IIA GF2 Software: Final Report

Jamie Magee (jam96)
Team 8
Gonville & Caius College

Contents

1 Description

Our logic simulator is able to simulate any number of circuits which include the following devices:

- Clocks
- Switches
- AND gates (Up to 16 inputs)
- NAND gates (Up to 16 inputs)
- OR gates (Up to 16 inputs)
- NOR gates (Up to 16 inputs)
- XOR gates
- D-Type flip-flops
- Signal generators

It uses files written in the language as specified in our EBNF in Appendix C, with the file extension `.gf2` and have MIME type `text/plain`. Errors in a definition file are reported fully to the user upon reading a definition file, and give unique error codes for each different type of error. There is no limit on the number of devices in a network (except for that implied by the available memory of the computer). There may also be an unlimited number of monitors. For a complete guide on how to operate our logic simulator, please see the user guide in Appendix D.

For the structure of our logic simulator we made use of modularisation through the use of object oriented programming. The logic circuit is internally represented using the network class, in addition to the devices class which stores details about the properties of each device. Names of devices are represented internally by a unique integer. The names class handles the storage of names as they are read in, as well as storing a list of reserved names upon instantiation. When a file is opened, it is read by the parser class, by creating an instance of the scanner class which reads through the definition file character, by character, building them up into symbols which are returned to the parser. Depending on the order of the symbols that were read in, the parser can create devices, connections or monitors (or throw errors). Once the entire definition file has been read in, the gui class interprets commands issued by the user and makes appropriate calls to the network, monitor and devices classes.

2 Development Style

We split the development of our logic simulator into five major phases: specification, design, implementation, testing and maintenance. The timeframe was then decided for each task and each task was assigned to either a team member or the whole team, depending on the nature of the task. A Gantt chart showing our time planning can be seen in Appendix F.

Each member of the team was also assigned a general project role as follows:

Project manager: (T Hillel) - Responsible for project planning including delegation of tasks and ensuring that the project runs to the set timescale.

Programming administrator: (J Magee) - Responsible for upkeep of the project directory including performing builds and keeping legacy versions of the simulator.

Client representative: (M Jackson) - Responsible for ensuring that the project meets the client's requirements for the logic simulator as defined in Appendix A of the GF2 Project Handout.

We made significant use of `git` for revision control, as well as GitHub for tracking bugs in the software and features required by the client. It also allowed us to work on the same file independently and merge our changes using the `git merge` command.

During the maintenance phase of the project we divided up the tasks and tackled them independently. They were assigned as follows:

Non-zero Hold Time of Bistables: J Magee

Signal Generators: T Hillel

Continuous Simulation: M Jackson

While the tasks were split up, and the person assigned to the task contributed the majority of the code, the power of `git` allowed other members of the team to contribute easily.

Overall I believe our team worked efficiently, and as a result we were able to achieve all the requirements of the client within the deadlines we were set.

3 My Contribution

I took on responsibility for writing the names and scanner classes. In addition, I wrote approximately 25% of the parser class. the names class stores a list of all the words used within a definition file, and methods to manipulate them. It is initialised with only the reserved words, but can be populated as a definition file is read. the scanner class reads through the definition file, character by character, and is able to return complete symbols to the parser. It is able to return the internal representation of a symbol, the type of symbol and optionally the value. The parser class analyses the definition file as it is read in according to the rules laid out in our EBNF. It is then able to create devices, connections and monitors that are laid out in the definition file. I wrote the `newConnection, monitorList` and `newMonitor` methods. The `newConnection` and `newMonitor` methods deal with reading in a connection and monitor respectively, and creating them using the network and monitor classes respectively. The `monitorList` class deals with reading in an entire `MONITOR` block, as defined by our EBNF, which can be seen in Appendix C

Once the majority of the software was written, I designed a definition file for each error and warning our logic simulator can throw and then wrote a shell script which would attempt to run each definition file, and record the output from our logic simulator. In addition to testing for errors, I wrote a shell script which would run through each of our test definition files, in Appendix B, and record the output. Both the shell scripts can be found in Appendix A.4.

During the maintenance phase of the project, I undertook the task to implement a non-zero hold time for d-type flip flops, as well as randomising the order of execution of devices. the non-deterministic characteristics of d-types required editing of the devices class, specifically the `execdtype` method. Randomising the order of execution of devices was implemented in the network class, and required reading the values from the existing devices list, shuffling the list (while still retaining clocks at the end of the list) and writing it back.

4 Testing

We used two main tests of testing - unit and system testing - both of which are industry standard practices. For our unit testing, Martin wrote an errors class which compared the actual output from various units of code, to the expected output. For system testing I wrote a shell script which passed definition files to the logic simulator and recorded the output in a text file. There were two variations on the shell script: One which ran known good definition files and therefore had to input the commands to run the simulation in addition to recording the output; Another which ran known bad definition files and only expected parsing errors which it recorded. An example of the output produced by the the test shell script is as follows:

```
processing sipo.gf2...
```

```
Logic Simulator: interactive command interface
# Running for 50 cycles
CLK2              :_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-_-
D1.Q              :___--__--__--__--__--__--__--__--__--__--__--__--_
D2.Q              :_____--__--__--__--__--__--__--__--__--__--__--__-
D3.Q              :_______--__--__--__--__--__--__--__--__--__--__--_
D4.Q              :_________--__--__--__--__--__--__--__--__--__--__-
# Logic Simulator: terminating.
```

An example of the output produced by the error shell script is as follows:

```
processing 12.gf2...
Line 11:
1.I1 = S1;
^
Error 0x000C: Connection must start with the name of a device
Unconnected Input : G1.I1
There is 1 error
```

5 Conclusions

Overall I believe that we worked well as a team, and were able to achieve the requirements set out by the client.

If we had more time I would improve our logic simulator by:

- Implementing a WYSIWYG GUI
- Improving the parser to allow simple error correction
- Expand the device library to include JK flip-flops

A Code Listings

A.1 Names Class

A.1.1 names.h

```
#ifndef names_h
#define names_h

#include <string>
#include <vector>

using namespace std;

//const int maxnames  = 200;  /* max number of distinct names */
//const int maxlength = 8;    /* max chars in a name string   */
const int blankname = -1;   /* special name                 */

const int lastreservedname = 34;

typedef int name;
typedef string namestring;
typedef unsigned int length;

class names
{

  private:
    vector<namestring> namelist; //Stores a list of reserved and declared names

  public:
    name lookup(namestring str);
    /* Returns the internal representation of the name given in character  */
    /* form.  If the name is not already in the name table, it is          */
    /* automatically inserted.                                             */

    name cvtname(namestring str);
    /* Returns the internal representation of the name given in character  */
    /* form.  If the name is not in the name table then 'blankname' is     */
    /* returned.                                                           */

    void writename(name id);
    /* Prints out the given name on the console                            */

    int namelength(name id);
    /* Returns length ie number of characters in given name               */

    namestring getnamestring(name id);
    /* Returns the namestring for the given name                           */

    names(void);
    /* names initialises the name table.  This procedure is called at      */
    /* system initialisation before any of the above procedures/functions  */
    /* are used.                                                           */
};

#endif /* names_h */
```

