

Conformal LEC failures debug by using Gates On the Fly

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Introduction

Gates On the Fly, GOF, is a schematic/ECO tool for netlist debugging and modification.

Main features:

- Flexible and partial Schematic to isolate only the related path
- Built-in functions like tracing path from point to point, logic cone extraction
- ECO in GUI mode
- ECO in script mode
- Logic cone replacement for large netlist changes
- Netlist tracing by using exported APIs
- Comment on schematic and PDF support for easy documentation
- Prime Time report file analysis and timing fix automation
- Placement view for timing path analysis with each segment highlighted with different color

The following demo shows how to use Gates On the Fly combining Conformal LEC tool to debug LEC failures.

The Conformal LEC way

LEC report

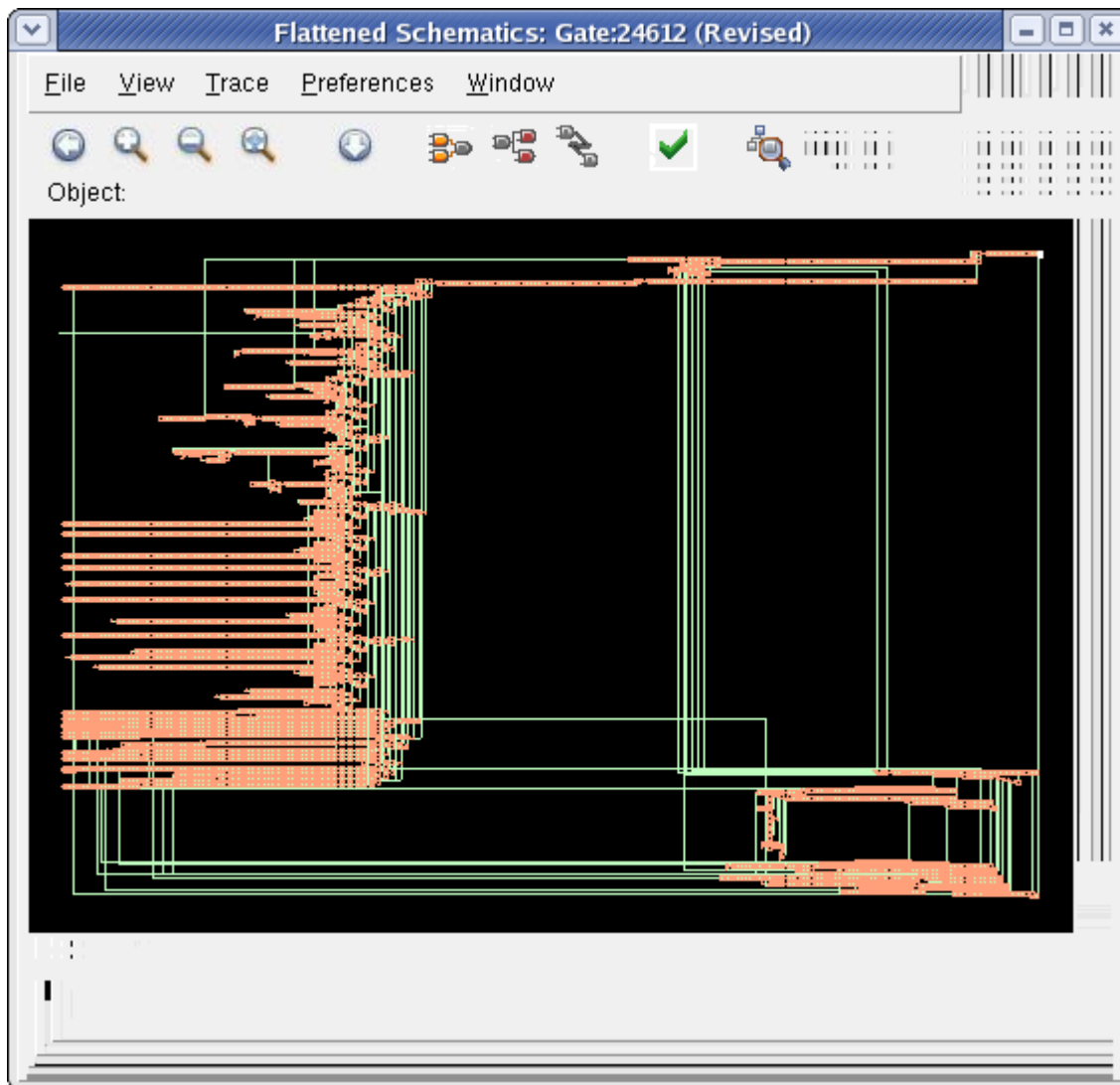
A netlist from the Physical Design Team showed 661 non-equivalent points by running LEC check

| Compared points | PO | DFF | DLAT | BBOX | Total |
|-----------------|-----|-------|------|------|-------|
| ----- | | | | | |
| Equivalent | 553 | 42253 | 98 | 62 | 42966 |
| ----- | | | | | |
| Non-equivalent | 0 | 646 | 0 | 15 | 661 |

Primary analysis showed each non-equivalent point had the same fanin endpoints in both revised and golden netlist, so the failure must be inside the logic cone.

Conformal LEC schematic

Conformal LEC GUI debug tool gave some useful information, but not sufficient and efficient. The schematic from LEC debug tool printed out too many gates and connections. The culprit gates were hiding somewhere. It's intimidating to dive into this full-blown schematic and catch the culprit gate.



Conformal LEC schematic prints out too many gates. It's not flexible to debug this schematic.

LEC diagnosis

LEC diagnosis result gave some clue in the potential error candidates, but how to use them?

Diagnosis for Non-equivalent key points:

(G) + 1703 DFF /core/crossbar/cfrg_xhncc_0

(R) + 10964 DFF /core/crossbar/cfrg_xhncc_0

Diagnosis points: [CLOCK]

(G) + 736683 AND /core/crossbar/FE_RC_10964_0

(R) + 2279312 BUF /core/crossbar/FE_OFC2712_xt_xhncc_txd_37_

Non-equivalent signal and its error candidates

| ID (R) | Type | Likelihood | Name |
|------------------------|--------|------------------|--|
| 523002 | DFF | | <i>/core/crossbar/cfrg_xhncc_0</i> |
| ----- Candidates ----- | | | |
| 1: | 113766 | BUF_X16M_RVT | 1.00 /core/crossbar/FE_OFC75663_scanmode_from_pad |
| 2: | 113767 | BUF_X3M_RVT | 1.00 /core/crossbar/FE_OFC341157_scanmode_from_pad |
| 3: | 114588 | BUF_X13M_RVT | 1.00 <i>/core/crossbar/FE_OFC34939_xt_sel_2_</i> |
| 4: | 114601 | NOR2XB_XOP7M_RVT | 1.00 /core/crossbar/u_mux_p214748365A28 |
| 5: | 114610 | NOR2B_X3M_RVT | 1.00 /core/crossbar/u_mux_p214748365A29 |
| 6: | 114825 | INV_X13M_RVT | 1.00 /core/crossbar/FE_OFC11881_jtag_mode |
| 7: | 117468 | INV_X2P5M_RVT | 1.00 /core/crossbar/u_gpio_p214748365A20030 |
| 8: | 114592 | BUF_X3M_RVT | 0.99 /core/crossbar/FE_OFC339934_scanmode_from_pad |
| 9: | 114593 | INV_X13M_RVT | 0.97 /core/crossbar/FE_OFC75793_scanmode_from_pad |

