Implementation Notes

Contents

0. Overview

The system operates in a number of phases.

1. Deduce the grammar of the language to be parsed from a set of `parsable` types, the equivalent of a set of EBNF productions, each with one or more alternatives and each alternative consisting of a sequence of components, e.g. punctuation, reserved words etc.
2. Build "first sets", the sets of lexemes which can begin strings described by each production, alternative and component. First sets are used to allow the parser to select alternatives without backtracking and to check that productions are not ambiguous. Definitions are also checked for left recursion at this stage.
3. Use the grammar to parse the input and build the objects it describes. Input to the parser is a stream of lexemes produced by the lexical analyser (`source_reader`) from the input text.

1. The source_reader class

As described above the purpose of the `source_reader` is to produce a stream of lexemes from the input text. The base class `lexeme` has a single field called `spelling`. All of the specific lexeme types are subtypes of this base class. They are documented in the following table.

Lexeme Type	Description
`punctuation`	Symbols not beginning with a letter or a digit, e.g. programming language operators, commas and semicolons etc. They can contain one or more characters, e.g. `:=` or `::=` or `!=`
`reserved_word`	Symbols beginning with a letter followed by further letters, digits or underscore characters, e.g. `begin end int32 a_word`
`number`	Symbols beginning with a digit possibly followed by further digits .
`real_number`	Symbols beginning with a digit possibly followed by further digits and containing a decimal point .
`identifier`	Symbols beginning with a letter followed by further letters, digits or underscore characters and which are not defined to be reserved words.
`string_literal`	Symbols beginning with a double quote followed by a character string and terminated by a double quote.
`char_literal`	Symbols beginning with a single quote followed by a single character and terminated by a single quote.

In addition to being read by the parser, these `lexeme` types are also used in conjunction with the `Parse` attribute to define fields of `parsable` types. For `number`, `real_number`, `identifier`, `string_literal` and `char_literal` lexemes the `source_reader` will assign the actual characters read from the input text to each lexeme's `spelling` field.

The `source_reader` constructors allow the input text to be defined by a `string`, a `FileStream` or a `StreamReader`. However, in the current implementation, regardless of which constructor is used, the input will be read and buffered in a single `string`.

The parser uses the following methods to interrogate the lexeme stream produced by the source reader.

```
internal bool symbol_is(Type kind)
```

Indicates if the current `lexeme` have the specified `Type`, e.g. `identifier`.

```
internal bool symbol_is(Type kind, string spelling)
```

Indicates if the current lexeme has the specified `Type` and `spelling`, e.g. `punctuation` with `spelling "!="`.

```
internal bool accept(Type kind)
```

If the current `lexeme` has the specified `Type` returns `true` and moves on to the next `lexeme` in the input. Otherwise returns `false`.

```
internal bool accept(Type kind, string spelling)
```

If the current `lexeme` has the specified `Type` and `spelling` returns `true` and moves on to the next `lexeme` in the input. Otherwise returns `false`.

```
internal void next_symbol()
```

Unconditionally moves on to the next lexeme in the input.

```
public void reset()
```

Moves to the first lexeme in the input. Not required after initial creation of the `source_reader`.

2. Grammar analysis

The details of the grammar represented by the `parsable` classes reachable from the initial call of `parsable.parse` or `parsable.define` are stored in a set of static fields belonging to the `parsable` class.

```
internal static Dictionary<string, production> productions;
internal static List<string>                   symbols;
internal static List<string>                   words;
internal static Stack<bool>                    checking_left_recursion_state;
internal static bool                           checking_left_recursion;
```

The dictionary of `productions` associates the name of each `parsable` class with a production (grammar definition). The name used is the short name of the type, e.g. `tree`. The two lists of strings are used to hold any punctuation symbols and reserved words discovered in field definitions marked with the `Parse` attribute. Before parsing begins, these two lists will be passed to the source_reader to allow it distinguish reserved words from identifiers and to know the set of valid punctuation symbols.

The `checking_left_recursion_state` and the `checking_left_recursion` fields are used by the algorithm used to check if productions are left recursive. This will be described later.