Listing 1: names.h

A.1.2 names.cc

```
#include "names.h"
#include <iostream>
#include <string>
#include <cstdlib>

using namespace std;

/* Name storage and retrieval routines */
```

```
9
10 names::names(void)  /* the constructor */
11 {
12   //Populate namelist with reserved words
13   namelist.push_back("DEVICES"); //0
14   namelist.push_back("CONNECTIONS"); //1
15   namelist.push_back("MONITORS"); //2
16   namelist.push_back("END"); //3
17   namelist.push_back("CLOCK"); //4
18   namelist.push_back("SWITCH"); //5
19   namelist.push_back("AND"); //6
20   namelist.push_back("NAND"); //7
21   namelist.push_back("OR"); //8
22   namelist.push_back("NOR"); //9
23   namelist.push_back("DTYPE"); //10
24   namelist.push_back("XOR"); //11
25   namelist.push_back("SIGGEN"); //12
26   namelist.push_back("I1"); //13
27   namelist.push_back("I2"); //14
28   namelist.push_back("I3"); //15
29   namelist.push_back("I4"); //16
30   namelist.push_back("I5"); //17
31   namelist.push_back("I6"); //18
32   namelist.push_back("I7"); //19
33   namelist.push_back("I8"); //20
34   namelist.push_back("I9"); //21
35   namelist.push_back("I10"); //22
36   namelist.push_back("I11"); //23
37   namelist.push_back("I12"); //24
38   namelist.push_back("I13"); //25
39   namelist.push_back("I14"); //26
40   namelist.push_back("I15"); //27
41   namelist.push_back("I16"); //28
42   namelist.push_back("DATA"); //29
43   namelist.push_back("CLK"); //30
44   namelist.push_back("SET"); //31
45   namelist.push_back("CLEAR"); //32
46   namelist.push_back("Q"); //33
47   namelist.push_back("QBAR"); //34
48 }
49
50 name names::lookup(namestring str)
51 {
52   if (cvtname(str) == blankname)
53   {
54     namelist.push_back(str);  //Insert new string
55     return namelist.size() - 1; //Return new strings internal name
56   }
57   else
58   {
59     return cvtname(str);
60   }
61 }
62
63 name names::cvtname(namestring str)
64 {
65   if (str == "") return blankname;
66   for (name id = 0; id < namelist.size(); id++)
67   {
68     if (namelist[id] == str) return id;   //Linear search of namelist vector
69   }
70   return blankname;
71 }
72
73 void names::writename(name id)
74 {
75   if (id == blankname) cout << "blankname";
76   else if (id > blankname && id < namelist.size()) cout << namelist[id];
77   else cout << "Incorrect id";
78 }
79
80 int names::namelength(name id)
81 {
82   if (id > blankname && id < namelist.size()) return namelist[id].length();
83   else return blankname;
84 }
```

```
85
86 namestring names::getnamestring(name id)
87 {
88   if (id > blankname && id < namelist.size()) return namelist[id];
89   else return "";
90 }
```

Listing 2: names.cc

A.2 Scanner Class

A.2.1 scanner.h

```
1  #ifndef scanner_h
2  #define scanner_h
3  #include <string>
4  #include <iostream>
5  #include <fstream>
6  #include <cstdlib>
7  #include "names.h"
8
9  using namespace std;
10
11 typedef int name;
12 typedef enum {namesym, numsym, devsym, consym, monsym, endsym, classsym, iosym, colon, semicol
       , equals, dot, badsym, eofsym} symbol;
13
14 class scanner
15 {
16   public:
17     symbol s;
18     names* nmz;//Pointer to instance of names class
19
20     scanner(names* names_mod,    //Pointer to names class
21         const char* defname,  //Name of file being read
22         bool& ok);          //True of file has been opened correctly
23     ~scanner();             //Destructor
24     void getsymbol(symbol& s,    //Symbol type read
25               name& id,       //Return symbol name (if it has one)
26               int& num,
27               string& numstring);       //Return symbol value (if it's a number)
28     void writelineerror();
29
30   private:
31     ifstream inf; //Input file
32     char curch;   //Current input character
33     char prevch;  //Previous input character. Used for finding line end
34     bool eofile;  //True for end of file
35     bool ok;     //True if the file has been opened correctly
36     int linenum;  //Number of lines in definition file
37     int cursymlen;  //Length of current symbol. Used for error printing
38     string line;  //Current line contents. Used for error printing
39
40     void getch(); //Gets next input character
41     void getnumber(int& number, string& numstring); //Reads number from file
42     void getname(name& id); //Reads name from file
43     string getline(); //Reads the line
44     void skipspaces(); //Skips spaces
45     void skipcomments(); //Skips comments
46 };
47
48 #endif
```

Listing 3: scanner.h

A.2.2 scanner.cc

```
1 #include <iostream>
2 #include "scanner.h"
```

```
3
4  using namespace std;
5
6  scanner::scanner(names* names_mod, const char* defname, bool& ok)
7  {
8    nmz = names_mod;
9    ok = 1;
10   inf.open(defname);  //Open file
11   if (!inf)
12   {
13     cout << "Error: cannot open file for reading" << endl;
14     ok = 0;
15   }
16   eofile = (inf.get(curch) == 0); //Get first character
17   linenum = 1;
18   s = badsym;//in case getline is called before getsymbol
19 }
20
21 scanner::~scanner()
22 {
23   inf.close();  //Close file
24 }
25
26 void scanner::getsymbol(symbol& s, name& id, int& num, string& numstring)
27 {
28   s = badsym;
29   cursymlen = 0;
30   skipspaces();
31   if (eofile) s = eofsym;
32   else
33   {
34     if (isdigit(curch))
35     {
36       s = numsym;
37       getnumber(num, numstring);
38     }
39     else
40     {
41       if (isalpha(curch))
42       {
43         getname(id);
44         if (id == 0) s = devsym;
45         else if (id == 1) s = consym;
46         else if (id == 2) s = monsym;
47         else if (id == 3) s = endsym;
48         else if (id > 3 && id < 13) s = classsym;
49         else if (id > 12 && id < lastreservedname+1) s = iosym;
50         else s = namesym;
51       }
52       else
53       {
54         switch (curch)
55         {
56           case '=':
57             s = equals;
58             getch();
59             break;
60           case ';':
61             s = semicol;
62             getch();
63             break;
64           case ':':
65             s = colon;
66             getch();
67             break;
68           case '.':
69             s = dot;
70             getch();
71             break;
72           case '/':
73             getch();
74             if (curch == '*')
75             {
76               getch();
77               skipcomments();
78               getsymbol(s, id, num, numstring);
```

```
79              }
80              break;
81            default:
82              s = badsym;
83              getch();
84              break;
85          }
86          cursymlen = 1;
87        }
88      }
89    }
90  }
91
92  void scanner::writelineerror()
93  {
94    string errorptr;
95    for (int i = 0; i < ((int)line.length() - cursymlen); i++)
96    {
97      errorptr.push_back(' ');
98    }
99    errorptr.push_back('^');
100   cout << "Line " << linenum << ":" << endl;
101   cout << getline() << endl;     //Outputs current line
102   cout << errorptr << endl; //Outputs a caret at the error
103 }
104
105 void scanner::getch()
106 {
107   prevch = curch;
108   eofile = (inf.get(curch) == 0); //get next character
109   if (prevch == '\n') //If eoline, clear the currently stored line
110   {
111     linenum++;
112     line.clear();
113   }
114   else if (prevch != '\r') //If we're not at the end of a line, add the char to the line
        string
115   {
116     line.push_back(prevch);
117   }
118 }
119
120 void scanner::getnumber(int& number, string& numstring)
121 {
122   numstring = "";
123   number = 0;
124   cursymlen = 0;
125   while (isdigit(curch) && !eofile)
126   {
127     numstring.push_back(curch);
128     number *= 10;
129     number += (int(curch) - int('0'));
130     cursymlen++;
131     getch();
132   }
133 }
134
135 void scanner::getname(name& id)
136 {
137   namestring str;
138   cursymlen = 0;
139   while (isalnum(curch) && !eofile)
140   {
141     str.push_back(curch);
142     cursymlen++;
143     getch();
144   }
145   id = nmz->lookup(str);
146 }
147
148 void scanner::skipspaces()
149 {
150   while (isspace(curch) || curch == '\n')
151   {
152     getch();
153     if (eofile) break;
```

```
154   }
155 }
156
157 void scanner::skipcomments()
158 {
159   while (!(prevch == '*' && curch == '/'))
160   {
161     getch();
162     if (eofile)
163     {
164       cout << "Reached end of file before comment was terminated" << endl;
165       break;
166     }
167   }
168   getch(); //Get to next useful char
169 }
170
171 string scanner::getline()
172 {
173   if (s != semicol)
174   {
175     while (curch != ';' && !eofile && curch != '\n')
176     {
177       getch();
178     }
179     if (curch != '\n' && curch != '\r' && !eofile)
180     {
181       line.push_back(curch);
182     }
183   }
184   return line;
185 }
```

