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Aim

To develop an LL (1) parser for a weather forecasting language that can generate daily weather forecasts for a given region. The parser will be able to process weather forecasts written in the language and generate a parse tree that can be used to extract information about the expected weather conditions for a particular location and time.

Additionally, the parser will be able to detect and report syntax errors in the input and provide suggestions for fixing the errors. The parser will be optimized for efficiency to handle a large volume of forecast requests in real-time, making it useful for meteorologists, weather researchers, and other weather enthusiasts.

The project will implement the LL (1) parsing technique using a programming language such as C++ and will use libraries for lexical analysis and parsing. The accuracy of the parser will be validatedby testing it against a set of input weather forecasts.

Requirements to run the script

To implement an LL(1) parser for weather forecasting in C, you will need the following software:

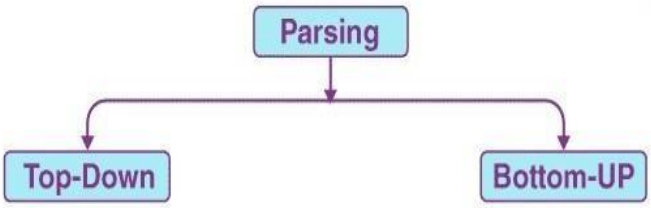
- A text editor or integrated development environment (IDE) to write and edit the parser code, such as Visual Studio Code, Sublime Text, or Code::Blocks.
- A C compiler, such as GCC or Clang, to compile the parser code into an executable file.
- A parser generator tool, such as Bison or Lemon, if you choose to use one to generate the parser code.

In addition to these software requirements, you may also need libraries or packages for handling input/output operations, string manipulation, and data structures, depending on the specific implementation of the parser.

Introduction

Parsing

The process of transforming the data from one format to another is called Parsing. This process can be accomplished by the parser. The parser is a component of the translator that helps to organize linear text structure following the set of defined rules which is known as grammar.



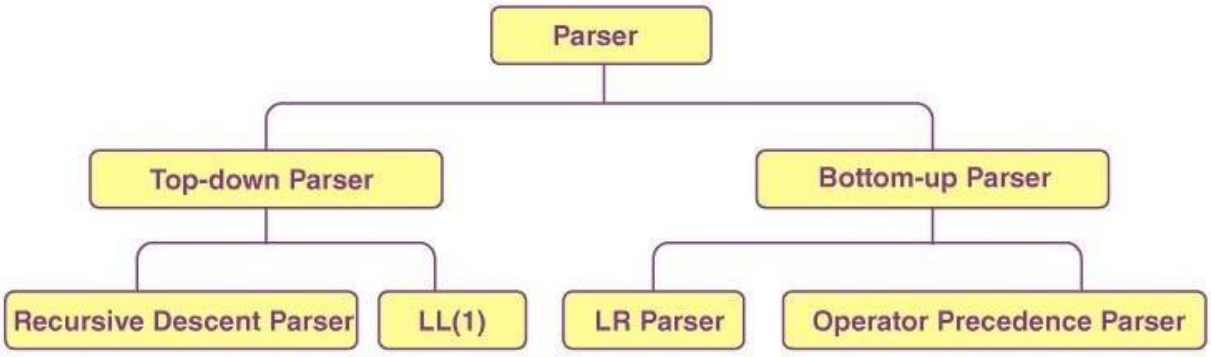
There are two types of Parsing:

- The Top-down Parsing

  The Top-Down Parser is the parser that generates parse for the given input string with the help of grammar productions by expanding the non-terminals i.e. it starts from the start symbol and ends on the terminals. It uses left most derivation.

