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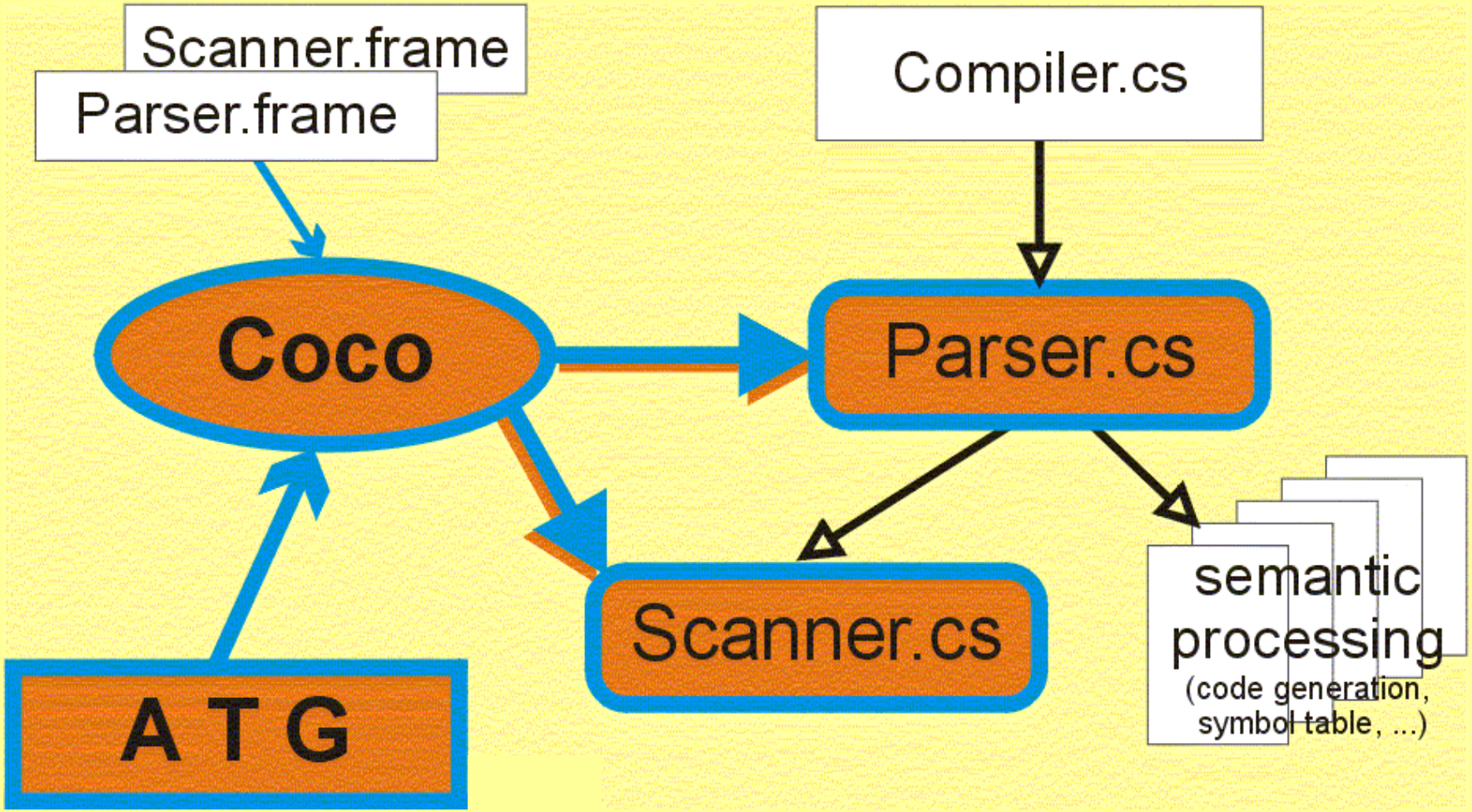
Compiler Generation Tools for C#

What's Coco/R?
What's the Project?

- *Coco/R*:
  - is an **easy-to-use** compiler generator
  - *Input:* attributed, context-free EBNF grammar
  - *Output:* **scanner &** recursive descent **parser**

- *"Compiler Generation Tools"* Project:
  - Extension of Coco/R
    - to use Coco/R for non-LL(1) grammars
    - to use semantic information to resolve LL(1) conflicts
  - ATG template for C#
    - provides complete parsing facilities for C# programs
    - add attributes and semantic actions for customized applications

Architecture of Coco/R



Coco/R 2.0b - What's new?