Listing 4: scanner.cc

A.3 Parser Class

A.3.1 parser.cc

```
1  #include <iostream>
2  #include "parser.h"
3  #include "error.h"
4
5  using namespace std;
6
7  /* The parser for the circuit definition files */
8
9  bool parser::readin(void)
10 {
11   //EBNF: specfile = devices connections monitors
12   bool deviceDone = false, connectionDone = false, monitorDone = false;
13   devicePresent = connectionPresent = monitorPresent = false;
14   cursym = badsym;
15   while (cursym != eofsym)
16   {
17     if (cursym != devsym && cursym != consym && cursym != monsym)
18     {
19       smz->getsymbol(cursym, curname, curint, numstring);
20     }
21     if (cursym == devsym)
22     {
23       if (deviceDone)
24       {
25         erz->newError(25);//Must only be one devices list
26       }
27       deviceDone = true;
28       deviceList();
29     }
30     else if (cursym == consym)
31     {
32       if (!deviceDone)
33       {
```

```
34          erz->newError(0); //must have device list first
35        }
36        if (connectionDone)
37        {
38          erz->newError(28);//Must only be one connections list
39
40        }
41        connectionDone = true;
42        connectionList();
43      }
44      else if (cursym == monsym)
45      {
46        if (!deviceDone | !connectionDone)
47        {
48          erz->newError(2); //Must have monitor list last
49        }
50        if (monitorDone)
51        {
52          erz->newError(29);//Must only be one Monitors list
53        }
54        monitorDone = true;
55        monitorList();
56      }
57      else if (cursym != eofsym)
58      {
59        while (cursym != devsym && cursym != consym && cursym != monsym && cursym != eofsym)
60        {
61          smz->getsymbol(cursym, curname, curint, numstring);
62          erz->countSymbols();
63        }
64        erz->symbolError(deviceDone, connectionDone, monitorDone);
65      }
66    }
67    if (!deviceDone)
68    {
69      erz->newError(26);//There must be a DEVICES block, it may not have been initialised
      properly
70    }
71    if (!connectionDone)
72    {
73      erz->newError(30);//There must be a CONNECTIONS block, it may not have been initialised
      properly
74    }
75    if (!monitorDone)
76    {
77      erz->newError(31);//There must be a MONITORS block, it may not have been initialised
      properly
78    }
79    netz->checknetwork(correctOperation);
80    anyErrors = erz->anyErrors();
81    return (correctOperation && !anyErrors);
82  }
83
84  void parser::deviceList()
85  {
86    //EBNF: devices = 'DEVICES' dev {';' dev} ';' 'END'
87    bool alreadyGotNextSymbol;
88    if (!devicePresent)
89    {
90      smz->getsymbol(cursym, curname, curint, numstring);
91      if (cursym == classsym)
92      {
93        alreadyGotNextSymbol = newDevice(curname);
94        devicePresent = true;
95      }
96      else if (cursym == endsym)
97      {
98        erz->newError(3); //must have at least one device
99        return;
100     }
101     else
102     {
103       erz->newError(4); //need a device type
104     }
105     if (!alreadyGotNextSymbol)
106     {
```

```
107         smz->getsymbol(cursym, curname, curint, numstring);
108       }
109     }
110     while (cursym == semicol)
111     {
112       smz->getsymbol(cursym, curname, curint, numstring);
113       if (cursym == classsym)
114       {
115         alreadyGotNextSymbol = newDevice(curname);
116       }
117       else if (cursym == endsym)
118       {
119         return;
120       }
121       else if (cursym == consym | cursym == devsym | cursym == monsym)
122       {
123         erz->newError(32);//Block must be terminated with 'END'
124         return;
125       }
126       else
127       {
128         erz->newError(5);//Expecting device name or END after semicolon (device name must start
      with letter)
129       }
130       if (!alreadyGotNextSymbol)
131       {
132         smz->getsymbol(cursym, curname, curint, numstring);
133       }
134     }
135     if (!alreadyGotNextSymbol) erz->newError(24);//must end line in semicolon
136     while (cursym != semicol && cursym != endsym && cursym != eofsym)
137     {
138       smz->getsymbol(cursym, curname, curint, numstring);
139     }
140     if (cursym == semicol)
141     {
142       deviceList();
143     }
144     if (cursym == endsym)
145     {
146       return;
147     }
148 }
149
150
151 bool parser::newDevice(int deviceType)
152 {
153   //EBNF: dev = clock|switch|gate|dtype|xor|siggen
154   bool symbolSkip = false;
155   smz->getsymbol(cursym, curname, curint, numstring);
156   if (cursym == namesym)
157   {
158     devlink nameCheck = netz->finddevice(curname);
159     if(nameCheck==NULL)
160     {
161       name devName = curname;
162       if (deviceType == 10)
163       {
164         dmz->makedevice(dtype, devName, 0, correctOperation); //create DTYPE with name devName
165         return symbolSkip;
166       }
167       if (deviceType == 11)
168       {
169         dmz->makedevice(xorgate, devName, 2, correctOperation); //create XOR with name devName
170         return symbolSkip;
171       }
172       smz->getsymbol(cursym, curname, curint, numstring);
173       if (cursym == colon)
174       {
175         smz->getsymbol(cursym, curname, curint, numstring);
176         if (cursym == numsym)
177         {
178           switch (deviceType)
179           {
180             case 4:
181               if (curint > 0)
```

```
182                 {
183                   dmz->makedevice(aclock, devName, curint, correctOperation); //create clock
    with curint and devName
184                 }
185                 else
186                 {
187                   erz->newError(6);//clock must have number greater than 0
188                   symbolSkip=true;
189                 }
190                 break;
191               case 5:
192                 if (curint == 1 || curint == 0)
193                 {
194                   dmz->makedevice(aswitch, devName, curint, correctOperation);//create switch
    with curint and devName
195                 }
196                 else
197                 {
198                   erz->newError(7);//switch must have either 0 or 1
199                   symbolSkip=true;
200                 }
201                 break;
202               case 6:
203               case 7:
204               case 8:
205               case 9:
206                 if (curint > 0 && curint < 17)
207                 {
208                   switch (deviceType)
209                   {
210                     case 6:
211                       dmz->makedevice(andgate, devName, curint, correctOperation);//create and
    gate with curint and devName
212                       break;
213                     case 7:
214                       dmz->makedevice(nandgate, devName, curint, correctOperation);//create nand
     gate with curint and devName
215                       break;
216                     case 8:
217                       dmz->makedevice(orgate, devName, curint, correctOperation);//create or
    gate with curint and devName
218                       break;
219                     case 9:
220                       dmz->makedevice(norgate, devName, curint, correctOperation);//create nor
    gate with curint and devName
221                       break;
222                     default:
223                       break;
224                   }
