1. Introduction
Domain-Specific Knowledge

A **task**: „Implement a program to store collections of words, that describe animals“

Categories of knowledge required to carry out a task:

General: knowledge applicable to a wide variety of tasks
e.g. English words; program in C

Domain-specific: knowledge applicable to all tasks of this type
e.g. group word in sets;
implement arbitrary numbers of sets of strings in C

Task-specific: knowledge about the particular task at hand
e.g. sets of words to characterize animals

A domain-specific language is used to describe the particular task

A domain-specific generator creates a C program that stores the particular set of strings.

Example for a Domain-Specific Generator

Input: collection of words:

```
colors{red blue green}
bugs{ant spider fly moth bee}
verbs{crawl walk run fly}
```

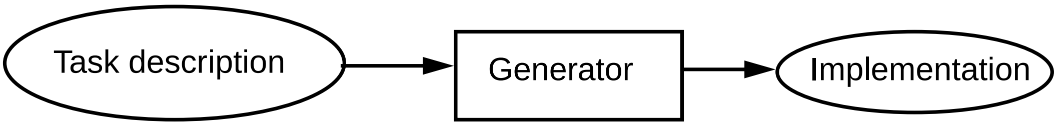
Output: C header file:

```
int number_of_sets = 3;

char *name_of_set[] = {
"colors",
"bugs",
"verbs"};

int size_of_set[] = {
3,
5,
4};

char *set_of_colors[] = {
"red",
"blue",
"green"};

char *set_of_bugs[] = {
"ant",
"spider",
"fly",
"moth",
"bee"};

char *set_of_verbs[] = {
"crawl",
"walk",
"run",
"fly"};

char **values_of_set[] = {
set_of_colors,
set_of_bugs,
set_of_verbs};
```

- simple domain-specific description
- errors easier to detect in the domain-specific description
- a number of tasks of the same kind
- constraints on representation using general knowledge require a more complex and detailed description (implementation)
- consistency conditions in the representation using general knowledge are difficult to check

GSS-1.3

The Generator Principle



Application generator: the most effective reuse method

[Ch. W. Kruger: Software Reuse]

narrow, specific application domain

completely understood
Implementation automatically generated

Abstractions on a high level
(using domain knowledge)

transformed into executable software

User understands
abstractions of the application domain

Generator expert understands
implementation methods

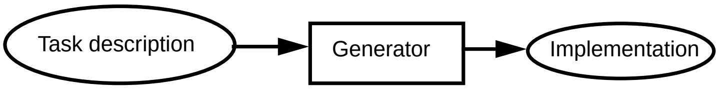
wide cognitive distance
generator makes expert knowledge available

Examples:

Data base report generator
GUI generator
Parser generator

GSS-1.4

Domain-Specific Languages for Generators



Domain-specific languages (DSL)

Domains outside of informatics
- Robot control
- Stock exchange
- Control of production lines
- Music scores

Software engineering domains
- Data base reports
- User interfaces
- Test descriptions
- Representation of data structures (XML)

Language implementation as domain
- Scanner specified by regular expressions
- Parser specified by a context-free grammar
- Language implementation specified for *Eli*

Some GSS Projects

Party organization
Soccer teams
Tutorial organization
Shopping lists
Train tracks layout

LED descriptions to VHDL
SimpleUML to XMI
Rule-based XML transformation

Generator: **transforms a specification language**
into an executable **program or/and into data,**
applies domain-specific methods and techniques

Reuse of Products

Product	What is reused?
Library of functions	Implementation
Module, component	Code
generic module	Planned variants of code
Software architecture	Design
Framework	Design and code
Design pattern	Strategy for design and construction
Generator	Knowledge, how to construct implementations from descriptions
Construction process	Knowledge, how to use and combine tools to build software

Ch. W. Kruger: Software Reuse, ACM Computing Surveys, 24(2), 1992

R. Prieto-Diaz: Status Report: Software reusability, IEEE Software, 10(3), 1993

Organisation of Reuse

How	Products	Consequences
ad hoc	• Code is copied and modified • adaptation of OO classes incrementally in sub-classes	• no a priori costs • very dangerous for maintanance
planned	• oo libraries, frameworks • Specialization of classes	• high a priori costs • effective reuse
automatic	• Generators, intelligent development environments	• high a priori costs • very effective reuse • wide cognitive distance