- The Bottom-up Parsing

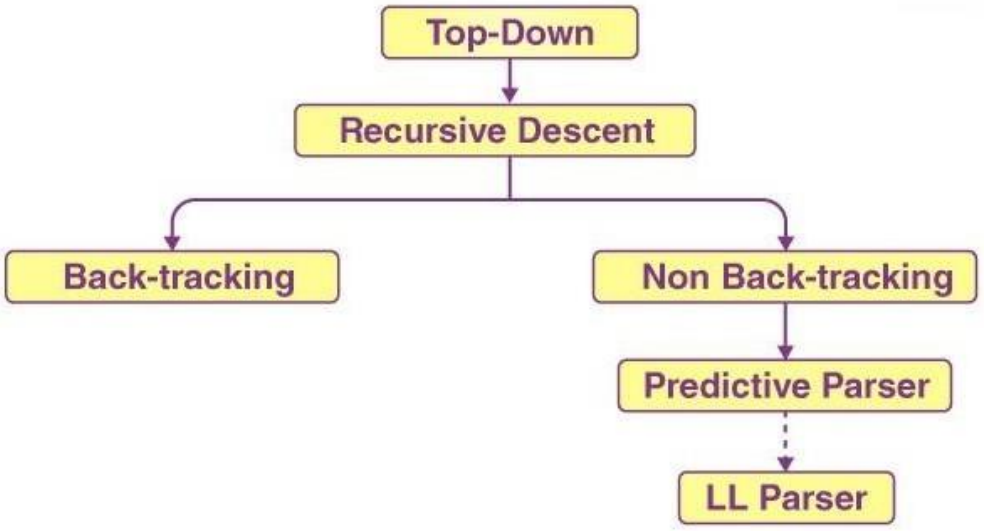
  The Bottom-Up Parser is the parser that generates the parse tree for the given input string with the help of grammar productions by compressing the non-terminals i.e. it starts from non-terminals and ends on the start symbol. It uses the reverse of the rightmost derivation.



Predictive Parser

Predictive parser is a recursive descent parser, which has the capability to predict which production is to be used to replace the input string. The predictive parser does not suffer from backtracking. To accomplish its tasks, the predictive parser uses a look-ahead pointer, which points to the next input symbols. To make the parser back-tracking free, the predictive parser puts some constraints on the grammar and accepts only a class of grammar known as LL(k) grammar.

Predictive parsing uses a stack and a parsing table to parse the input and generate a parse tree. Both the stack and the input contains an end symbol $ to denote that the stack is empty and the input is consumed. The parser refers to the parsing table to take any decision on the input and stack element combination. In recursive descent parsing, the parser may have more than one production to choose from for a single instance of input, whereas in predictive parser, each step has at most one production to choose. There might be instances where there is no production matching the input string, making the parsing procedure to fail.



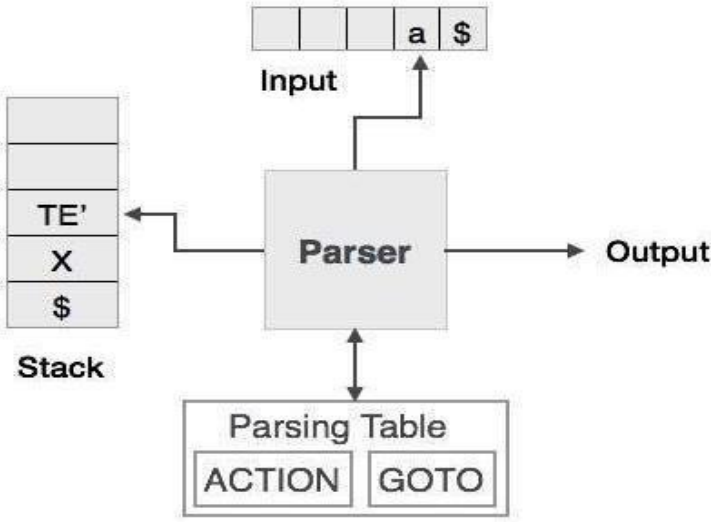
LL Parser

An LL Parser accepts LL grammar. LL grammar is a subset of context-free grammar but with some restrictions to get the simplified version, in order to achieve easy implementation. LL grammar can be implemented by means of both algorithms namely, recursive-descent or table-driven.

LL parser is denoted as LL(k).

A top-down parser that uses a one-token look ahead is called an LL (1) parser.

- The first L indicates that the input is read from left to right.
- The second L says that it produces a left-to-right derivation.
- And the 1 says that it uses one look ahead token.



Structure

Components

Input buffer − holds input string to be parsed.

Stack − holds sequence of grammar symbols.

Predictive parsing algorithm − contains steps to parse the input string; controls the parser's process.

Parsing table − contains entries based on which parsing actions has to be carried out.