Note, two instances have been marked in red, which will be the two tracing points for Gates On the Fly

The GOF way

Load netlists and related instances

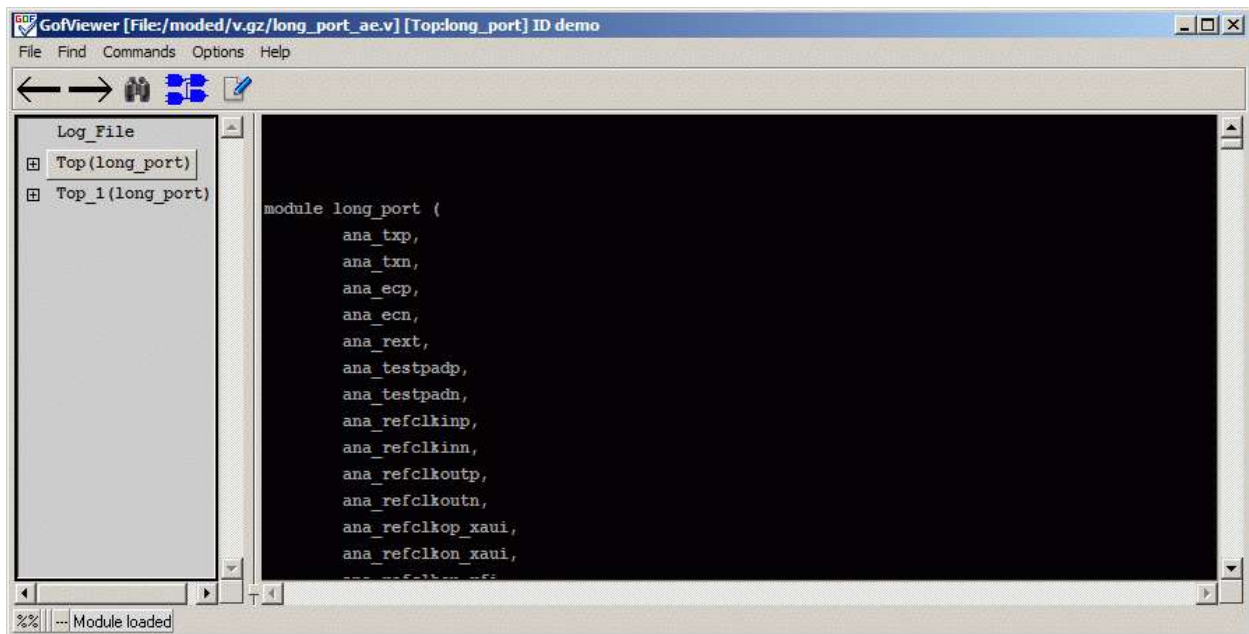
The command line to loading revised and golden netlists into GOF

```
gof -lib hvt.lib -lib rvt.lib -Top_1 golden_netlist.v revised_netlist.v
```

“-lib” option is for library files

“-Top_1” options is to load the golden netlist, extra netlist can be loaded by “-Top_2” and so on
The revised netlist has no option in the front.

The first GUI window is GofViewer, netlist viewer. The left hand side has the two netlists hierarchies.
The right hand side lists a module of one netlist.

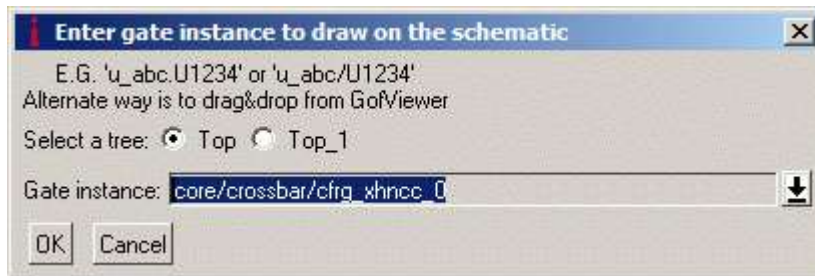


Gates On the Fly Use Case: Conformal LEC failures debug

You can use either press Ctrl-g (Ctrl key and 'g' key pressed together) to load an instance to schematic to use Ctrl-f to pop a search window to search the string in the right side window. When the instance is found in the netlist, double click the instance to bring schematic.

Before press keys, you can select the instance name in a text window so that GOF can automatically grab the string in clipboard and display the string in loading or searching window

