4 The NETCMP network comparator

The netlist files generated by the NEWOL extractor can be compared to a reference netlist (generated, for example, by the LOG/ANALOG schematic capture system) using the NETCMP network comparison program. This program is external to NEWOL, and must be run separately. NETCMP prompts for two .NTK files, and for a file into which to write the results of the comparison.

The comparator works by alternately considering transistors and nodes. These are divided into *equivalence classes*; initially, transistors are divided by type (p and n), and nodes are divided by fanout (number of n and p gates and drain/sources). The algorithm then subdivides the transistors into classes whose terminals connect to nodes which are themselves in the same classes. The node classes are then subdivided according to the transistor classes that connect to them. This procedure is repeated until no further subdivision is possible. Ideally, at this point, all equivalence classes have exactly two elements (one from each circuit being compared). In some cases, *automorphisms* exist where an equivalence class contains an even number of indistinguishible elements (e.g. parallel driver transistor structures) – by default, automorphisms are not flagged as errors. A true error exists if the subdivision algorithm wants to fracture an equivalence class into classes with odd numbers of elements. These error classes are printed *in their entirety* when the algorithm reaches its fixed-point. Nodes are printed with their fanouts (number of n-gates (ng), n-source/drains (ns), p-gates (pg) and p-source/drains (ps)).

The most effective way to use the comparator output is the following:

1. Make sure that both circuits contain the same number of transistors.
2. Make sure that both circuits contain the same number of nodes.
3. Get the fanout of the power nodes right. These are easy to find: V_{dd} connects to a *large* number of p-source/drains, and *Gnd* connects to a similarly large number of n-source/drains.
4. Look for patterns in the outputs. In general, it is easier to locate nodes with different transistor fan-outs. It is often possible to identify two nodes in one circuit which, if they were connected, would sum up to one node in the other circuit. Then go looking for missing wires in the geometry or schematic.
5. Look for differences between topologies and logic. For example, on a logic diagram, the two inputs of a NAND gate are equivalent. In a VLSI layout, however, they are not at all the same (think about the pull-down chain).

6. The hardest problems to find are in highly symmetric networks. For example, taking the wrong output from a flip-flop is a serious logical error, but a subtle topological problem.

Sample session with NETCMP:

```
NETCMP #1.04; compiled Sep 5, 1985 5:12 pm
  Enter output file name [/spool/apple.text/MASS]: (cr)
Enter input filename 1 : [.NTK] csrltcell
Parsing file: csrltcell.ntk
Found:  9 N Transistors,    9 P Transistors, 18 Total Transistors,
        11 Non-orphan Nodes, 0 Orphans,       11 Total Nodes.
Enter input filename 2 : [.NTK] csrltcell.lntk
Parsing file: csrltcell.lntk
Found:  9 N Transistors,    9 P Transistors, 18 Total Transistors,
        11 Non-orphan Nodes, 0 Orphans,       11 Total Nodes.
netcmp> ?
NETCMP command summary
   auto -- toggle display of automorphisms
   comp -- compare the networks
   quit -- exit the program
   help -- print this list
   dbug -- toggle debug mode
   slow -- ALWAYS consider classes for subdivision
   long -- print extra long results
   dump -- dump data structure
   node -- print info about node
   read -- read .ntk files
netcmp> comp
Iteration: 1; Transistor classes = 9 (+7); Node classes = 7 (+0)
  Memory left = 1762K; used = 23K

Iteration: 2; Transistor classes = 9 (+0); Node classes = 7 (+0)
  Memory left = 1762K; used = 23K

************  results of fixed-point iteration **************
1 difference found.
netcmp> quit
```

Sample output from NETCMP:

```
Parsing file: netcmp.NTK
```

```
Found:  9 N Transistors,    9 P Transistors, 18 Total Transistors,
        11 Non-orphan Nodes, 0 Orphans,       11 Total Nodes.

Parsing file: netcmp2.NTK
Found:  9 N Transistors,    9 P Transistors, 18 Total Transistors,
        11 Non-orphan Nodes, 0 Orphans,       11 Total Nodes.

Iteration: 1; Transistor classes = 9 (+7); Node classes = 7 (+0)
Iteration: 2; Transistor classes = 9 (+0); Node classes = 7 (+0)
************  results of fixed-point iteration **************

-----------------------------------------------
   (2)  Node: _5 fanout:     pg=0 ng=0 ps=1 ns=2
   (1)  Node: MINUS fanout:  pg=0 ng=0 ps=1 ns=1
   (1)  Node: PLUS fanout:   pg=2 ng=2 ps=2 ns=2
   (2)  Node: _7 fanout:     pg=2 ng=2 ps=2 ns=1

1 difference found.
```

(Interpretation of above results: a source/drain of a transistor connecting to node 5 in the layout SHOULD have been connected to node 6 instead. This assumes that circuit (1) is the schematic representation and is correct.)