- **LL(1) conflict resolution**
  - new keyword: **IF (** *boolean expression* **)**
  - peek functionality in Scanner
- user-defined names for tokens
  - new keyword: **TOKENNAMES**
- user-defined namespace for generated types
  - new keyword: **NAMESPACE**

NAMESPACE

CSharp.atg

```
using System.Collections;
NAMESPACE at.jku.ssw.Coco
COMPILER CS
...
```

Scanner.cs

```
using System.Collection;
namespace at.jku.ssw.Coco {
  public class Token {...}
  public class Buffer {...}
  public class Scanner {...}
  public class Errors {...}
}
```

Parser.cs

```
using System.Collections;
namespace at.jku.ssw.Coco {
  public class Tokens {...}
  public class Parser {...}
}
```

LL(1) Conflicts

- LL(1) conflicts:
  - explicit alternatives: e.g. `A = a b | a c.`
  - options: e.g. `A = [ a ] a b.`
  - iterations: e.g. `A = { a } a b.`

- Conflict resolution:
  - factorization:
    e.g. `A = ab | ac.` ⇨ `A = a ( b | c ).`
  - transform left recursion into iteration:
    e.g. `A = Ab | c.` ⇨ `A = c { b }.`

LL(1) Conflicts (cont.)

- Conflict resolution (cont.):

  but sometimes transformations

  - **do not help**

```
IdentList = ident { "," ident } [ "," ].
```

  - **are undesireable**

```
UsingClause = "using" [ ident "=" ] Qualident ";".
Qualident   = ident { "." ident }.
```

```
UsingClause = "using" ident ( { "." ident }
                            | "=" Qualident
                            ) ";" .
```

Conflict Resolvers

CSharp.atg

```
COMPILER CS
...
static bool NotFinalComma () {
  Scanner.StartPeek();
  return la.kind == Tokens.Comma &&
         Scanner.Peek().kind == Tokens.Ident;
}
...
PRODUCTIONS
...
IdentList
= ident { IF (NotFinalComma())
          "," ident
        } [ "," ] .
...
```

in Parser.cs

```
static void IdentList () {
  Expect(ident);
  while (NotFinalComma()) {
    Expect(",");
    Expect(ident);
  }
  if (la.kind == ",") Get();
}
```

Peek functionality

CSharp.atg

```
COMPILER CS
...
static bool NotFinalComma () {
  Scanner.StartPeek();
  return la.kind == Tokens.Comma &&
         Scanner.Peek().kind == Tokens.Ident;
}
...
```

Scanner Interface:

public static Token Scan ()

... returns next token, moves current token & peek token ahead

public static Token Peek ()

... returns next peek token, moves peek token ahead (***not*** current token)

public static Token StartPeek ()

... makes sure peeking starts from current token

TOKENNAMES

CSharp.atg

```
COMPILER CS
...
static bool NotFinalComma () {
  Scanner.StartPeek();
  return la.kind == Tokens.Comma &&
         Scanner.Peek().kind == Tokens.Ident;
}
...
TOKENNAMES
  "," = Comma
  ident = Ident
  "(" = LPar
  ")" = RPar
  ...
```

in Parser.cs

```
public class Tokens () {
  public const int Comma = 2;
  public const int Ident = 1;
  public const int LPar = 3;
  public const int RPar = 4;
  ...
}
```

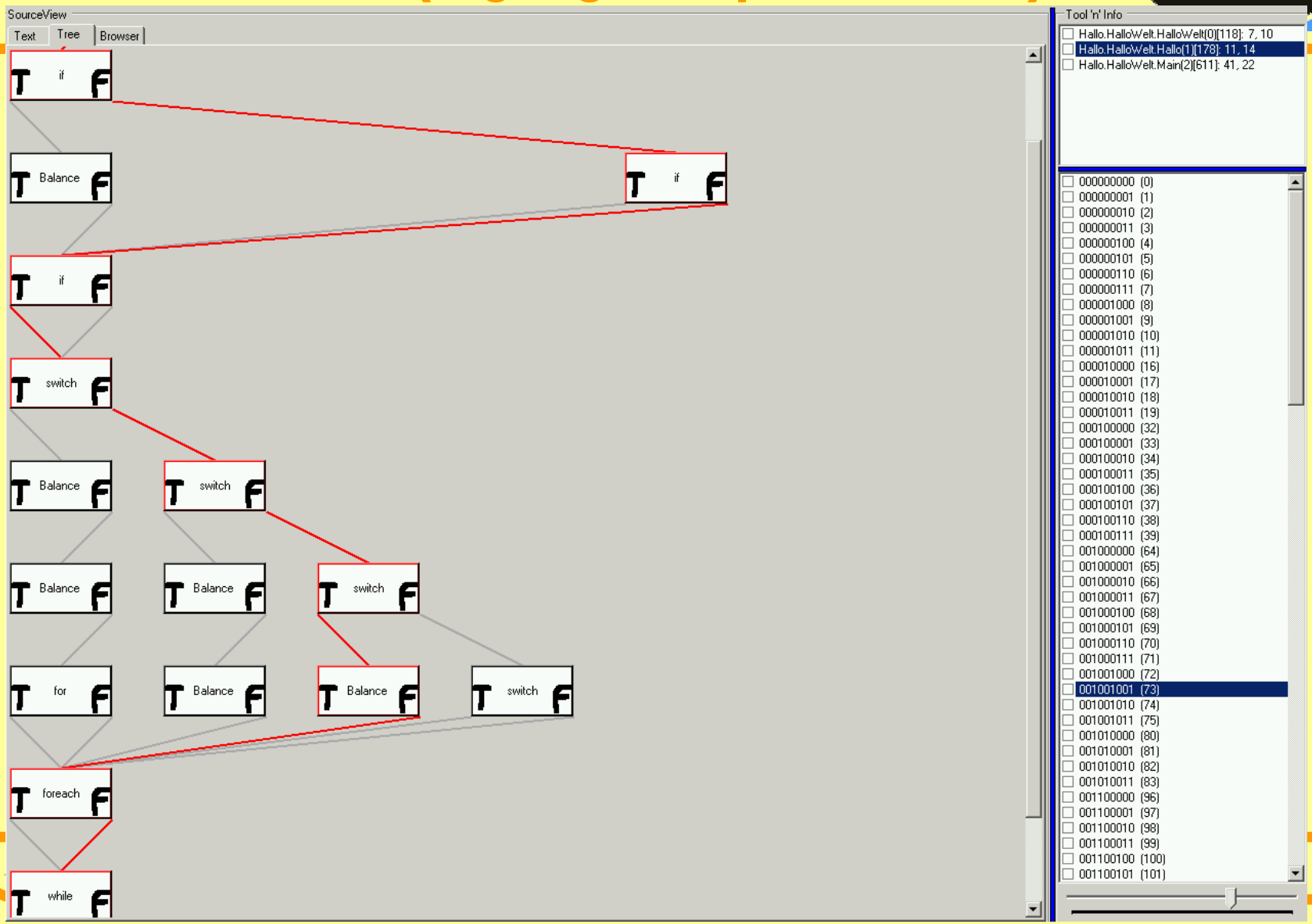
Applications (on-going projects)