225                 }
226                 else
227                 {
228                   erz->newError(8);//must have between 1 and 16 inputs to a GATE
229                   symbolSkip=true;
230                 }
231                 break;
232               case 12:
233                 if (isBinary(numstring))
234                 {
235                   sequence waveform;
236                   for (int i=0; i<numstring.length(); i++)
237                   {
238                     waveform.push_back(numstring[i]=='1');
239                   }
240                   smz->getsymbol(cursym, curname, curint, numstring);
241                   symbolSkip=true;
242                   while (cursym==numsym)
243                   {
244                     if (isBinary(numstring))
245                     {
246                       for (int i=0; i<numstring.length(); i++)
247                       {
248                         waveform.push_back(numstring[i]=='1');
249                       }
250                       smz->getsymbol(cursym, curname, curint, numstring);
251                     }
```

```
252                     else
253                     {
254                       erz->newError(36); //Must be a binary input
255                       symbolSkip=true;
256                       break;
257                     }
258                   }
259                   dmz->makesiggen(devName, waveform); //create SIGGEN with name devName
260                 }
261                 else
262                 {
263                   erz->newError(36); //Must be a binary input
264                   symbolSkip=true;
265                 }
266                 break;
267               default:
268                 break;
269             }
270             return symbolSkip;
271           }
272           else
273           {
274             erz->newError(9);//clock needs clock cycle number
275             symbolSkip=true;
276           }
277         }
278         else
279         {
280           erz->newError(10);//need colon after name for CLOCK/SWITCH/GATE type
281           symbolSkip=true;
282         }
283       }
284       else
285       {
286         erz->newError(27);//attempting to give two devices the same name, choose an alternative
      name
287         symbolSkip=true;
288       }
289     }
290     else if (cursym!=badsym)
291     {
292       erz->newError(33);//using reserved word as device name
293       symbolSkip=true;
294     }
295     else
296     {
297       erz->newError(11);//name must begin with letter and only containing letter number and _
298       symbolSkip=true;
299     }
300     return symbolSkip;
301   }
302
303   void parser::connectionList()
304   {
305     //EBNF: connections = 'CONNECTIONS' {con ';'} 'END'
306     bool connectionError;
307     if (!connectionPresent)
308     {
309       smz->getsymbol(cursym, curname, curint, numstring);
310       if (cursym == endsym)
311       {
312         if (!connectionPresent)
313         {
314           erz->newWarning(0);//No Connections
315         }
316         return;
317       }
318       else if (cursym == namesym)
319       {
320         connectionError = newConnection();
321         connectionPresent = true;
322       }
323       else
324       {
325         erz->newError(12);//connection must start with the name of a device
326       }
```

```
327     if (!connectionError)
328     {
329       smz->getsymbol(cursym, curname, curint, numstring);
330     }
331   }
332   while (cursym == semicol)
333   {
334     smz->getsymbol(cursym, curname, curint, numstring);
335     if (cursym == namesym)
336     {
337       connectionError = newConnection();
338     }
339     else if (cursym == endsym)
340     {
341       return;
342     }
343     else if (cursym == consym | cursym == devsym | cursym == monsym)
344     {
345       erz->newError(32);//Block must be terminated with 'END'
346       return;
347     }
348     else
349     {
350       erz->newError(13);//connection must start with the name of a device or end of device
      list must be terminated with END (not semicolon)
351     }
352     if (!connectionError)
353     {
354       smz->getsymbol(cursym, curname, curint, numstring);
355     }
356   }
357   if (!connectionError) erz->newError(24);//must end line in semicolon
358   while (cursym != semicol && cursym != endsym && cursym != eofsym)
359   {
360     smz->getsymbol(cursym, curname, curint, numstring);
361   }
362   if (cursym == semicol)
363   {
364     connectionList();
365   }
366   if (cursym == endsym)
367   {
368     return;
369   }
370 }
371
372 bool parser::newConnection()
373 {
374   //EBNF: con = devicename'.'input '=' devicename['.'output]
375   bool symbolSkip = false;
376   devlink devtype = netz->finddevice(curname);
377   if (devtype != NULL)
378   {
379     connectionInName = curname;
380     smz->getsymbol(cursym, curname, curint, numstring);
381     if (cursym == dot)
382     {
383       smz->getsymbol(cursym, curname, curint, numstring);
384       devtype = netz->finddevice(connectionInName);
385       inplink ilist = netz->findinput(devtype, curname);
386       if (cursym == iosym && ilist != NULL)
387       {
388         name inputPin = curname;
389         smz->getsymbol(cursym, curname, curint, numstring);
390         if (cursym == equals) //SEARCH - you have got to here
391         {
392           smz->getsymbol(cursym, curname, curint, numstring);
393           devtype = netz->finddevice(curname);
394           if (devtype != NULL)
395           {
396             connectionOutName = curname;
397             switch (devtype ? devtype->kind : baddevice)
398             {
399               case 7:
400                 smz->getsymbol(cursym, curname, curint, numstring);
401                 if (cursym == dot)
```

```
402                 {
403                   smz->getsymbol(cursym, curname, curint, numstring);
404                   outplink olist = netz->findoutput(devtype, curname);
405                   if (cursym == iosym && olist != NULL)
406                   {
407                     if (ilist->connect==NULL)
408                     {
409                       netz->makeconnection(connectionInName, inputPin, connectionOutName,
    curname, correctOperation);
410                       return symbolSkip;
411                     }
412                     else if (ilist->connect==netz->findoutput(devtype, curname))
413                     {
414                       namestring repeatedInput = smz->nmz->getnamestring(connectionInName);
415                       namestring repeatedOutputDevice = smz->nmz->getnamestring(
    connectionOutName);
416                       namestring repeatedOutputPin = smz->nmz->getnamestring(curname);
417                       namestring repeatedOutput = repeatedOutputDevice + "." +
    repeatedOutputPin;
418                       erz->connectionWarning(repeatedInput, repeatedOutput);//generate
    warnning for repeated connection
419                     }
420                     else
421                     {
422                       erz->newError(37);//attempting to input 2 ouputs into same input
423                       symbolSkip=true;
424                     }
425                   }
426                   else
427                   {
428                     erz->newError(34); //Not valid output for dtype
429                   }
430                 }
