Generalized linked list

Generalized Lists

- A generalized list, *A*, is a finite sequence of $n \geq 0$ elements, a_0, a_1, a_2, …, a_{n-1}, where a_i, is either an atom or a list. The elements a_i, $0 \leq i \leq n - 1$, that are not atoms are said to be the sublists of *A*.
- A list *A* is written as $A = (a_0, \ldots, a_{n-1})$, and the length of the list is *n*.
- A list name is represented by a capital letter and an atom is represented by a lowercase letter.
- a_0 is the head of list *A* and the rest $(a_1, \ldots, a_{n-1})$ is the tail of list *A*.

Examples of Generalized Lists

- *A* = ( ): the null, or empty, list; its length is zero.
- *B* = (*a*, (*b, c*)): a list of length two; its first element is the atom *a*, and its second element is the linear list (*b, c*).
- *C* = (*B, B,* ( )): A list of length three whose first two elements are the list *B*, and the third element is the null list.
- *D* = (*a, D*): is a recursive list of length two; *D* corresponds to the infinite list *D* = (*a*, (*a*, (*a*, …))).
- head(*B*) = '*a*' and tail(*B*) = (*b, c*), head(tail(*C*))=*B* and tail(tail(*C*)) = ( ).
- Lists may be shared by other lists.
- Lists may be recursive.

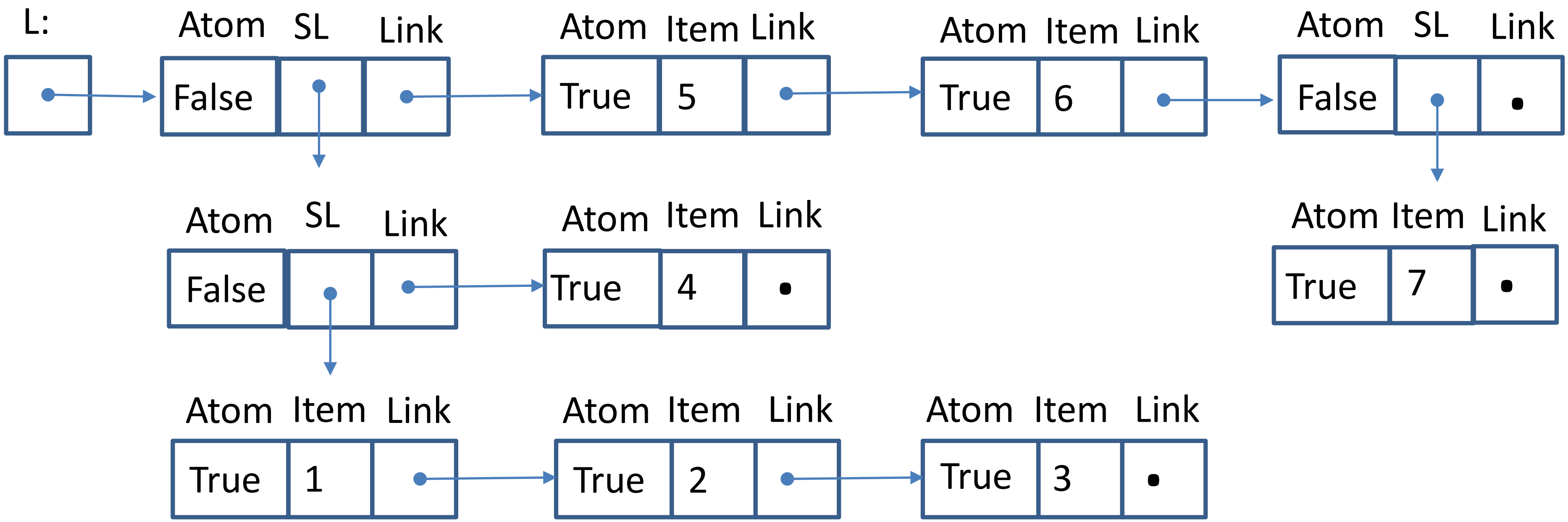
Generalized Lists

- A **generalized list** is a list in which the individual list items are permitted to be sublists.
- **Example**: *(a_1, a_2, (b_1, (c_1, c_2), b_3), a_4, (d_1, d_2), a_6)*
- If a list item is not a sublist, it is said to be **atomic**.

- Generalized lists can be represented by sequential or linked representations.

