CS 4100
Pascal Highlights

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Based on slides by Istvan Jonyer
Book by MacLennan

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Issues with Extensibility

- Inefficiency
  - New syntax is translated to kernel constructs
  - Inefficiencies are magnified
- Poor diagnostics
  - Compiler errors are issued at kernel-level, which may be confusing to programmer
  - Language is hard to read, since people make up their own syntax
- Upside
  - Research on minimal requirement for PL's

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Move Toward Simplicity

- Niklaus Wirth suggests changes to Algol-60
  - Non-numeric data types
  - Removing baroque features
  - Maintain efficiency (compile and run-time)
  - Can be taught systematically
- Implements Algol-W (after changes are rejected by Algol committee)
  - Evolves into Pascal, competed in 1970

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Pascal - 3rd Generation

- Developed 1968-1970
  - 29 page report
- Revised 1972
- International Standard 1982
- Popular teaching language

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Pascal's Syntax

- Pascal's syntax is like Algol's (p. 171)
- Major changes
  - program … end.
  - procedure <declarations> begin <statements> end;
  - var, const, type
  - *for*-loop: simplified
  - case-statement

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var, const, type

- const
  - Constant parameter declaration

```
const Max = 900;
```

- type
  - Type declarations introduced by "type"

```
type index = 1 .. Max;
```

- var
  - Variables declared after "var"

```
var
  i: index;
  sum, ave, val: real;
```

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Data Structures

- Primitives are like Algol's
  - real, integer, Boolean, **char**
  - Char holds one character
    - Strings are arrays of chars

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Enumeration Types: Issues

- Problem:
  - How to manipulate non-numeric data?
  - Mon, Tue, Wed,… Male/Female,
- Using number is very confusing (error prone)
  - today := 5; // Friday
  - tomorrow := today + 1; // next day
  - Issues: Sunday: 0 or 1? Start week with Monday?
- Assign numbers to meaningful variables
  - Mon = 1, Tue = 2, … male = 0, female = 1, …
- Security Issue: compiler allows meaningless operations
  - Year : = (month + male)/DayOfWeek

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Enumeration Types

- Pascal introduces enumeration types

```
type
  month = (Jan, Feb, Mar, Apr, May, …);
  sex = (male, female);
var
  thisMonth : month;
  gender : sex;
begin
  thisMonth := Feb;
  gender := female;
```

- Supported operations for all enumerated types
  :=, succ, pred, =, <>, <, =, >, <=, >=

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Enumeration Types

- Advantages
  - High level
    - Lets programmers write what they mean
  - Secure
    - Type checking is performed
    - No meaningless operations
  - Efficient
    - Allows optimization of storage
    - E.g.: Days of week can be stored in 3 bits

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Subrange Types

- Improve security by allowing variable to take on values meaningful for their use only

```
var DayOfMonth: 1 .. 31;
type Weekday = Mon .. Fri;
```

  - Checking of valid values are checked as part of type checking
  - Many programming errors come down to subrange violations (array out of bounds)
  - Efficient: Allows compact storage of variable
  - Subranges of discrete types are allowed
    - integer, enumerated, char

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Set Types

- Pascal provides facilities for sets

```
set of <ordinal type>
```

  - Ordinal type: enumeration, char, Boolean, subrange
  - Not integer or real

```
var S, T: set of 1..10;
```

  - S, T can hold a set of numbers between 1 and 10
    - vs a single number between 1 and 10:

```
var S, T: 1..10;
```

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Efficiency of Sets

- Set types are restricted to be ordinal to be efficient

```
var S, T: set of 1..10;
```

  - S, T take only 10 bits to represent: 1 bit for each number
    - Bit = 0 means number is not is set
    - Bit = 1 means number is in set
  - `S := [1,2,3,5,7];`

	1	2	3	4	5	6	7	8	9	10
S =	1	1	1	0	1	0	1	0	0	0

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Set Operations

- Initialization/Assignment
  []
  `T := [1..6];`
- Membership
  in
  `if 4 in T then …`
- Union, intersection, difference
  +, *, -
  `S * T, S + T, …`
- Comparisons
  - Subset, equality, non-equality
  - <=, >=, =, <>
  - Proper subset (<) is not provided

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Efficiency of Sets

- Sets are implemented using bit masks
  - Therefore, operations on sets can be implemented using logical operations
  - Intersection: logical *and*
  - Union: logical *or*
  - Difference: logical *exclusive or*
- Logical operations are the fastest a computer can do
- Memory efficiency: 1 bit per element

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Sets

- Considered an example of elegance
  - High-level
  - Readable
  - Efficient
  - Secure

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Elegance Principle

- Confine your attention to things that *look* good because they *are* good

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Array Types

- Arrays are more general than Algol's
  - Base type of arrays can be non-primitives
  - Index types are introduced
  - Subscripts can be other than integers
    - Char, subrange, enumerated types

```
var A: array [1..100] of real;
var Occur: array [char] of integer;
var HoursWorked: array [Mon..Fri] of 0..24;

for day := Mon to Fri do
  TotalHours := TotalHours + HoursWorked[day];
```

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Dimensions

- Only single-dimension arrays are allowed!!!
- However:
  - Base type of array can be another array!!!

```
var M: array [1..20] of array [1..100] of real;
```

  - Dereferencing: `M[3][5]`
- *Syntactic sugar*:

```
var M: array [1..20, 1..100] of real;
M[3, 5]
```

(Doesn't affect functionality, sweeter for human use.)

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