6. Structured Output

Generator outputs structured text:

- programm in a suitable programming language
- data in suitable form (e.g. XML) to be processed by specific tools
- text in suitable form (e.g. HTML) to be presented by a text processor

Transformation phase of the generator defines the structure of the texts:

- parameterized text patterns
- instances of text patterns hierarchally nested

a text pattern with 2 parameters:

#define ☐ **Kind** ☐

2 instances:

#define intKind 1

#define PairPtrKind 2

```
#ifndef WRAPPER_H
#define WRAPPER_H

#include "Pair.h"

#define noKind      0
#define intKind 1
#define PairPtrKind 2
#define floatKind 3
class intWrapper;
class PairPtrWrapper;
class floatWrapper;
class Object {
public:
  class WrapperExcept {};
  int getKind () { return kind; }

  int getintValue ();
  PairPtr getPairPtrValue ();
  float getfloatValue ();
protected:
  int kind;
};
```


Lecture Generating Software from Specifications WS 2013/14 / Slide 601

Objectives:

Motivate patterns in structured texts

In the lecture:

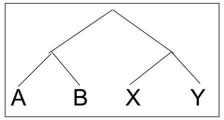
The topics of the slides are explained:

- different kinds of target texts,
- patterns in the output of the Wrapper Generator

„Structure Clash“ on Text Output

abstract program tree
drives creation of the target text by a tree walk

target text
is composed of fragments



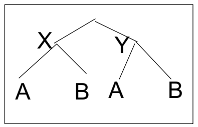
tree walk **order does not fit** to sequence of target text fragments

X A B Y A B

solution: text is composed into a buffer, and sequentially written from there

here:

the buffer is a tree or DAG representing pattern applications



Lecture Generating Software from Specifications WS 2013/14 / Slide 602

Objectives:

Recognize the structure clash

In the lecture:

The topics of the slides are explained

PTG: Pattern-Based Text Generator

Generates **constructor functions** from **specifications of text patterns**

A. PTG provides a Specification language for text patterns
each is a sequence of text fragments and insertion points

```
#define int Kind 1
```

B. PTG generates constructor functions
that build a data structure of pattern applications

one function per pattern
one parameter per insertion point

The functions are called on the tree walk.

C. PTG generates output functions
they walk recursively through the data structure to output the target text

Lecture Generating Software from Specifications WS 2013/14 / Slide 603

Objectives:

Identify the tasks of PTG

In the lecture:

User specifies "what" - PTG implements "how":

- apply a pattern,
- build the data structure,
- output the data structure.

PTG's Specification Language: Introductory Example

Pattern: named sequence of C string literals and insertion points

```
KindDef:
   "#define " $ string "Kind \t" $ int "\n"

WrapperHdr:
   "#ifndef WRAPPER_H\n"
   "#define WRAPPER_H\n\n"
   $1 /* Includes */

   "\n#define noKind      0\n"
   $2 /* KindDefs */
   "\n"

   $3 /* ClassFwds */
   "\n"

   "class Object {\n"
   "public:\n"
   "  class WrapperExcept {};\n"
   "  int getKind () { return kind; }\n"
   $4 /* ObjectGets */
   "protected:\n"
   "  int kind;\n"
   "};\n\n"
```

```
#define int Kind 1
```

```
#ifndef WRAPPER_H
#define WRAPPER_H

#include "Pair.h"

#define noKind      0
#define intKind 1
#define PairPtrKind 2
#define floatKind 3

class intWrapper;
class PairPtrWrapper;
class floatWrapper;

class Object {
public:
 class WrapperExcept {};
 int getKind () { return kind; }

 int getintValue ();
 PairPtr getPairPtrValue ();
 float getfloatValue ();
protected:
 int kind;
};
```


Lecture Generating Software from Specifications WS 2013/14 / Slide 604

Objectives:

First idea of the specification language

In the lecture:

Properties of the language

- simple and easy to understand,
- close to intended result.

Constructor Functions

A **constructor function** for each pattern.

A parameter for each insertion point:

```
PTGNode PTGKindDef (char *a, int b) {...}

PTGNode PTGWrapperHdr (PTGNode a, PTGNode b, PTGNode c, PTGNode d)
   {...}
```

Call of a constructor function

- creates an instance of the pattern with the supplied arguments and
- yields a reference to that instance

```
ik = PTGKindDef ("int", 1);

hdr = PTGWrapperHdr (ik, xx, yy, zz);
```

The arguments of calls are such references (type **PTGNode**) or they are values of the type specified in the pattern (e. g. string or int)

Such calls are used to **build the data structure bottom-up.**
It is acyclic, a DAG.

