define MTH_LOW_QWORD(x)    Mathematica::Cast<UInt32>(x & MTH_QWORD_MASK)
00034
00035 constexpr auto MTH_VERSION = "Version 0.0.16a";
00036 constexpr auto MTH_NO_MESSAGE = "No message provided.";
00037 constexpr auto MTH_FLOAT32_EPSILON = 1.192092896e-07F;
00038
00039 constexpr auto MTH_QWORD_MASK = 0xffffffff;
00040 constexpr auto MTH_DWORD_MASK = 0xffff;
00041 constexpr auto MTH_WORD_MASK = 0xff;
00042
00043 enum class ELexiconTokenType;
00044 enum class EMathNodeType;
00045
00046 struct LexiconToken;
00047 struct MathNode;
00048
00049 namespace Mathematica
00050 {
00051     // === Smart pointers ===
00052     template<typename T, typename ... Args>
00053     constexpr Scope<T> MakeScope(Args&& ... args)
00054     {
00055         return std::make_unique<T>(std::forward<Args>(args)...);
00056     }
00057
00058     template <typename T, typename ... Args>
00059     constexpr Ref<T> MakeRef(Args&&... args)
00060     {
00061         return std::make_shared<T>(std::forward<Args>(args)...);
00062     }
```

```
00063
00064     // === Pair ===
00065     template <typename F, typename S>
00066     constexpr Pair<F, S> MakePair(F&& first, S&& second)
00067     {
00068         return std::make_pair<F, S>(std::forward<F>(first), std::forward<S>(second));
00069     }
00070
00071     // === Any ===
00072     template <typename T>
00073     constexpr auto AnyCast(const Any& value)
00074     {
00075         return std::any_cast<T>(value);
00076     }
00077
00078     // === Casts ===
00079     template <typename F, typename S>
00080     constexpr auto Cast(const S& what)
00081     {
00082         return static_cast<F>(what);
00083     }
00084
00085     template <typename T>
00086     constexpr auto Recast(const void* what)
00087     {
00088         return reinterpret_cast<T>(what);
00089     }
00090
00091     // === Debug and files ===
00092     void Assert(const char* expression, const char* file, const char* function, Int32 line, const
      char* message);
00093     void DisplayFunctionInfo(const char* functionName, const char* callerFunction);
00094     String RelativeToBuildPath(String file);
00095
00096     // === Miscellaneous ===
00097     void ClearScreen();
00098     // TODO : Add implementations for Number as well.
00099     Int32 Max(Int32 a, Int32 b);
00100     Int32 Min(Int32 a, Int32 b);
00101     UInt32 Max(UInt32 a, UInt32 b);
00102     UInt32 Min(UInt32 a, UInt32 b);
00103
00104     template<typename T>
00105     void Swap(T& a, T& b);
00106
00107     template<typename T>
00108     T GetValueFromAnyCast(const Any& data);
00109
00110     // === Functions ===
00111     FRationalBinaryRational GetBinaryFunctionFromRawData(const String& data);
00112     char   ToChar(FRationalBinaryRational address);
00113     String Stringify(FRationalBinaryRational address);
00114
00115     // === String manipulation ===
00116     // * The following functions are not locale-safe.
00117     // * This might change in the future.
00118     void TransformToLower(String& string);
00119     void TransformToUpper(String& string);
00120
00121     bool IsLetter(char Char);
00122     bool FindAt(String string, String substr, UInt32 where);
00123
00124     Vector<String> SeparateString(String string, char separetor = ' ');
00125     void Replace(String& string, char what, char with);
00126     void RemoveQuotes(String& string);
00127
00128     // === Token ===
00129     void DisplayTokenArray(const Vector<LexiconToken>& tokenArray, bool bInline = true);
00130     void DisplayTokenUUID(const Vector<LexiconToken>& tokenArray, bool bInline = true);
00131     String Stringify(ELexiconTokenType type);
00132
00133     // === Tree ===
00134     void DisplayParsedTree(const Ref<MathNode>& node);
00135     String Stringify(EMathNodeType type);
00136     String Stringify(RationalNumber number);
00137 };
```

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