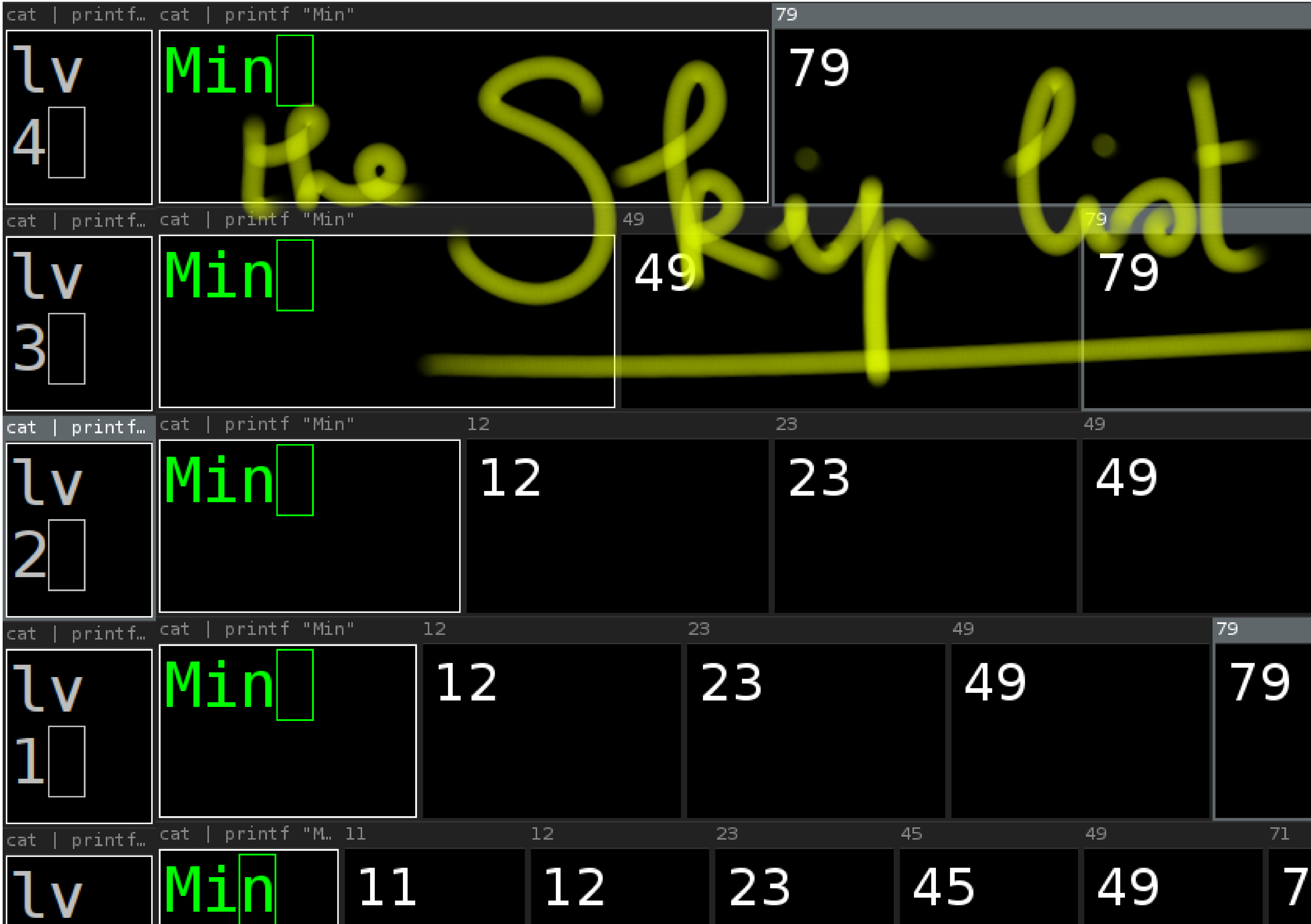
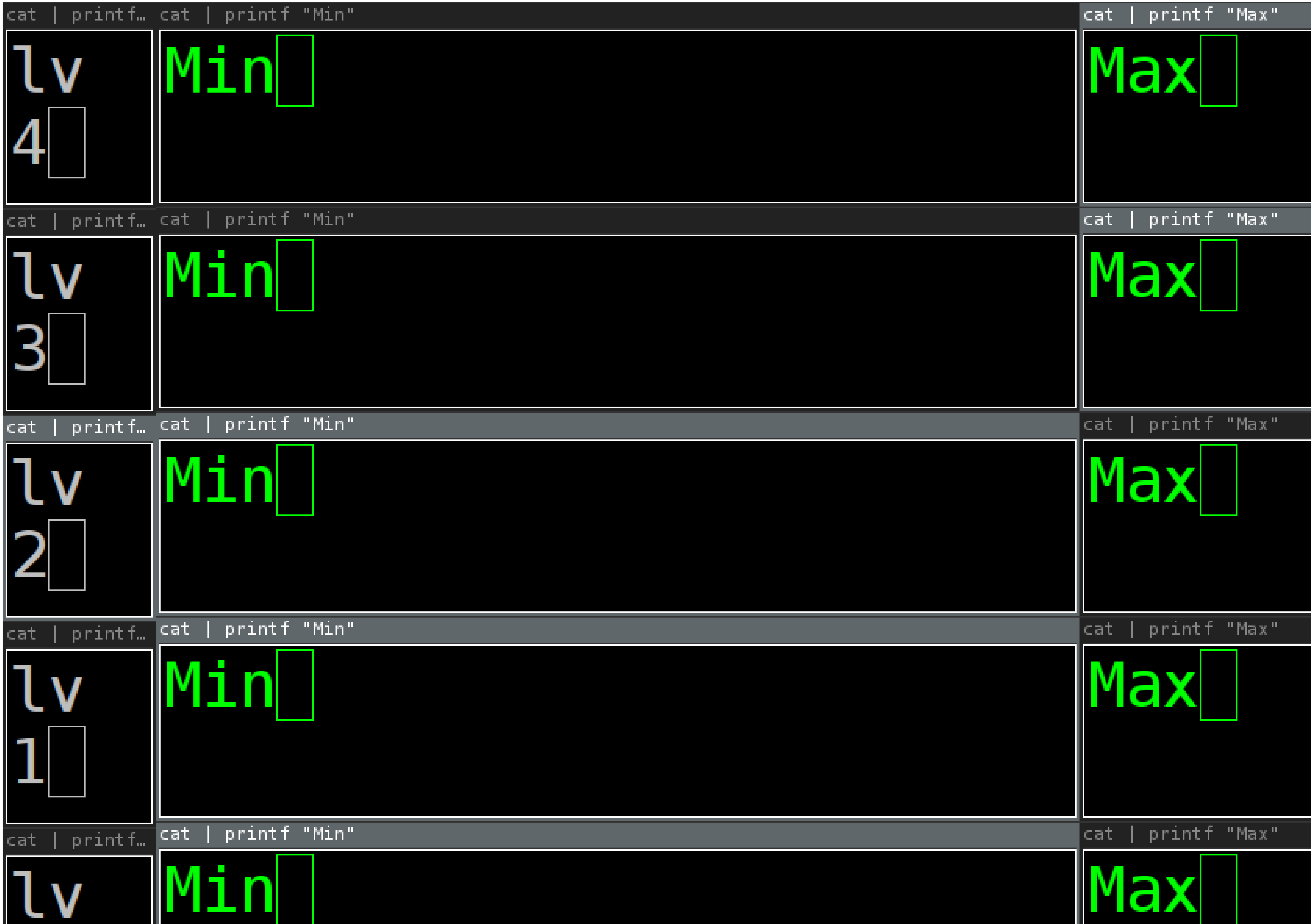
# the Skip list



```
cat | printf…   cat | printf "Min"   79
lv              Min                  79
4

cat | printf…   cat | printf "Min"   49   79
lv              Min                  49   79
3

cat | printf…   cat | printf "Min"   12   23   49
lv              Min                  12   23   49
2

cat | printf…   cat | printf "Min"   12   23   49   79
lv              Min                  12   23   49   79
1

cat | printf…   cat | printf "M… 11   12   23   45   49   71
lv              Min              11   12   23   45   49   7
```



```
cat | printf…
lv
4
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
3
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
2
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
1
```

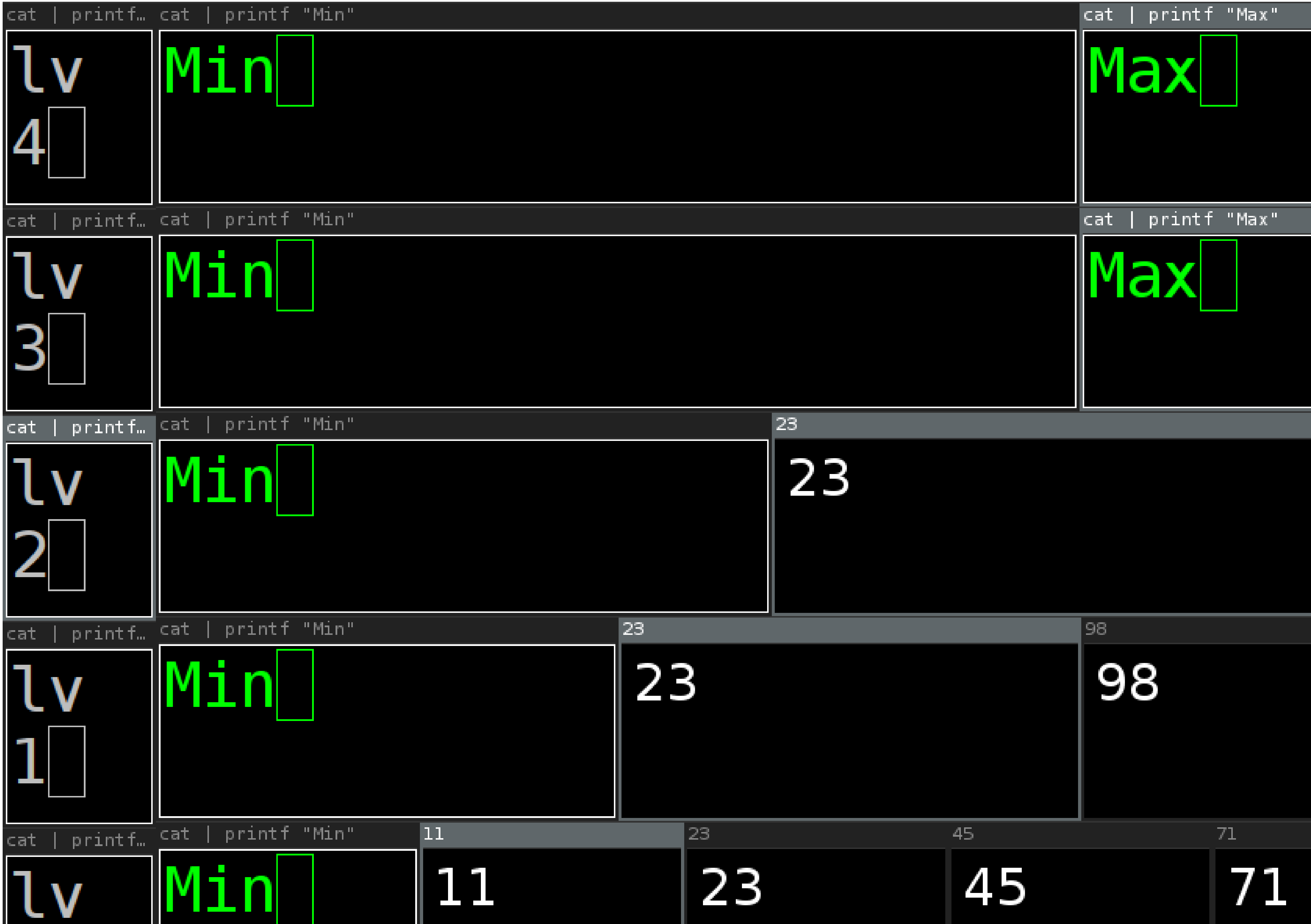
```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```



```
cat | printf…
lv
4
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
3
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
2
```

```
cat | printf "Min"
Min
```

```
23
23
```

```
cat | printf…
lv
1
```

```
cat | printf "Min"
Min
```

```
23
23
```

```
98
98
```

```
cat | printf…
lv
```

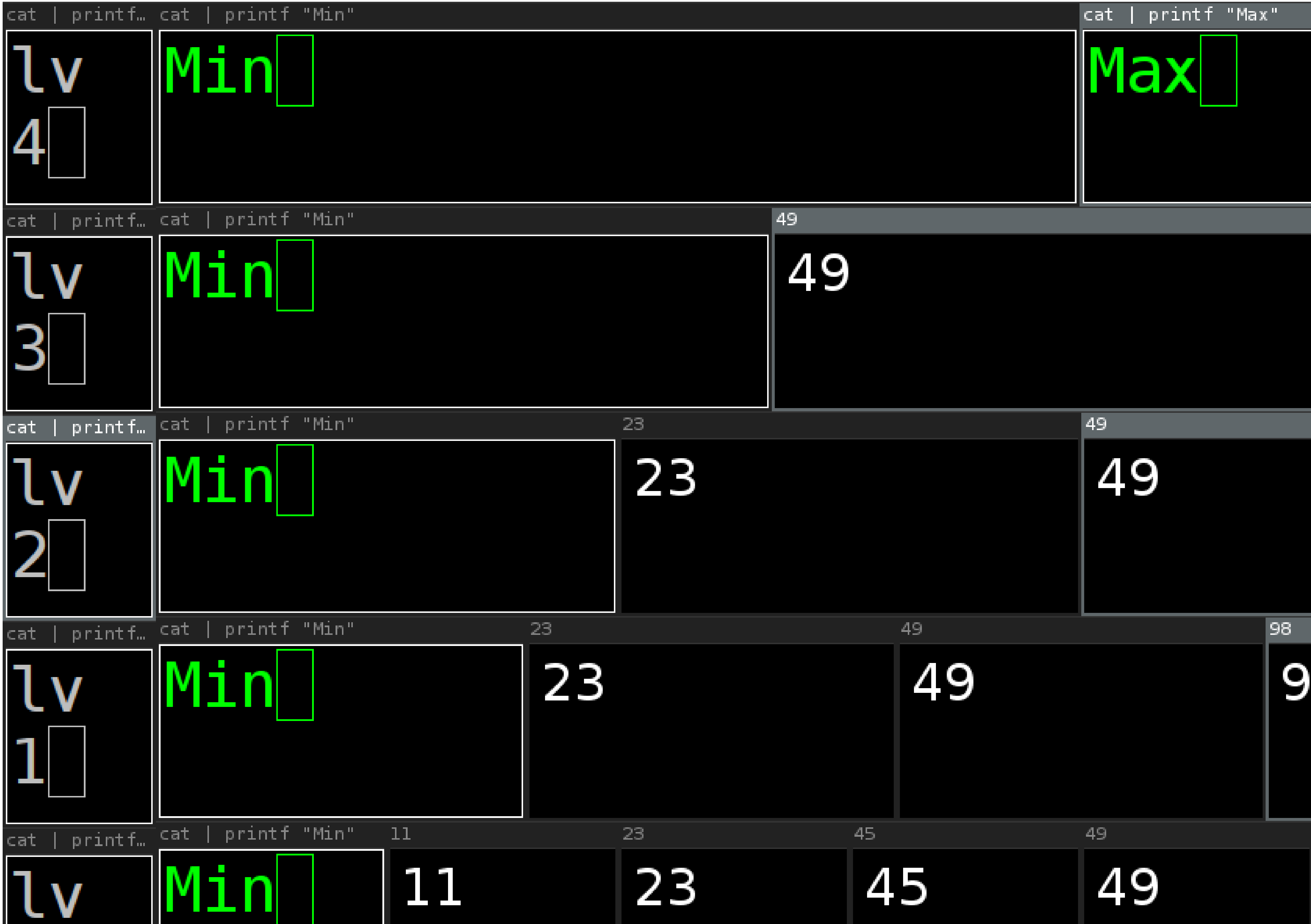
```
cat | printf "Min"
Min
```

