Compiler Construction

Names, scopes and lifetimes

Names, Identifiers, Symbols

Terminology

Names, **identifiers** and **symbols** are three ways to denote the same thing

Goal

Mechanism to refer some entities: variables, type, function, namespace, control structure, etc

Identifiers

- usually alphanumeric and underscore, letter fist, without whitespaces
- ALGOL 60 and Fortran ignore withespaces
- Limitation on the length
  - 6 characters for the original Fortran (Fortran 90, 31)
  - ISO C: 31 characters
  - No limit for most of the other
- Case insensitive (Modula-2 and Ada)

cstats: Counting Symbols

```
g++ -E -P "$@" \
  | tr -cs '[:alnum:]_' '[\n*]' \
  | grep '^[[:alpha:]]' \
  | grep -v -E -w "$cxx_keywords" > $tmp.1
total=$(wc -lc < $tmp.1 \
        | awk '{print $1 " (" $2 " chars)"}')
sort $tmp.1 \
  | uniq -c \
  | sed 's/^   //;s/\t/ /' \
  | sort -rn >$tmp.2
unique=$(sed -s 's/.* //' $tmp.2 | wc -lc \
         | awk '{print $1 " (" $2 " chars)"}')
echo $total occurrences of $unique symbols.
sed 42q $tmp.2 \
  | pr --page-width=60 --column=3 --omit-header
rm -f $tmp.*
```

Lemon (as-of 2019-01-15)

```
15182 (78642 chars) occurrences of 1082 (8875 chars) symbols.
1868 gt                176 lineno              87 rule
 943 quot              155 lt                  87 h
 654 i                 149 cp                  82 np
 458 amp               148 s                   78 filename
 373 lemp              146 name                72 z
 347 rp                139 cfp                 71 fp
 306 n                 116 next                70 array
 297 psp               109 stp                 69 ht
 227 fprintf           108 p                   69 config
 199 sp                107 a                   62 errorcnt
 198 out               101 type                62 action
 187 j                  94 state               61 lem
 182 x                  91 symbol              60 d
 177 ap                 89 c                   56 data
```

GCC's C Parser

```
18958 (198353 chars) occurrences of 5835 (89396 chars) symbols.
2676 tree                89 new_type_flag     38 build_nt
1579 ttype               70 cpp_reader        36 itype
1123 yyvsp               69 build_tree_lis    36 build_x_binary
 909 yyval               67 parse             35 yychar
 358 ftype               65 y                 35 frob_opname
 247 t                   61 obstack           35 d
 206 gt_pointer_ope      58 GTY               34 e
 200 common              46 identifier        33 tree_code_type
 192 size_t              43 error             33 operator_name_
 175 code                40 cp_global_tree    33 C
 171 tree_code           39 yyn               32 got_scope
 123 FILE                39 s                 31 IDENTIFIER_NOD
  97 rtx                 39 lookups           30 tree_class_che
  95 type                38 TREE_LIST         30 global_trees
```

Tiger Compiler's Driver (as-of 1.70)

```
8544 (83423 chars) occurrences of 1320 (16098 chars) symbols.
 603 std              76 FILE             48 hash
 354 size_t           74 false_type       47 iterator_trait
 351 noexcept         73 declval          47 begin
 334 size_type        71 reverse_iterat   46 compare
 274 basic_string     64 difference_typ   46 char_traits
 268 type             62 pointer          42 integral_const
 202 constexpr        61 pair             41 allocator
 158 char_type        56 int_type         40 C
 153 forward          55 locale_t         39 first
 114 value            53 value_type       37 string
  96 decltype         53 move_iterator    37 replace
  94 true_type        52 move             37 basic_istream
  80 size             50 traits_type      36 exception_ptr
  77 base             48 length           35 wstring
```

Save Time and Space

One unique occurrence for each identifier

- **In C** a simple *const char**
- **In C++** an iterator in a std::set
  Sets have the important property that inserting a new element into a set does not invalidate iterators that point to existing elements.

Definition of scopes

Question answered by scopes

When are names created and destroyed?

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Scope

The **textual** region in the **source file** in which the name is *available*

Why scopes?

Scoped-less world

- No scopes in assembly or in MFS
- Without scopes, names have global influence

Scoped world

- The programmer can focus on local influence
- Scopes are the first form of modularity

Static vs. Dynamic Scoping

Static scoping

The scope can be compute a compile time

Dynamic scoping

The scope depends on runtime conditions such as the function calls

Static scoping

- In most languages (Ada, C, Tiger, FORTRAN, Scheme, Perl (`my`), etc.).
- Enables static binding.
- Enables static typing.
- Enables strong typing (Ada, ALGOL 68, Tiger).
  - safer
  - faster
  - clearer

Dynamic Scoping

In most scripting/interpreted languages (Perl (`local`), Shell Script, TEX etc.) but also in Lisp

Dynamic Scoping in TeX

```
% \x, \y undefined.
{
  % \x, \y undefined.
  \def \x 1
  % \x defined, \y undefined.
  \ifnum \a < 42
    \def \y 51
  \fi
  % \x defined, \y may be defined.
}
% \x, \y undefined.
```

Prevents static typing

Scopes in C++

- Block scope
- Function parameter scopes
- Function scopes
- Namespace scopes
- Class scopes
- Templates scopes
- *modules?*

Scopes in Tiger

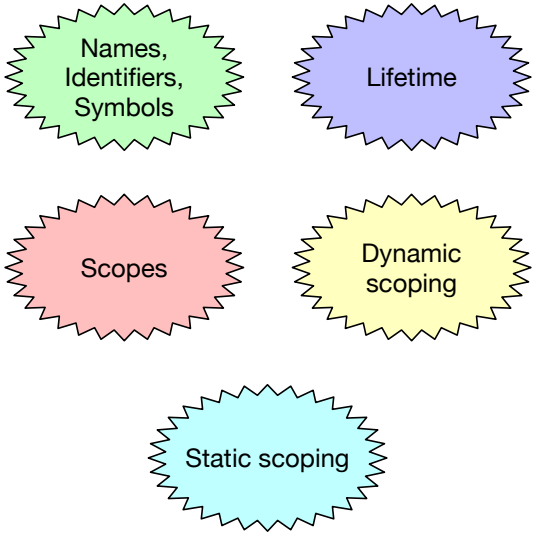
```
let
  var a := 3
  function f1() =
         ( a := a + 1 )
in
  let var a := 4
      function f2() =
             ( f1() )
  in
      f2()
  end
end
```

Lifetime

When are objects created and destroyed?

- Deferred to a later lecture
- Lifetime is a different matter, related to the execution (as opposed to visibility).
- Extent bound to lifetime of block tend to promote global variables (Pascal).

Summary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Lifetime
Scopes
Dynamic scoping
Static scoping