Values, Types, Variables, Operators

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CS252.HACD: Fundamentals of Relational Databases
Section 2: Values, Types, Variables, Operators

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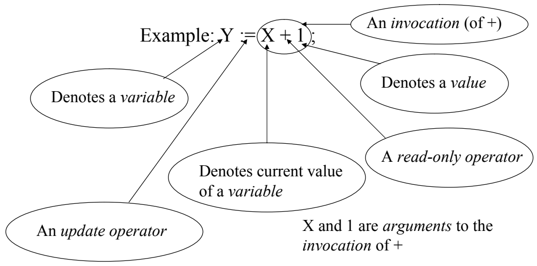
Anatomy of an Imperative



X and 1 are *arguments* to the *invocation* of +

Y and X+1 are *arguments* to the *invocation* of :=

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Important Distinctions

The following very important distinctions emerge from all this and should be firmly taken on board:

- Value versus variable
- Variable versus variable reference
- Update operator versus read-only operator
- Operator versus invocation
- Parameter versus argument
- Parameter subject to update versus parameter not subject to update

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A Closer Look at an Operator (+)

Look – it's a relation!

a	b	c
1	2	3
2	3	5
2	1	3

and so on (ad infinitum)

The predicate: $a + b = c$

Attributes *a* and *b* can be considered as the *parameters* of +.

It's also a *function*: no two tuples with the same *a* value also have the same *b* value, so, given an *a* and a *b*, we know the *c*.

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An Operator Definition

In **Tutorial D**:

```
OPERATOR HIGHER_OF ( A INTEGER, B INTEGER )
                        RETURNS INTEGER ;
   IF A > B THEN RETURN A ;
            ELSE RETURN B ;
   END IF ;
END OPERATOR ;
```

So the invocation HIGHER_OF(2,3) = 3

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What Is a Type?

A type (= "domain") is a **named set** of **values**.

Examples:

WEEKDAY:
{ Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday }

INTEGER:
{ …, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, … }

Monday etc. and -7 etc. are *literals*. Every value of every type should be able to be denoted by some literal.

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What is a Type For?

It is for *constraining* the values permitted for some purpose.

For example, constraining:
- the values that can be assigned to a variable
- the values that can be substituted for a parameter
- the values that an operator can yield when invoked
- the values that can appear for a given attribute of a relation

The *declared type* (of the variable, parameter, operator or attribute) constrains its possible values to be of that type.

What is the Type of This?

StudentId	Name	CourseId
S1	Anne	C1
S1	Anne	C2
S2	Boris	C1
S3	Cindy	C3
S4	Devinder	C1

Perhaps RELATION { StudentId SID, Name NAME, CourseId CID }
where SID is the declared type of StudentId , NAME that of Name, and CID that of CourseId.

How to Write This as a Literal?

StudentId	Name	CourseId
S1	Anne	C1
S1	Anne	C2
S2	Boris	C1
S3	Cindy	C3
S4	Devinder	C1

See next slide …

A Relation Literal in **Tutorial D**

Try:

```
RELATION {

      TUPLE { StudentId S1, CourseId C1, Name Anne      },
      TUPLE { StudentId S1, CourseId C2, Name Anne      },
      TUPLE { StudentId S2, CourseId C1, Name Boris     },
      TUPLE { StudentId S3, CourseId C3, Name Cindy     },
      TUPLE { StudentId S4, CourseId C1, Name Devinder }

             }
```

But this assumes that S1, C1, and Boris are themselves valid literals. They aren't in most languages, including **Tutorial D**.

Literals for Student Ids, etc

Recall the declared types of the attributes: SID, NAME, CID.

Suppose that values of type SID *are represented by* character strings (values of type CHAR).

Suppose that character strings are denoted by text in quotes, like this: 'S1'.

Then a literal for the student identifier S1 might be: SID ('S1')

SID ('S1') is an invocation of an operator called SID whose single parameter is of type CHAR.

We call SID a *selector,* because it can be used to "select" *any* value of type SID.

A Tuple Literal

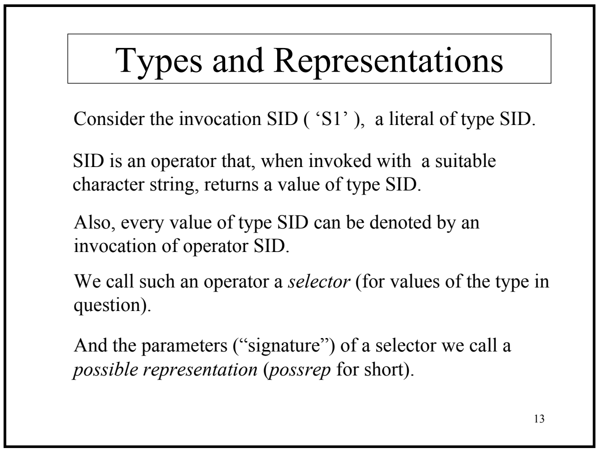
From our first try:

```
TUPLE { StudentId S1, CourseId C1, Name Anne }
```

We can now write this as:

```
TUPLE {
         StudentId SID ( 'S1' ) ,
         CourseId CID ( 'C1' ) ,
         Name NAME( 'Anne' )
        }
```

…and that's just fine. (See the lecture Notes for the relation literal.)