Process

- Initially, the stack contains $ at the bottom of the stack.
- The input string to be parsed is placed in the input buffer with $ as the end marker.
- If X is a non-terminal on the top of stack and the input symbol being read is a, the parser chooses a production by consulting entry in the parsing table M[X, a].
- Replace the non-terminal in stack with the production found in M[X, a] in such a way that the leftmost symbol of right side of production is on the top of stack, i.e., the production has to be pushed to stack in reverse order.
- Compare the top of stack symbol with input symbol.
- If it matches, pop the symbol from stack and advance the pointer reading the input buffer.
- If no match is found repeat from step 2. Stop parsing when the stack is empty (holds $) and input buffer reads end marker ($).

Implementation

It is possible to implement LL (1) parsing for a weather forecast by following these steps:

1. Define the grammar for the weather forecast:
    a. The grammar should describe the structure of the input weather forecast. For example, a simple grammar for a weather forecast may include rules for temperature, Outlook, and Humidity.
2. Build the parsing table:
    a. The parsing table is a data structure that is used by the parser to determine the next action to take based on the current input symbol and the top of the stack.
    b. To build the parsing table, you will need to compute the First and Follow sets for each nonterminal symbol in the grammar. These sets are used to determine which production rule to use when parsing a given input symbol.
3. Write the LL (1) parser:
    a. Once the parsing table has been built, you can write the LL (1) parser. The parser reads the input symbols one at a time and uses the parsing table to determine the next action to take.
    b. If the input cannot be parsed based on the grammar and parsing table, the parser will report an error.
4. Test the parser:
    a. It is important to test the parser thoroughly with a variety of input weather forecasts to ensure that it is parsing correctly.

In conclusion, implementing LL (1) parsing for a weather forecast requires defining a grammar, building the parsing table, writing the LL (1) parser, and testing the parser. With these steps, it is possible to parse a weather forecast and extract the relevant information.

Example:

Weather Forecasting is an important application area where parsing techniques can be applied. In this grammar, we will implement an LL (1) parser for a simplified weather forecasting language.

The grammar rules for the language are as follows:

Actual Grammar	Productions/Input
S -> Weather	S=W
Weather -> Outlook Temperature Humidity	W=OTH
Outlook -> sunny	O=s
Outlook -> cloudy	O=c
Outlook -> rainy	O=r
Temperature -> hot	T=h
Temperature -> mild	T=m
Temperature -> freezing	T=f
Humidity -> wet	H=w
Humidity -> dry	H=d

Here,

Start symbol S, Weather, Outlook, Temperature, and Humidity are Non-terminals.

Sunny, cloudy, rainy, hot, mild, freezing, wet and dry are terminals.

Points to remember

- Epsilon is represented by '#'.
- Productions are of the form A=B, where 'A' is a single Non-Terminal and 'B' can be any combination of Terminals and Non- Terminals.
- The L.H.S. of the first production rule is the start symbol.
- Left recursion should be removed.
- Left factoring should be done.
- Each production of a non-terminal is entered on a different line.
- Only Upper Case letters are Non-Terminals and everything else is a terminal.
- Do not use '!' or '$' as they are reserved for special purposes.
- All input Strings to be parsed should end with a '$'.