```
11
11
```

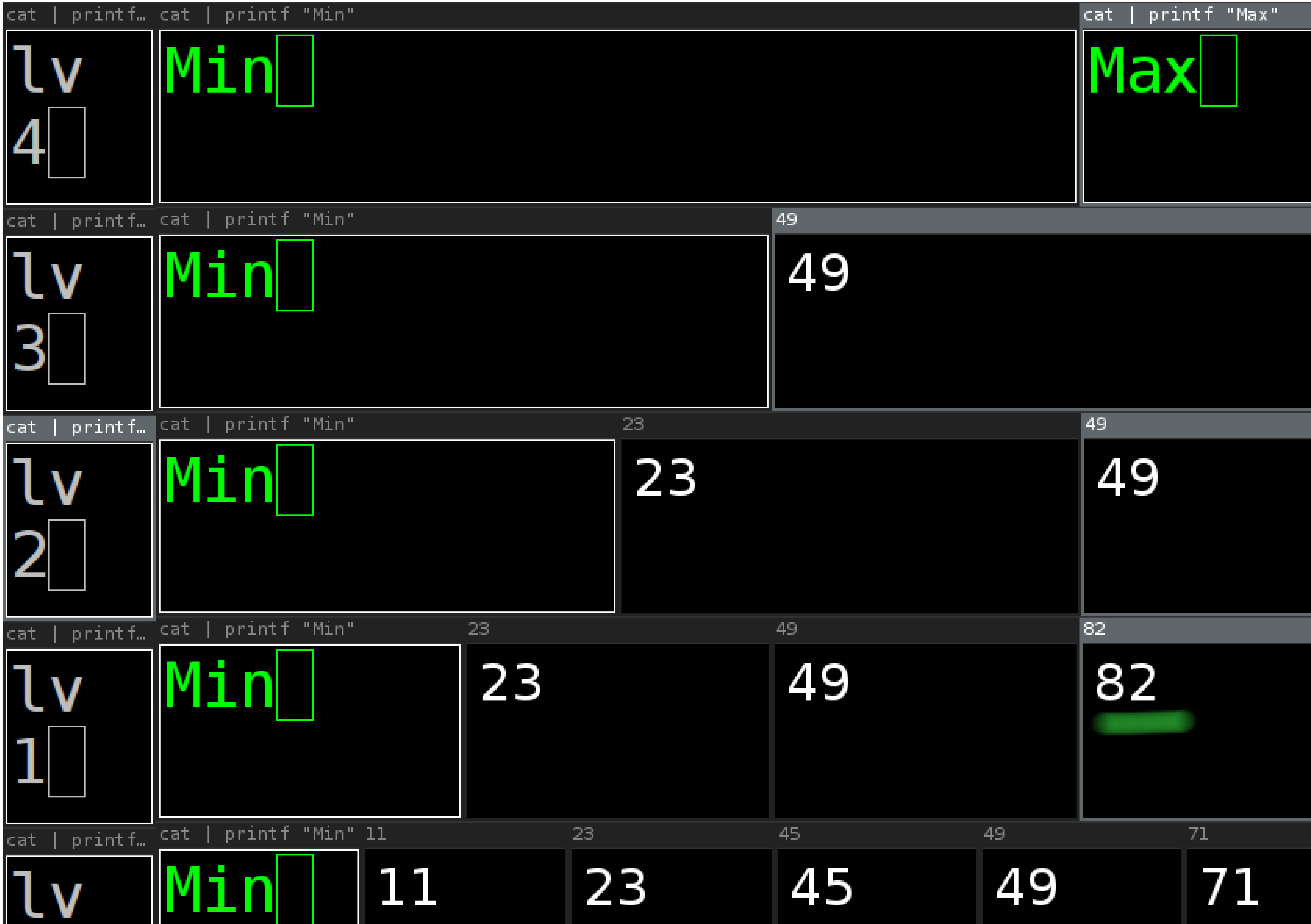
```
23
23
```

```
45
45
```

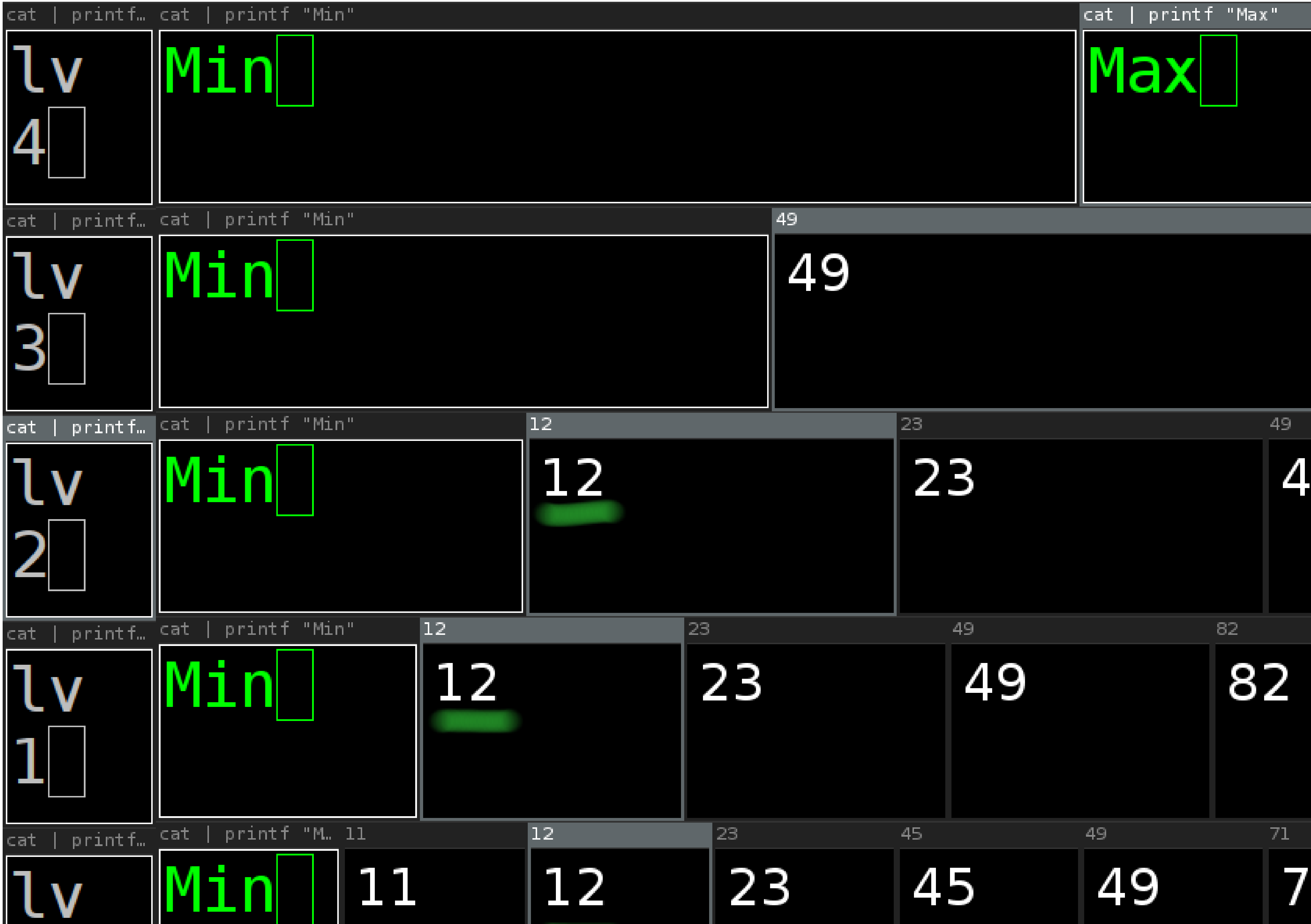
```
71
71
```



```
cat | printf…   cat | printf "Min"                          cat | printf "Max"
lv              Min                                         Max
4

cat | printf…   cat | printf "Min"          49
lv              Min                         49
3

cat | printf…   cat | printf "Min"    23                    49
lv              Min                   23                    49
2

cat | printf…   cat | printf "Min"   23          49          98
lv              Min                  23          49          9
1

cat | printf…   cat | printf "Min"   11     23     45     49
lv              Min                  11     23     45     49
```



```
cat | printf…  cat | printf "Min"                                   cat | printf "Max"
lv             Min                                                  Max
4

cat | printf…  cat | printf "Min"                   49
lv             Min                                  49
3

cat | printf…  cat | printf "Min"       23                          49
lv             Min                      23                          49
2

cat | printf…  cat | printf "Min"  23               49              82
lv             Min                 23               49              82
1

cat | printf…  cat | printf "Min" 11     23         45        49        71
lv             Min         11            23         45        49        71
```



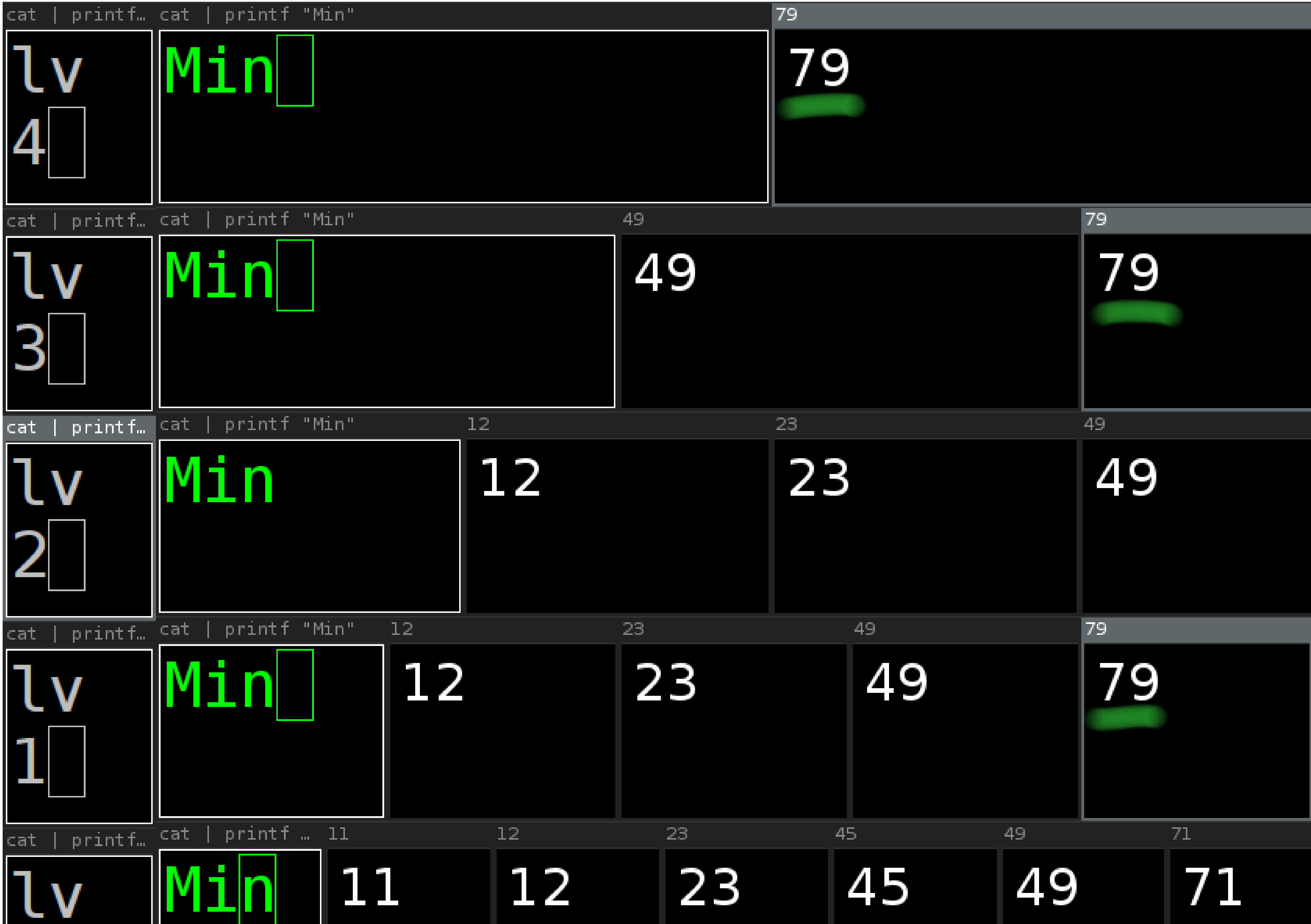
```
cat | printf…   cat | printf "Min"                         cat | printf "Max"
lv              Min                                        Max
4
```

