Universidad Nacional
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**And**

**The alphaX team introduces**

# AlphaX Compiler

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**Compilers.**

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# Compiler

A *compiler* is a program that translates a source program written in some high-level programming language (such as Java or in this case precisely, C) into machine code for some computer architecture. The generated machine code can be later executed many times against different data each time. In other words, compiling is the transformation from Source Code (human readable) into machine code (computer executable).

The aforementioned "machine language" is difficult to impossible for humans to read and understand (much less debug and maintain), thus the need for "high level languages" such as C. The compiler ensures that out program is TYPE correct. For example, we are not allowed to assign a string to an integer variable. It also ensures that our program is syntactically correct. For example, "x * y" is correct valid, but "x @ y" is not. It is very important to know that the compiler does **not** ensure that our program is logically correct.

Our development was made based on the following process division:

- First of all, it's important to make the analysis of the source program, checking its validation, generating the AST (abstract syntax tree), implementing a lexical analysis phase, all of this to build the complete information to go to the next part of the entire process which is
- Generate the machine code for the specific platform's architecture.

Making this division allows to the complete process being easy to supervise and debug in case of failures, even it leaves an important base to be scalable for another programming languages. Pipeline architecture makes the steps dependents from each other's results, which means the data flow goes through different sequential phases.

# Schedule (Phase I – First Delivery)

| Delivery | Date | Activities |
|---|---|---|
| **First: Integers** | 1st Week – from the 2nd through the 6th of November | Installation of every necessary software: Elixir, Git and Visual Studio. Review different Elixir tutorials to start getting familiar with the (for us) new language, also do a quick research about the functioning of UNIX systems; make the |

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|---|---|---|
| | | Nora Sandler's article our compass to reach the objective. |
| | 2nd Week – from the 9th through the 13th of November | Identify the different modules of the compiler to start the task assignment to each team member, start class-independent reviews of the base program provided by the domain expert: Ing. Norberto Ortigoza and assign Fridays as meeting days. |
| | 3rd Week – from the 23rd through the 27th of November | Complete first programming block, called Lexer and start developing other programming blocks, like parser and the Back-End part. |
| | 4th Week – from the 30th of November through the 4th of December | Start pairing each part of the code in way that every output of each programmed block corresponds with the input of the next one, when this is done carry out the pre-established test plan to verify the correct functionality of the compiler. Once this done, start and finish the documentation part. |
| | Additional days: from the 5th through the 9th of December | Debug every part of this phase of the project including both documentation (presentation, etc.) and code. |

# Project Requirements

In this first delivery, the main objective is to compile a program which must be written on C programming language; the structure of the program shall be as following:

```
int main(){
    return constant;
}
```

The colors are not randomized; words in red are reserved words from C programming language, black characters are: open and close parenthesis and open and close braces are those who give the function a function structure, semicolon ends up the statement and finally “constant” represents any integral number. The output of the entire process must be an executable file.

On the other hand, we have functional requirements:

- The compiler must include an "-h" flag, which is going to deploy the entire option menu with all the available flags for the user.
- The compiler must include a "-t" flag, which is going to show the token list retrieved from the compilation.
- The compiler must include an "-a" flag, which is going to show the Abstract Syntax Tree build from the compilation.
- The compiler must include an "-s" flag, this one is going to generate just the assembler file without an executable file.
- The compiler must include an "-o" flag, this option must include a new name provided by the user for changing the executable file's name and this way doing it more customizable.
- The execution of the compiler must be able to perform on command prompt (or terminal) based on UNIX systems.
- The executable file must have the same name of the compiled file and must be placed on the same directory.
- The compiler must be developed under Elixir programming language.

And non-functional requirements:

- It is necessary to provide a user's manual; this must be clear and precise for an easy understanding of anyone who could try to use it.
- Version control using Git-Hub.