Roles of Provider and Reuser

Reusable products are

- Constructed and prepared for being reused. Role: provider
- Reused for a particular application. Role: reuser

Provider and reuser are on the **same level of experience:**

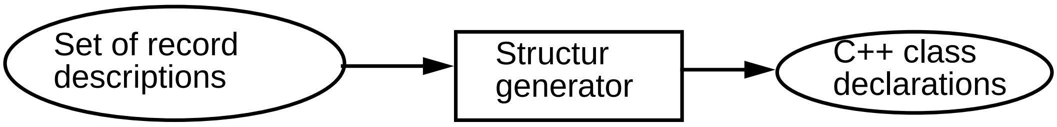
- The **same person**, group of persons, profession
- Provider assumes his own level of understanding for the reuser
- Examples: reuse of code, design patterns

Provider is an **expert, reusers** are **amateurs:**

- Reuse bridges a **wide cognitive distance**
- **Expert knowledge** is made available for **non-experts**
- Application domain has to be **completely understood** by the expert; **that knowledge is then encapsulated**
- Requires domain-specific **notions on a high level**
- Examples: Generators, frameworks, intelligent development environments

Project: Structure Generator (Lect. Ch. 8, Book Ch. 7)

Generator implements described record structures
useful tool in **software construction**



```
Customer ( addr:      Address;
           account:   int; )

Address (  name:   String;
           zip:    int;
           city:   String; )

import String from "util.h"
```

```
#include "util.h"

typedef class Customer_Cl *Customer;
typedef class Address_Cl *Address;

class Customer_Cl {
   private:
     Address addr_fld;
     int account_fld;
   public:
     Customer_Cl
        (Address addr, int account)
     {  addr_fld=addr;
        account_fld=account; }
...
};
```

GSS-1.9

Task Decomposition for the Implementation of Domain-Specific Languages

Structuring	**Lexical analysis**	**Scanning** **Conversion**
	Syntactic analysis	**Parsing** **Tree construction**
Translation	**Semantic analysis**	**Name analysis** **Property analysis**
	Transformation	**Data mapping** **Action mapping**

[W. M. Waite, L. R. Carter: Compiler Construction, Harper Collins College Publisher, 1993]

Corresponds to task decomposition for

frontends of compilers for programming languages (no machine code generation)
source-to-source transformation

GSS-1.9a

Design and Specification of a DSL

Structuring	**Lexical analysis**	**Design the notation of tokens** **Specify them by regular expressions**
	Syntactic analysis	**Design the structure of descriptions** **Specify it by a context-free grammar**
Translation	**Semantic analysis**	**Design binding rules for names and properties of entities.** **Specify them by an attribute grammar**
	Transformation	**Design the translation into target code.** **Specify it by text patterns and their intantiation**

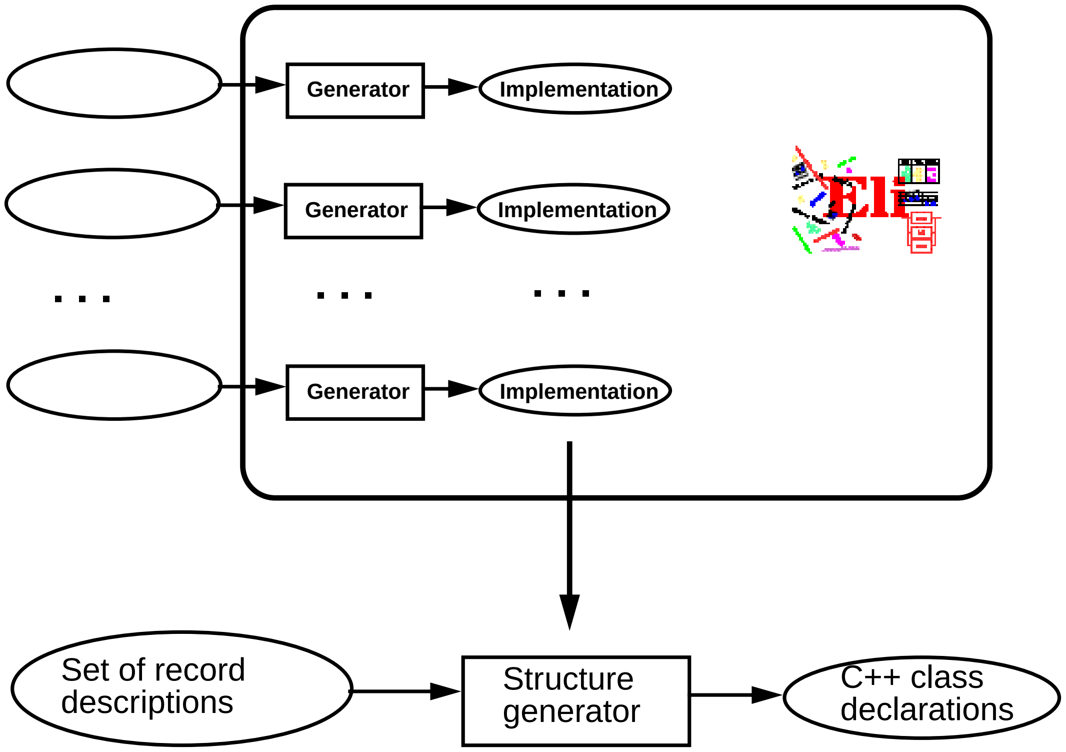
```
Customer ( addr:      Address;
           account:   int; )

Address (  name:   String;
           zip:    int;
           city:   String; )

import String from "util.h"
```