```
cat | printf…   cat | printf "Min"                         49
lv              Min                                        49
3
```

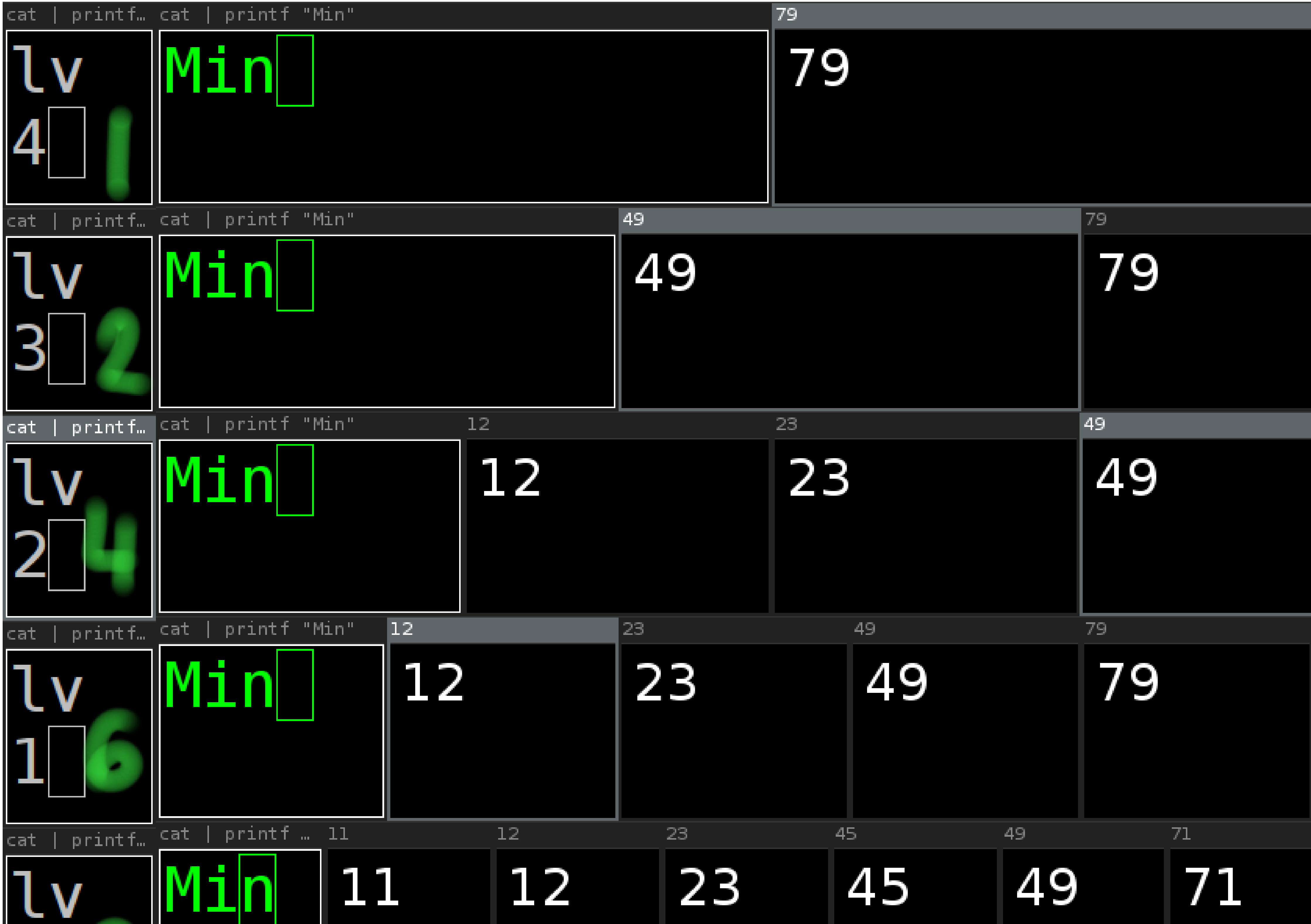
```
cat | printf…   cat | printf "Min"    12         23         49
lv              Min                   12         23         4
2
```

```
cat | printf…   cat | printf "Min"   12        23        49        82
lv              Min                  12        23        49        82
1
```

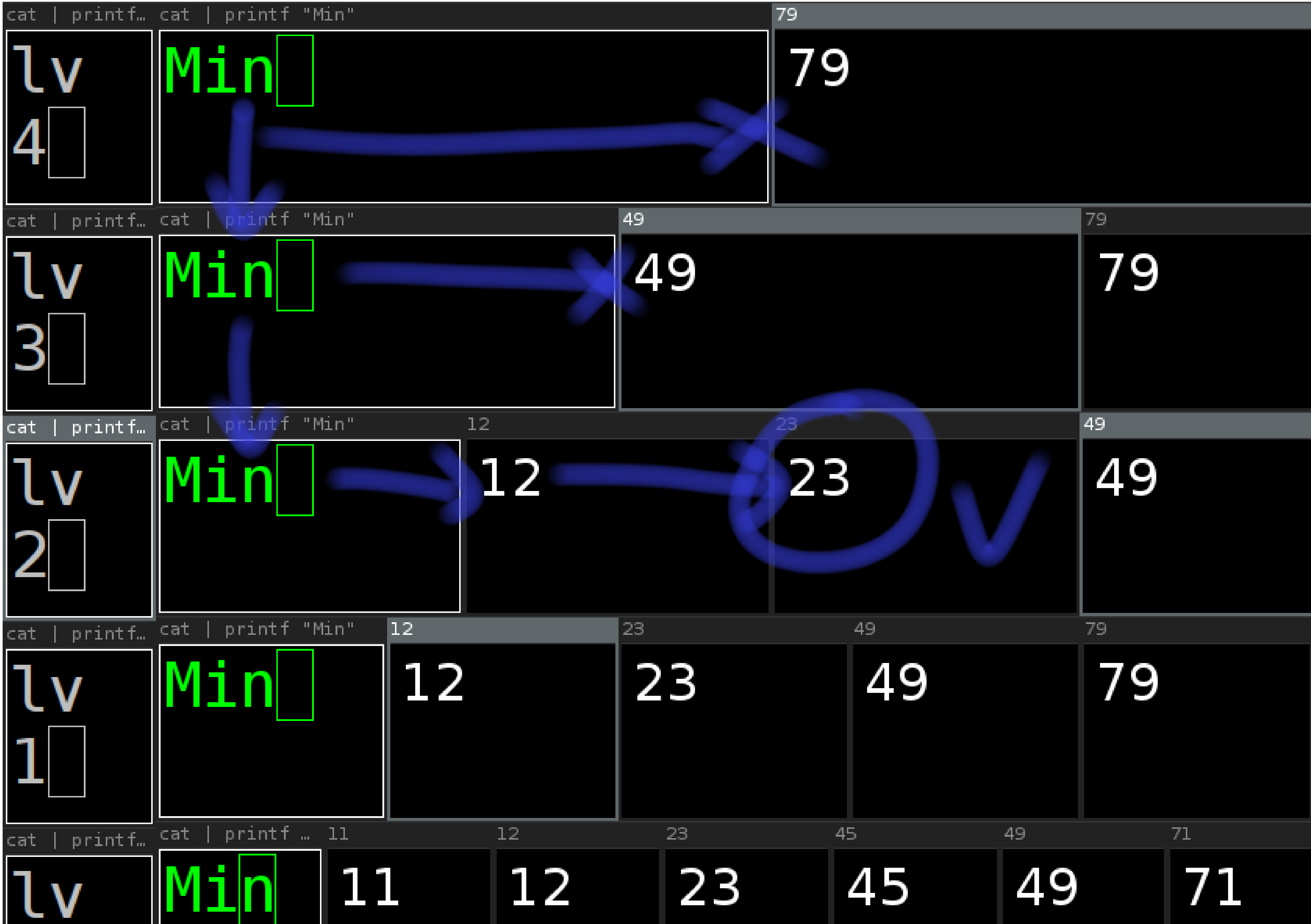
```
cat | printf…   cat | printf "M…  11     12     23     45     49     71
lv              Min               11     12     23     45     49     7
```



```
cat | printf…  cat | printf "Min"                        79
lv             Min                                       79
4

cat | printf…  cat | printf "Min"     49                 79
lv             Min                    49                 79
3

cat | printf…  cat | printf "Min"  12        23         49
lv             Min                 12        23         49
2

cat | printf…  cat | printf "Min" 12    23     49      79
lv             Min                12    23     49      79
1

cat | printf…  cat | printf … 11   12   23   45   49   71
lv             Min            11   12   23   45   49   71
```



```
cat | printf…   cat | printf "Min"   79
lv              Min                  79
4

cat | printf…   cat | printf "Min"   49   79
lv              Min                  49   79
3

cat | printf…   cat | printf "Min"   12   23   49
lv              Min                  12   23   49
2

cat | printf…   cat | printf "Min"   12   23   49   79
lv              Min                  12   23   49   79
1

cat | printf…   cat | printf …   11   12   23   45   49   71
lv              Min              11   12   23   45   49   71
```



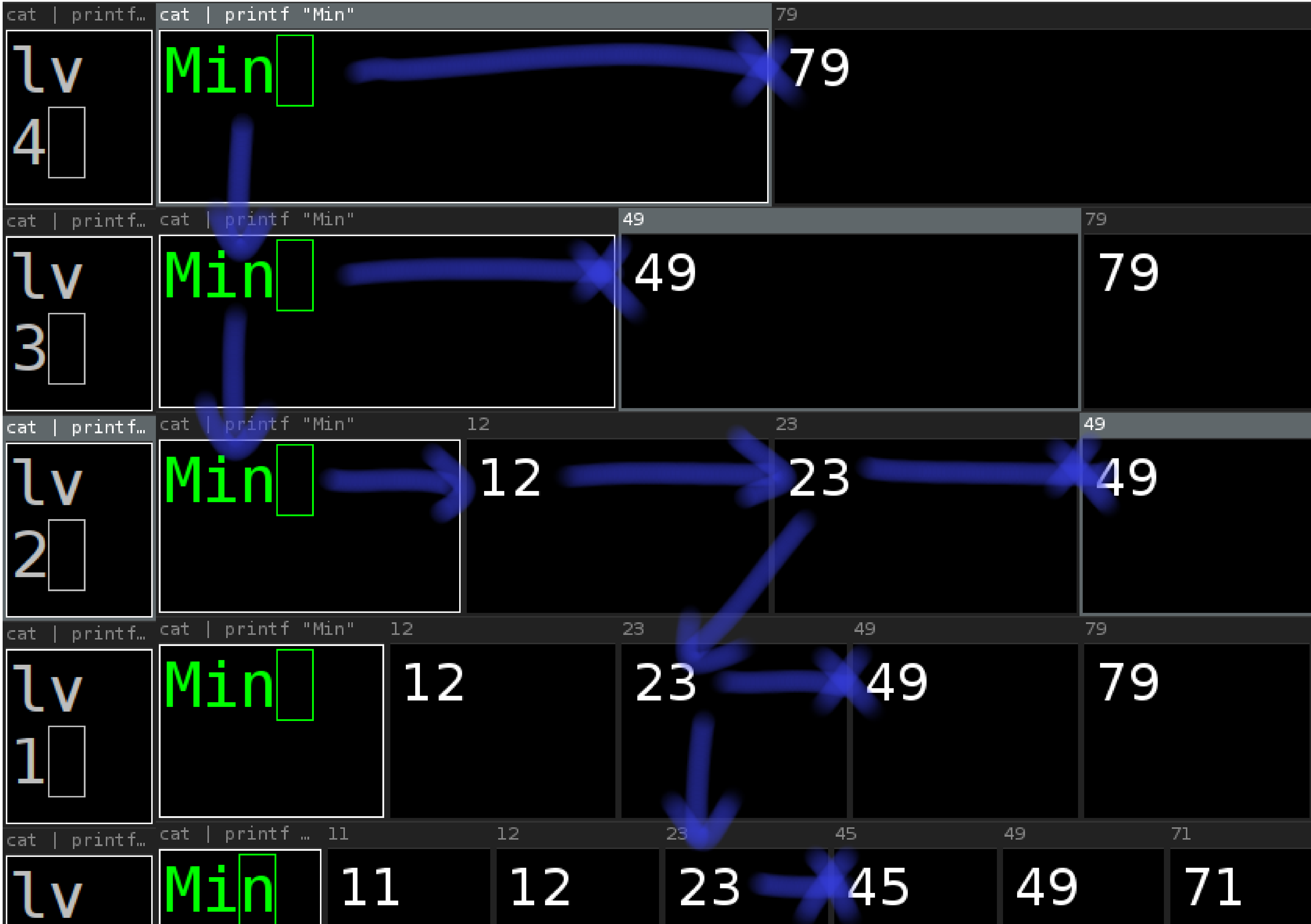
```
cat | printf…   cat | printf "Min"              79
lv              Min                             79
4
```

```
cat | printf…   cat | printf "Min"      49              79
lv              Min                     49              79
3
```

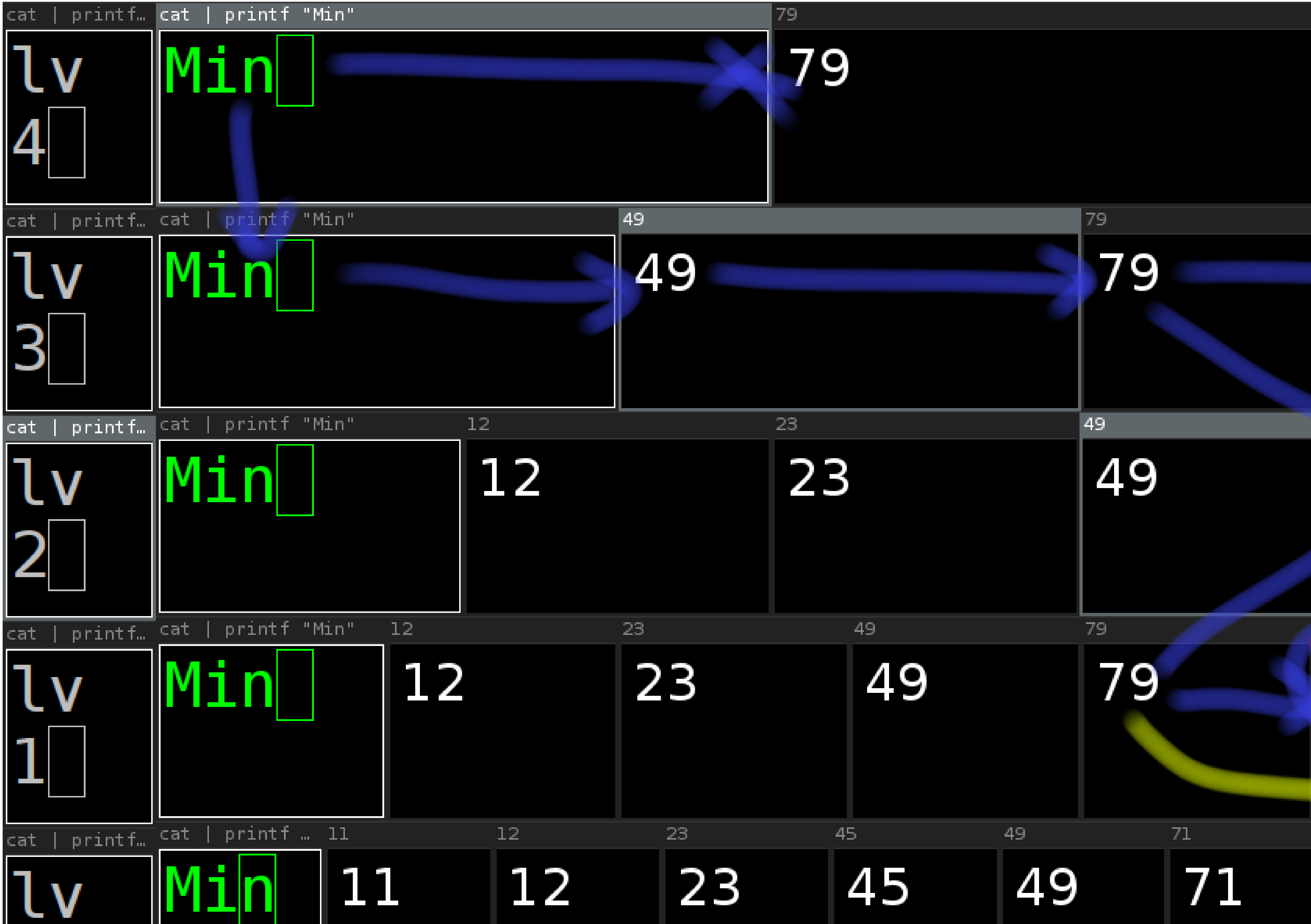
```
cat | printf…   cat | printf "Min"  12          23          49
lv              Min                 12          23          49
2
```