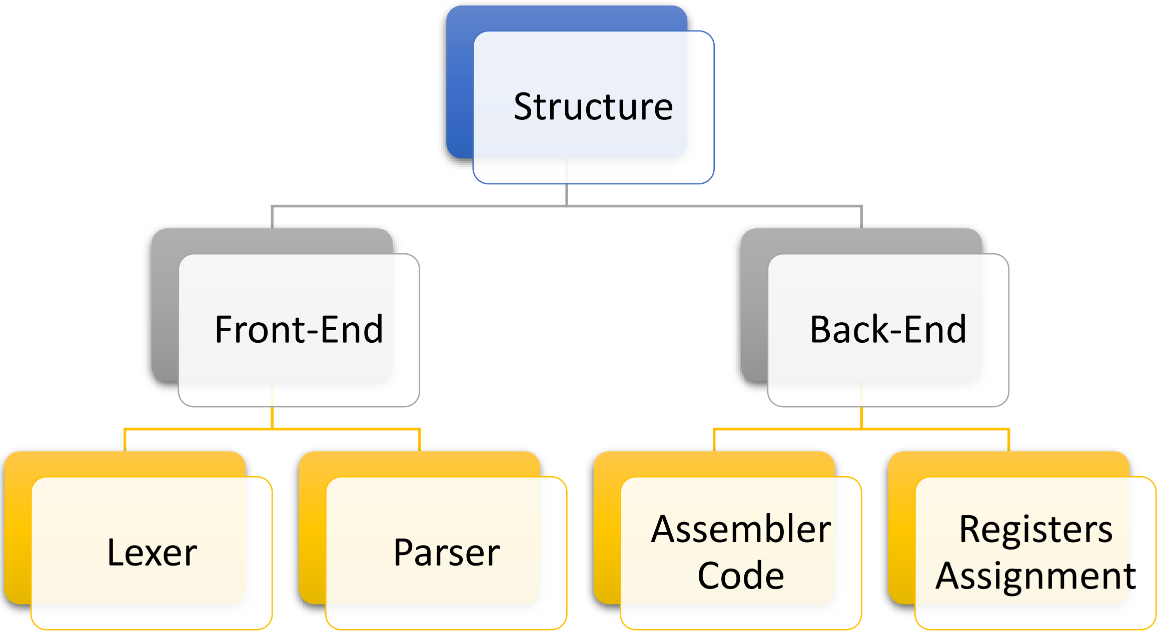
# Architecture

As we've seen on class, one of the fundamental principles of compilers is that the compiler must preserve the meaning of the program being compiled, this process is well known as the analysis of the semantic. Also, the compiler must ensure the improvement of the input program in a way that it can be easily to understand by the ISA of the processor.

We defined the Compiling process with the following Structure: Source Program (as the main input) this goes to the Front End Block then its output goes to the Optimizer block, its output serve as the input of the Back End block and finally its output becomes in the Target Program.

So, following what has been mentioned our Front-end consists on 2 essential parts: Lexer (which is the lexical analyzer) and the Parser (where the syntax is checked); every process is made based on the C programming language lexical and syntactical rules. In the Back-end part is where the compiler communicates with the computer through the assembler code; here's where the instruction's selection and the registers assignment are made.

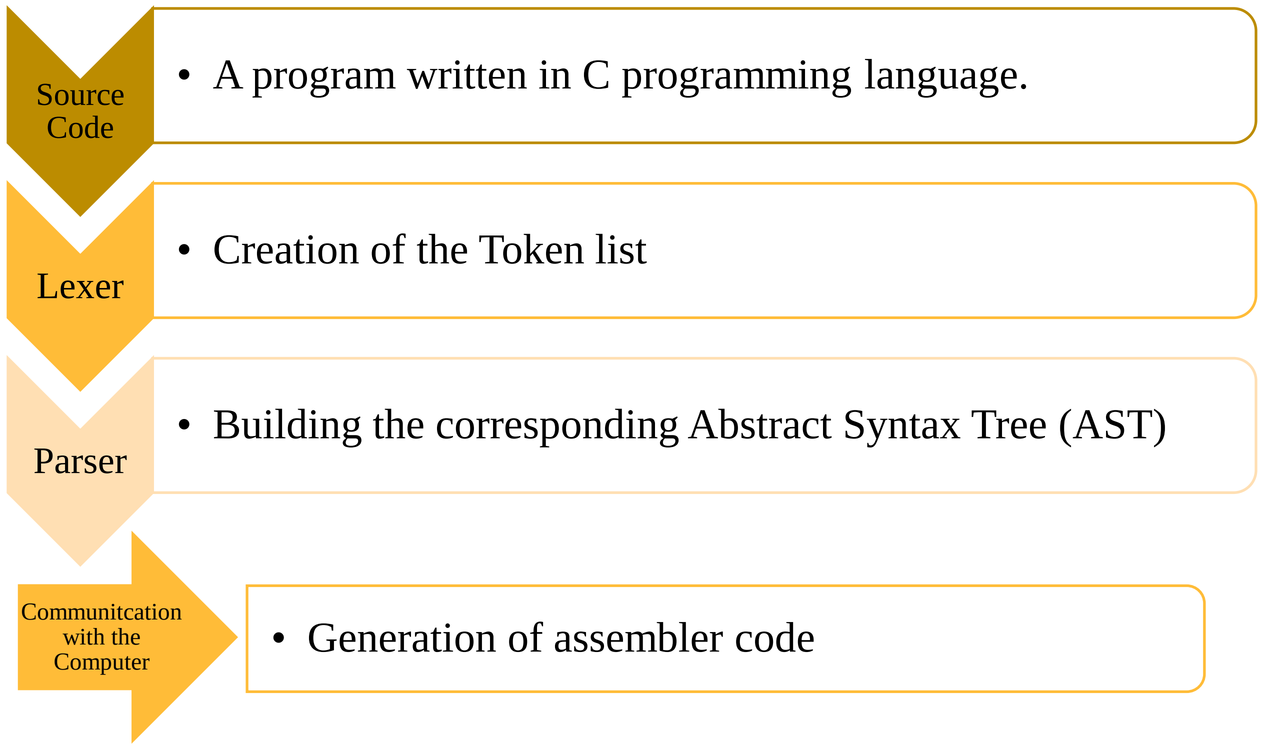
The next diagram summarizes the above established:



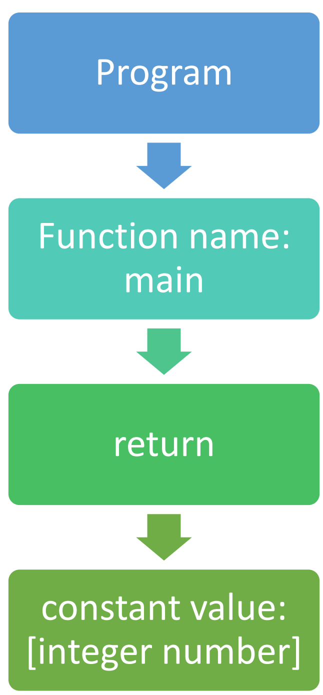

# Implementation

At this point of the document it is very clear to notice that our implementation was based on a standard building compiler. At the beginning of the compiling process the first step is to access to the *Lexer*, here's where the lexical analysis occurs verifying that every character between words, parenthesis, braces, the constant (which is an integer number) and the semicolon are typed correctly, in this phase the order of the characters is not important or even if there are not present either; the output of this part of the process is a complete list of each present character on the program, that is called the ***token list.*** The next step is going to happen in the Parser. The input of this one is the *token list*; here's where the syntax of each of the characters included in the token list shall suffer a reviewing process. This review consists of verifying the coherence between characters (that is, the order between them) and also that the *token list* is complete, so if any are missing (either reserved word, punctuation mark, etc.) the compilation won't continue. If the Parser does not throw any error, the main process can continue to build the *Abstract Syntax Tree* (AST). This kind of structure allows to easily manipulate the syntactical information of the source code and also apreciate the hierarchical relationship that exists between the organization of the content of the program that is being compiled. The final step/phase is to generate the corresponding assembler code which is going to be generated in the programming block called *Linker*. This name is given because this part of the code works as an association among the tokens (human readable) and what the computer can understand (binary code).

Basically, our compiler works as following:




Example of an expected AST



# Conclusions

The team concludes that the main objective of this phase of the project was totally covered, this is because we have learned the functioning of each essential part of a compiler and this can be reflected in the well-functioning of our program. We learned that Lexer must be the in charge-part of separate every string of the source code and gather them into so called *token list*. Also, we understand how important is the correct building of the AST because this is one way to clearly represent the structure of a program making evident the relationship that exists between reserved words, important characters (just as braces, parenthesis, etc.), constants and variables. In general, we all agreed that the most difficult part was the generation of the assembler code this due to non-solid bases from past signatures, nevertheless we did the necessary thing to get ahead that part of this phase and make it as best as we could. On the other hand, we had a lot of problems within the team which made us divide it to not create a huge impact in the on-going process of work and learning of any of us, besides this problems made us realize we still have an important number of opportunity areas where we already are working on and with all this lessons we hope to grow as professionals and as people all for our good and to prepare us for the future.