Code

Parser.c

```
#include<stdio.h>
#include<ctype.h>
#include<string.h>
#include<stdlib.h>

void followfirst(char , int , int);
void findfirst(char , int , int);
void follow(char c);

int count,n=0;
char calc_first[10][100];
char calc_follow[10][100];
int m=0;
char production[10][10], first[10];
char f[10];
int k;
char ck;
int e;

int main(int argc,char **argv)
{
    int jm=0;
    int km=0;
    int i,choice;
    char c,ch;
    printf("How many productions ? :");
    scanf("%d",&count);
    printf("\nEnter %d productions in form A=B where A and B are grammar symbols
:\n\n",count);
    for(i=0;i<count;i++)




    {
        scanf("%s%c",production[i],&ch);
    }
    int kay;
    char done[count];
    int ptr = -1;
    for(k=0;k<count;k++){
        for(kay=0;kay<100;kay++){
            calc_first[k][kay] = '!';
        }
    }
    int point1 = 0,point2,xxx;
```

```
    for(k=0;k<count;k++)
    {
        c=production[k][0];
        point2 = 0;
        xxx = 0;
        for(kay = 0; kay <= ptr; kay++)
            if(c == done[kay])
                xxx = 1;
        if (xxx == 1)
            continue;
        findfirst(c,0,0);
        ptr+=1;
        done[ptr] = c;
        printf("\n First(%c)= { ",c);
        calc_first[point1][point2++] = c;
        for(i=0+jm;i<n;i++){
            int lark = 0,chk = 0;
            for(lark=0;lark<point2;lark++){
                if (first[i] == calc_first[point1][lark]){
                    chk = 1;
                    break;
                }
            }
            if(chk == 0){
                printf("%c, ",first[i]);
                calc_first[point1][point2++] = first[i];
            }
        }
        printf("}\n");
        jm=n;
        point1++;
    }
    printf("\n");
    printf("--------------------------------------------------------------------------------\n\n");
    char donee[count];
    ptr = -1;
    for(k=0;k<count;k++){
        for(kay=0;kay<100;kay++){
            calc_follow[k][kay] = '!';
        }
    }
    point1 = 0;
    int land = 0;
    for(e=0;e<count;e++)
    {
        ck=production[e][0];
        point2 = 0;
        xxx = 0;
        for(kay = 0; kay <= ptr; kay++)
            if(ck == donee[kay])
```

```
                xxx = 1;
        if (xxx == 1)
            continue;
        land += 1;
        follow(ck);
        ptr+=1;
        donee[ptr] = ck;
        printf(" Follow(%c) = { ",ck);
        calc_follow[point1][point2++] = ck;
        for(i=0+km;i<m;i++){
            int lark = 0,chk = 0;
            for(lark=0;lark<point2;lark++){
                if (f[i] == calc_follow[point1][lark]){
                    chk = 1;
                    break;
                }
            }
            if(chk == 0){
                printf("%c, ",f[i]);
                calc_follow[point1][point2++] = f[i];
            }
        }
        printf(" }\n\n");
        km=m;
        point1++;
    }
    char ter[10];
    for(k=0;k<10;k++){
        ter[k] = '!';
    }
    int ap,vp,sid = 0;
    for(k=0;k<count;k++){
        for(kay=0;kay<count;kay++){
            if(!isupper(production[k][kay]) && production[k][kay]!= '#' &&
production[k][kay] != '=' && production[k][kay] != '\0'){
                vp = 0;
                for(ap = 0;ap < sid; ap++){
                    if(production[k][kay] == ter[ap]){
                        vp = 1;
                        break;
                    }
                }
                if(vp == 0){
                    ter[sid] = production[k][kay];
                    sid ++;
                }
            }
        }
    }
    ter[sid] = '$';
```

```
    sid++;
    printf("\n\t\t\t\t\t\t\t The LL(1) Parsing Table for the above grammer :-");
    printf("\n\t\t\t\t\t\t\t^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^\n"
);
    printf("\n\t\t\t=========================================================================
=============================================================\n");
    printf("\t\t\t\t|\t");
    for(ap = 0;ap < sid; ap++){
        printf("%c\t\t",ter[ap]);
    }
    printf("\n\t\t\t=========================================================================
=============================================================\n");
    char first_prod[count][sid];
    for(ap=0;ap<count;ap++){
        int destiny = 0;
        k = 2;
        int ct = 0;
        char tem[100];
        while(production[ap][k] != '\0'){
            if(!isupper(production[ap][k])){
                tem[ct++] = production[ap][k];
                tem[ct++] = '_';
                tem[ct++] = '\0';
                k++;
                break;
            }
            else{
                int zap=0;
                int tuna = 0;
                for(zap=0;zap<count;zap++){
                    if(calc_first[zap][0] == production[ap][k]){
                        for(tuna=1;tuna<100;tuna++){
                            if(calc_first[zap][tuna] != '!'){
                                tem[ct++] = calc_first[zap][tuna];
                            }
                            else
                                break;
                        }
                    break;
                    }
                }
                tem[ct++] = '_';
            }
            k++;
        }
        int zap = 0,tuna;
        for(tuna = 0;tuna<ct;tuna++){
            if(tem[tuna] == '#'){
                zap = 1;
            }
```

```
            else if(tem[tuna] == '_'){
                if(zap == 1){
                    zap = 0;
                }
                else
                    break;
            }
            else{
                first_prod[ap][destiny++] = tem[tuna];
            }
        }
    }
    char table[land][sid+1];
    ptr = -1;
    for(ap = 0; ap < land ; ap++){
        for(kay = 0; kay < (sid + 1) ; kay++){
            table[ap][kay] = '!';
        }
    }
    for(ap = 0; ap < count ; ap++){
        ck = production[ap][0];
        xxx = 0;
        for(kay = 0; kay <= ptr; kay++)
            if(ck == table[kay][0])
                xxx = 1;
        if (xxx == 1)
            continue;
        else{
            ptr = ptr + 1;
            table[ptr][0] = ck;
        }
    }
    for(ap = 0; ap < count ; ap++){
        int tuna = 0;
        while(first_prod[ap][tuna] != '\0'){
            int to,ni=0;
            for(to=0;to<sid;to++){