3. The grammar classes

As stated previously each production is associated with one or more alternatives and each alternative is represented by a sequence of components. The `production` class contains a list of alternatives described by the `alternative` class. The `alternative` class contains a list of components. The `component` base class is inherited by each of the specific component classes, e.g. `identifier_component`, `number_component` etc. All of these classes support the same basic set of functions and have fields for storing their first sets and indicating if they may match empty sequences in the input, e.g. an optional or iterated component. The classes representing productions and alternatives support similar operations but do not inherit from `component` because they have slightly different requirements.

```
internal class component
{
  public lexeme_set firsts;
  public bool       maybe_empty;

  protected component()..

  public virtual void analyse()...

  public virtual void parse(source_reader source)...

  public delegate FieldInfo get_field_info();

  public virtual void unparse_object(parsable o, get_field_info get_field, source_builder source)...

  public virtual void unparse(source_builder source)...
}
```

The `analyse` method is used recursively starting from the `production` associated with the top level `parsable` type. A `production` applies it to all of its alternatives. An `alternative` applies it to all its components. A `component` applies it to any sub-components. At the end of this process the `maybe_empty` state, i.e. may specify zero-length sequences, and the `firsts`, i.e. the initial symbols of any component, alternative or production, of every element will be known, assuming the grammar is neither left-recursive nor ambiguous.

The parse method is also applied recursively starting from the top level type. A production chooses an alternative to parse based on the current lexeme available from the source_reader and the firsts of each alternative. If no alternative matches the current lexeme, and no alternatives maybe_empty, a parse_error exception is thrown. Once an alternative has been selected it applies the parse method sequentially to each of its components until the last one is reached or the next lexeme does not match a component, in which case a parse_error exception is thrown.

The unparse_object method is overridden by classes that inherit from component so that they can add appropriate output to the source_builder. The get_field_info function is supplied by the unparse_object method of the alternative class as it iterates through its components. When called by a component, it provides access to the Reflection.FieldInfo for the field associated with the component. In conjunction with the parsable object parameter o this allows the field value to be accessed.

The unparse method is applied recursively from the top level production by calling the parsable.unparse_grammar method to build a formatted text of the whole grammar.

The complete set of component classes is as follows.

Component Class	**Description**
terminal_component	A non-empty component (maybe_empty == false) that must match a specific string of characters.
identifier_component	A non-empty component that matches a characters representing an identifier.
number_component	A non-empty component that matches a characters representing a simple integer number.
real_component	A non-empty component that matches a characters representing a real number possibly containing a decimal point.
reserved_word_component	A non-empty component that must match a specific string of characters representing a reserved_word.
string_literal_component	A non-empty component that matches a string of characters between double quotes.
char_literal_component	A non-empty component that matches a single character between single quotes.
iterated_component<t>	A possibly empty component that matches zero or more strings as defined by the production associated with type t.
optional_component<t>	A possibly empty component that matches zero or one string as defined by the production associated with type t
alt_component	A component that matches one of a set of punctuation symbols or reserved_words that represent values of an enumerated type. If the type includes an empty option the component maybe_empty.
non_terminal_component	A component that matches a string defined by a particular production. If the production maybe_empty, then the component maybe_empty.

4. The alternative class

The following redacted source of the alternative class shows how an alternative determines its firsts and also part of the left-recursion checking algorithm. It also shows that each alternative is associated with a specific Type. This is because alternatives are defined by sub-types of a parsable type. Where sub-types are used this way, a production will only be associated with the parsable base type, but each alternative will be associated with a specific sub-type of that base type. This allows the correct objects to be created as alternatives are selected during parsing.

```
internal class alternative
{
  public List<component> components;
  public lexeme_set      firsts;
  public bool            maybe_empty;
  public Type            alternative_type;

  public alternative(List<component> components, Type alternative_type)...

  public void analyse(production parent)
  {
```

```
    maybe_empty                  = true;
    parent.maybe_left_recursive = true;
    parsable.start_checking_for_left_recursion();
    foreach (var c in components)
    {
      c.analyse();
      if (maybe_empty)
      {
        firsts.insert(c);
        if (!c.maybe_empty)
        {
          maybe_empty                      = false;
          parent.maybe_left_recursive      = false;
          parsable.checking_left_recursion = false;
        }
      }
    }
    parent.maybe_left_recursive = false;
    parsable.end_checking_for_left_recursion();
  }

  public void parse(source_reader source)...

  public void unparse_object(parsable o, source_builder source)...

  public void unparse(source_builder source)...
}
```