```
cat | printf…   cat | printf "Min"  12      23      49      79
lv              Min                 12      23      49      79
1
```

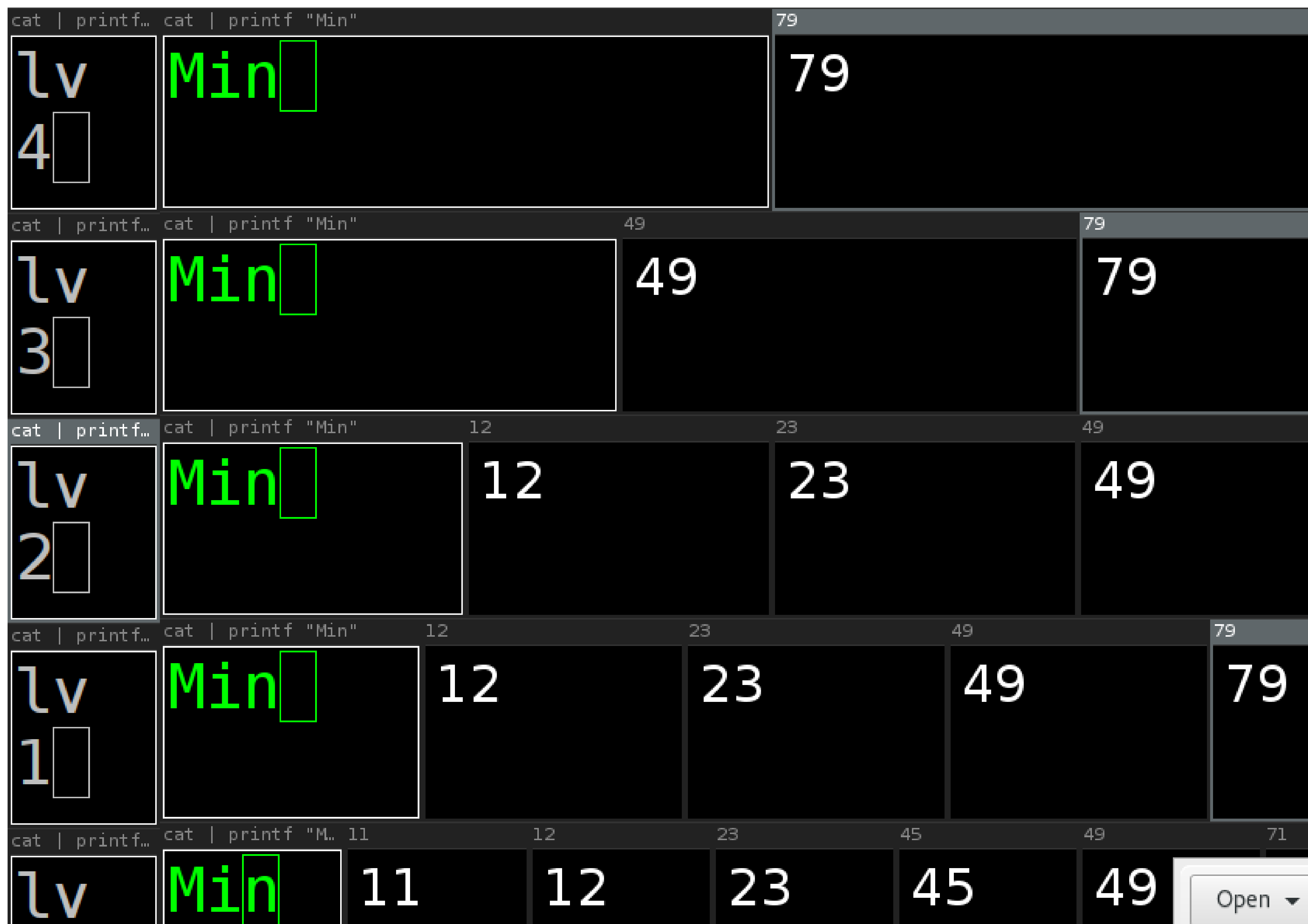
```
cat | printf…   cat | printf …  11    12    23    45    49    71
lv              Min             11    12    23    45    49    71
```



```
cat | printf…  cat | printf "Min"                      79
lv 4           Min                                     79

cat | printf…  cat | printf "Min"      49              79
lv 3           Min                     49              79

cat | printf…  cat | printf "Min"  12        23        49
lv 2           Min                 12        23        49

cat | printf…  cat | printf "Min"  12     23     49     79
lv 1           Min                 12     23     49     79

cat | printf…  cat | printf …  11   12   23   45   49   71
lv             Min             11   12   23   45   49   71
```



```
cat | printf…   cat | printf "Min"                79
lv              Min                               79
4

cat | printf…   cat | printf "Min"     49                     79
lv              Min                    49                     79
3

cat | printf…   cat | printf "Min"   12            23             49
lv              Min                  12            23             49
2

cat | printf…   cat | printf "Min"   12      23      49      79
lv              Min                  12      23      49      79
1

cat | printf…   cat | printf …   11     12     23     45     49     71
lv              Min              11     12     23     45     49     71
```



```
lv
4
```

```
Min
```

```
79
```

```
lv
3
```

```
Min
```

```
49
```

```
79
```

```
lv
2
```

```
Min
```

```
12
```

```
23
```

```
49
```

```
lv
1
```

```
Min
```

```
12
```

```
23
```

```
49
```

```
79
```

```
lv
```

```
Min
```

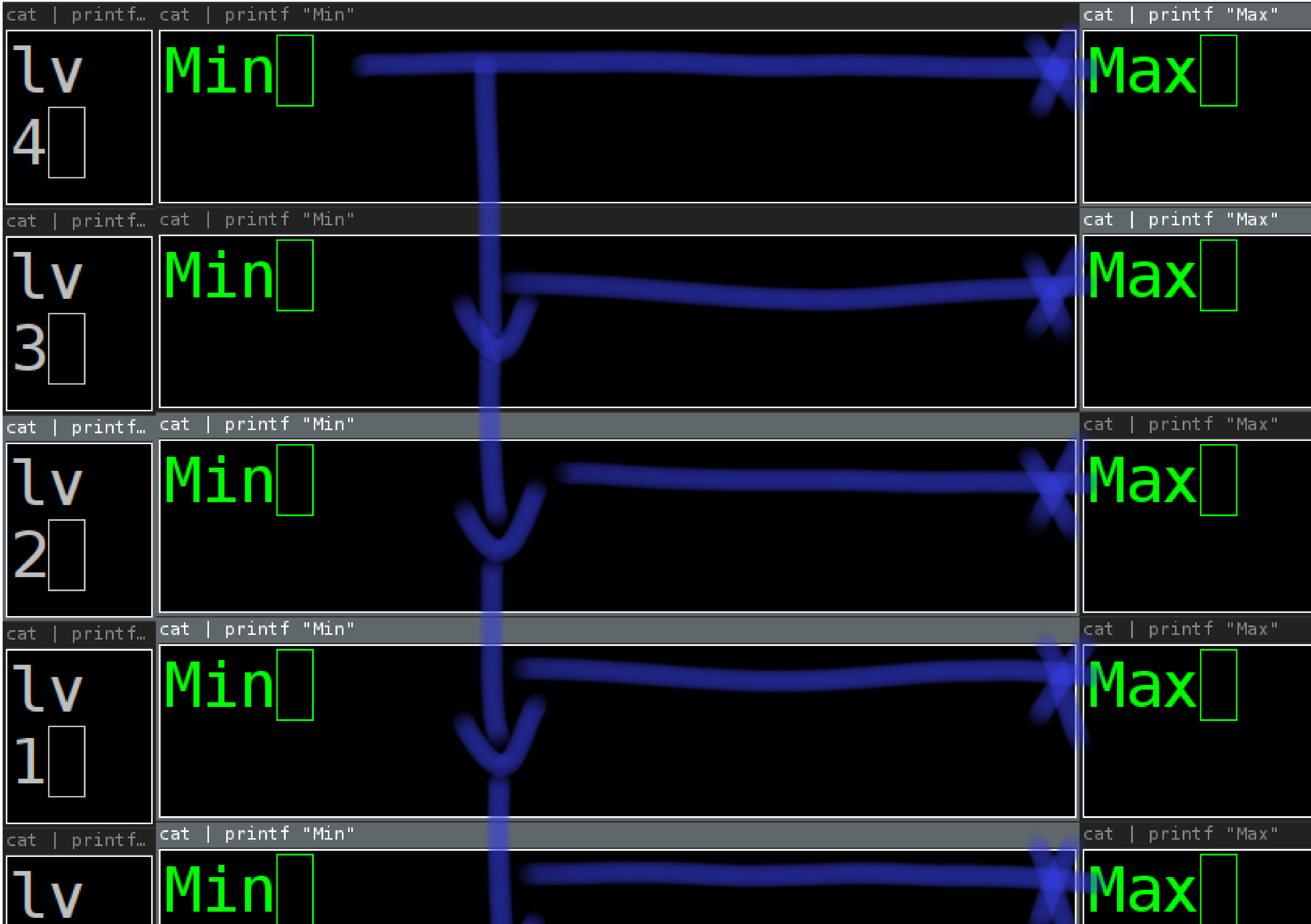
```
11
```

```
12
```

```
23
```

```
45
```

```
49
```



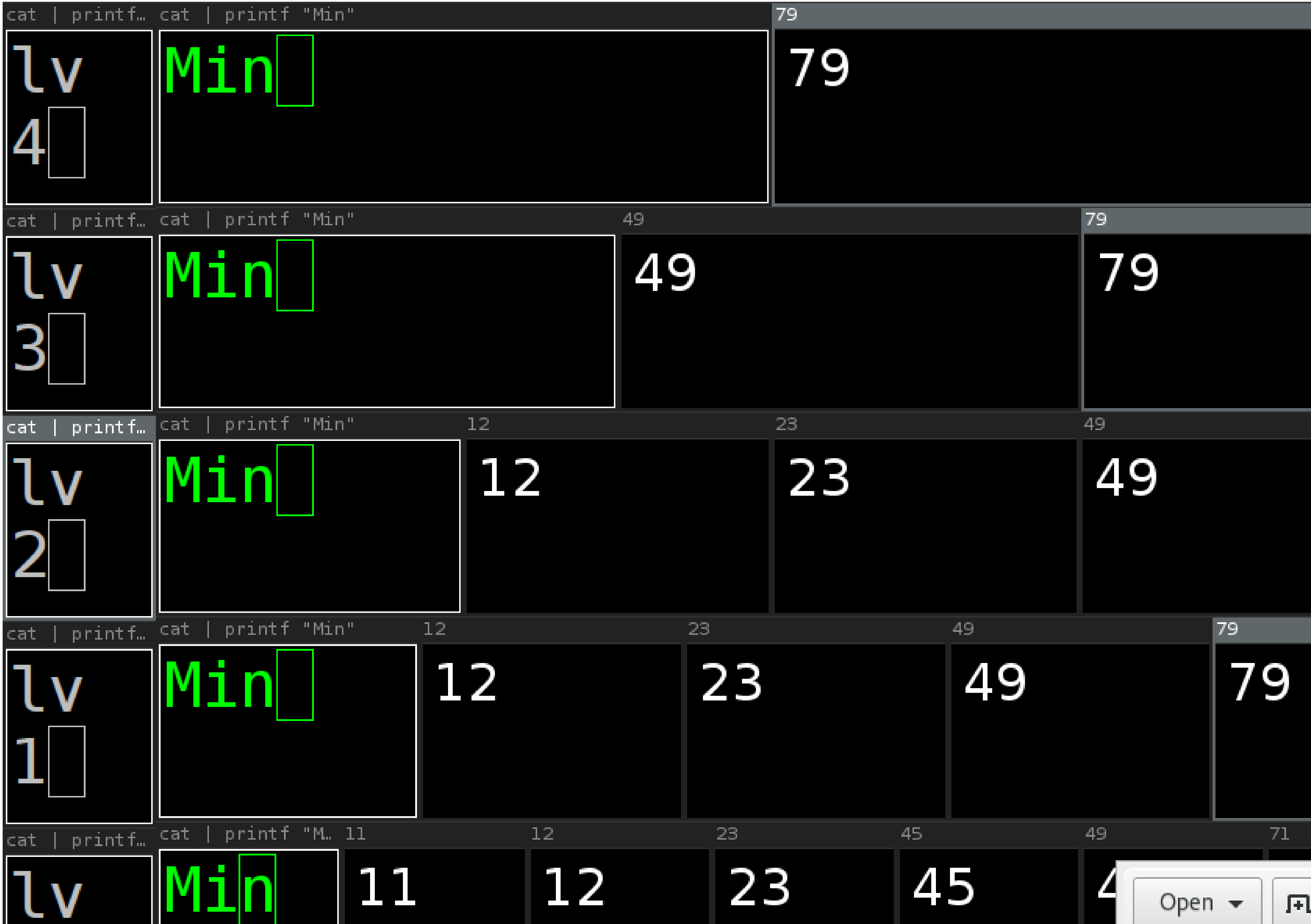
```
cat | printf…
lv
4

cat | printf "Min"
Min

cat | printf "Max"
Max
```

```
cat | printf…
lv
3

cat | printf "Min"
Min

cat | printf "Max"
Max
```

```
cat | printf…
lv
2

cat | printf "Min"
Min

cat | printf "Max"
Max
```

```
cat | printf…
lv
1

cat | printf "Min"
Min

cat | printf "Max"
Max
```

```
cat | printf…
lv

cat | printf "Min"
Min

cat | printf "Max"
Max
```



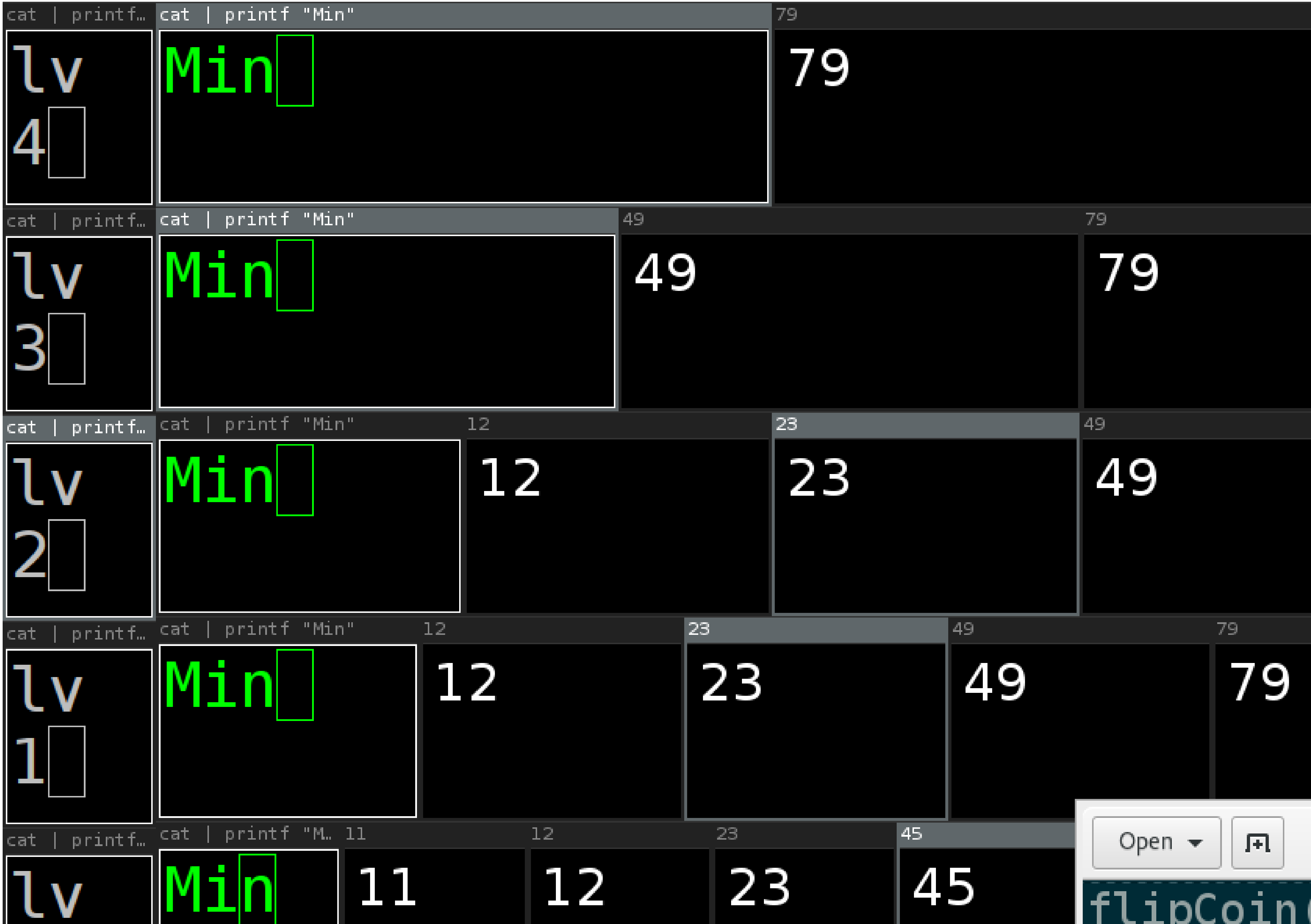
```
cat | printf…   cat | printf "Min"   79
lv
4               Min                  79
```