Types and Representations

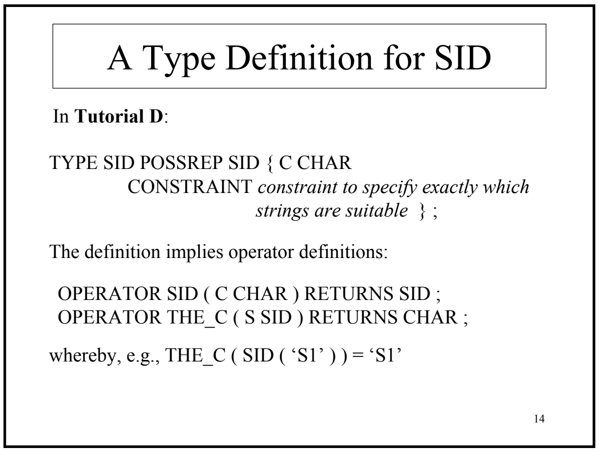
Consider the invocation SID (‘S1’), a literal of type SID.

SID is an operator that, when invoked with a suitable character string, returns a value of type SID.

Also, every value of type SID can be denoted by an invocation of operator SID.

We call such an operator a *selector* (for values of the type in question).

And the parameters (“signature”) of a selector we call a *possible representation* (*possrep* for short).



A Type Definition for SID

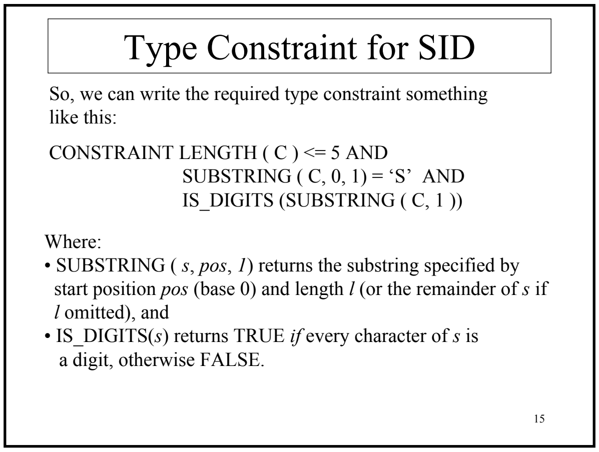
In **Tutorial D**:

```
TYPE SID POSSREP SID { C CHAR
          CONSTRAINT constraint to specify exactly which
                              strings are suitable } ;
```

The definition implies operator definitions:

```
OPERATOR SID ( C CHAR ) RETURNS SID ;
OPERATOR THE_C ( S SID ) RETURNS CHAR ;
```

whereby, e.g., THE_C (SID (‘S1’)) = ‘S1’



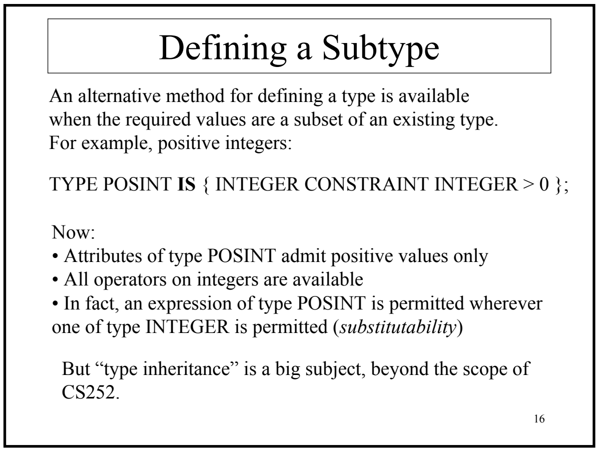
Type Constraint for SID

So, we can write the required type constraint something like this:

```
CONSTRAINT LENGTH ( C ) <= 5 AND
                  SUBSTRING ( C, 0, 1) = ‘S’  AND
                  IS_DIGITS (SUBSTRING ( C, 1 ))
```

Where:

- SUBSTRING (*s*, *pos*, *l*) returns the substring specified by start position *pos* (base 0) and length *l* (or the remainder of *s* if *l* omitted), and
- IS_DIGITS(*s*) returns TRUE *if* every character of *s* is a digit, otherwise FALSE.