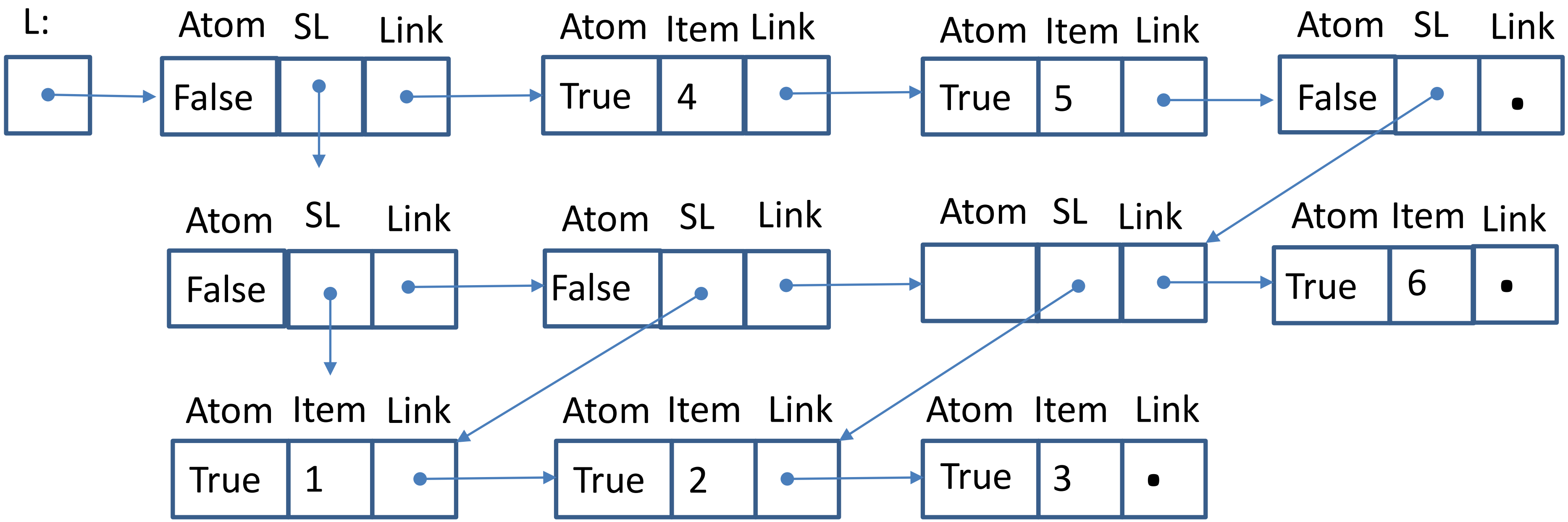
Generalized Lists (cont'd)

- The generalized list *L=(((1,2,3), 4) , 5, 6, (7))* can be represented without shared sublists as follows:



Generalized Lists (cont’d)

- The generalized list *L=(((1, 2, 3), (1, 2, 3), (2, 3), 6), 4, 5, ((2, 3), 6)* can be represented with shared sublists as follows:



```
struct General_Linked_list
{
   int Atom  ; // 0 or 1
   union
    {  struct  Generl_Linked_list   *dptr;
       int data;
    }
  struct Generl_Linked_list   *link;
}
```

Printing Generalized Lists

```
void PrintList(GenListNode *L)
{
      GenListNode *G;

      printf(“(“);
      G=L;
      while (G != NULL){
             if (G->Atom){
                printf(“%d”, G->SubNode.Item);
             } else {
                printList(G->SubNode.SubList);
             }
             if (G->Link != NULL) printf(“,”);
             G=G->Link;
      }
      printf(“)”);
}
```

Applications of Generalized Lists

- Artificial Intelligence programming languages LISP and Prolog offer generalized lists as a language construct.

- Generalized lists are often used in Artificial Intelligence applications.

- More in the courses “Artificial Intelligence” and “Logic Programming”.

Generalized List Application Example

$$p(x,y,z) = x^{10}y^3z^2 + 2x^8y^3z^2 + 3x^8y^2z^2 + x^4y^4z + 6x^3y^4z + 2yz$$

- Consider the polynomial $P(x, y, z)$ with various variables. It is obvious the sequential representation is not suitable to this.
- What if a linear list is used?
  - – The size of the node will vary in size, causing problems in storage management.
- Let’s try the generalized list.

Generalized List Application Example

- $P(x, y, z)$ can be rewritten as follows:

$$((x^{10}+2x^{8})y^{3}+3x^{8}y^{2})z^{2}+((x^{4}+6x^{3})y^{4}+2y)z$$

- The above can be written as $Cz^2 + Dz$. Both C and D are polynomials themselves but with variables x and y only.
- If we look at polynomial C only, it is actually of the form $Ey^3 + Fy^2$, where E and F are polynomial of x only.
- Continuing this way, every polynomial consists of a variable plus coefficient-exponent pairs. Each coefficient is itself a polynomial.