Task Decomposition for the Structure Generator

Structuring	Lexical analysis	Recognize the symbols of the description Store and encode identifiers
	Syntactic analysis	Recognize the structure of the description Represent the structure by a tree
Translation	Semantic analysis	Bind names to structures and fields Store properties and check them
	Transformation	Generate class declarations with constructors and access methods

```
Customer ( addr:     Address;
           account:  int; )

Address (  name:  String;
           zip:   int;
           city:  String; )

import String from "util.h"
```

Eli Generates a Structure Generator



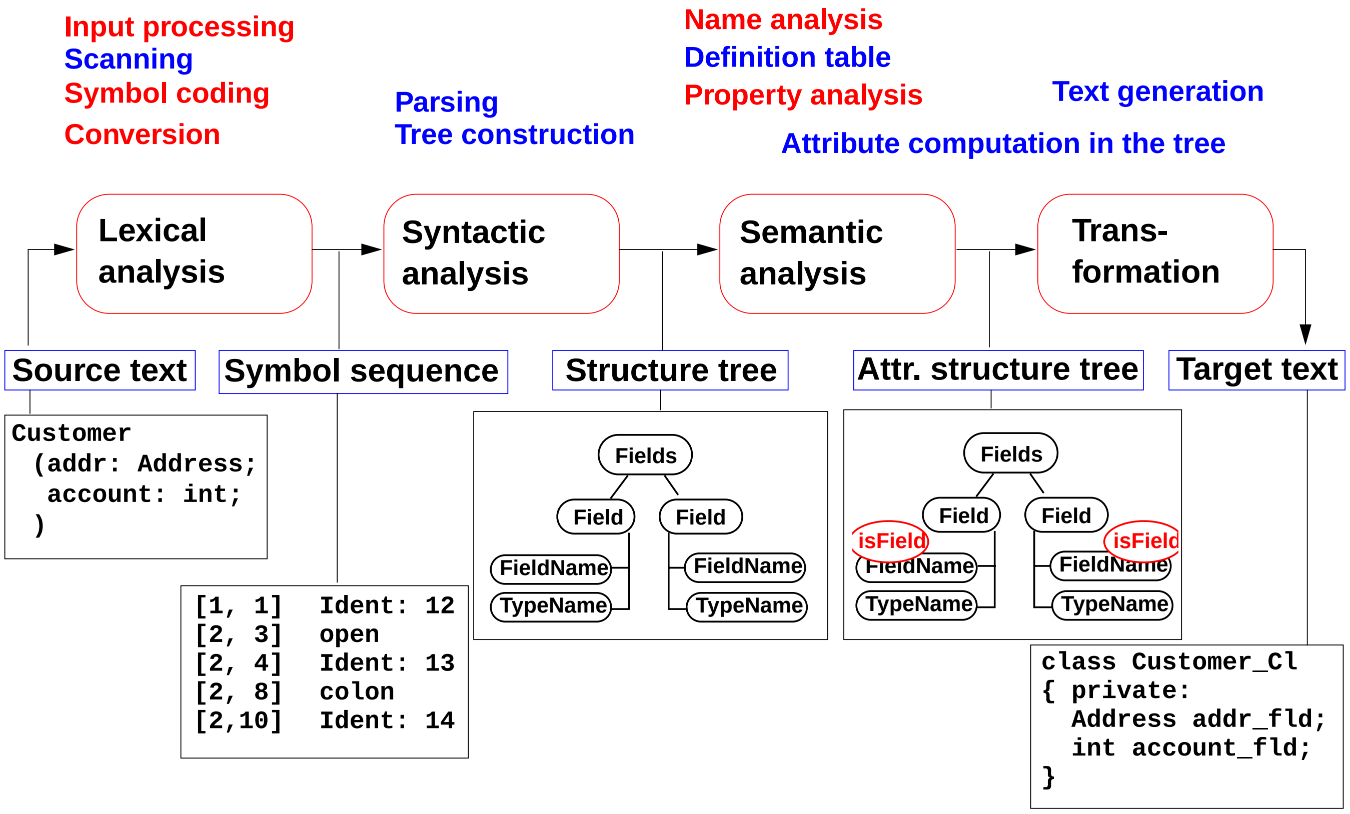
Set of record descriptions

Structure generator

C++ class declarations

Task Decomposition Determines the Architecture of the Generator

Specialized tools solve specific sub-tasks for creating of the product:



Input processing
Scanning
Symbol coding
Conversion

Parsing
Tree construction

Name analysis
Definition table
Property analysis

Text generation

Attribute computation in the tree

Lexical analysis → Syntactic analysis → Semantic analysis → Trans-formation

Source text | Symbol sequence | Structure tree | Attr. structure tree | Target text

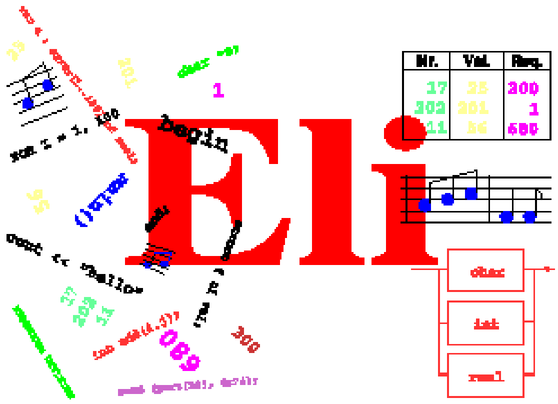
```
Customer
  (addr: Address;
   account: int;
  )
```

```
[1, 1]   Ident: 12
[2, 3]   open
[2, 4]   Ident: 13
[2, 8]   colon
[2,10]   Ident: 14
```

```
class Customer_Cl
{ private:
   Address addr_fld;
   int account_fld;
}
```

The Eli System

- **Framework for language implementation**
- Suitable for any kind of textual language:
  domain-specific languages,
  programming languages
- **state-of-the-art compiler technique**