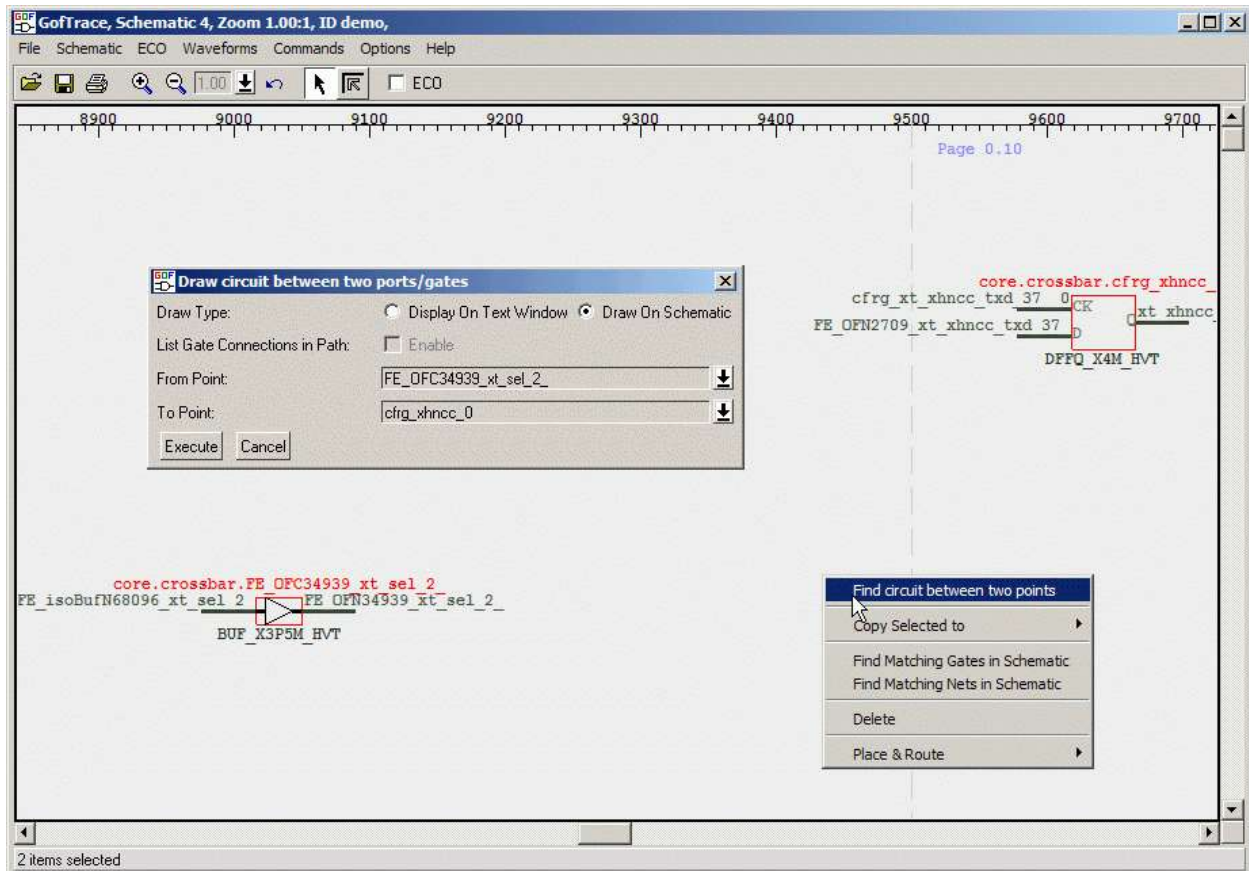
Here is the loading window



Load one of the error candidate instance into the schematic as well, we get GofTrace, schematic window

Find path from candidate to end point

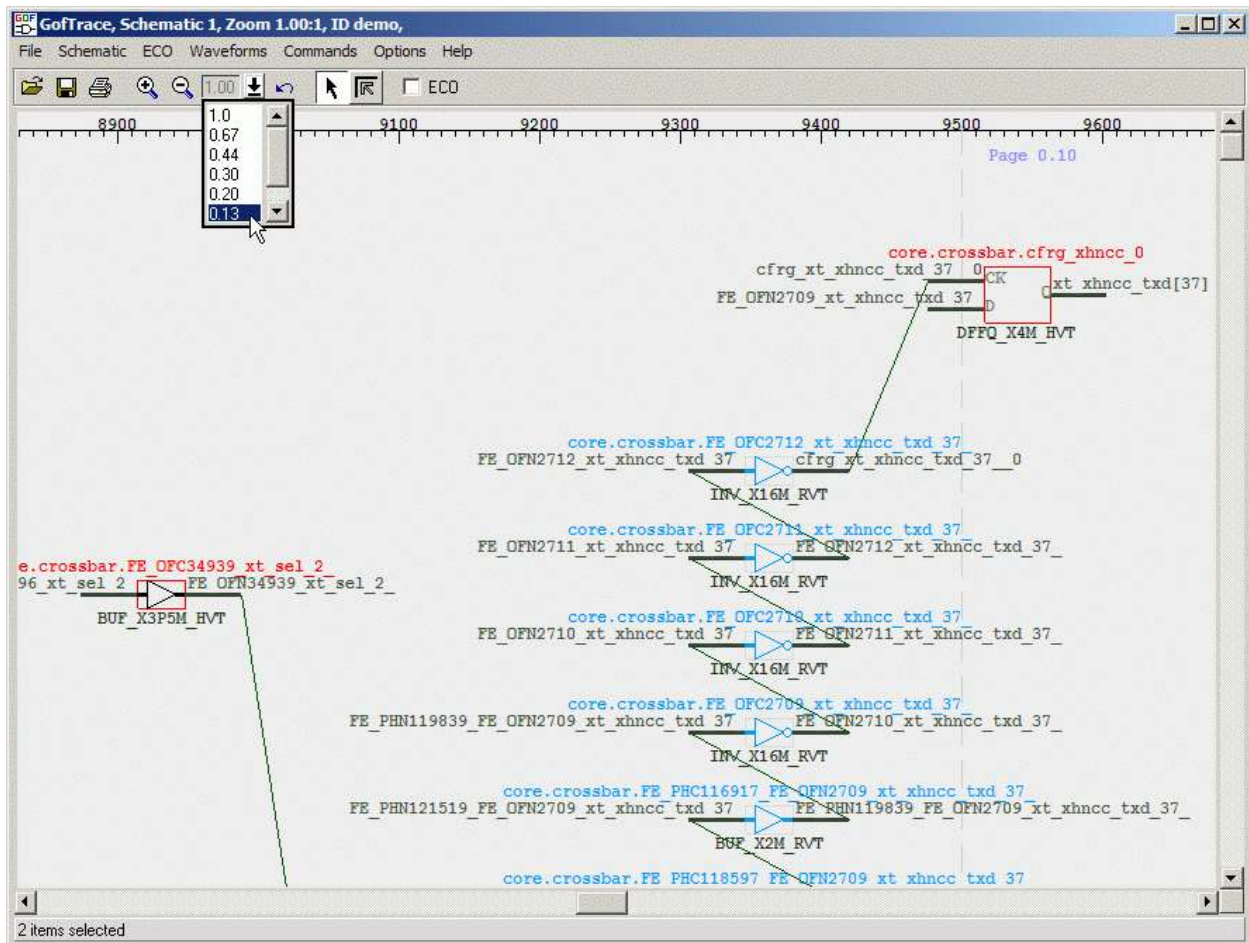
- Select the two instances
- Right click mouse right key to pop up menu
- Select 'Find circuit between two points'
- Adjust the correct From/To points, the source should be in From Point, the sink in To Point.
- Check 'Draw On Schematic', or 'Display On Text Window' for experimental
- Click 'Execute' button