```
cat | printf…   cat | printf "Min"   49   79
lv
3               Min                  49   79
```

```
cat | printf…   cat | printf "Min"   12   23   49
lv
2               Min                  12   23   49
```

```
cat | printf…   cat | printf "Min"   12   23   49   79
lv
1               Min                  12   23   49   79
```

```
cat | printf…   cat | printf "M…   11   12   23   45   49   71
lv              Min                11   12   23   45   4
```



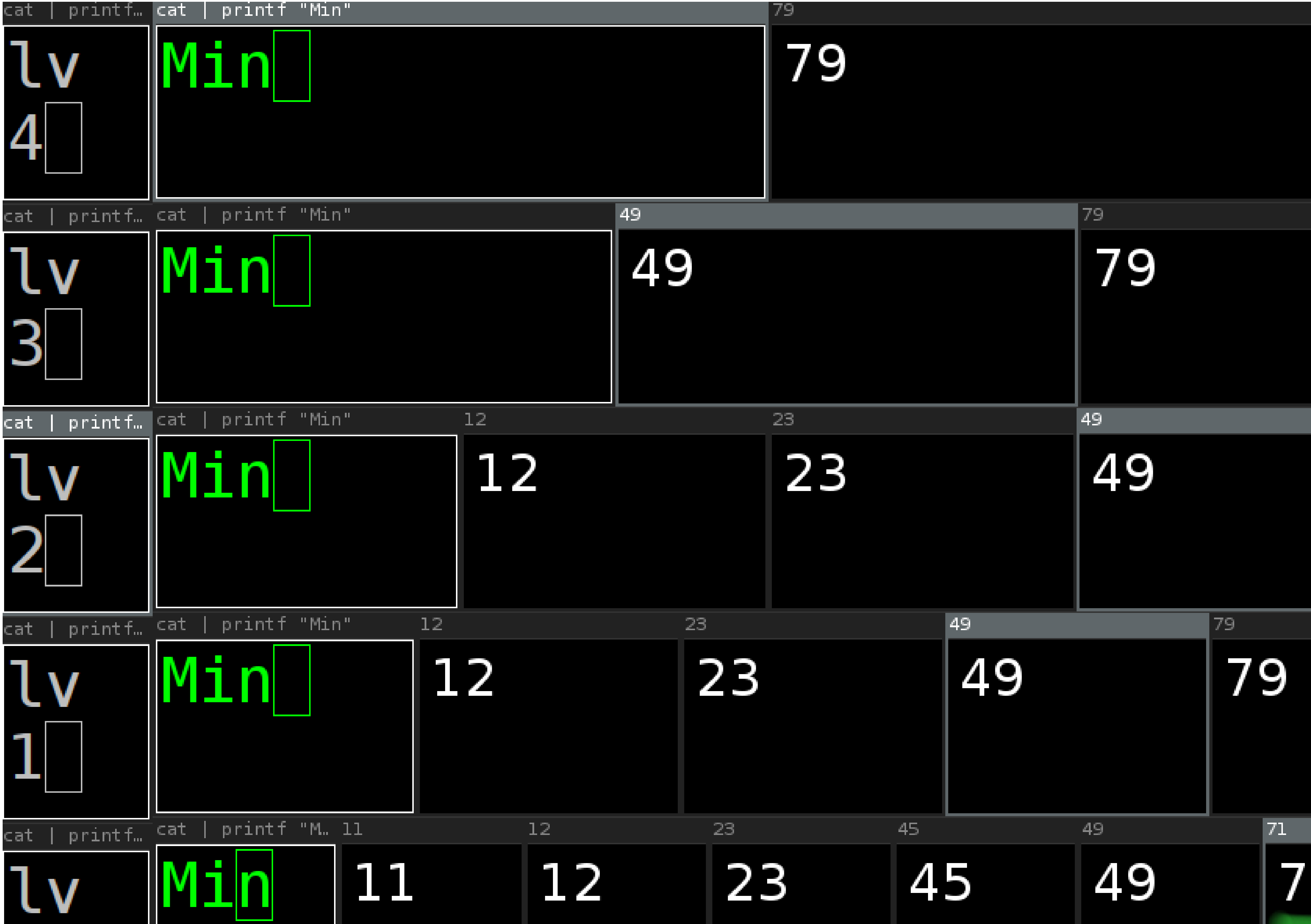
```
cat | printf…   cat | printf "Min"   79
lv              Min                  79
4
```

```
cat | printf…   cat | printf "Min"   49   79
lv              Min                  49   79
3
```

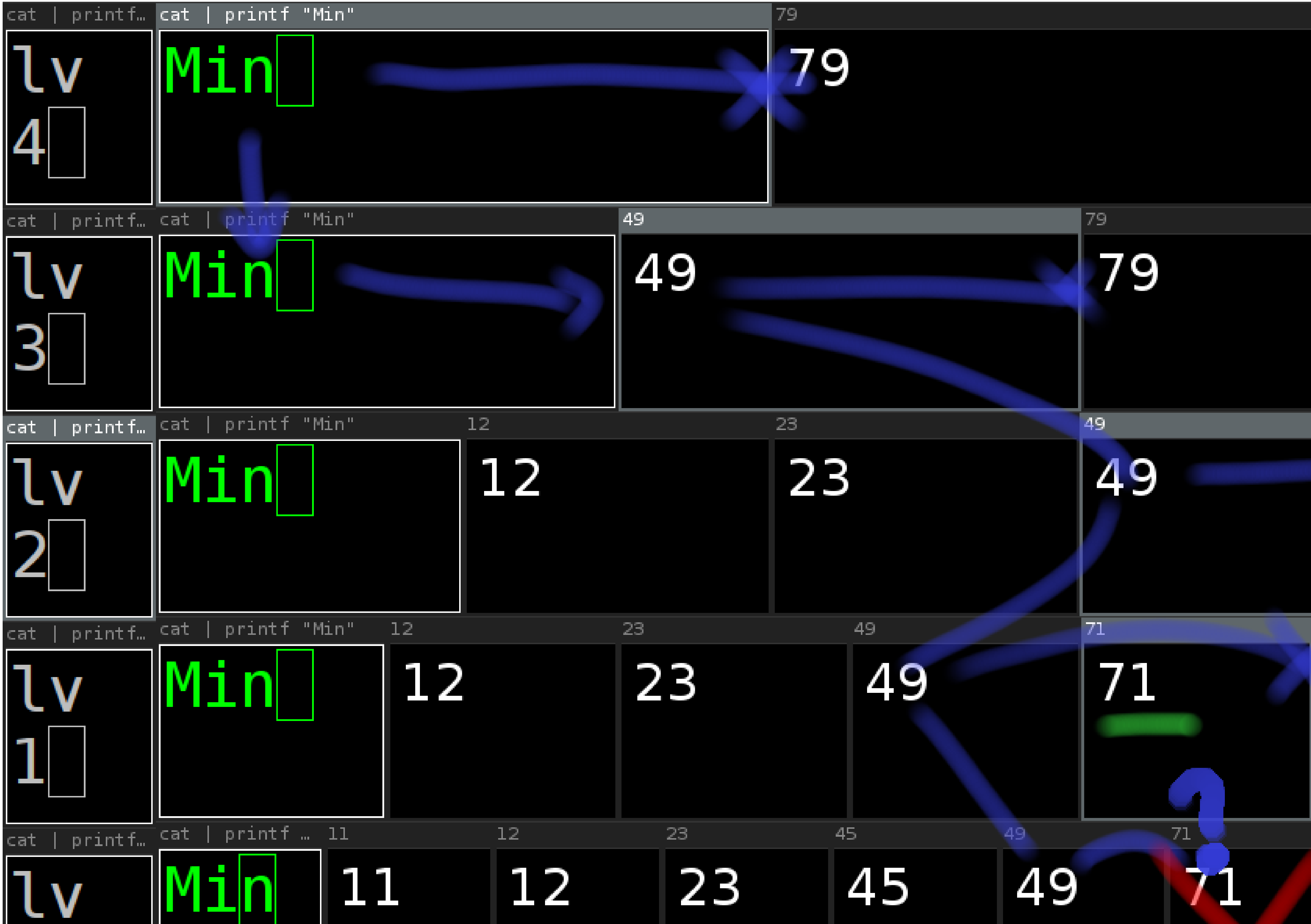
```
cat | printf…   cat | printf "Min"   12   23   49
lv              Min                  12   23   49
2
```

```
cat | printf…   cat | printf "Min"   12   23   49   79
lv              Min                  12   23   49   79
1
```

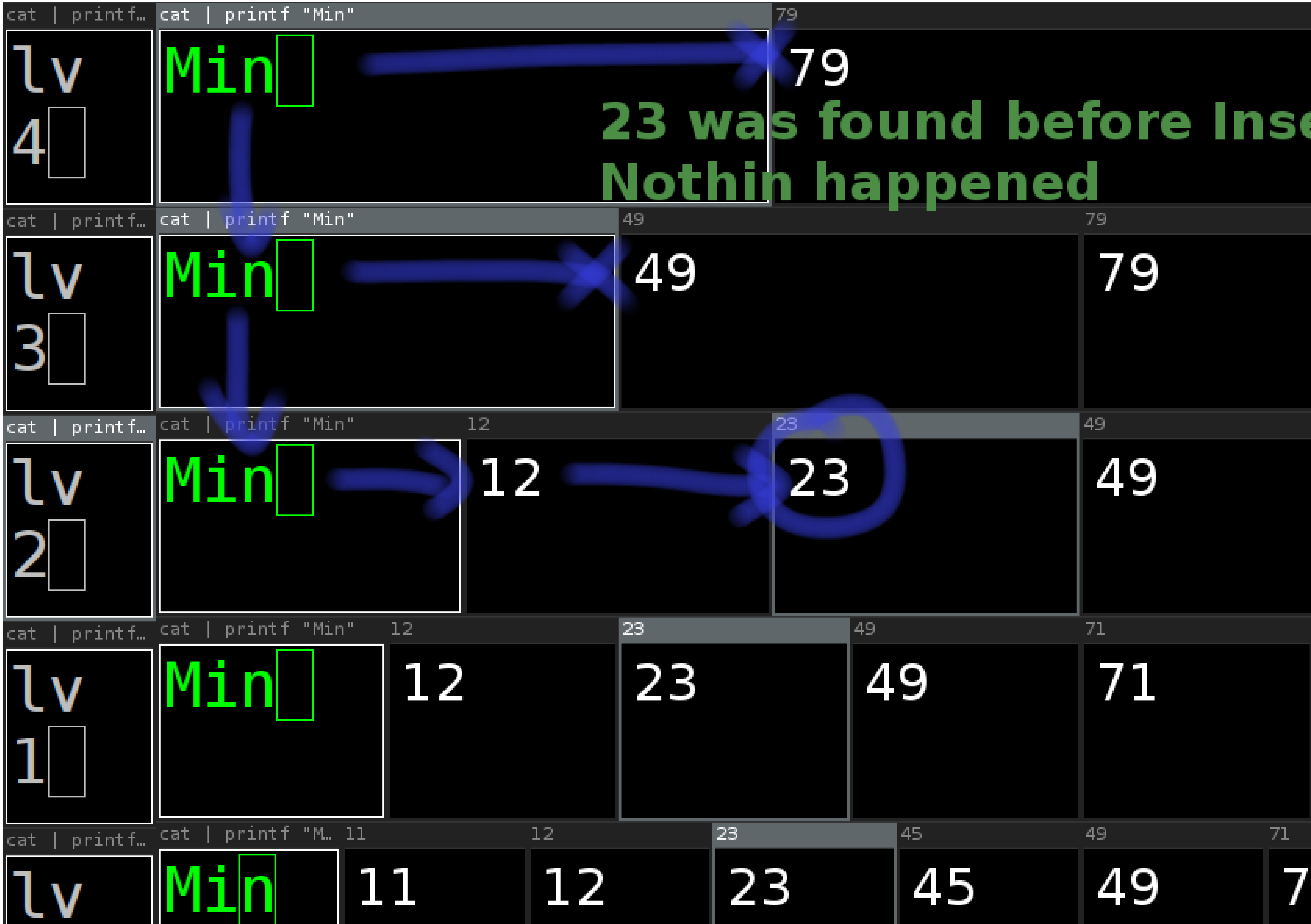
```
cat | printf…   cat | printf "M…   11   12   23   45
lv              Min                11   12   23   45
```