Lecture Generating Software from Specifications WS 2013/14 / Slide 605

Objectives:

Use of constructor functions

In the lecture:

The following topics are explained

- Signature,
- types of parameters and insertion points,
- calls build the data structure.

Output Functions

Predefined output functions:

- Call:

  ```
  PTGOutFile ("example.h", hdr);
  ```

  initiates a recursive walk through the data structure
  starting from the given node (2nd argument)
- All text fragments of all pattern instances are output in the specified order.
- Shared substructures are walked through and are output on each visit from above.
- User defined functions may be called during the walk, in order to cause side-effects (e.g. set and unset indentation).

Lecture Generating Software from Specifications WS 2013/14 / Slide 606

Objectives:

Understand automized output

In the lecture:

The topics of the slide are explained

Important Techniques for Pattern Specification

Elements of pattern specifications:

- string literals in C notation `"Value ();\n"`
- value typed insertion points `$string` `$int`
- untyped insertion points (**PTGNode**) `$` `$1`
- comments in C notation `$ /* Includes */`
  e.g. to explain the purpose of insertion points

All charaters that **separate tokens** in the output and that **format the output** have to be **explicitly specified** using string literals `" "` `";\n"` `"\tpublic:"`

Identifiers can be augmented by prefixes or suffixes:

```
KindDef: "#define "$ string "Kind \t" $ int "\n"
```

may yield

```
#define PairPtrKind    2
```

There are advanced techniques to create „pretty printed“ output (see PTG documentation).

Objectives:

Learn fundamenteal pattern techniques

In the lecture:

The topics of the slide are explained.

Important Techniques: Indexed Insertion Points

Indexed insertion points: `$1` `$2 ...`

1. Application: **one argument is to be inserted at several positions**:

```
ObjectGet: "  " $1 string " get" $1 string "Value ();\n"
```

call: `PTGObjectGet ("PairPtr")` result: `PairPtr getPairPtrValue ();`

2. Application: **modify pattern - use calls unchanged**:

today: `Decl: $1 /*type*/ " " $2 /*names*/ ";\n"`

tomorrow: `Decl: $2 /*names*/ ": " $1 /*type*/ ";\n"`

unchanged call: `PTGDecl (tp, ids)`

Rules:

- If n is the greatest index of an insertion point the constructor function has n parameters.
- If an index does not occur, its parameter exists, but it is not used.
- The order of the parameters is determined by the indexes.
- Do not have both indexed and non-indexed insertion points in a pattern.

Objectives:

Learn to use indexed insertion points

In the lecture:

The topics of the slide are explained.

Important Techniques: Typed Insertion Points

Untyped insertion points: `$` `$1`

Instances of patterns are inserted, i.e. the results of calls of constructor functions
Parameter type: **`PTGNode`**

Typed insertion points: `$ string` `$1 int`

Values of the given type are passed as arguments and output at the required position
Parameter type as stated, e.g. **`char*`**, **`int`**, or other basic types of C

```
KindDef: "#define " $ string "Kind \t" $ int "\n"
```

call: `PTGKindDef ("PairPtr", 2)`

Example for an application: generate identifiers

```
KindId:      $ string "Kind"           PTGKindId("Flow")
CountedId:   "_" $ string "_" $ int    PTGCountedId("Flow", i++)
```

Example for an application: conversion into a pattern instance

```
AsIs:   $ string   PTGAsIs("Hello")
Numb:   $ int      PTGNumb(42)
```

Rule:

- **Same index** of two insertion points **implies the same types**.

Lecture Generating Software from Specifications WS 2013/14 / Slide 609

Objectives:

Learn to use typed insertion points

In the lecture:

The topics of the slide are explained.