Notice that the analyse method only adds components to its firsts until it gets to the first component that may not be empty. There is a static variable checking_left_recursion belonging to the parsable class (see above) that controls the checking of recursive references to productions. Before analysing any of its components the analyse method sets its parent production's state variable parent.maybe_left_recursive to true. If a reference to the parent is encountered while analysing the components of the alternative, and both the parent's maybe_left_recursive variable and the global checking_left_recursion variable are true, then the reference is left recursive and an exception will be thrown. The actual check will happen in the analysis method of the non_terminal_component class. The parsable.start_checking_for_left_recursion method is used to preserve the current state of the global checking_left_recursion variable on the global checking_left_recursion_state stack before setting it to true. This is necessary because recursive calls to analyse the alternatives of other productions may occur while analysing the components of the current alternative.

When the first non-empty component is encountered both the parent's maybe_left_recursive variable and the global checking_left_recursion variable are set to false so that any further recursive references to the parent production do not cause errors. After all the components of the alternative have been analysed, the parsable.end_checking_for_left_recursion() method is used to restore the original state of the global checking_left_recursion variable from the global checking_left_recursion_state stack. The parent's maybe_left_recursive variable is also set to false in case no non-empty component was encountered.

5. The production class

The following redacted version of the production class shows how a production analyses its alternatives and checks to determine if they are ambiguous. A new production is created and associated with each parsable type reachable from the root type. If the associated type has subtypes, the add_alternative method will be use to add their details to the production. Otherwise a single alternative is added based on the fields of the type.

The analyse method uses the defined field to prevent endless recursion when recursive references to the production occur within its definition. It analyses each of its alternatives in sequence. After each alternative has been analysed, its firsts will be defined and these are checked for any intersection with the cumulative firsts of the production itself. If there is an intersection, this indicates that the production's alternatives are ambiguous and an exception is thrown. If there is no intersection, the firsts of the alternative are added to the firsts of the production. In addition the maybe_empty status of the production is updated according to the maybe_empty status of the alternative.

```
internal class production
{
  public Type              t;
  public List<alternative> alternatives;
  public lexeme_set        firsts;
  public bool              maybe_empty;
  public bool              defined;
  public bool              maybe_left_recursive;
  public List<FieldInfo>   fields;

  public production(Type t)...

  public void add_alternative(List<component> components, Type alternative_type)...
```

```
  public void analyse()
  {
    if (!defined)
    {
      defined = true;
      foreach (var a in alternatives)
      {
        a.analyse(this);
        if (a.firsts.intersects(firsts))
          parsable.grammar_error("The alternatives of " + t.Name + " are ambigous");
        firsts.insert(a.firsts);
        maybe_empty = maybe_empty || a.maybe_empty;
      }
    }
  }

  public void parse(source_reader source)...

  public void unparse_object(parsable o, source_builder source)...

  public void unparse(source_builder source, int id_width)...
}
```

6. The `parsable` library public methods

The following redacted version of the `parsable` class shows the top-level methods used to define a grammar starting from the root of the `parsable` object hierarchy.

The `reset` method allows the static variables of the class to be reinitialised to allow multiple grammars to be processed.

The `define` method constructs the grammar objects described previously for some `parsable` type `t` and passes the symbol and reserved word definition discovered in the `parsable` object field attributes to the `source_reader`, which is then reset ready for parsing to begin. If `define` is not called explicitly, it will be called by the `parse` method.

```
public class parsable
{
  internal static Dictionary<string, production> productions;
  internal static List<string>                   symbols;
  internal static List<string>                   words;
  internal static Stack<bool>                    checking_left_recursion_state;
  internal static bool                           checking_left_recursion;
  internal static Stack<object>                  elements;

  public static void reset()...

  public static void define<t>(source_reader source) where t: parsable, new()
  {
    analyse(typeof(t));
    foreach (production p in parsable.productions.Values) p.firsts.flattern();
    source.define_symbols(symbols);
    foreach (string w in words) source.add_reserved_word(w);
    source.reset();
  }

  public static t parse<t>(source_reader source) where t: parsable, new()
  {
    define<t>(source);
    production root = productions[typeof(t).Name];
    root.parse(source);
    if (!source.symbol_is(typeof(punctuation), "<eof>"))
      error("Extra symbols before end of source");
    return (t)elements.Pop();
  }

  public static void unparse_object<t>(t o, source_builder source) where t: parsable, new()...

  public static void unparse_grammar(source_builder source)...

  public static void unparse_firsts(source_builder source)...

  public static void parsed()
  {
  }
}
```

