6.2 Declarations

A complete B-Minor program is a sequence of declarations. Each declaration states the existence of a variable or a function. A variable declaration may optionally give an initializing value. If none is given, it is given a default value of zero. A function declaration may optionally give the body of the function in code; if no body is given, then the declaration serves as a prototype for a function declared elsewhere.

For example, the following are all valid declarations:

```
b: boolean;
s: string = "hello";
f: function integer ( x: integer ) = { return x*x; }
```

A declaration is represented by a `decl` structure that gives the name, type, value (if an expression), code (if a function), and a pointer to the next declaration in the program:

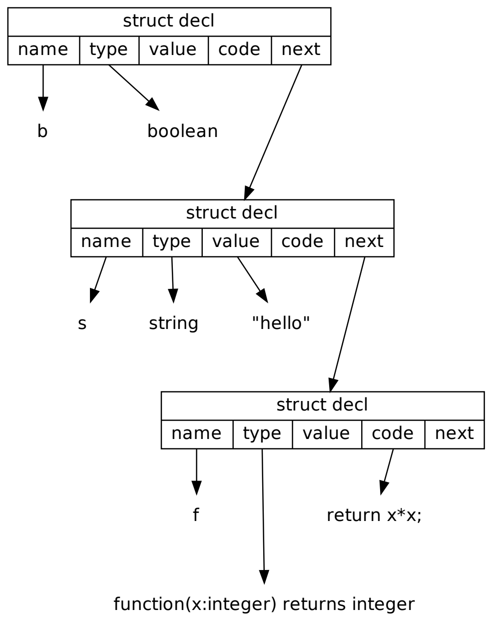
```
struct decl {
    char *name;
    struct type *type;
    struct expr *value;
    struct stmt *code;
    struct decl *next;
};
```

Because we will be creating a lot of these structures, you will need a factory function that allocates a structure and initializes its fields, like this:

```
struct decl * decl_create( char *name,
                           struct type *type,
                           struct expr *value,
                           struct stmt *code,
                           struct decl *next )
{
    struct decl *d = malloc(sizeof(*d));
    d->name = name;
    d->type = type;
    d->value = value;
    d->code = code;
    d->next = next;
    return d;
}
```

(You will need to write similar code for statements, expressions, etc, but we won't keep repeating it here.)

The three declarations on the preceding page can be represented graphically as a linked list, like this:



Note that some of the fields point to nothing: these would be represented by a null pointer, which we omit for clarity. Also, our picture is incomplete and must be expanded: the items representing types, expressions, and statements are all complex structures themselves that we must describe.

6.3 Statements

The body of a function consists of a sequence of statements. A statement indicates that the program is to take a particular action in the order specified, such as computing a value, performing a loop, or choosing between branches of an alternative. A statement can also be a declaration of a local variable. Here is the `stmt` structure:

```
struct stmt {
    stmt_t kind;
    struct decl *decl;
    struct expr *init_expr;
    struct expr *expr;
    struct expr *next_expr;
    struct stmt *body;
    struct stmt *else_body;
    struct stmt *next;
};
```

```
typedef enum {
    STMT_DECL,
    STMT_EXPR,
    STMT_IF_ELSE,
    STMT_FOR,
    STMT_PRINT,
    STMT_RETURN,
    STMT_BLOCK
} stmt_t;
```

The `kind` field indicates what kind of statement it is:

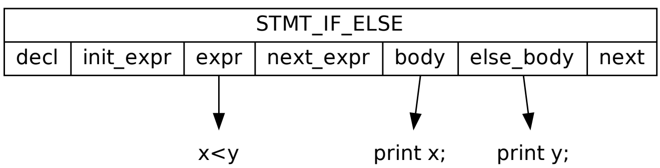
- `STMT_DECL` indicates a (local) declaration, and the `decl` field will point to it.
- `STMT_EXPR` indicates an expression statement and the `expr` field will point to it.
- `STMT_IF_ELSE` indicates an if-else expression such that the `expr` field will point to the control expression, the `body` field to the statements executed if it is true, and the `else_body` field to the statements executed if it is false.
- `STMT_FOR` indicates a for-loop, such that `init_expr`, `expr`, and `next_expr` are the three expressions in the loop header, and `body` points to the statements in the loop.
- `STMT_PRINT` indicates a `print` statement, and `expr` points to the expressions to print.
- `STMT_RETURN` indicates a `return` statement, and `expr` points to the expression to return.
- `STMT_BLOCK` indicates a block of statements inside curly braces, and `body` points to the contained statements.

And, as we did with declarations, we require a function `stmt_create` to create and return a statement structure:

```
struct stmt * stmt_create( stmt_t kind,
    struct decl *decl, struct expr *init_expr,
    struct expr *expr, struct expr *next_expr,
    struct stmt *body, struct stmt *else_body,
    struct stmt *next );
```

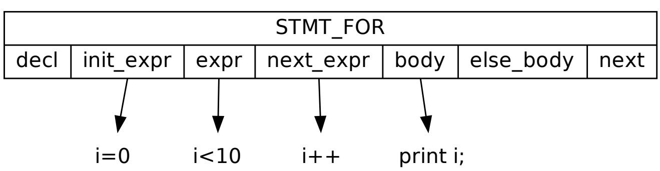
This structure has a lot of fields, but each one serves a purpose and is used when necessary for a particular kind of statement. For example, an if-else statement only uses the `expr`, `body`, and `else_body` fields, leaving the rest null:

```
if( x<y ) print x; else print y;
```



A for-loop uses the three `expr` fields to represent the three parts of the loop control, and the `body` field to represent the code being executed:

```
for(i=0;i<10;i++) print i;
```



6.4 Expressions

Expressions are implemented much like the simple expression AST shown in Chapter 5. The difference is that we need many more binary types: one for every operator in the language, including arithmetic, logical, comparison, assignment, and so forth. We also need one for every type of leaf value, including variable names, constant values, and so forth. The name field will be set for EXPR_NAME, the integer_value field for EXPR_INTEGER_LITERAL, and so on. You may need to add values and types to this structure as you expand your compiler.

```
struct expr {
    expr_t kind;
    struct expr *left;
    struct expr *right;

    const char *name;
    int integer_value;
    const char *
       string_literal;
};
```

```
typedef enum {
    EXPR_ADD,
    EXPR_SUB,
    EXPR_MUL,
    EXPR_DIV,
    ...
    EXPR_NAME,
    EXPR_INTEGER_LITERAL,
    EXPR_STRING_LITERAL
} expr_t;
```

As before, you should create a factory for a binary operator:

```
struct expr * expr_create( expr_t kind,
                           struct expr *L,
                           struct expr *R );
```

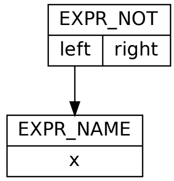
And then a factory for each of the leaf types:

```
struct expr * expr_create_name( const char *name );
struct expr * expr_create_integer_literal( int i );
struct expr * expr_create_boolean_literal( int b );
struct expr * expr_create_char_literal( char c );
struct expr * expr_create_string_literal
                                ( const char *str );
```

Note that you can store the integer, boolean, and character literal values all in the integer_value field.

A few cases deserve special mention. Unary operators like logical-not typically have their sole argument in the `left` pointer:

`!x`



A function call is constructed by creating an `EXPR_CALL` node, such that the left-hand side is the function name, and the right hand side is an unbalanced tree of `EXPR_ARG` nodes. While this looks a bit awkward, it allows us to express a linked list using a tree, and will simplify the handling of function call arguments on the stack during code generation.

`f(a,b,c)`