Defining a Subtype

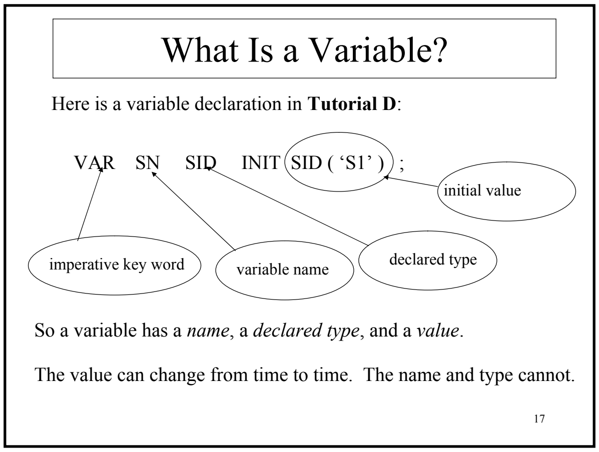
An alternative method for defining a type is available when the required values are a subset of an existing type. For example, positive integers:

TYPE POSINT **IS** { INTEGER CONSTRAINT INTEGER > 0 };

Now:

- Attributes of type POSINT admit positive values only
- All operators on integers are available
- In fact, an expression of type POSINT is permitted wherever one of type INTEGER is permitted (*substitutability*)

But “type inheritance” is a big subject, beyond the scope of CS252.



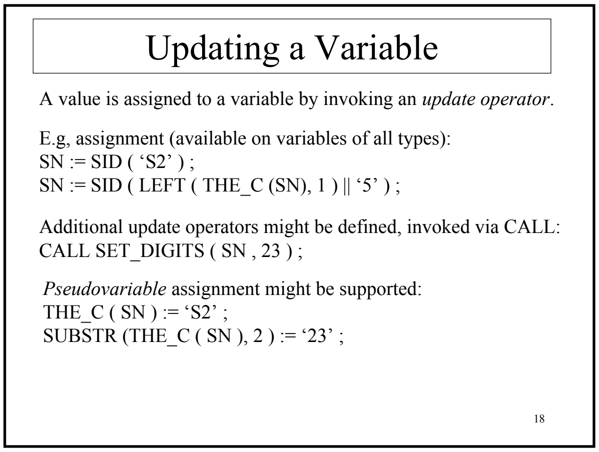
What Is a Variable?

Here is a variable declaration in **Tutorial D**:

VAR SN SID INIT SID (‘S1’) ;

So a variable has a *name*, a *declared type*, and a *value*.

The value can change from time to time. The name and type cannot.



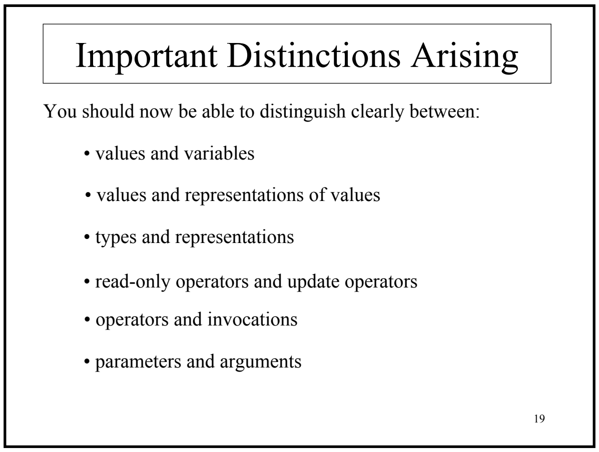
Updating a Variable

A value is assigned to a variable by invoking an *update operator*.

E.g, assignment (available on variables of all types):
SN := SID (‘S2’) ;
SN := SID (LEFT (THE_C (SN), 1) || ‘5’) ;

Additional update operators might be defined, invoked via CALL:
CALL SET_DIGITS (SN , 23) ;

Pseudovariable assignment might be supported:
THE_C (SN) := ‘S2’ ;
SUBSTR (THE_C (SN), 2) := ‘23’ ;



Important Distinctions Arising

You should now be able to distinguish clearly between:

- values and variables
- values and representations of values
- types and representations
- read-only operators and update operators
- operators and invocations
- parameters and arguments

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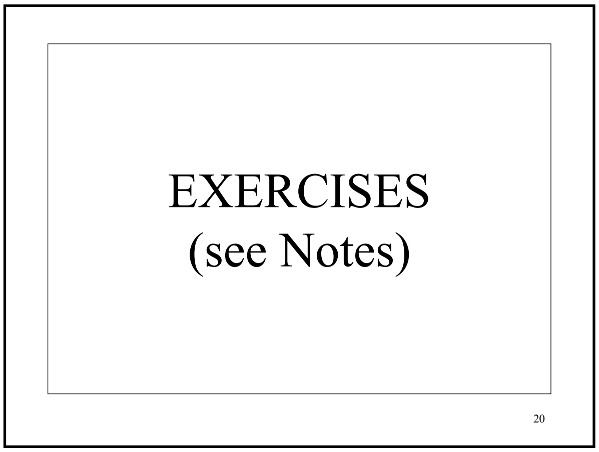

EXERCISES (see Notes)

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