Gates On the Fly Use Case: Conformal LEC failures debug

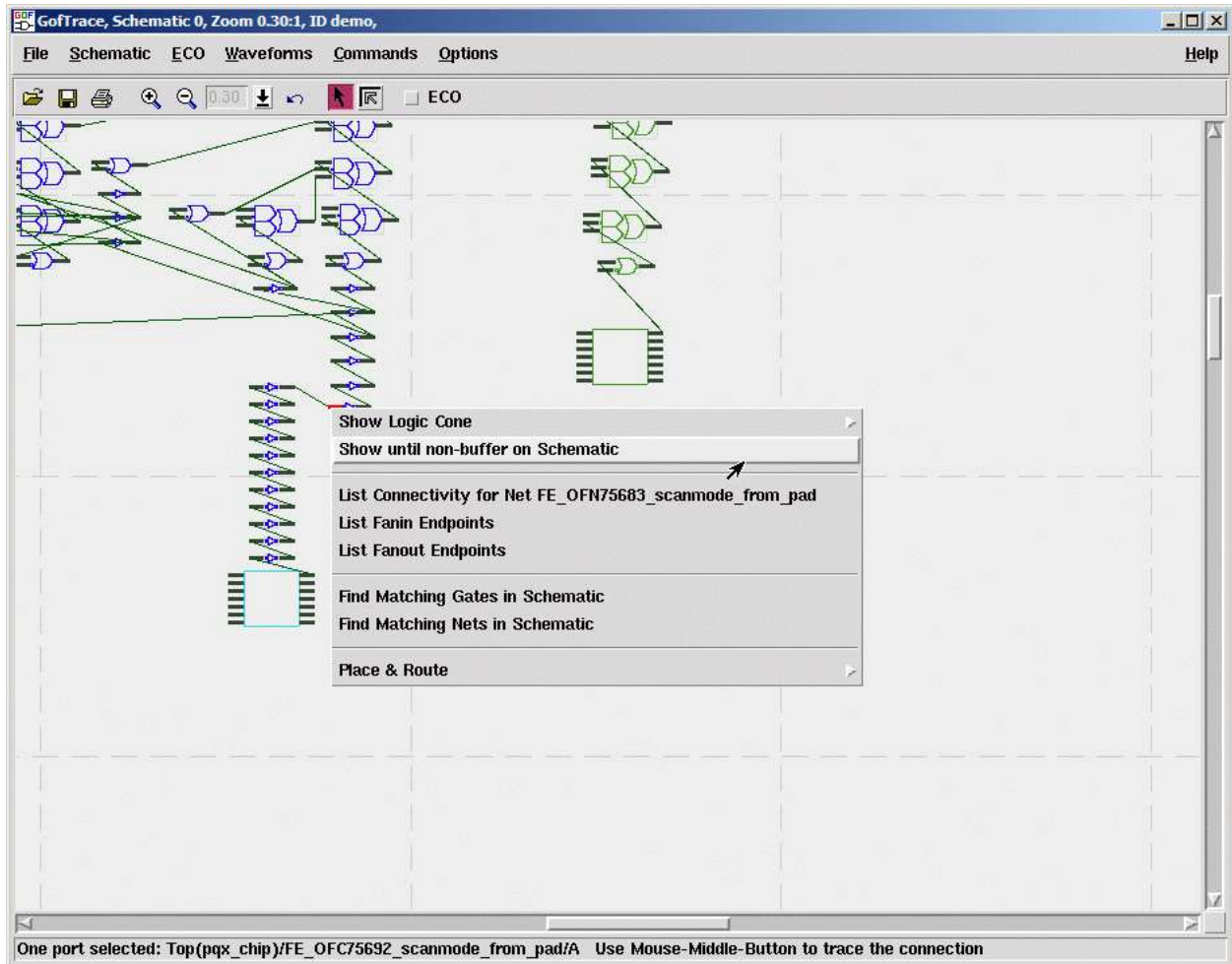
GOF draws only the paths between the source point and the sink point. The source point is one of the error candidates and the sink point is one failing point. Refer to LEC diagnosis in page 3.

- The schematic can be zoomed in/out to view the whole circuit or the detail area
- Any cell on the schematic can be moved around to a new proper position for easy view
- Save/Restore button can save the schematic for later usage or restore previous saved schematic
- Use mouse middle button pressing on cell's input or output pins to expand the schematic



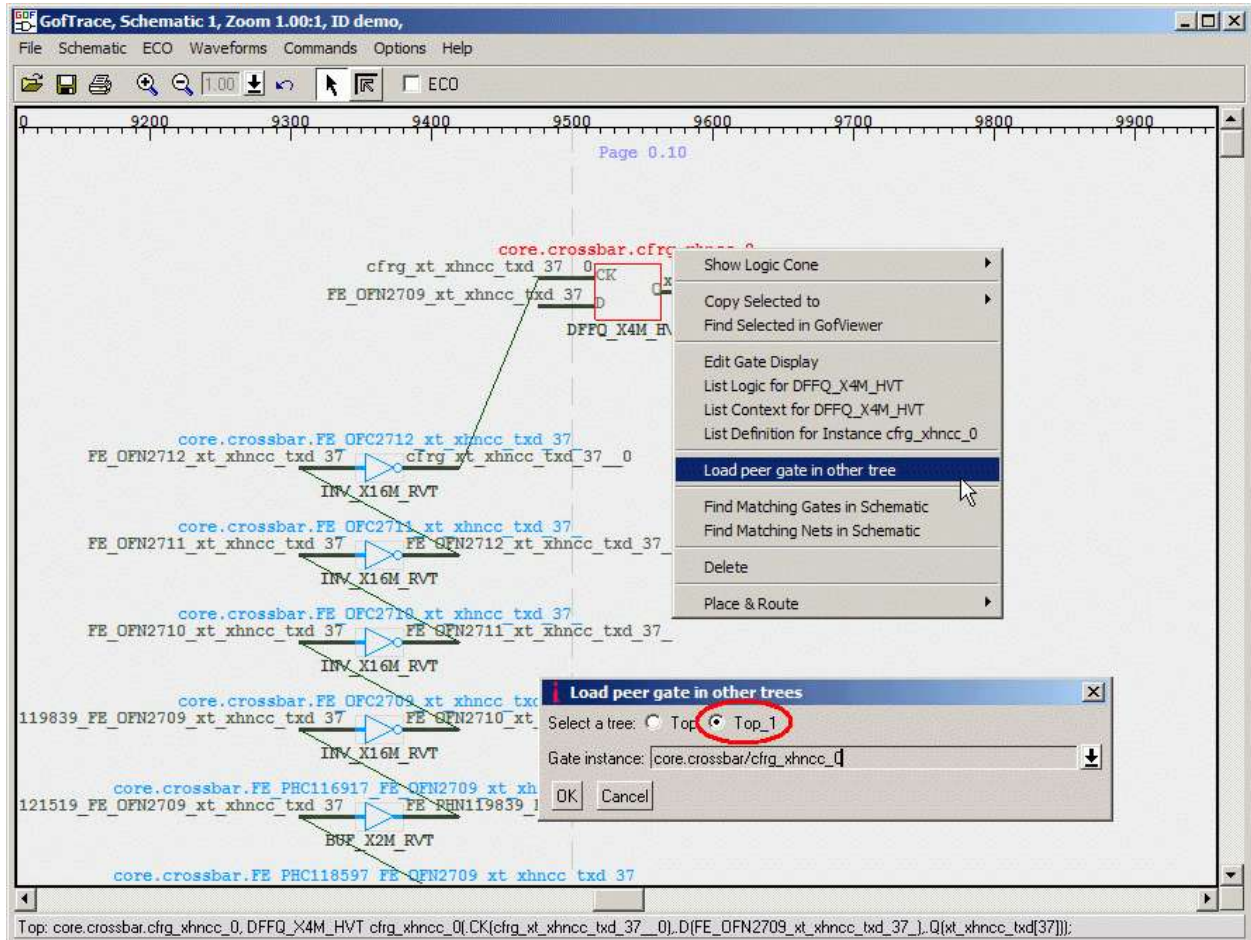
Gates On the Fly Use Case: Conformal LEC failures debug

Other schematic tracing feature includes 'Show until non-buffer on Schematic', which draw all driving buffers/inverters until non-buffer or non-inverter cell.