```
cat | printf…
lv
4

cat | printf "Min"
Min

79
79

cat | printf…
lv
3

cat | printf "Min"
Min

49
49

79
79

cat | printf…
lv
2

cat | printf "Min"
Min

12
12

23
23

49
49

cat | printf…
lv
1

cat | printf "Min"
Min

12
12

23
23

49
49

79
79

cat | printf…
lv

cat | printf "M…
Min

11
11

12
12

23
23

45
45

49
49

71
7
```

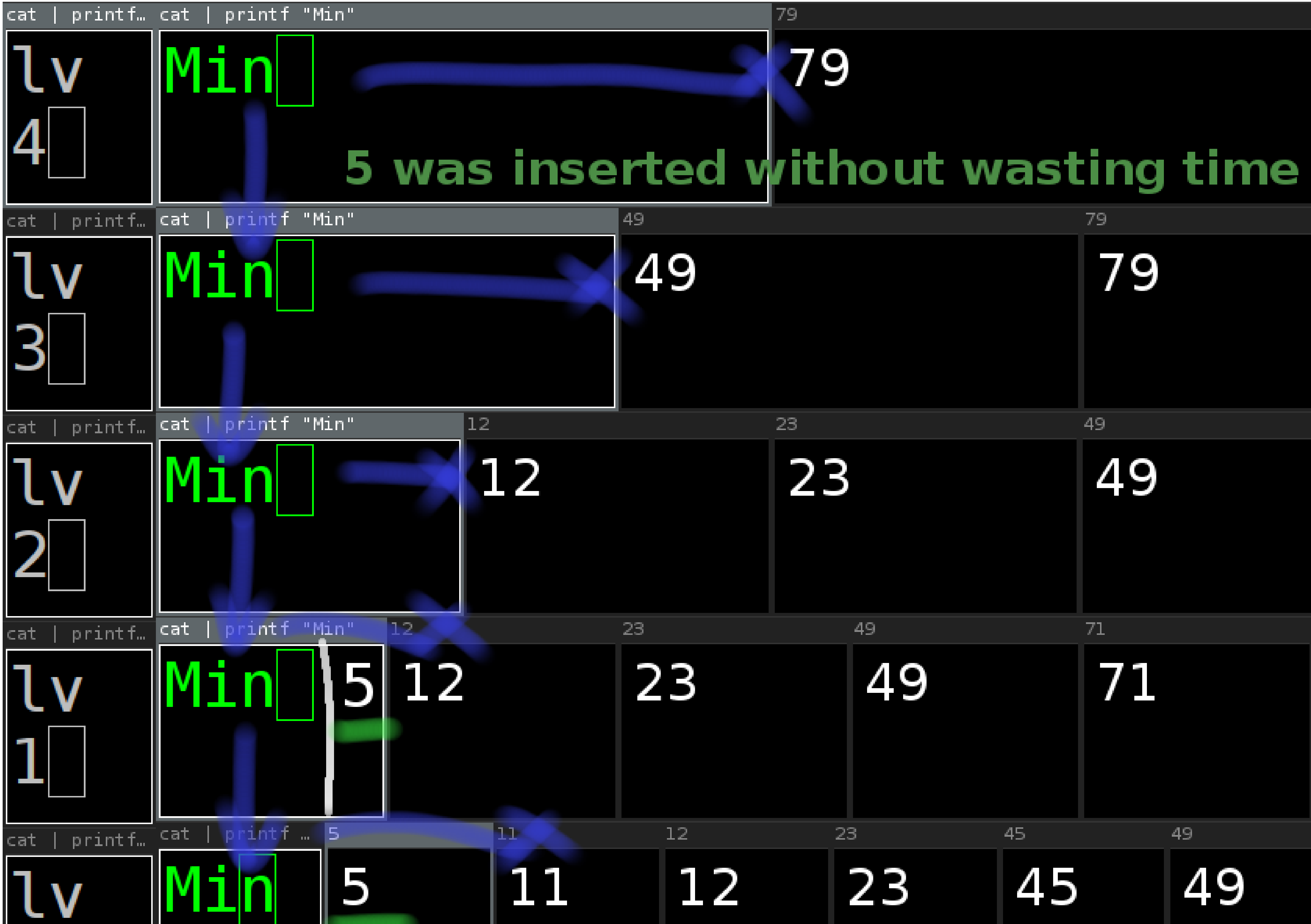


```
cat | printf…   cat | printf "Min"   79
lv              Min                  79
4

cat | printf…   cat | printf "Min"   49   79
lv              Min                  49   79
3

cat | printf…   cat | printf "Min"   12   23   49
lv              Min                  12   23   49
2

cat | printf…   cat | printf "Min"   12   23   49   71
lv              Min                  12   23   49   71
1

cat | printf…   cat | printf …   11   12   23   45   49   71
lv              Min              11   12   23   45   49   71
```



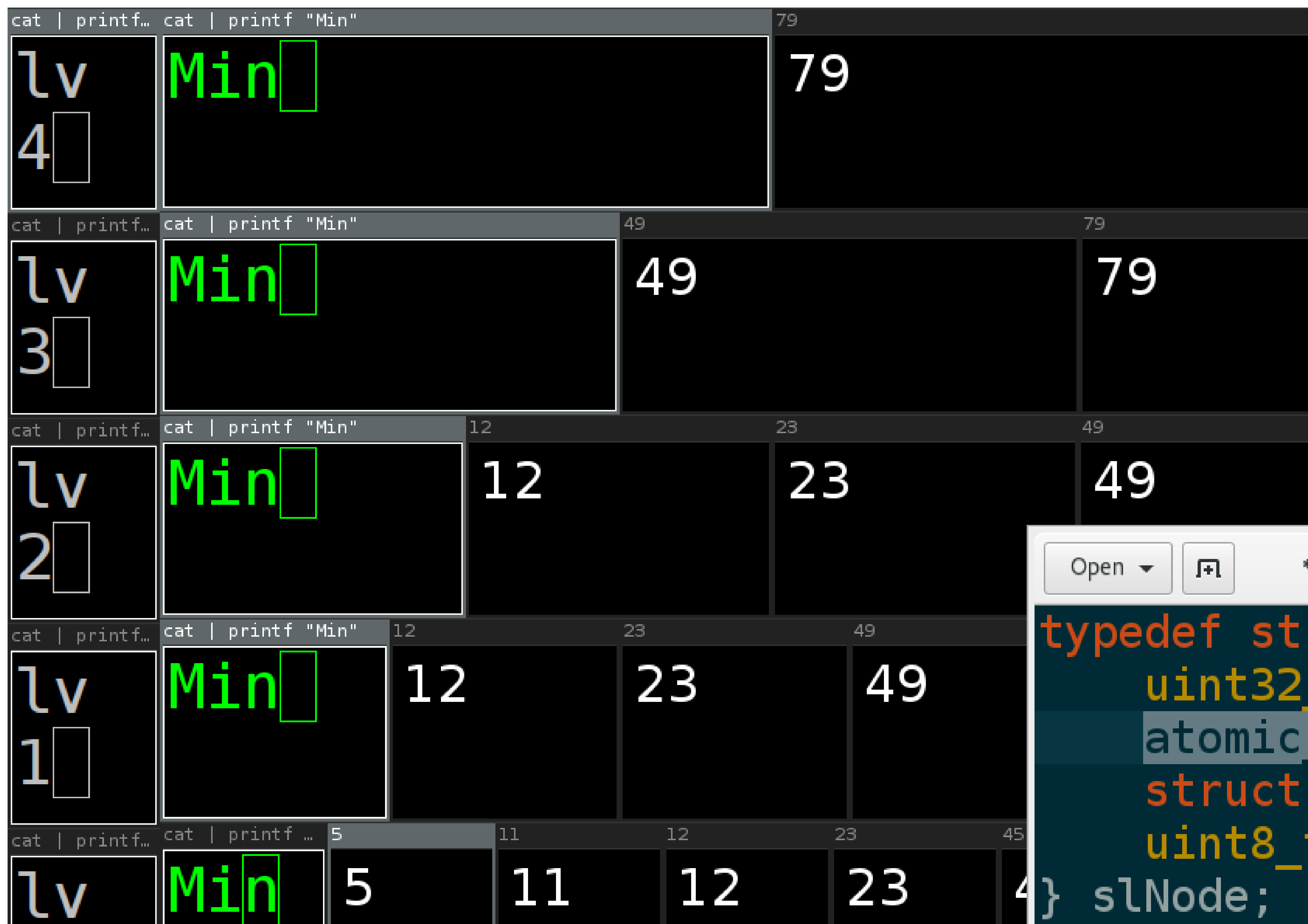
23 was found before Inse

Nothin happened