The internal `analyse` method used by `define` is responsible for traversing the `parsable` type hierarchy, constructing one `production` for each type and adding alternatives and their components according to the fields of the `parsable` objects that are marked with the Parse attribute.

```
internal static void analyse(Type definition)
{
  if (!productions.Keys.Contains(definition.Name))
  {
    add_production(definition);
    if (has_parsable_subtypes(definition))
      analyse_parsable_subtypes(definition);
    else if (has_parsable_fields(definition, definition))
      anaylse_parsable_fields(definition, definition);
    else
      grammar_error("Class " + definition.Name + " must have parsable fields or parsable subtypes");
    productions[definition.Name].analyse();
  }
}
```

This method is not only called by define at the top-level, but also for every parsable type reachable from the root type. It checks to see if a production for the type already exists in order to avoid re-analysis of the type due to recursive references. If not it adds a new production object to the list of productions. If the type has nested parsable subtypes the analyse_parsable_subtypes method will iterate through them and add an alternative, with appropriate components, to the new production for each one. If there are no parsable subtypes the anaylse_parsable_fields method iterates through the fields of the type marked with the Parse attribute and adds a single alternative, with the appropriate components, to the new production. If the type has neither parsable subtypes nor fields marked with the Parse attribute, an exception is raised.

7. The parsing process

The parsable class's parse method initiates the parsing process by calling define as described above to build the representation of the grammar. It then selects the production corresponding to its generic type parameter and calls its parse method. If the production's parse method returns without throwing an exception due to a parsing error, the parse method checks that the source_reader has reached the end of the source. If parsing the root production has terminated successfully, the top of the elements stack will contain an object which can be returned as the result of the parse.

```
public void parse(source_reader source)
{
  int alternative_index = 0;
  int elements_parsed   = 0;
  Type element_type     = t;
  if (firsts.can_accept(source) || maybe_empty)
  {
    foreach (var a in alternatives)
    {
      if (a.firsts.can_accept(source) || a.maybe_empty)
      {
        int first_element_index = parsable.elements.Count;
        a.parse(source);
        int final_element_index = parsable.elements.Count;
        elements_parsed = final_element_index - first_element_index;
        element_type    = a.alternative_type;
        break;
      }
      alternative_index = alternative_index + 1;
    }
  }
  else parsable.error("Missing " + t.Name);
  push_result(alternative_index, elements_parsed, element_type);
}
```

If the firsts of the production include the current lexeme available from the source_reader, or the production maybe empty, the parse method iterates through the alternatives until it finds one that can start with the current lexeme. Only one alternative can satisfy this condition as the alternatives are known to be unambiguous by this stage. When the appropriate alternative is found, its parse method will be called. If the alternative can be parsed without throwing an exception because the source does not match the grammar, the push_result method is used to retrieve the values of the fields for this object from the elements stack. Using these it will create a new instance of the type corresponding to the production and assign values to its fields. The new object is then pushed onto the elements stack where it will be used to define other objects.

```
private void push_result(int alternative_index, int elements_parsed, Type element_type)
{
  if (t.Name != element_type.Name) return;
  ConstructorInfo constructor = element_type.GetConstructor(new Type[] { });
  if (constructor != null)
  {
    var parsed_object  = (parsable)constructor.Invoke(new object[] { });
    var field_elements = new Stack<object>();
    for (int i = 1; i <= elements_parsed; i = i + 1) field_elements.Push(parsable.elements.Pop());
```

```
    assign_fields(parsed_object, field_elements, alternative_index);
    parsed_object.parsed();
    parsable.elements.Push(parsed_object);
  }
  else
   parsable.grammar_error
   ("Class " + t.Name + " must have an accessible parameterless, default constuctor");
}
```

The guard at the beginning of push_result is required to handle the case where a subtype of the current production type has just been parsed. For example if some type t ha three subtypes t1, t2 and t3. The grammar analyser will construct a production for t as show below.

```
  <t> ::= <t1> | <t2> | <t3>;
```

If one of the alternatives of <t> is parsed successfully, it will leave an object of the corresponding subtype on the elements stack. At the top-level this could be returned as the result of parsing the type t, or it could be assigned to a field of type t in another object. Creating an instance of the base type t would be superfluous.