                if(first_prod[ap][tuna] == ter[to]){
                    ni = 1;
                }
            }
            if(ni == 1){
                char xz = production[ap][0];
                int cz=0;
                while(table[cz][0] != xz){
                    cz = cz + 1;
                }
                int vz=0;
                while(ter[vz] != first_prod[ap][tuna]){
                    vz = vz + 1;
```

```
                }
                table[cz][vz+1] = (char)(ap + 65);
            }
            tuna++;
        }
    }
    for(k=0;k<sid;k++){
        for(kay=0;kay<100;kay++){
            if(calc_first[k][kay] == '!'){
                break;
            }
            else if(calc_first[k][kay] == '#'){
                int fz = 1;
                while(calc_follow[k][fz] != '!'){
                    char xz = production[k][0];
                    int cz=0;
                    while(table[cz][0] != xz){
                        cz = cz + 1;
                    }
                    int vz=0;
                    while(ter[vz] != calc_follow[k][fz]){
                        vz = vz + 1;
                    }
                    table[k][vz+1] = '#';
                    fz++;
                }
                break;
            }
        }
    }
    for(ap = 0; ap < land ; ap++){
        printf("\t\t\t   %c\t|\t",table[ap][0]);
        for(kay = 1; kay < (sid + 1) ; kay++){
            if(table[ap][kay] == '!')
                printf("\t\t");
            else if(table[ap][kay] == '#')
                printf("%c=#\t\t",table[ap][0]);
            else{
                int mum = (int)(table[ap][kay]);
                mum -= 65;
                printf("%s\t\t",production[mum]);
            }
        }
        printf("\n");
        printf("\t\t\t------------------------------------------------------------
------------------------------------------------------------");
        printf("\n");
    }
    int j;
    printf("\n\nPlease enter the desired INPUT STRING = ");
```

```
    char input[100];
    scanf("%s%c",input,&ch);
    printf("\n\t\t\t\t\t==========================================================
==================\n");
    printf("\t\t\t\t\t\tStack\t\t\tInput\t\t\tAction");
    printf("\n\t\t\t\t\t==========================================================
==================\n");
    int i_ptr = 0,s_ptr = 1;
    char stack[100];
    stack[0] = '$';
    stack[1] = table[0][0];
    while(s_ptr != -1){
        printf("\t\t\t\t\t\t");
        int vamp = 0;
        for(vamp=0;vamp<=s_ptr;vamp++){
            printf("%c",stack[vamp]);
        }
        printf("\t\t\t");
        vamp = i_ptr;
        while(input[vamp] != '\0'){
            printf("%c",input[vamp]);
            vamp++;
        }
        printf("\t\t\t");
        char her = input[i_ptr];
        char him = stack[s_ptr];
        s_ptr--;
        if(!isupper(him)){
            if(her == him){
                i_ptr++;
                printf("POP ACTION\n");
            }
            else{
                printf("\nString Not Accepted by LL(1) Parser !!\n");
                exit(0);
            }
        }
        else{
            for(i=0;i<sid;i++){
                if(ter[i] == her)
                    break;
            }
            char produ[100];
            for(j=0;j<land;j++){
                if(him == table[j][0]){
                    if (table[j][i+1] == '#'){
                        printf("%c=#\n",table[j][0]);
                        produ[0] = '#';
                        produ[1] = '\0';
                    }
```

```
                    else if(table[j][i+1] != '!'){
                        int mum = (int)(table[j][i+1]);
                        mum -= 65;
                        strcpy(produ,production[mum]);
                        printf("%s\n",produ);
                    }
                    else{
                        printf("\nString Not Accepted by LL(1) Parser !!\n");
                        exit(0);
                    }
                }
            }
            int le = strlen(produ);
            le = le - 1;
            if(le == 0){
                continue;
            }
            for(j=le;j>=2;j--){
                s_ptr++;
                stack[s_ptr] = produ[j];
            }
        }
    }
    printf("\n\t\t\t==========================================================================
============================================================\n");
    if (input[i_ptr] == '\0'){
        printf("\t\t\t\t\t\t\t\tYOUR STRING HAS BEEN ACCEPTED !!\n");
    }
    else
        printf("\n\t\t\t\t\t\t\t\tYOUR STRING HAS BEEN REJECTED !!\n");
    printf("\t\t\t==========================================================================
============================================================\n");
}

void follow(char c)
{
    int i ,j;
    if(production[0][0]==c){
        f[m++]='$';
    }
    for(i=0;i<10;i++)
    {
        for(j=2;j<10;j++)
        {
            if(production[i][j]==c)
            {
                if(production[i][j+1]!='\0'){
                    followfirst(production[i][j+1],i,(j+2));
                }
                if(production[i][j+1]=='\0'&&c!=production[i][0]){
```

```
                    follow(production[i][0]);
                }
            }
        }
    }
}

void findfirst(char c ,int q1 , int q2)
{
    int j;
    if(!(isupper(c))){
        first[n++]=c;
    }
    for(j=0;j<count;j++)
    {
        if(production[j][0]==c)
        {
            if(production[j][2]=='#'){
                if(production[q1][q2] == '\0')
                    first[n++]='#';
                else if(production[q1][q2] != '\0' && (q1 != 0 || q2 != 0))
                {
                    findfirst(production[q1][q2], q1, (q2+1));
                }
                else
                    first[n++]='#';
            }
            else if(!isupper(production[j][2])){
                first[n++]=production[j][2];
            }
            else {
                findfirst(production[j][2], j, 3);
            }
        }
    }
}

void followfirst(char c, int c1 , int c2)
{
    int k;
    if(!(isupper(c)))
        f[m++]=c;
    else{
        int i=0,j=1;
        for(i=0;i<count;i++)
        {
            if(calc_first[i][0] == c)
                break;
        }
        while(calc_first[i][j] != '!')
```