```
lv   Min                    79
4

lv   Min          49            79
3

lv   Min      12        23       49
2

lv   Min  5  12      23      49      71
1

lv   Min  5   11   12   23   45   49
```

5 was inserted without wasting time



```
lv
4
```

```
Min
```

```
79
```

```
lv
3
```

```
Min
```

```
49
```

```
79
```

```
lv
2
```

```
Min
```

```
12
```

```
23
```

```
49
```

```
lv
1
```

```
Min
```

```
12
```

```
23
```

```
49
```

```
lv
```

```
Min
```

```
5
```

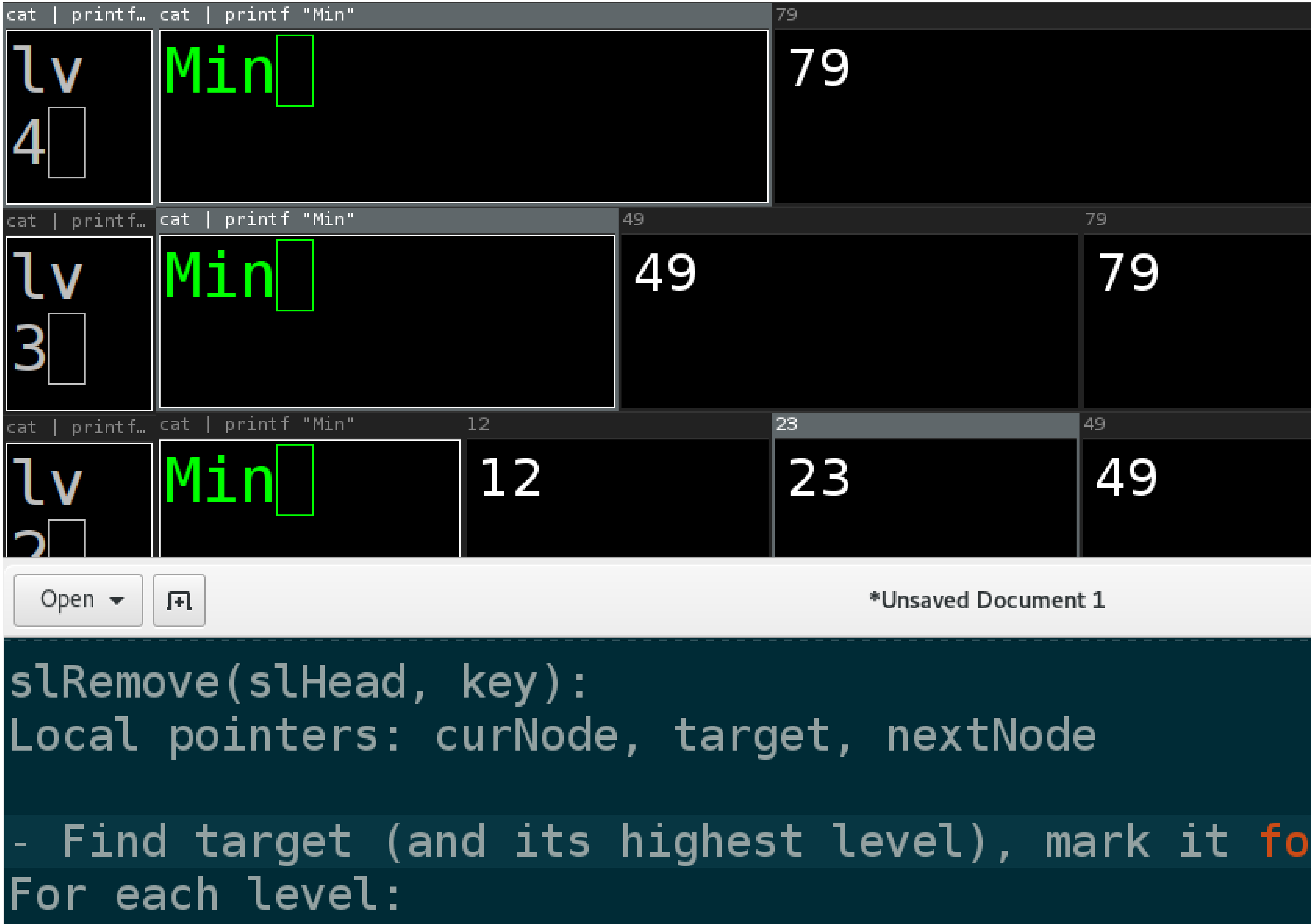
```
11
```

```
12
```

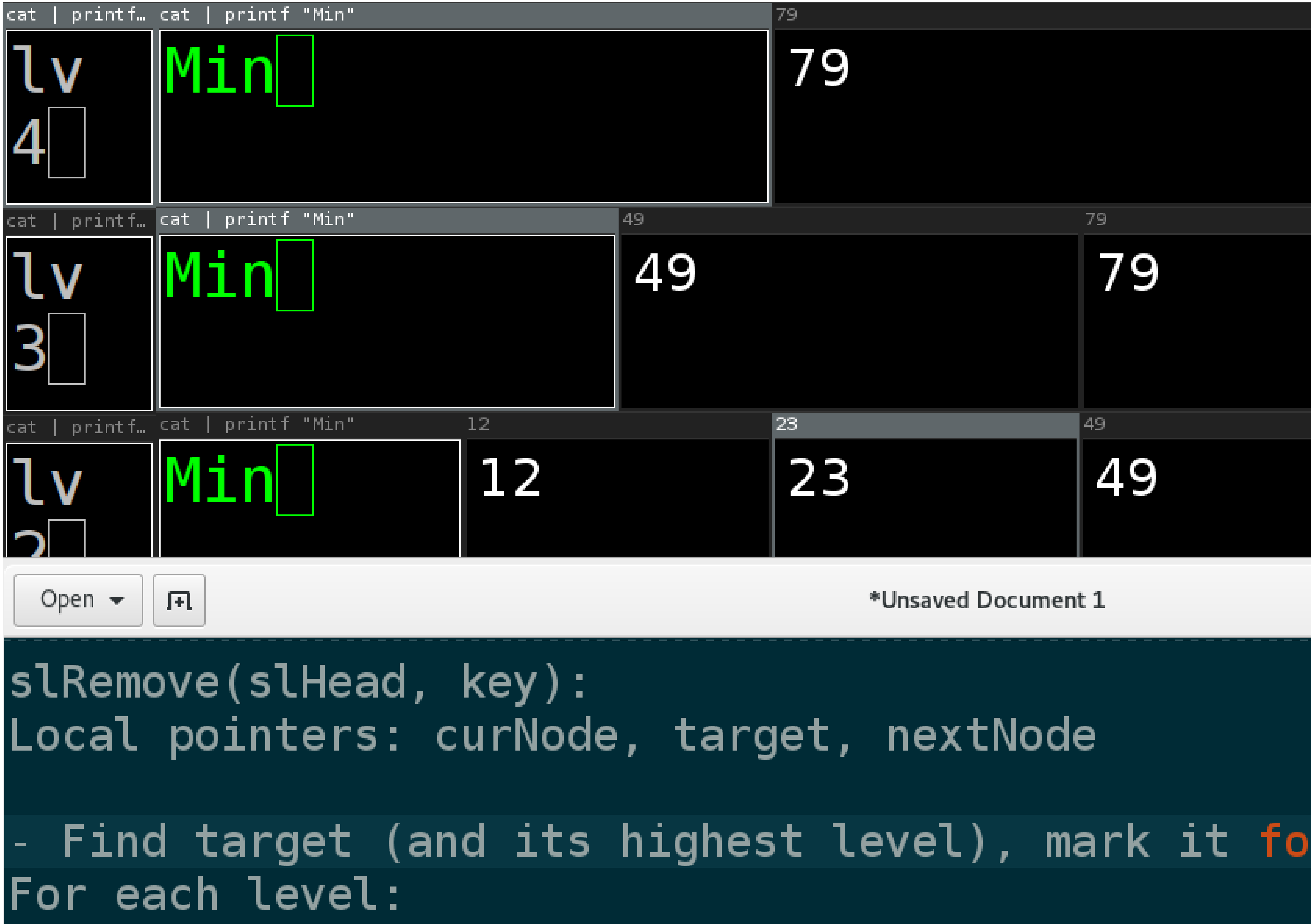
```
23
```

```
4
```

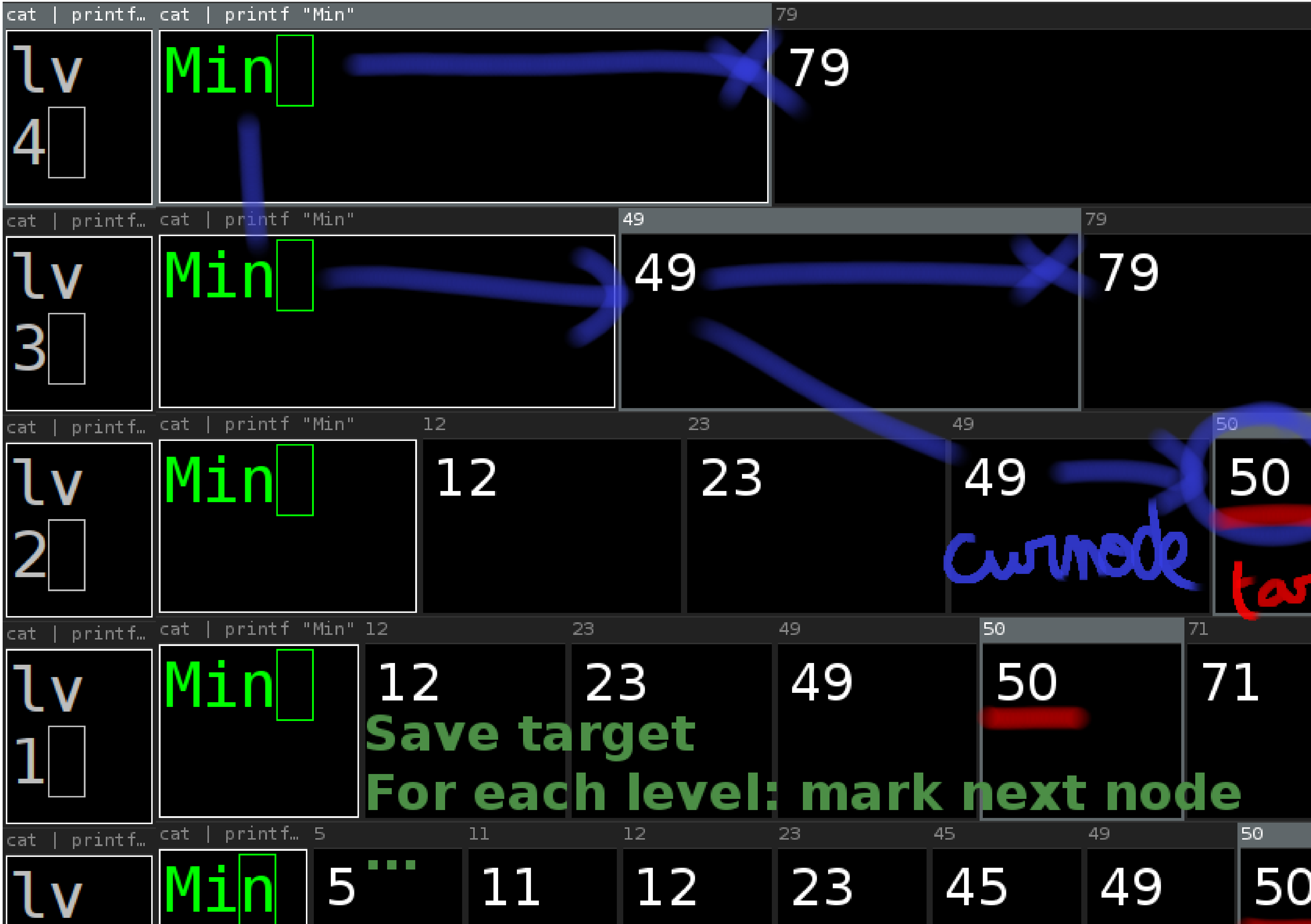
```
typedef st
    uint32_
    atomic
    struct
    uint8_
} slNode;
```



```
slRemove(slHead, key):
Local pointers: curNode, target, nextNode

- Find target (and its highest level), mark it fo
For each level:
```



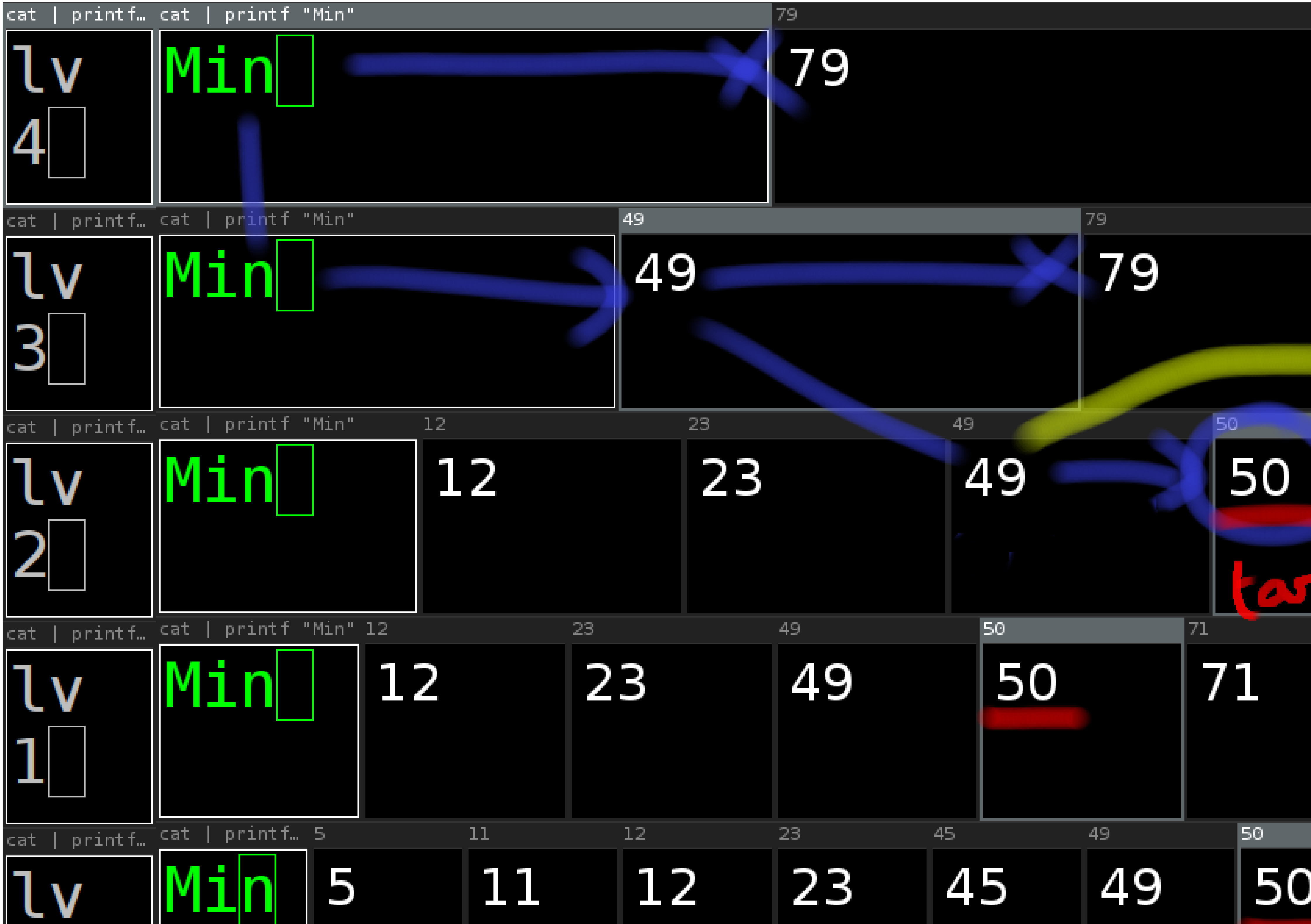
```
slRemove(slHead, key):
Local pointers: curNode, target, nextNode

- Find target (and its highest level), mark it fo
For each level:
```



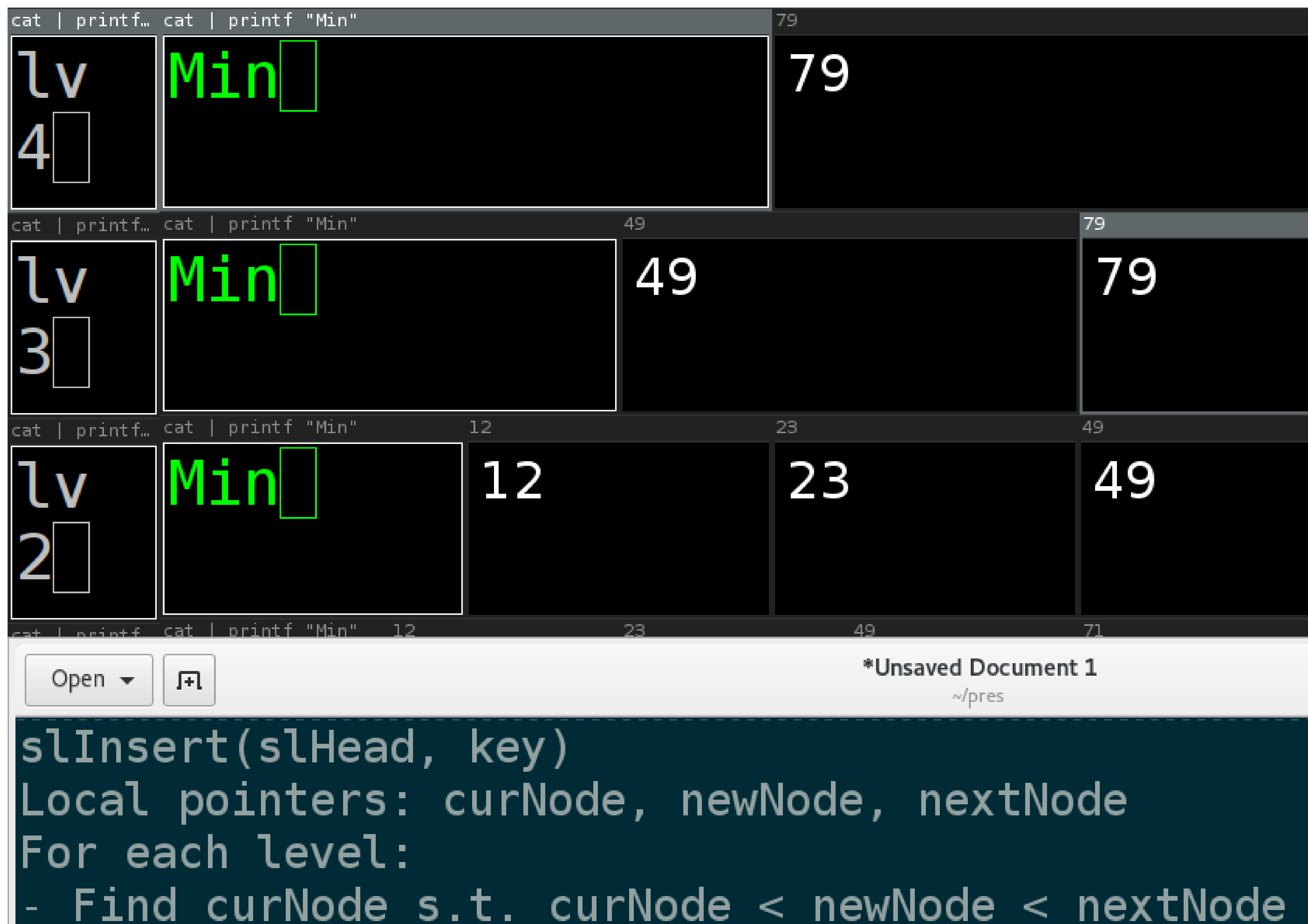
```
cat | printf…  cat | printf "Min"                         79
lv             Min                                        79
4

cat | printf…  cat | printf "Min"          49             79
lv             Min                         49             79
3

cat | printf…  cat | printf "Min"   12        23        49        50
lv             Min                  12        23        49        50
2

cat | printf…  cat | printf "Min" 12      23      49      50      71
lv             Min                12      23      49      50      71
1

cat | printf…  cat | printf…  5    11    12    23    45    49    50
lv             Min            5""  11    12    23    45    49    50
```

**Save target**

**For each level: mark next node**

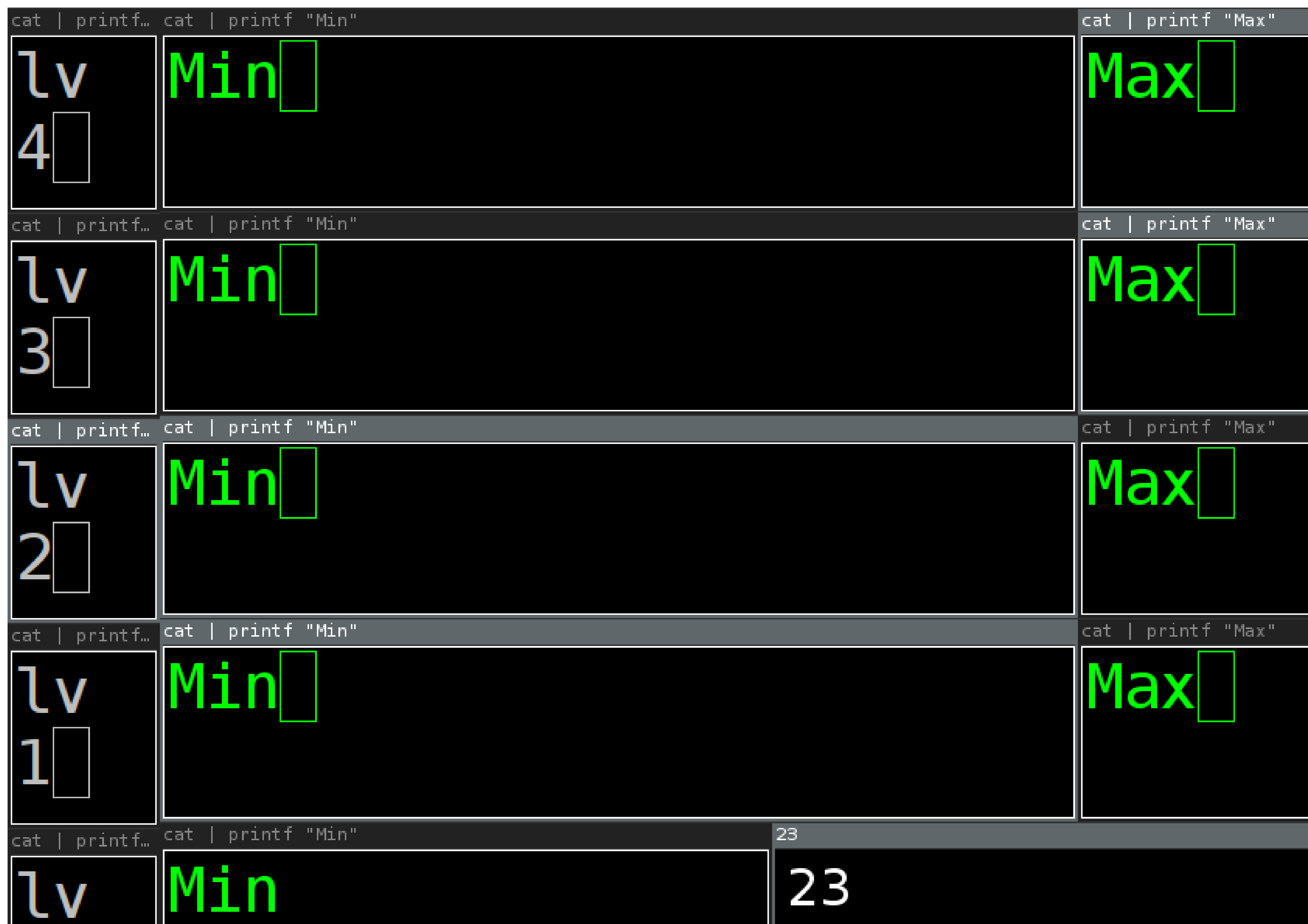