431                 else
432                 {
433                   erz->newError(14);  //Expect a dot after dtype
434                   symbolSkip=true;
435                 }
436                 break;
437               default:
438               //check the connection is unique
439                 if (ilist->connect==NULL)
440                 {
441                   netz->makeconnection(connectionInName, inputPin, connectionOutName,
    blankname, correctOperation);
442                   return symbolSkip;
443                 }
444                 else if (ilist->connect==netz->findoutput(devtype, blankname))
445                 {
446                   namestring repeatedInput = smz->nmz->getnamestring(connectionInName);
447                   namestring repeatedOutput = smz->nmz->getnamestring(connectionOutName);
448                   erz->connectionWarning(repeatedInput, repeatedOutput);//generate warnning
    for repeated connection
449                 }
450                 else
451                 {
452                   erz->newError(37);//attempting to input 2 ouputs into same input
453                   symbolSkip=true;
454                 }
455                 break;
456             }
457           }
458           else
459           {
460             erz->newError(15); //Device does not exist
461             symbolSkip=true;
462           }
463         }
464         else
465         {
466           erz->newError(16);//Must specify output to connect to input with equals sign
467           symbolSkip=true;
468         }
469       }
470       else
471       {
```

```
472           erz->newError(17);//specify valid input gate after dot
473           symbolSkip=true;
474         }
475       }
476       else
477       {
478         erz->newError(18);//need to seperate connection input with a '.' (or need to specify
      input)
479         symbolSkip=true;
480       }
481     }
482     else
483     {
484       erz->newError(19); //Device does not exist
485       symbolSkip=true;
486     }
487     return symbolSkip;
488 }
489
490 void parser::monitorList()
491 {
492   //EBNF: monitors = 'MONITORS' {mon ';'} 'END'
493   bool monitorError;
494   if (!monitorPresent)
495   {
496     smz->getsymbol(cursym, curname, curint, numstring);
497     if (cursym == endsym)
498     {
499       if (!monitorPresent)
500       {
501         erz->newWarning(1);//No Monitors
502       }
503       return;
504     }
505     else if (cursym == namesym)
506     {
507       monitorError = newMonitor();
508       monitorPresent = true;
509     }
510     else
511     {
512       erz->newError(20);//monitor must start with the name of a device
513     }
514     if (!monitorError)
515     {
516       smz->getsymbol(cursym, curname, curint, numstring);
517     }
518   }
519   while (cursym == semicol)
520   {
521     smz->getsymbol(cursym, curname, curint, numstring);
522     if (cursym == namesym)
523     {
524       monitorError = newMonitor();
525     }
526     else if (cursym == endsym)
527     {
528       return;
529     }
530     else if (cursym == consym | cursym == devsym | cursym == monsym)
531     {
532       erz->newError(32);//Block must be terminated with 'END'
533       return;
534     }
535     else
536     {
537       erz->newError(21);//monitor must start with the name of a device or end of device list
      must be terminated with END (not semicolon)
538     }
539     if (!monitorError)
540     {
541       smz->getsymbol(cursym, curname, curint, numstring);
542     }
543   }
544   if (!monitorError) erz->newError(24);//must end line in semicolon
545   while (cursym != semicol && cursym != endsym && cursym != eofsym)
```

```
546   {
547     smz->getsymbol(cursym, curname, curint, numstring);
548   }
549   if (cursym == semicol)
550   {
551     monitorList();
552   }
553   if (cursym == endsym)
554   {
555     return;
556   }
557 }
558
559 bool parser::newMonitor()
560 {
561   //EBNF: mon = devicename['.'output]
562   bool symbolSkip = false;
563   devlink devtype = netz->finddevice(curname);
564   if (devtype != NULL)
565   {
566     monitorName = curname;
567     switch (devtype ? devtype->kind : baddevice)
568     {
569       case 7:
570         smz->getsymbol(cursym, curname, curint, numstring);
571         if (cursym == dot)
572         {
573           smz->getsymbol(cursym, curname, curint, numstring);
574           outplink olist = netz->findoutput(devtype, curname);
575           bool alreadyMonitored = mmz->IsMonitored(olist);
576           if (!alreadyMonitored)
577           {
578             if (cursym == iosym && olist != NULL)
579             {
580               mmz->makemonitor(monitorName, curname, correctOperation);
581               return symbolSkip;
582             }
583             else
584             {
585               erz->newError(34); //Not valid output for dtype
586             }
587           }
588           else
589           {
590             namestring repeatedMonitorDevice = smz->nmz->getnamestring(monitorName);
591             namestring repeatedMonitorPin = smz->nmz->getnamestring(curname);
592             namestring repeatedMonitor = repeatedMonitorDevice + "." + repeatedMonitorPin;
593             erz->monitorWarning(repeatedMonitor); //repeated monitors
594             if (cursym == iosym && olist != NULL)
595             {
596               mmz->makemonitor(monitorName, curname, correctOperation);
597               return symbolSkip;
598             }
599             else
600             {
601               erz->newError(34); //Not valid output for dtype
602             }
603           }
604         }
605         else
606         {
607           erz->newError(22);  //Expect a dot after dtype
608           symbolSkip=true;
609         }
610       default:
611         outplink olist = netz->findoutput(devtype, blankname);
612         bool alreadyMonitored = mmz->IsMonitored(olist);
613           if (!alreadyMonitored)
614           {
615             mmz->makemonitor(monitorName, blankname, correctOperation);
616           }
617           else
618           {
619             namestring repeatedMonitor = smz->nmz->getnamestring(curname);
620             erz->monitorWarning(repeatedMonitor); //repeated monitors
621             mmz->makemonitor(monitorName, curname, correctOperation);
```

```
622             }
623           return symbolSkip;
624       }
625     }
626     else
627     {
628       erz->newError(23);//bad device monitor
629       symbolSkip=true;
630     }
631     return symbolSkip;
632 }
633
634 bool parser::isBinary(string numstring)
635 {
636     for (int i=0; i<numstring.length(); i++)
637     {
638       if (numstring[i]!='0' && numstring[i]!='1')
639         {
640           return false;
641         }
642     }
643     return true;
644 }
645
646 parser::parser(network* network_mod, devices* devices_mod, monitor* monitor_mod, scanner*
      scanner_mod, error* error_mod)
647 {
648     netz = network_mod;   /* make internal copies of these class pointers */
649     dmz = devices_mod;    /* so we can call functions from these classes  */
650     mmz = monitor_mod;    /* eg. to call makeconnection from the network  */
651     smz = scanner_mod;    /* class you say:                               */
652     erz = error_mod; /* netz->makeconnection(i1, i2, o1, o2, ok);    */
653     /* any other initialisation you want to do? */
654 }
```