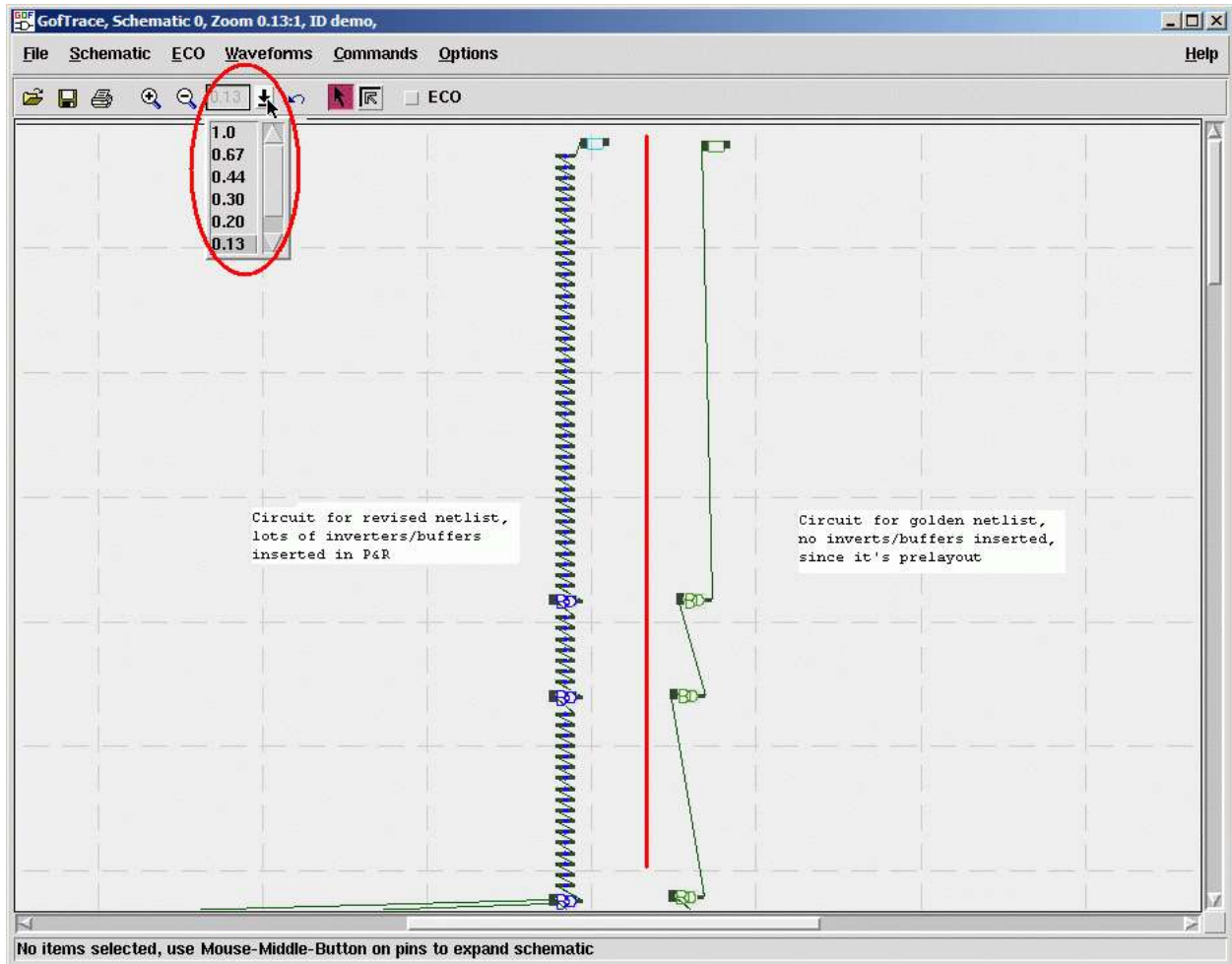
Create same path for golden netlist

Use Ctrl-g to load instances from golden netlist. Or select an instance in revised path, right click to pop up the menu, and select 'Load peer gate in other tree', select 'Top_1' for the other tree which is golden netlist.



Gates On the Fly Use Case: Conformal LEC failures debug

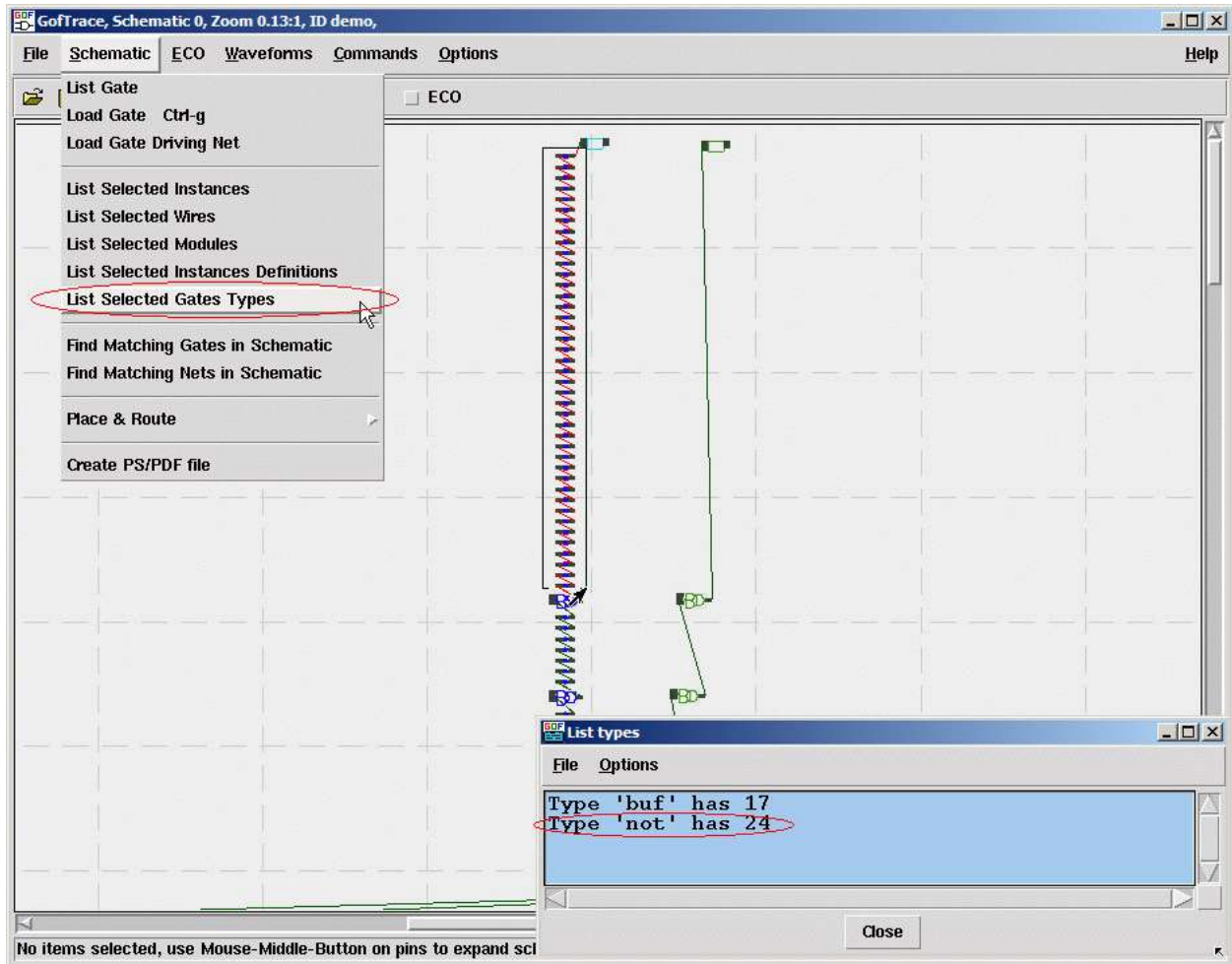
Use proper zoom in/out to get good view. Trace the golden netlist by mouse middle button clicking on cell input/output pins. We get the two circuit side by side. All the non-buffer/inverter paths are the same, so the mismatch must be in the buffer/inverter paths



Analyze segment by segment

Select the first group of buffers/inverters driving the sink by press mouse left button and move to the end of the chain, release the button, all the cells in the group are selected.