Important Techniques: Sequences of Text Elements

Pairwise concatenation:

```
Seq: $ $            PTGSeq(PTGFoo(...),PTGBar(...))
                    res = PTGSeq(res, PTGFoo(...));
```

The application of an empty pattern yields `PTGNULL`

```
PTGNode res = PTGNULL;
```

Sequence with optional separator:

```
CommaSeq:  $ {", "} $            res = PTGCommaSeq (res, x);
```

Elements that are marked optional by **`{}`** are not output,
if at least one insertion has the value **`PTGNULL`**

Optional parentheses:

```
Paren:  {"("} $ {")"}
```

no **`( )`** around empty text

The Eli specification **`$/Output/PtgCommon.fw`** makes some of these useful pattern definitions available: **`Seq, CommaSeq, AsIs, Numb`**

Lecture Generating Software from Specifications WS 2013/14 / Slide 610

Objectives:

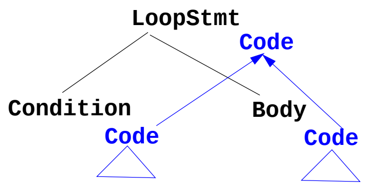
Create sequences of text elements

In the lecture:

The topics of the slide are explained.

Compose Target Text in Adjacent Contexts

Attributes in adjacent tree contexts




```
ATTR Code: PTGNode;

RULE: LoopStmt ::= Condition Body COMPUTE

   LoopStmt.Code =
      PTGWhile (Condition.Code, Body.Code);

END;
```

Application of the **While** pattern

Lecture Generating Software from Specifications WS 2013/14 / Slide 611

Objectives:

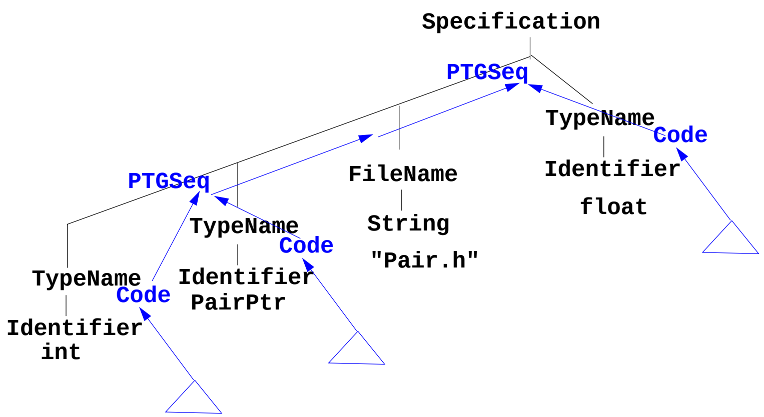
Compose text bottom-up

In the lecture:

Pattern instantiation as computation in tree context

Compose Subtree Elements

Example wrapper generator; consider abstract program tree for some input:
Specification is a sequence of tree nodes of type **TypeName** and **FileName**



Attributes **TypeName.Code** contain references to created pattern applications; they are composed by **PTGSeq** applications.

Lecture Generating Software from Specifications WS 2013/14 / Slide 612

Objectives:

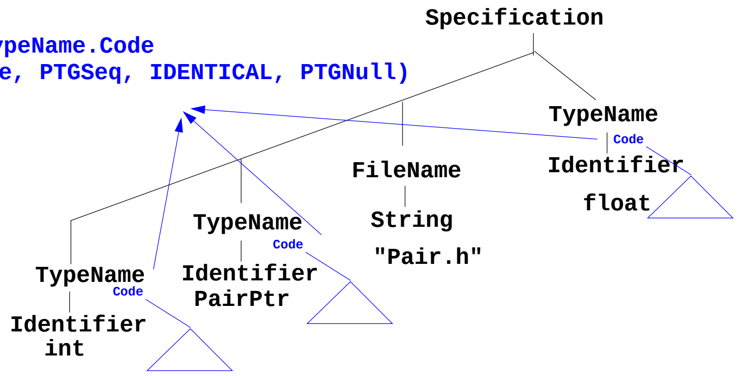
Compose sequences

In the lecture:

Recall example wrapper generator

CONSTITUENTS Composes Attributes of a Subtree

```
CONSTITUENTS TypeName.Code
   WITH (PTGNode, PTGSeq, IDENTICAL, PTGNull)
```



CONSTITUENTS composes **TypeName.Code** attributes of the subtree

	WITH (PTGNode,	PTGSeq,	IDENTICAL,	PTGNull)
Meaning:	type	dyadic composition function	monadic composition function	constant function for optional subtrees

Lecture Generating Software from Specifications WS 2013/14 / Slide 613

Objectives:

Compose sequences using CONSTITUENTS

In the lecture:

Recall CONSTITUENTS technique

- access attributes of a subtree
- composition functions
- scheme reused for PTG text composition