Output:

```
How many productions ? :10

Enter 10 productions in form A=B where A and B are grammar symbols :

S=W
W=OTH
O=s
O=c
O=r
T=h
T=m
T=f
H=w
H=d

 First(S)= { s, c, r, }

 First(W)= { s, c, r, }

 First(O)= { s, c, r, }

 First(T)= { h, m, f, }

 First(H)= { w, d, }

------------------------------------------------

 Follow(S) = { $,  }

 Follow(W) = { $,  }

 Follow(O) = { h, m, f,  }

 Follow(T) = { w, d,  }

 Follow(H) = { $,  }
```

```
                    The LL(1) Parsing Table for the above grammer :-
                    ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

=================================================================================================

       |       s       c       r       h       m       f       w       d       $
=================================================================================================

   S   |       S=W     S=W     S=W
-------------------------------------------------------------------------------------------------

   W   |       W=OTH   W=OTH   W=OTH
-------------------------------------------------------------------------------------------------

   O   |       O=c     O=c     O=r
-------------------------------------------------------------------------------------------------

   T   |                               T=h     T=m     T=f
-------------------------------------------------------------------------------------------------

   H   |                                                       H=w     H=d
-------------------------------------------------------------------------------------------------
```

String Parsing

Parsing a string is important for many reasons.

Firstly, parsing allows us to analyze the structure of a string and identify its constituent parts. This is useful in many applications, such as programming languages, where we need to identify the syntax of a program and execute it accordingly.

Secondly, parsing can help us identify errors or issues with the input string. For example, in a programming language, parsing can identify syntax errors that prevent the program from executing.

Lastly, parsing can help us generate useful output based on the input string. In the case of weather forecasting, parsing can identify the weather outlook, temperature, and humidity, and use this information to generate a forecast for the user.

Overall, parsing is an important tool for analyzing, validating, and generating output based on input strings in many different applications.