Listing 5: parser.cc

`parser.cc` was written with joint effort between myself and Tim. I contributed approximately 25% of the code.

A.4 Test Scripts

A.4.1 test.sh

```
1 #!/bin/bash
2 echo "" > error.txt
3 for f in *.gf2
4 do
5   echo "processing $f..."
6   echo "processing $f..." >> test.txt
7   echo -e "r 50\r\nq\r\n" | ../src/logsim $f >> test.txt
8   echo -e '\n' >> test.txt
9 done
```

Listing 6: test.sh

A.4.2 error.sh

```
1 #!/bin/bash
2 echo "" > error.txt
3 for f in *.gf2
4 do
5   echo "processing $f..."
6   echo "processing $f..." >> error.txt
7   echo -e "r 50\r\nq\r\n" | ../../src/logsim $f >> error.txt
8   echo -e '\n' >> error.txt
9 done
```

Listing 7: error.sh

B Test Definition Files

All supplied definition files and circuit diagrams were written and designed by myself.

B.1 XOR Gate

B.1.1 Definition File

```
DEVICES
SWITCH S1:0;
SWITCH S2:1;
NAND G1:2;
NAND G2:2;
NAND G3:2;
NAND G4:2;
END

CONNECTIONS
G1.I1 = S1;
G1.I2 = S2;
G2.I1 = S1;
G2.I2 = G1;
G3.I1 = G1;
G3.I2 = S2;
G4.I1 = G2;
G4.I2 = G3;
END

MONITORS
S1;
S2;
G4;
END
```

Listing 8: xor.gf2

B.1.2 Circuit Diagram

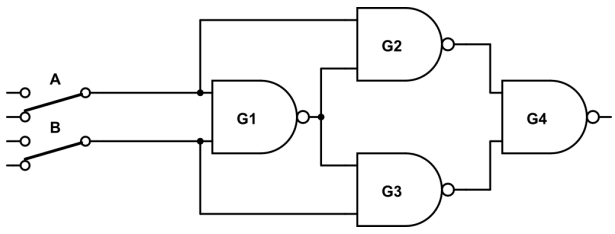


Figure 1: Circuit diagram of an XOR gate implemented using NAND gates

B.2 4-bit Adder

B.2.1 Definition File

```
DEVICES
/* 4 bit inputs */
SWITCH A0:1;
SWITCH A1:0;
SWITCH A2:0;
SWITCH A3:0;
SWITCH B0:1;
SWITCH B1:0;
SWITCH B2:0;
```

```
SWITCH B3:0;
SWITCH C0:1; /* Carry in */
AND AND1:2;
AND AND2:2;
AND AND3:2;
AND AND4:2;
AND AND5:2;
AND AND6:2;
AND AND7:2;
AND AND8:2;
XOR XOR1;
XOR XOR2;
XOR XOR3;
XOR XOR4;
XOR XOR5;
XOR XOR6;
XOR XOR7;
XOR XOR8;
OR OR1:2;
OR OR2:2;
OR OR3:2;
OR OR4:2;
END

CONNECTIONS
/* LSB adder */
XOR1.I1 = A0;
XOR1.I2 = B0;
AND1.I1 = XOR1;
AND1.I2 = C0;
AND2.I1 = A0;
AND2.I2 = B0;
XOR2.I1 = XOR1;
XOR2.I2 = C0;
OR1.I1 = AND1;
OR1.I2 = AND2;

XOR3.I1 = A1;
XOR3.I2 = B1;
AND3.I1 = XOR3;
AND3.I2 = OR1;
AND4.I1 = A1;
AND4.I2 = B1;
XOR4.I1 = XOR3;
XOR4.I2 = OR1;
OR2.I1 = AND3;
OR2.I2 = AND4;

XOR5.I1 = A2;
XOR5.I2 = B2;
AND5.I1 = XOR5;
AND5.I2 = OR2;
AND6.I1 = A2;
AND6.I2 = B2;
XOR6.I1 = XOR5;
XOR6.I2 = OR2;
OR3.I1 = AND5;
OR3.I2 = AND6;

/* MSB Adder */
XOR7.I1 = A3;
XOR7.I2 = B3;
AND7.I1 = XOR7;
AND7.I2 = OR3;
AND8.I1 = A3;
AND8.I2 = B3;
XOR8.I1 = XOR7;
XOR8.I2 = OR3;
OR4.I1 = AND7;
OR4.I2 = AND8;
END

MONITORS
/* Outputs */
XOR2;
XOR4;
```

```
XOR6;
XOR8;
OR4; /* Carry out */
END
```

Listing 9: 4bitadder.gf2

B.2.2 Circuit Diagram

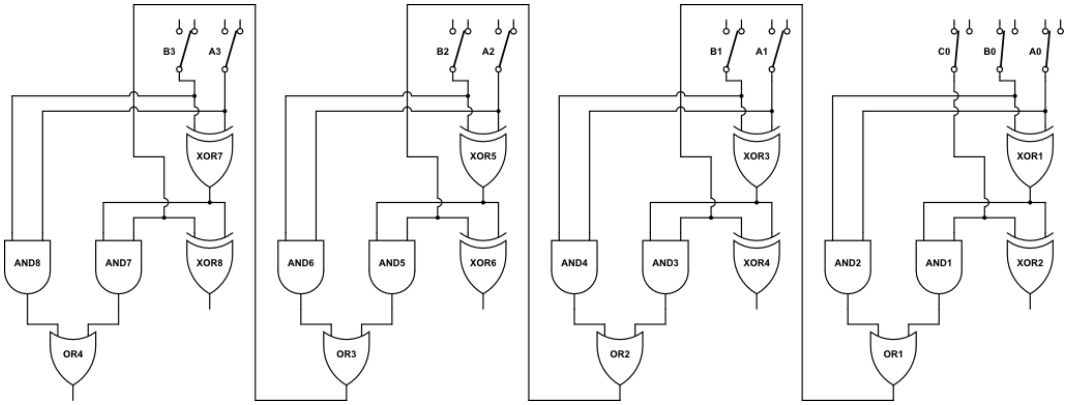


Figure 2: Circuit diagram of a 4-bit adder

B.3 Serial In Parallel Out Shift Register

B.3.1 Definition File

```
DEVICES
CLOCK CLK1:2;
CLOCK CLK2:1;
SWITCH S:0; /* Set switch */
SWITCH R:0; /* Reset switch */
DTYPE D1;
DTYPE D2;
DTYPE D3;
DTYPE D4;
END

CONNECTIONS
D1.DATA = CLK1;
D2.DATA = D1.Q;
D3.DATA = D2.Q;
D4.DATA = D3.Q;
D1.CLK = CLK2;
D2.CLK = CLK2;
D3.CLK = CLK2;
D4.CLK = CLK2;
D1.SET = S;
D2.SET = S;
D3.SET = S;
D4.SET = S;
D1.CLEAR = R;
D2.CLEAR = R;
D3.CLEAR = R;
D4.CLEAR = R;
END

MONITORS
CLK2;
D1.Q;
D2.Q;
D3.Q;
D4.Q;
END
```

Listing 10: sipo.gf2

B.3.2 Circuit Diagram

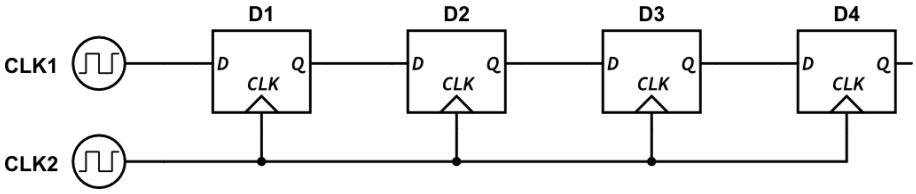


Figure 3: Circuit diagram of a serial in parallel out shift register

NB The software used to draw the circuit diagram does not support the same style of D flip-flop used in the definition file, and Fig. 3 was the closest achievable.