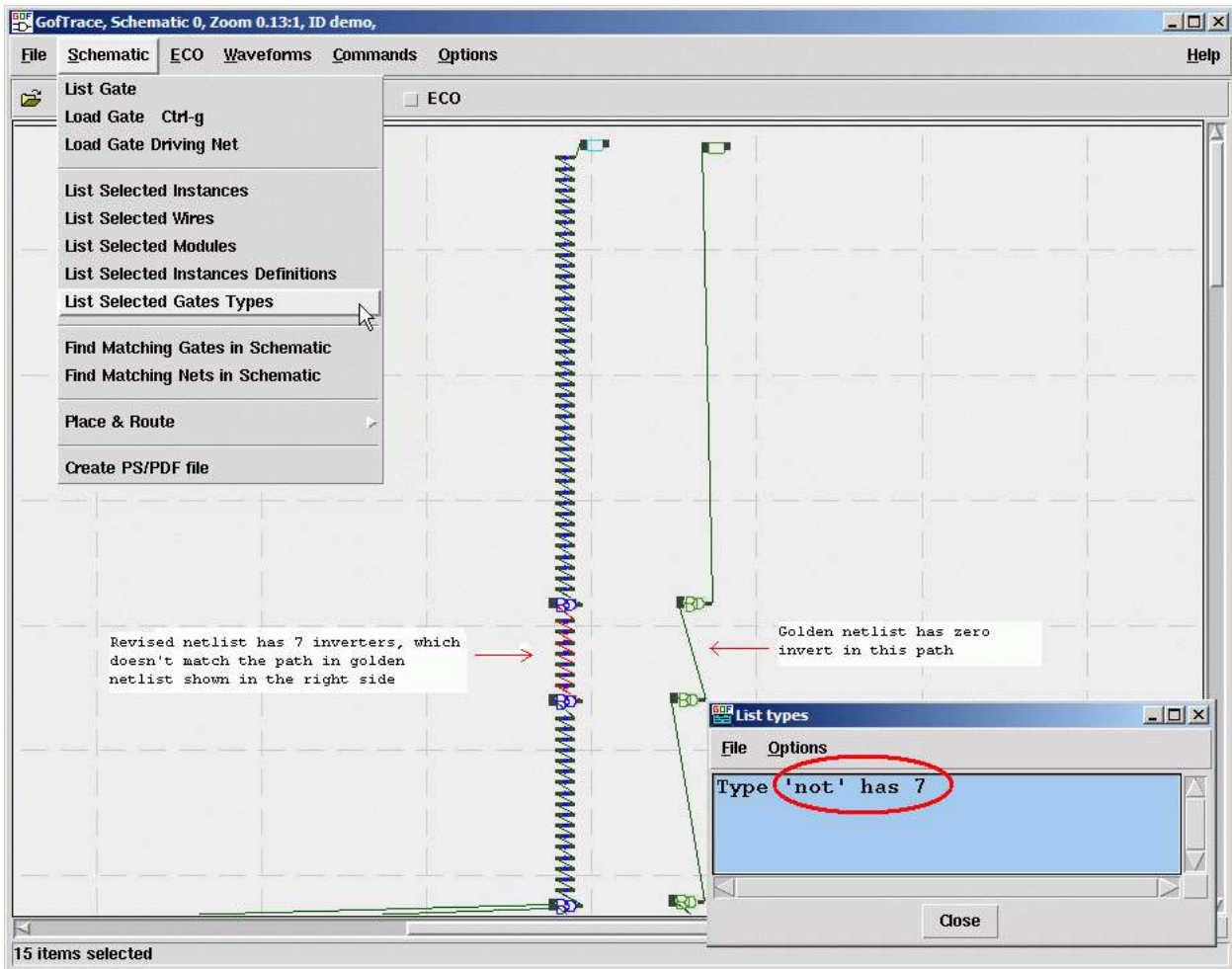
Click menu Schematic->'List Selected Gates Types', we get 'List types' window which shows the inverter number is even number and matches the golden path.



Catch the issue

Select the second group of buffers/inverters, and do the same analysis. The inverter number is 7 which doesn't match golden path!

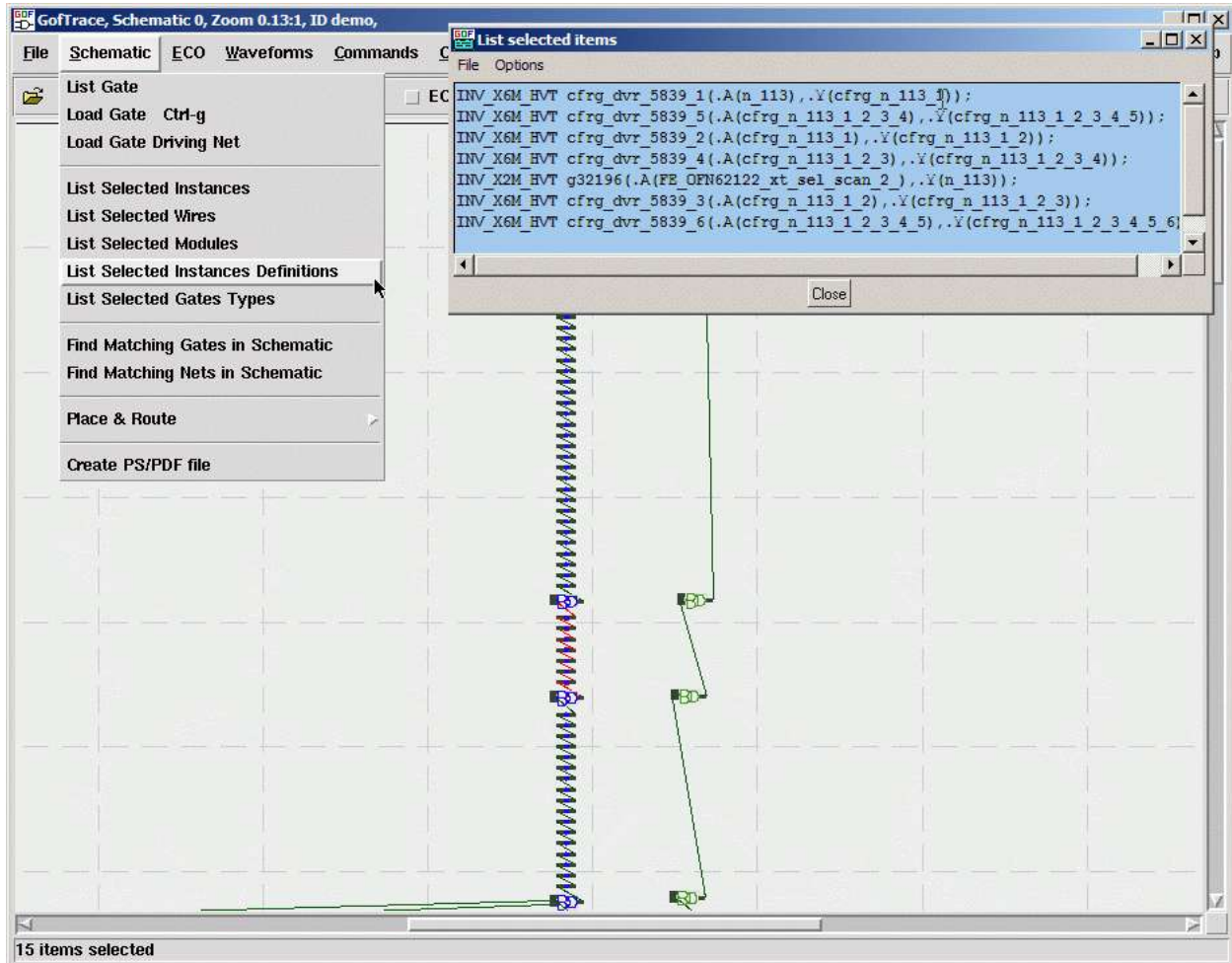
Revised netlist from Physical Design Team has gone through several ECO scripts, so some ECO operations much have swapped the gate type.