- Based on the (complete)
  task decomposition (cf. GSS-1.9)
- **Automatic construction process**



- Used for many **practical projects** world wide
- Developed, extended, and maintained since1989 by
  William M. Waite (University of Colorado at Boulder),
  Uwe Kastens (University of Paderborn), and
  Antony M. Sloane (Macquarie University, Sydney)
- **Freely available** via Internet from
  http://eli-project.sourceforge.net

Hints for Using Eli

1. **Start Eli**:
   `/comp/eli/current/bin/eli [-c cacheLocation][-r]`
   Without **`-c`** a cache is used/created in directory **`~/.ODIN.`** **`-r`** resets the cache

2. **Cache**:
   Eli stores all intermediate products in cache, a tree of directories and files.
   Instead of recomputing a product, Eli reuses it from the cache.
   The cache contains only derived data; can be recomputed at any time.

3. **Eli Documentation**:
   Guide for New Eli Users: Introduction including a little tutorial
   Products and Parameters and *Quick Reference Card*: Description of Eli commands
   Translation Tasks: Conceptual description of central phases of language implementation.
   Reference Manuals, *Tools* and *Libraries* in Eli, *Tutorials*

4. **Eli Commands**:
   A common form: Specification : Product > Target   e.g.
   ```
   Wrapper.fw : exe > .
   ```
   from the specification derive the executable and store it in the current directory
   ```
   Wrapper.fw : exe : warning >
   ```
   from ... derive the executable, derive the warnings produced and show them

5. **Eli Specifications**: A set of files of specific file types.

6. **Literate Programming**: FunnelWeb files comprise specifications and their documentation