1. **Input String**: rainy mild wet

Output:

Stack based approach:

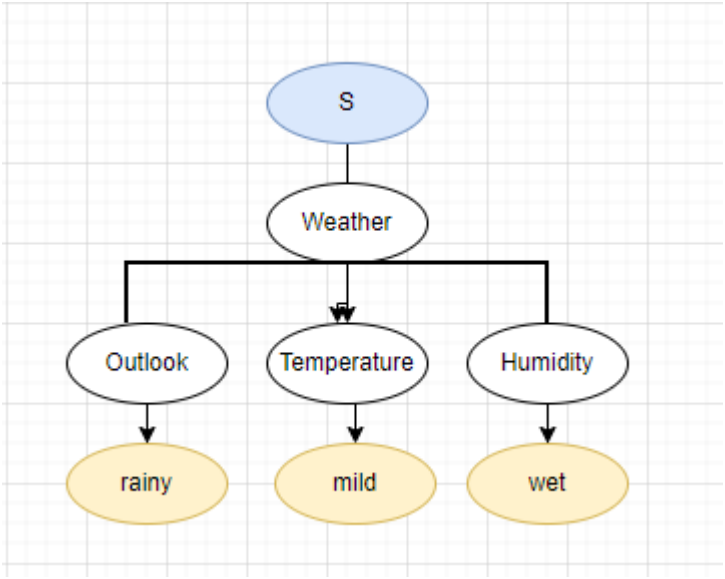
```
rmw$

================================================================================
        Stack                   Input                   Action
================================================================================
        $S                      rmw$                    S=W
        $W                      rmw$                    W=OTH
        $HTO                    rmw$                    O=r
        $HTr                    rmw$                    POP ACTION
        $HT                     mw$                     T=m
        $Hm                     mw$                     POP ACTION
        $H                      w$                      H=w
        $w                      w$                      POP ACTION
        $                       $                       POP ACTION

================================================================================

                        YOUR STRING HAS BEEN ACCEPTED !!
================================================================================
```

Parse Tree:



1. **Input String**: sunny S hot dry

   Output:

```
Please enter the desired INPUT STRING = sShd$

                                    ================================================================================
                                            Stack                   Input                   Action
                                    ================================================================================
                                            $S                      sShd$                   S=W
                                            $W                      sShd$                   W=OTH
                                            $HTO                    sShd$                   O=s
                                            $HTs                    sShd$                   POP ACTION
                                            $HT                     Shd$                    T=f
                                            $Hf                     Shd$
String Not Accepted by LL(1) Parser !!
```

The string is rejected by the parser.

Result

The result of the project is the successful development of an LL (1) parser for a weather forecasting language that can generate daily weather forecasts for a given region. The parser can process weather forecasts written in the language and generate a parse tree that can be used to extract information about the expected weather conditions for a particular location and time.
The parser is optimized for efficiency to handle a large volume of forecast requests in real-time.

Conclusions

It can detect and report syntax errors in the input making the parser more user-friendly and accurate. The LL (1) parser is developed using the LL (1) parsing technique, which is a top-down parsing technique that is implemented using a predictive parsing table. The predictive parsing table is generated based on the production rules of the language and helps in identifying the next input symbol during parsing.

The parser is tested using a set of input weather forecasts, and the output generated by the parser is validated against the expected output to ensure the accuracy of the parser. The project provides a fast and efficient solution for weather forecasting that can be used by meteorologists, weather researchers, and other weather enthusiasts.

The LL (1) parser helps in identifying patterns and trends in weather conditions, which can be used to make more accurate and informed weather forecasts. Overall, the project is successful in achieving its objective of developing an LL (1) parser for a weather forecasting language.

Future Scope and Applications

Scope:

The LL (1) parser for weather forecasting language has a broad scope as it can be used by a wide range of professionals and weather enthusiasts. It can be used for generating daily weather forecasts for a given region, identifying patterns and trends in weather conditions, and making more accurate and informed weather forecasts. The parser can also be used to analyze historical weather data to make predictions and generate reports. It can also be used to develop weather monitoring systems for agricultural and industrial applications, aviation and marine industries, and government agencies.

Applications:

The LL (1) parser for weather forecasting language has many applications, including but not limited to:

- Meteorology: The parser can be used to generate daily weather forecasts and analyze historical weather data to make predictions and generate reports for meteorologists and weather researchers.
- Agriculture: The parser can be used to develop weather monitoring systems for agricultural applications to help farmers make informed decisions about crop management, irrigation, and pest control.
- Aviation and Marine Industries: The parser can be used to generate weather forecasts for pilots and ship captains to plan their routes and avoid hazardous weather conditions.
- Government Agencies: The parser can be used by government agencies responsible for disaster management and emergency response to predict weather-related disasters such as floods, hurricanes, and tornadoes.
- Weather Enthusiasts: The parser can be used by weather enthusiasts to make more accurate and informed weather forecasts for personal and recreational purposes.

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