- White-Box-Testing Tool
- CodeDOM-Parser (System.CodeDom.Compiler.ICodeParser)
- C#-Source-Code-Analyzer
  - gathers static information about a program
    - Lines of Code (with / without comments)
    - Number of instructions, selections, loops, method calls, ...
    - Complexity measures: McCabe, Rechenberg, ...
    - ...
- Online-C#-Syntaxhighlighter (produces HTML)
  - at http://dotnet.jku.at/applications/cs2html
  - major update coming soon!

White-Box-Testing Tool

- supports testing by measuring and visualizing **path coverage** of test runs
- client/server architecture via HTTP
  - client: WBT tool
  - server: instrumented program under test
- instruments C# source code (*with Coco/R generated parser*) to log covered paths
- visualizes the paths in
  - a control flow graph
  - the source code

WBT Tool (highlighted path in CFG)



WBT Tool (highlighted path in code)

SourceView

Text | Tree | Browser

```
public int Hallo() {
      if (a && b) {
            Console.WriteLine("Hallo Welt!");
      }
      else if (a || d) {

      }
      if (b && d) {

      }

      switch (i) {
            case 1 : case 2 :       for (int j=0;
            case 3 : break;
            case 4 : break;
            default : break;
      }


      foreach(char c in "test") {
            Console.WriteLine(c);
      }

      while (i<23) {
            i++;
      }

      return i;
```

Methods 'n' Paths

- [ ] Hallo.HalloWelt.HalloWelt(0)[119]: 7, 10
- [x] Hallo.HalloWelt.Test(1)[182]: 12, 15
- [ ] Hallo.HalloWelt.Hallo(2)[270]: 20, 14
- [ ] Hallo.HalloWelt.Main(3)[703]: 50, 22

- [ ] 100000111 (263)
- [ ] 100001000 (264)
- [ ] 100001001 (265)
- [ ] 100001010 (266)
- [ ] 100001011 (267)
- [ ] 100010000 (272)
- [ ] 100010001 (273)
- [ ] 100010010 (274)
- [ ] 100010011 (275)
- [ ] 100100000 (288)
- [ ] 100100001 (289)
- [ ] 100100010 (290)
- [ ] 100100011 (291)
- [ ] 100100100 (292)
- [ ] 100100101 (293)
- [ ] 100100110 (294)
- [ ] 100100111 (295)
- [ ] 101000000 (320)
- [ ] 101000001 (321)
- [ ] 101000010 (322)
- [ ] 101000011 (323)

Plans for WBT Tool

- use CodeDOM-Tree
  - as model for visualization
  - to do instrumentation there
- improve path visualization
- redesign GUI
- single process (instead of client/server architecture) to
  - increase speed
  - simplify usage

Links

- Main Project Site:
  http://dotnet.jku.at/Projects/Rotor
- Rotor Community Site Project "cocotools":
  http://cocotools.sscli.net
- Questions, comments, ... ?

Thanks to
Werner Vogels & Co.

Screenshot: cocotools.sscli.net