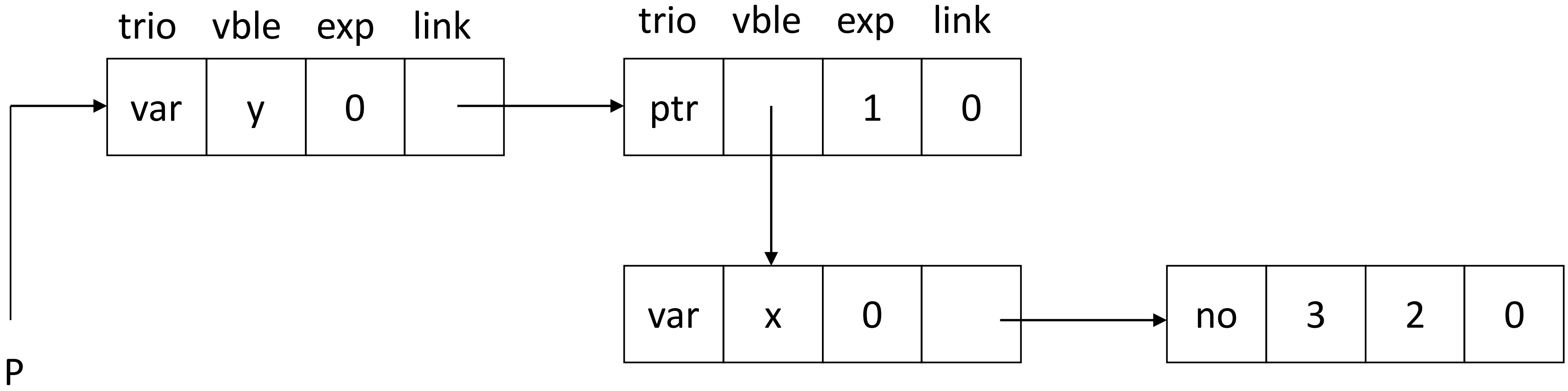
PolyNode structure

```
enum Triple{ var, ptr, no };
Struct  PolyNode
{
    PolyNode *link;
    int exp;
    Triple trio;
    union {
        char vble;
        PolyNode *dlink;
        int coef;
    };
};
```

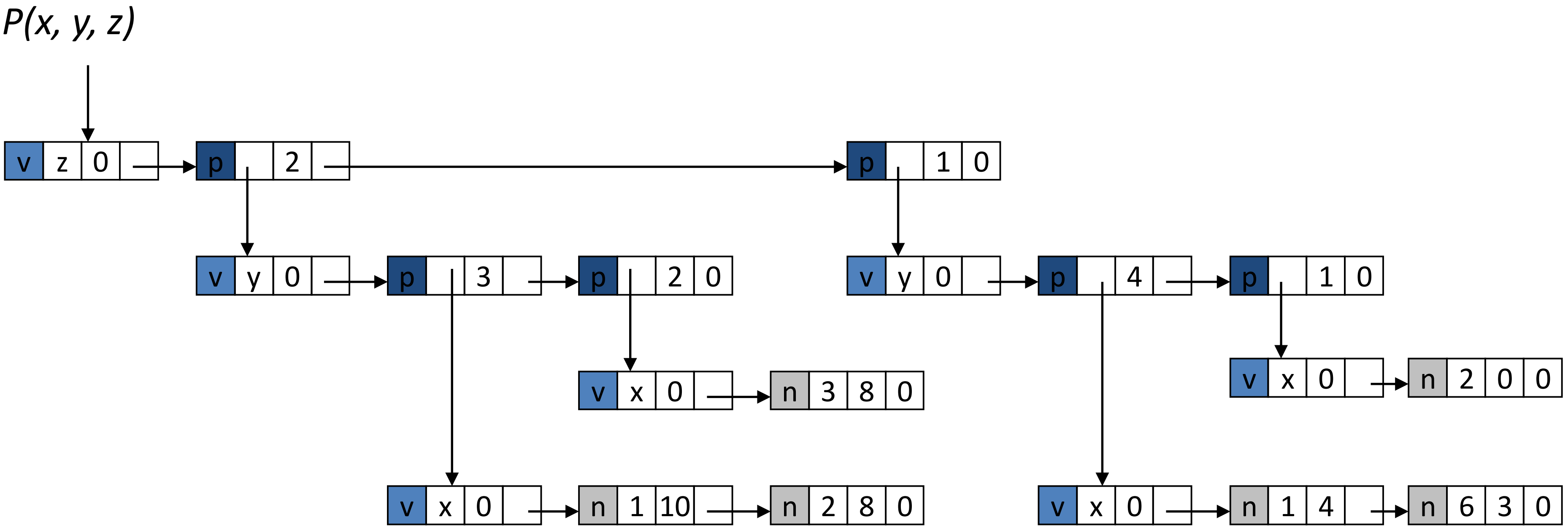
PolyNode in C

- trio == var: the node is a head node.
  - vble indicates the name of the variable. Or it is an integer point to the variable in a variable table.
  - exp is set to 0.
- trio == ptr: coefficient itself is a list and is pointed by the field dlink. exp is the exponent of the variable on which the list is based on.
- trio == no, coefficient is an integer and is stored in coef. exp is the exponent of the variable on which the list is based on.

Representing $3x^2y$



Representation of $P(x, y, z)$


P(x, y, z)
v z 0
p 2
p 1 0
v y 0
p 3
p 2 0
v y 0
p 4
p 1 0
v x 0
n 3 8 0
v x 0
n 2 0 0
v x 0
n 1 10
n 2 8 0
v x 0
n 1 4
n 6 3 0