Gates On the Fly Use Case: Conformal LEC failures debug

What we can do now is to list the all seven inverters and send to Physical Team.

Click Menu Schematic->'List Selected Instances Definitions', and get the window showing the suspicious seven inverter instance definitions. Save it to a file and send to Physical Design Team for analysis



Experimental fix analysis

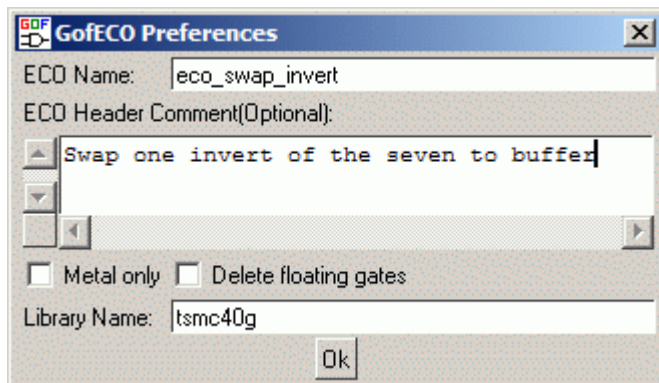
In parallel, we can analyze the seven inverters in GOF. They all have only one fanout. Use mouse middle button to click on output pin to trace fanouts. So swap any of them to buffer should have the same effect.

Create PDF file for future reference. ECO can start now.

GOF ECO

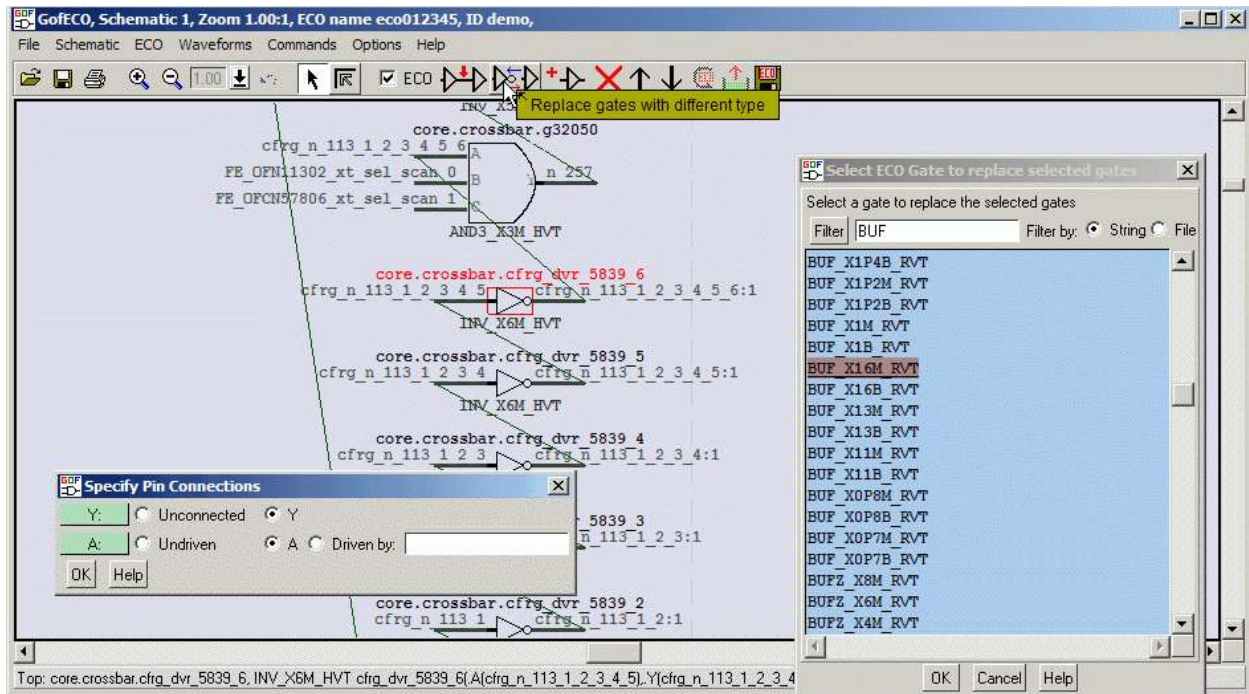
GUI ECO

Click the 'ECO' button in GofTrace, the schematic window, and input the ECO preference information



Gates On the Fly Use Case: Conformal LEC failures debug

Select one of the seven inverter, click ECO button 'Replace Gates with different type'. Pick 'BUF_X16M' and click 'OK', in the 'Specify Pin Connections' window, use the default set.