The parse method of the alternative class is shown below.

```
public void parse(source_reader source)
{
  foreach (var c in components) c.parse(source);
}
```

This simply iterates through the components of the alternative calling the parse method of each one. If parsing any component fails to match the source, an exception will be thrown. Otherwise and appropriate set of objects representing the result of paring the alternative will be left on the elements stack.

Three representative examples of the parse methods for components are show below. The simplest case is for a component that matches a lexeme with a fixed spelling. In this case a punctuation symbol.

```
public override void parse(source_reader source)
{
  if (!source.accept(typeof(punctuation), spelling)) parsable.error("Missing " + spelling);
}
```

The accept method of source_reader either returns true, if the current lexeme is a punctuation symbol with the required spelling, and advances the source to the next lexeme, or it returns false. The value of spelling is a field of the punctuation_component setup by the grammar analyser from the second parameter of a Parse attribute associated with a field of type punctuation in a parsable class.

When a component matches some string without a fixed spelling it is necessary to return a value on the elements stack representing the details. Two examples are show below. The first is the parse method for the identifier_component class, in which case the identifier lexeme containing the actual spelling of the identifier is returned.

```
public override void parse(source_reader source)
{
  if (source.symbol_is(typeof(identifier)))
  {
    parsable.elements.Push(source.current);
    source.next_symbol();
  }
  else parsable.error("Missing identifier");
}
```

The second case shows the parse method of the number_component class. This parses the string recognised as a number into an int value and returns it on the elements stack.

```
public override void parse(source_reader source)
{
  if (source.symbol_is(typeof(number)))
  {
    parsable.elements.Push(int.Parse(((number)source.current).spelling));
    source.next_symbol();
  }
  else parsable.error("Missing number");
}
```

The final example of a component parse method shows the non_terminal_component parse method. In this case the non_terminal_component class has a field of type production called definition. The grammar analyser will have set this field to a reference to the appropriate production so that its parse method, as described above, can be called here This will result in an object of the type associated with the production being pushed onto the elements stack.

```
public override void parse(source_reader source)
{
  definition.parse(source);
}
```

8. The lexeme_set class

An important part of grammar analysis is the construction of first sets for productions, alternatives and components. First sets are represented by instances of the lexeme_set class. An outline of the lexeme_set class is shown below. The fields of the class store the various kinds of elements included in a set. A list of symbols maintains all of the spellings of all the punctuation symbols contained in a set. A list of words contains the spellings of all the reserved_words, and a set of boolean values indicate if a set contains a number, real number, identifier, string literal or character literal.

A set is created with these lists empty and all the boolean values set to false, i.e. the set as a whole is empty. Values are added via the insert methods. In the simplest case a terminal_component representing a punctuation symbol might be inserted into the set. This would cause its spelling to be added to the list of symbols if it were not already present. Similarly inserting a reserved_word_component would add its spelling to the list of words if it were not already present. Inserting an identifier_component would set the contains_id field to true, and so on. It is also possible to insert all the elements of another set. Again no elements are duplicated. This is required in the definition of a production where the firsts of all its alternatives must be inserted into firsts of the production.

Where the definition of a production starts with a non_terminal_component, i.e. a reference to another production, the firsts of the referenced production may not be defined until later in grammar analysis. To handle this case the lexeme_set class keeps a list of unique productions whose firsts are required to be included in a set.

The intersects method is used to check that the alternatives of a production are not ambiguous. As each alternative is defined within a production a check is made to see if its firsts intersect, i.e. contain common elements, with the cumulative firsts of the parent production.

During parsing the can_accept method is used to determine if the current lexeme available from the source_reader is contained in a lexeme_set.

The flatten method is used at the end of grammar analysis when the firsts of all productions are known. It inserts the firsts of each of the productions in the set's productions list and then clears the list. This allows the can_accept method to be executed while parsing using only the simple symbols and words lists and the boolean fields without having to check the firsts of productions recursively.

```
class lexeme_set
{
  private List<string>     symbols;
  private List<string>     words;
  private List<production> productions;
  private bool             contains_number;
  private bool             contains_real;
  private bool             contains_id;
  private bool             contains_string;
  private bool             contains_char;

  public lexeme_set()...

  public void insert(component c)...

  public void insert(lexeme_set s)...

  public void insert(production p)...

  public bool intersects(lexeme_set s)...

  public bool can_accept(source_reader source)...

  public void flattern()...

  public string unparse()...
}
```