B.4 Gated D Latch

B.4.1 Definition File

```
DEVICES
CLOCK CLK1:1;
CLOCK CLK2:2;
NAND G1:1;
AND G2:2;
AND G3:2;
NOR G4:2;
NOR G5:2;
END

CONNECTIONS
G1.I1 = CLK1;
G2.I1 = G1;
G2.I2 = CLK2;
G3.I1 = CLK2;
G3.I2 = CLK1;
G4.I1 = G2;
G4.I2 = G5;
G5.I1 = G4;
G5.I2 = G3;
END

MONITORS
CLK1; /* D */
CLK2; /* E */
G4; /* Q */
G5; /* QBAR */
END
```

Listing 11: sipo.gf2

B.4.2 Circuit Diagram

NB The software used to draw the circuit diagram does not support the NAND gates with one input. Therefore the NAND gate G1 was substituted for a NOT gate as can be seen in Fig. 4.

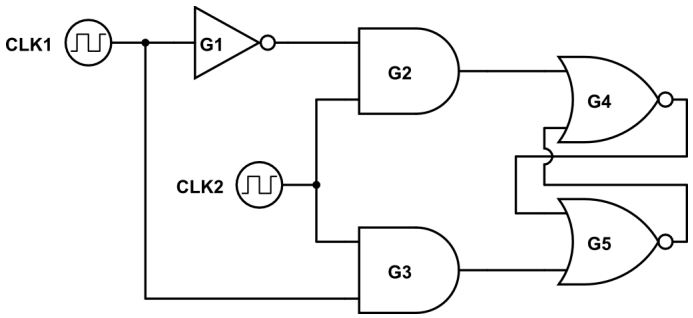


Figure 4: Circuit diagram of a Gated D Latch

B.5 Signal Generator Example

B.5.1 Definition File

```
DEVICES
SIGGEN S1
    :1101010101010101001010101010101010100101010101010101010101010101001010001101010101001;

SIGGEN S2: 1 1   1  0 0 1 0 1 0 1 0 1 0;
SIGGEN S3:1;
SIGGEN S4:0;
AND A1:4;
END

CONNECTIONS
A1.I1=S1;
A1.I2=S2;
A1.I3=S3;
A1.I4=S4;
END

MONITORS
S1;
S2;
S3;
S4;
A1;
END
```

Listing 12: siggen.gf2

B.5.2 Circuit Diagram

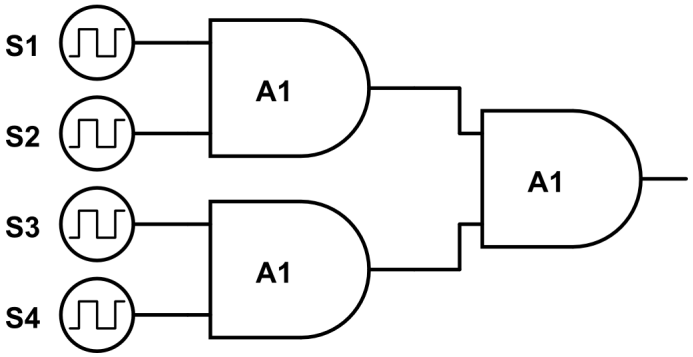


Figure 5: Circuit diagram using a signal generator

NB The software used to draw the circuit diagram does not support the AND gates with four inputs. Therefore three AND gates with two inputs each were substituted for the single AND gate, A1, with four inputs as can be seen in Fig. 5.

C EBNF

```
specfile = devices connections monitors

devices = 'DEVICES' dev ';' {dev ';'} 'END'
connections = 'CONNECTIONS' {con ';'} 'END'
monitors = 'MONITORS' {mon ';'} 'END'

dev = clock|switch|gate|dtype|xor|siggen
con = devicename'.'input '=' devicename['.'output]
mon = devicename['.'output]

devicename = letter {'_'|letter|digit}
input = 'I'('1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'|
  '10'|'11'|'12'|'13'|'14'|'15'|'16')|'DATA'|'CLK'|'SET'|'CLEAR'
output = 'Q'['BAR']

clock = 'CLOCK' devicename':'digit{digit}
switch = 'SWITCH' devicename':'('0'|'1')
gate = ('AND'|'NAND'|'OR'|'NOR') devicename':'('1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|
  '9'|'10'|'11'|'12'|'13'|'14'|'15'|'16')
dtype = 'DTYPE' devicename
xor = 'XOR' devicename
siggen = 'SIGGEN' devicename':'('0'|'1'){'0'|'1'}
```

Listing 13: EBNF

D User Guide

Opening files: To open a definition file, click the `File` menu followed by the `Open` option. You will be presented with a file selection dialogue. The file selection dialogue will only show definition files (Files with the `.gf2` file extension). Upon selecting a file, any errors in the definition file will be written to the message window, otherwise the Logic Simulator is ready to use.