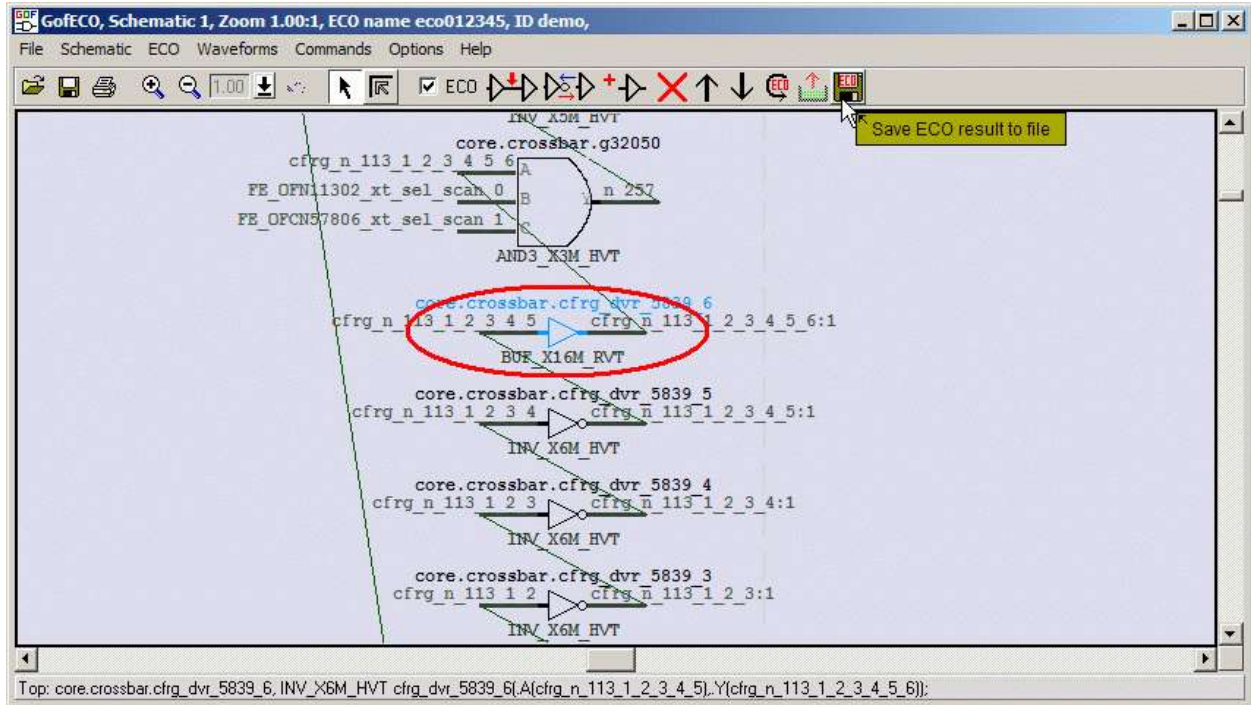


Gates On the Fly Use Case: Conformal LEC failures debug

The inverter is replaced by a buffer, click 'Save ECO result to file' button to save the ECO result in verilog netlist or other formats like SOC Encounter ECO script, Synopsys TCL format.

Run another round of LEC to see if the ECO netlist has fixed some failures.

The debugging/fixing process normally has multiply iterations.



Script mode ECO

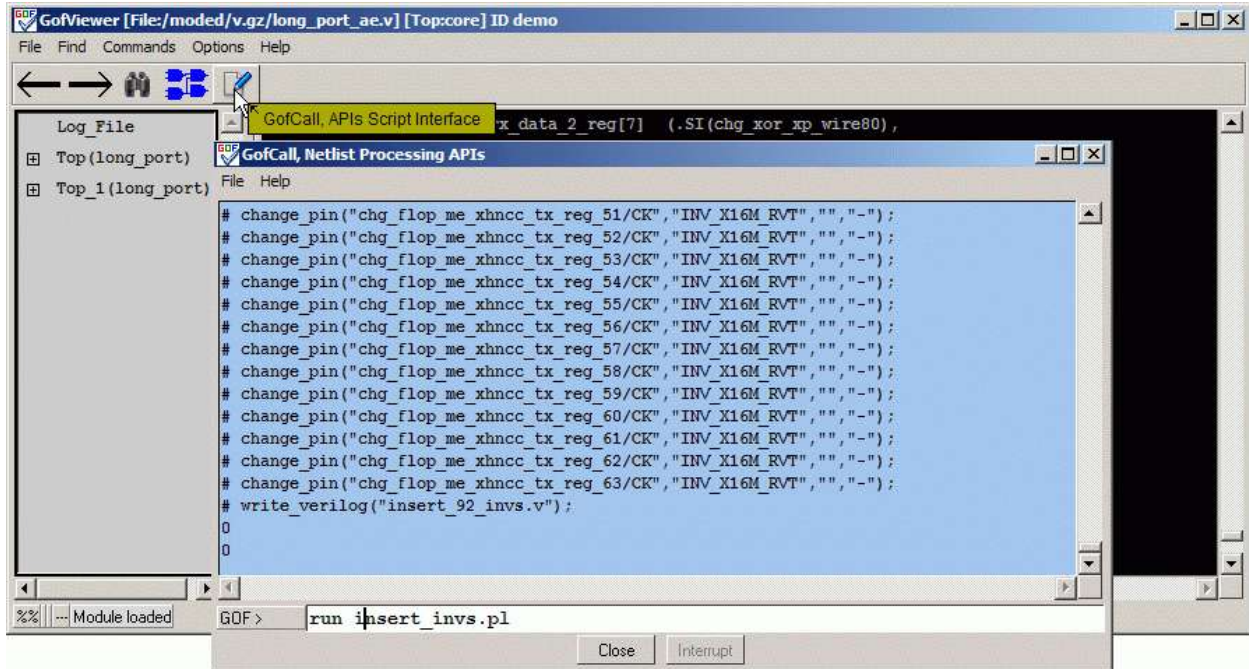
After several iterations, the total failings were down to 92 points and all of them were flops' clock inputs. We decided to use GOF script mode ECO to insert inverter to each clock pin of the flops. So an ECO script was created. We dumped the failing end points to a file named "non_eq.pnt" which was processed by the ECO script to extract flop instance name.

```
1. # File name: insert_invs.pl
2. use strict;
3. undo_eco;
4. open(FIN, "non_eq.pnt");
5. open(FOUT, ">fix_92.for_soc");
6. while(<FIN>){
7.     my ($flop) = (m/(\w+_reg(\d+)?)/); # Get flop instance name
8.     print "$flop\n";
9.     my @pins = get_pins("-input", "$flop"); # The clock pin can be CKN or CK
10.    print "@pins\n";
11.    if(grep($_ =~ m/CKN/, @pins)){
12.        change_pin("$flop/CKN", "INV_X16M_RVT", "", "-");
13.        print FOUT "ecoAddRepeater -term $flop/CKN -cell INV_X16M_RVT\n";
14.    }else{
15.        change_pin("$flop/CK", "INV_X16M_RVT", "", "-");
16.        print FOUT "ecoAddRepeater -term $flop/CK -cell INV_X16M_RVT\n";
17.    }
18. }
19. close(FIN);
20. close(FOUT);
21. write_verilog("insert_92_invs.v"); # Save the ECO result to verilog netlist
```

Gates On the Fly Use Case: Conformal LEC failures debug

In the script file, GOF APIs `undo_eco/get_pins/change_pin/write_verilog` are used. You can run 'help' command in GofCall window to get more detail help information. The script can either run in GofCall window, key in "run insert_invs.pl" and press return or in the command line with "-run" option

`gof -lib libs.lib netlists.v -run insert_invs.pl`



LEC check on 'insert_invs.v' against golden netlist showed no more mismatches.

Conclusion

GOF's rich schematic features make it a good choice in debugging complicated LEC failure. The built-in "On the fly" ECO function highly decreases turn-around time for large netlist processing.