9. The source_builder class

The source_builder class implements a wrapper for the C# StringBuilder class and provides facilities for generating multi-line text with controlled indentation. It can be used in conjunction with the following interface defined by the library. Classes which inherit from parsable can also implement the unparsable interface to allow the original text to be regenerated after parsing, or to generate an alternative textual representation from the input.

```
public interface unpasable
{
  void unparse(source_builder source);
}
```

By itself, the `source_builder` class allows textual representations of a number of standard types, e.g. `string`, `int` and `double`, to be added to the output text. Textual representations of other types can be added by first converting them to strings. Text can also be added from files. The generated text is extracted by using the `ToString` method.

```
public class source_builder
{
  public int  indentation_size {get; set;}
  public bool single_line      {get; set;}

  public source_builder()...

  public void reset()...

  public override string ToString()...

  public void write(string value)...

  public void write_file(string path)...

  public void write(bool value)...

  public void write(int value)...

  public void write(double value)...

  public void new_line()...

  public void new_line(int n)...

  public void indent()...

  public void outdent()...

  public void indent(int indentation_size)...

  public void outdent(int indentation_size)...

  public void write(int index, params string[] values)...

  public delegate void action<t>(t e);

  public void iterate<t>(List<t> ts, action<t> writer)...

  public void separate<t>(List<t> ts, action<t> writer, string separator)...

  public void separate_lines<t>(List<t> ts, action<t> writer, int lines)...
}
```

The `reset` method clears any text that has already been generated. It is called automatically when a new `source_builder` is created but may be called subsequently to start a new text. The `new_line` method allows one or more new lines to be inserted into the output. Nested indentation is controlled by the `indent` and `outdent` methods. The following example shows how this works. Each call of `indent` should be matched by a call of `outdent` and these calls should occur before the next call of `new_line` where the indentation change is required.

```
source.write("{");
  source.indent();
  source.new_line ();
  source.write("one();");
  source.new_line ();
  source.write("two();");
  source.new_line ();
  source.outdent();
source.write("}");
```

This example would cause the following text to be generated.

```
{
  one();
  two();
}
```

Spaces are used to generate indentation, and the number of spaces is controlled by the `indentation_size` property which by default is 2. There are variants of the `indent` and `outdent` methods that allow the `indentation_size` to be overridden. Matching calls of these methods should generally specify the same indentation size, e.g. `indent(7); …; outdent(7);` Temporarily setting the `single_line` property to `true` allows any multi-line formatting to be suppressed. This includes both newlines and indentation.

There are a number of methods designed to work with sequences of values. The following example would add the (zero-based) nth parameter `string` to the text. The string ??? is added if `n` is out of range.

```
source.write(n, "plus", "minus", "times", "divide");
```

Alternatively the string may be extracted from an array. The following would add the same text as the previous example.

```
string[] operators = new string[]{"plus", "minus", "times", "divide"};
source.write(n, operators);
```

The `iterate`, `separate` and `separate_lines` methods work with lists in conjunction with the `action` delegate. By way of an example a list of objects that implement the `unparsable` interface might be unparsed as follows.

```
List<unpasable> elements = …
source.iterate(elements, (e) => e.unparse(source));
```