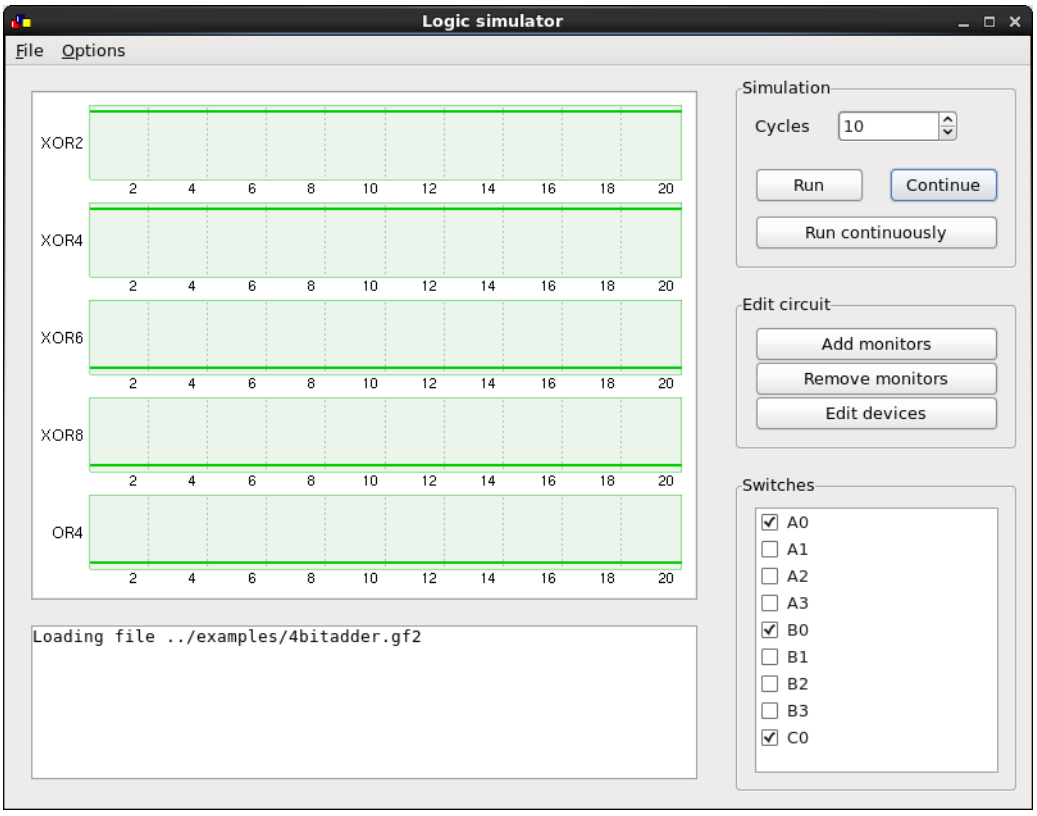


Figure 6: The view upon running a simulation

Running simulations: In order to run a simulation you must first enter a number of cycles you wish the simulation to run for (default is `10`) then press the run button. The monitored signals will be displayed in the left display panel. You may choose to continue the simulation by pressing the `Continue` button, or run the simulation continuously by pressing the `Continuous Simulation` button.

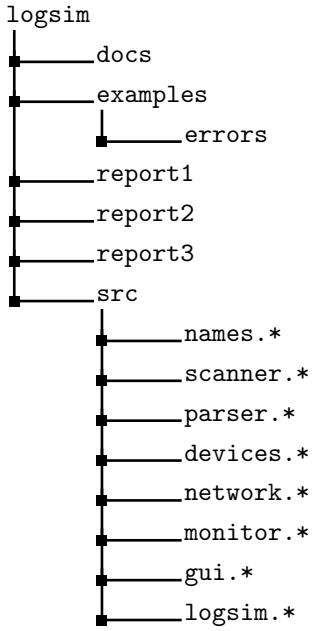
Adding or removing monitors: You can edit the signals that are monitored and displayed in the main window. To add monitors, click the `Add monitors` button and select the monitor, or monitors, you wish to add followed by the `OK` button. To remove monitors, press the `Remove monitors` button and select the monitor, or monitors, you wish to remove followed by the `OK` button

Editing devices: To edit devices, click the `Edit devices` button. From the Edit devices dialogue you can change the device's name, type and number of inputs (if applicable). You can also change the inputs to, or ouputs from a device.

Changing switch states: If your circuit contains any switches, you can change the state of the switch by changing the state of the check box beside its name.

Changing simulator settings: You can change certain settings relating to the operation of the logic simulator. Click the `Options` menu and from here you can change or reset settings as well as adjust the continuous run speed. By clicking `Edit options` you can change the trace options and debugging options.

E File Listing



docs contains documentation relevant to our logic simulator such as: EBNF, reserved words, and our Gantt chart.

examples contains our example definition files as listed in Appendix B as well as the test shell script listed in Appendix A.4.

errors contains definition files which contain deliberate errors and are used to test our error checking functionality. In addition this folder contains the error.sh shell script listed in Appendix A.4.

report1, report2 and **report3** contain our first, second and final report respectively.

src contains the source code for our logic simulator. The functionality of the major classes is outlined beneath.

names stores a list of all the words used within a definition file, and methods to manipulate them. It is initialised with only the reserved words, but can be populated as a definition file is read.

scanner reads through the definition file, character by character, and is able to return complete symbols to the parser. It is able to return the internal representation of a symbol, the type of symbol and optionally the value.

parser analyses the definition file as it is read in according to the rules laid out in our EBNF. It is then able to create devices, connections and monitors that are laid out in the definition file.

devices is used to create and execute devices.

network stores information about the devices, including the connections between each device.

monitor implements signal monitors, which are used to display the points of interest, as determined from the definition file, in the GUI.

gui provides a graphical user interface for the user, and allows for advanced features such as circuit and monitor editing without having to edit the definition file. We have implemented the GUI with a modular approach, and as such there are several gui related classes e.g. gui-canvas, gui-id, gui-misc, etc.

logsim ties all the other classes together and allows the user to fully simulate logic circuits.

F Gantt Chart

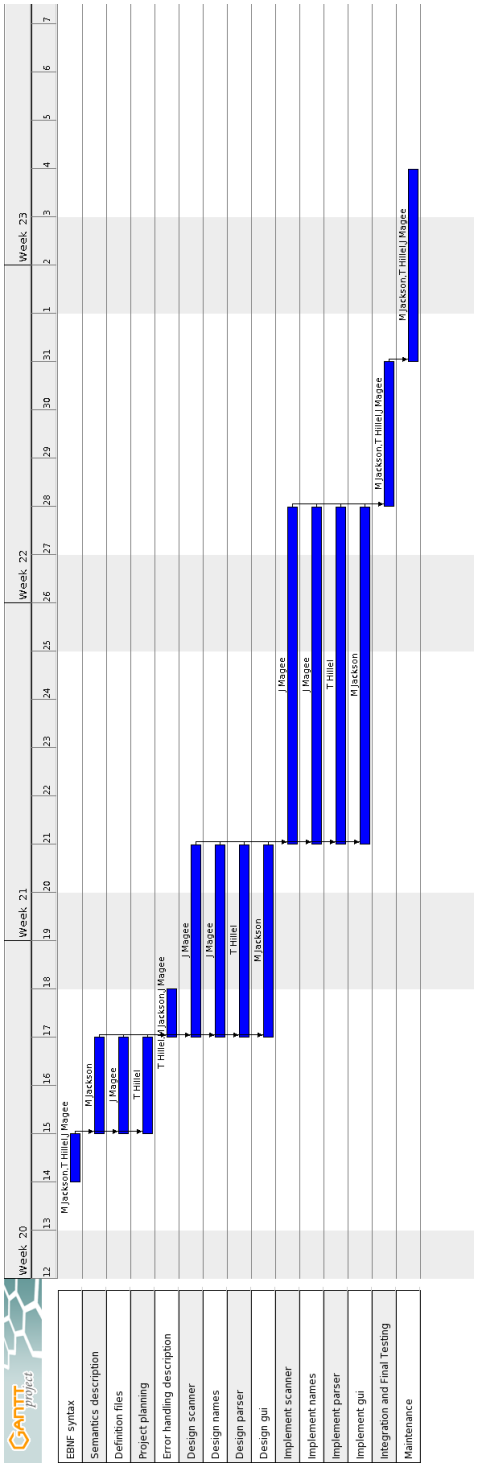


Figure 7: Gantt chart showing our development cycle