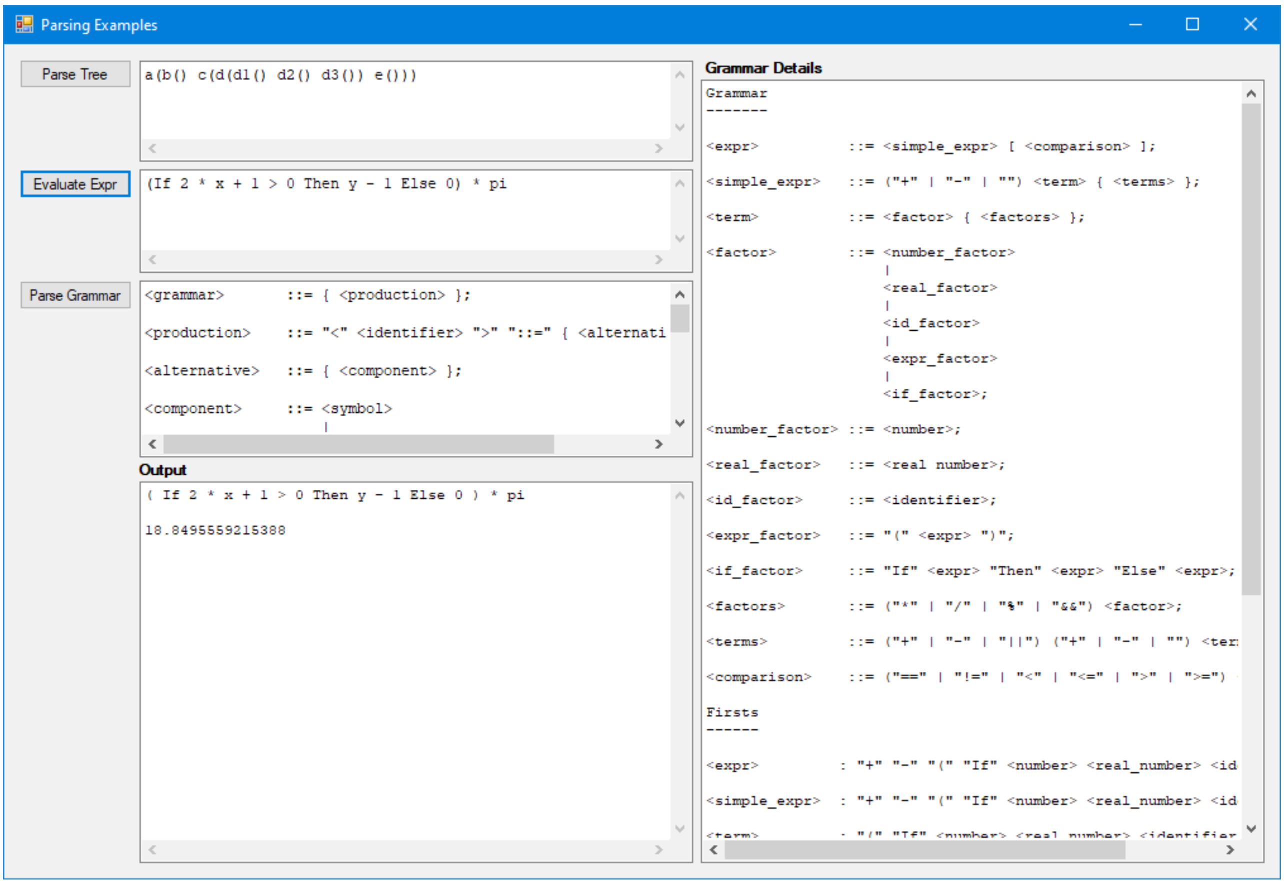
The previous example could have been accomplished using the `Linq` `foreach` method, however the following examples show how formatting can be inserted between `unparsable` elements. To insert new lines between, but not before or after, a list of elements the `separate_lines` method can be used.

```
List<unpasable> elements = …
source.separate_lines(elements, (e) => e.unparse(source));
```

To insert a specific separator between elements, the `separate` method can be used. The following example would add a bracketed, comma separated list of elements to the output. This assumes that each element `unparses` into text without new lines. If elements `unparse` into multi-line text, a more complex unparsing strategy, possibly involving indentation, would be required.

```
List<unpasable> elements = …
source.write("(");
source.separate(elements, (e) => e.unparse(source), ", ");
source.write(")");
```

10. Examples



The Examples folder contains a complete program which includes three different examples that can be run from the single form show below. The Parse Tree button loads the tree class described in the Reflexive introductory pdf document. It then parses the text in the box to the right of the button. A textual representation of the grammar constructed from the tree class and the first set for trees are displayed in the Grammar Details box and the output from unparsing the resulting tree objects is displayed in the output box.

The Evaluate Expr button loads classes representing expressions similar to those found in many programming languages. These are organised such that the resulting grammar defines the precedence of the operators involved. It then parses an expression from the text in the box to its right. Each of the resulting objects supports an interface called `evaluator` that allows it to be evaluated. To simplify the example no type checking is performed, but this would be easy to add via another interface. The full grammar and firsts for each of the productions are displayed and the result of evaluating the expression is displayed in the output box.

The Parse Grammar button loads classes representing grammars similar, but not identical to, those used by the system itself. It then parses the text in the box to its right and unparses the result into the output box.

The example program and the library itself are backward comparable (look it up!) to .Net Framework 3.5 and can be build with VS2008 or later.