```
cat | printf…  cat | printf "Min"                 79
lv             Min                                79
4

cat | printf…  cat | printf "Min"       49                    79
lv             Min                      49                    79
3

cat | printf…  cat | printf "Min"  12         23         49         50
lv             Min                 12         23         49         50
2                                                                   tar

cat | printf…  cat | printf "Min" 12       23       49       50       71
lv             Min                12       23       49       50       71
1

cat | printf…  cat | printf…  5    11    12    23    45    49    50
lv             Min            5    11    12    23    45    49    50
```



```
cat | printf…  cat | printf "Min"                79
lv 4           Min                               79

cat | printf…  cat | printf "Min"    49                      79
lv 3           Min                   49                      79

cat | printf…  cat | printf "Min"  12          23          49
lv 2           Min                 12          23          49

cat | printf…  cat | printf "Min"  12          23          49          71
```

```
slInsert(slHead, key)
Local pointers: curNode, newNode, nextNode
For each level:
- Find curNode s.t. curNode < newNode < nextNode
```



```
lv
4
```

```
Min
```

```
Max
```

```
lv
3
```

```
Min
```

```
Max
```

```
lv
2
```

```
Min
```

```
Max
```

```
lv
1
```

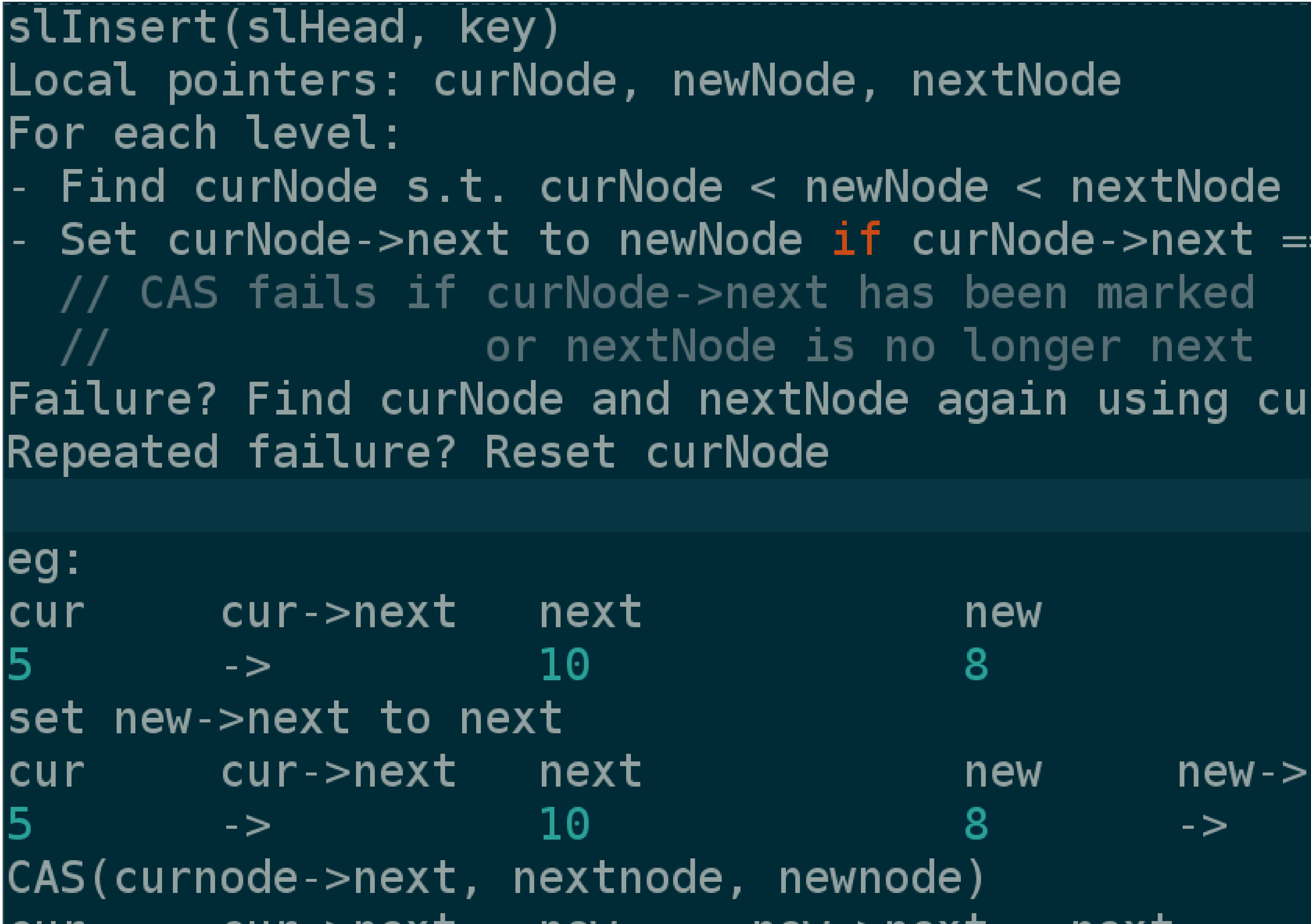
```
Min
```

```
Max
```

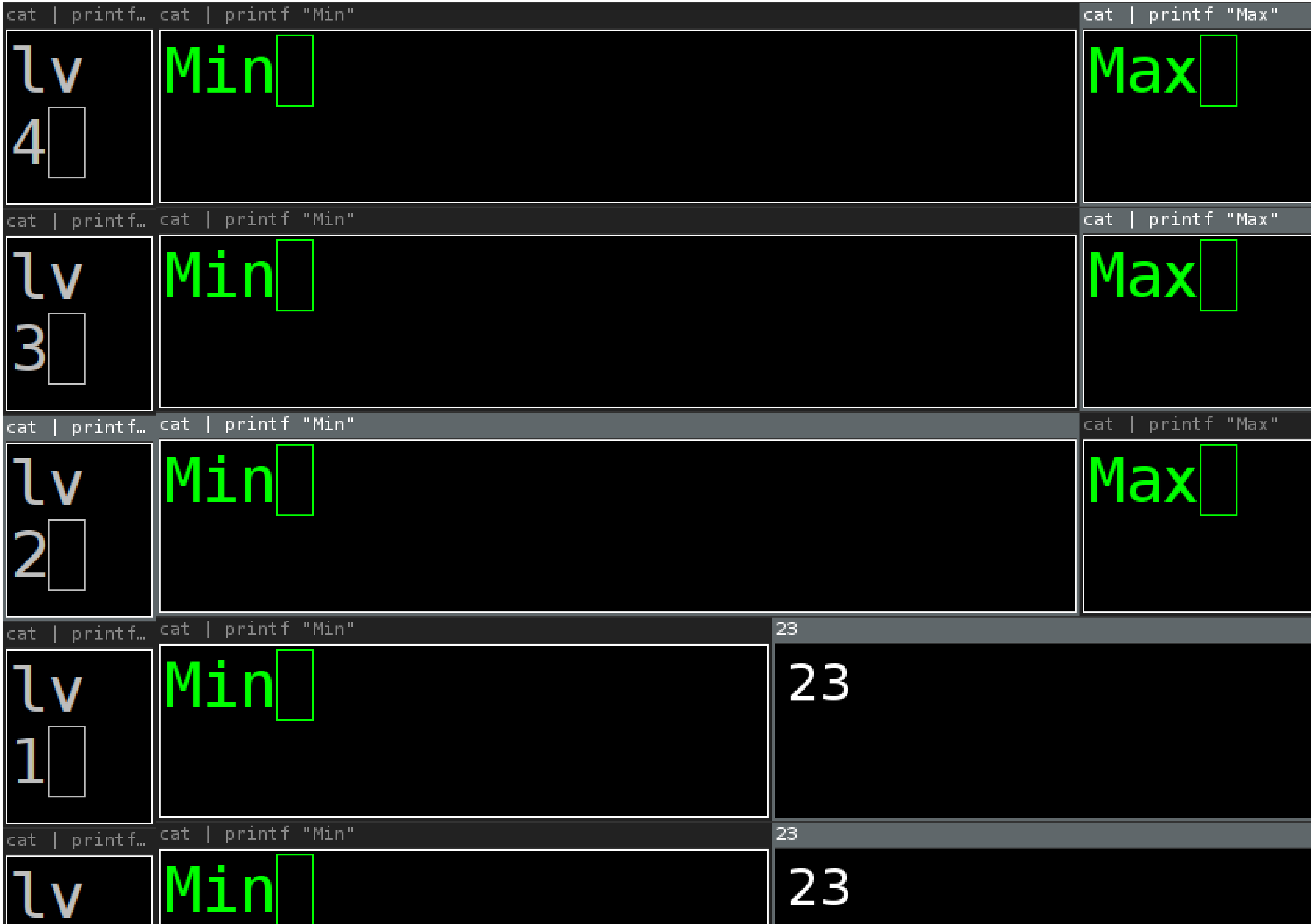
```
lv
```

```
Min
```

```
23
```



```
slInsert(slHead, key)
Local pointers: curNode, newNode, nextNode
For each level:
- Find curNode s.t. curNode < newNode < nextNode
- Set curNode->next to newNode if curNode->next ==
  // CAS fails if curNode->next has been marked
  //               or nextNode is no longer next
Failure? Find curNode and nextNode again using cu
Repeated failure? Reset curNode


eg:
cur     cur->next   next            new
5       ->          10              8
set new->next to next
cur     cur->next   next            new     new->
5       ->          10              8       ->
CAS(curnode->next, nextnode, newnode)
cur     cur->next   new     new->next   next
```



```
cat | printf…
lv
4
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
3
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
2
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
1
```

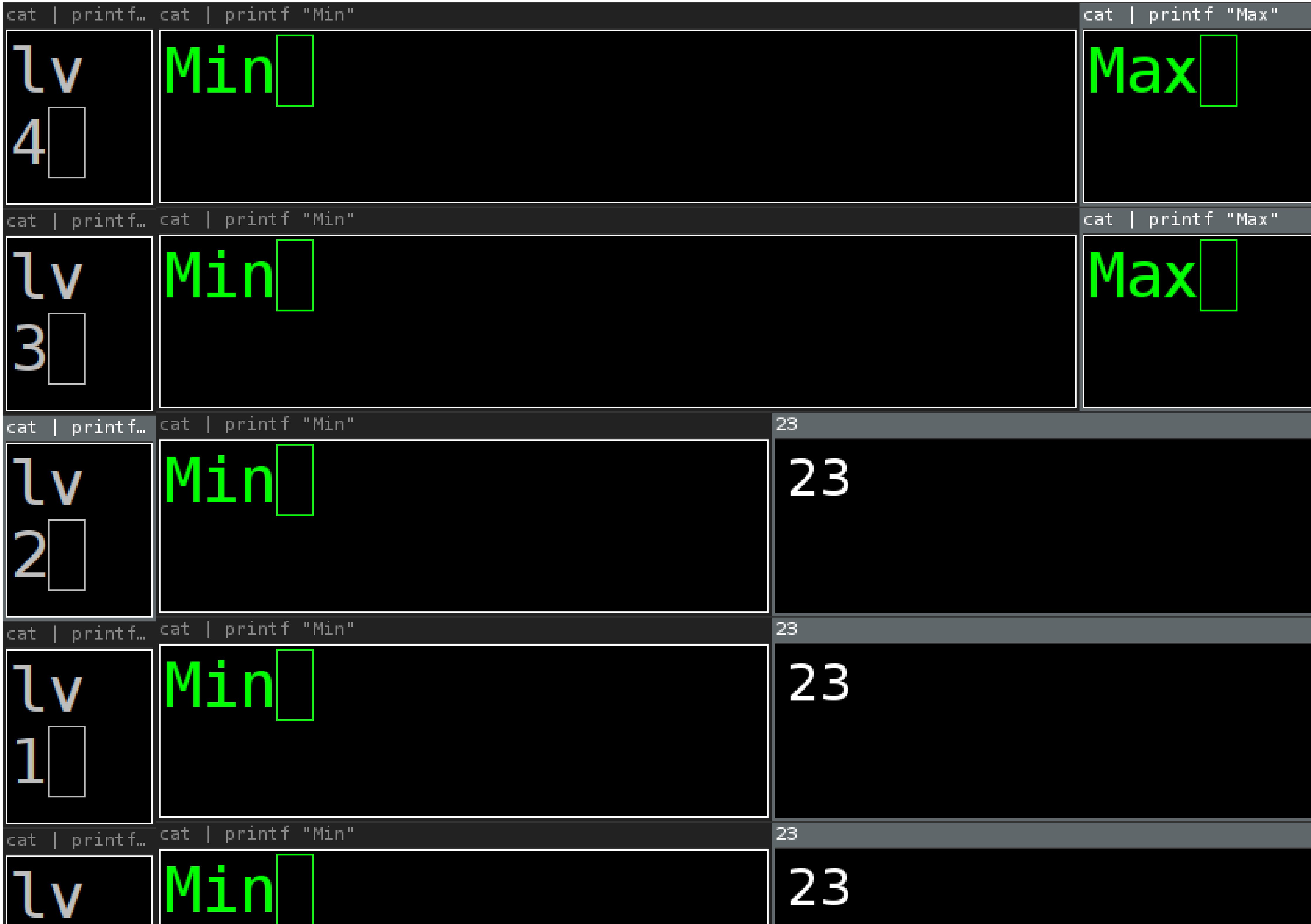
```
cat | printf "Min"
Min
```

```
23
23
```

```
cat | printf…
lv
```

```
cat | printf "Min"
Min
```

```
23
23
```



```
cat | printf…
lv
4
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
3
```

```
cat | printf "Min"
Min
```

```
cat | printf "Max"
Max
```

```
cat | printf…
lv
2
```

```
cat | printf "Min"
Min
```

```
23
23
```

```
cat | printf…
lv
1
```

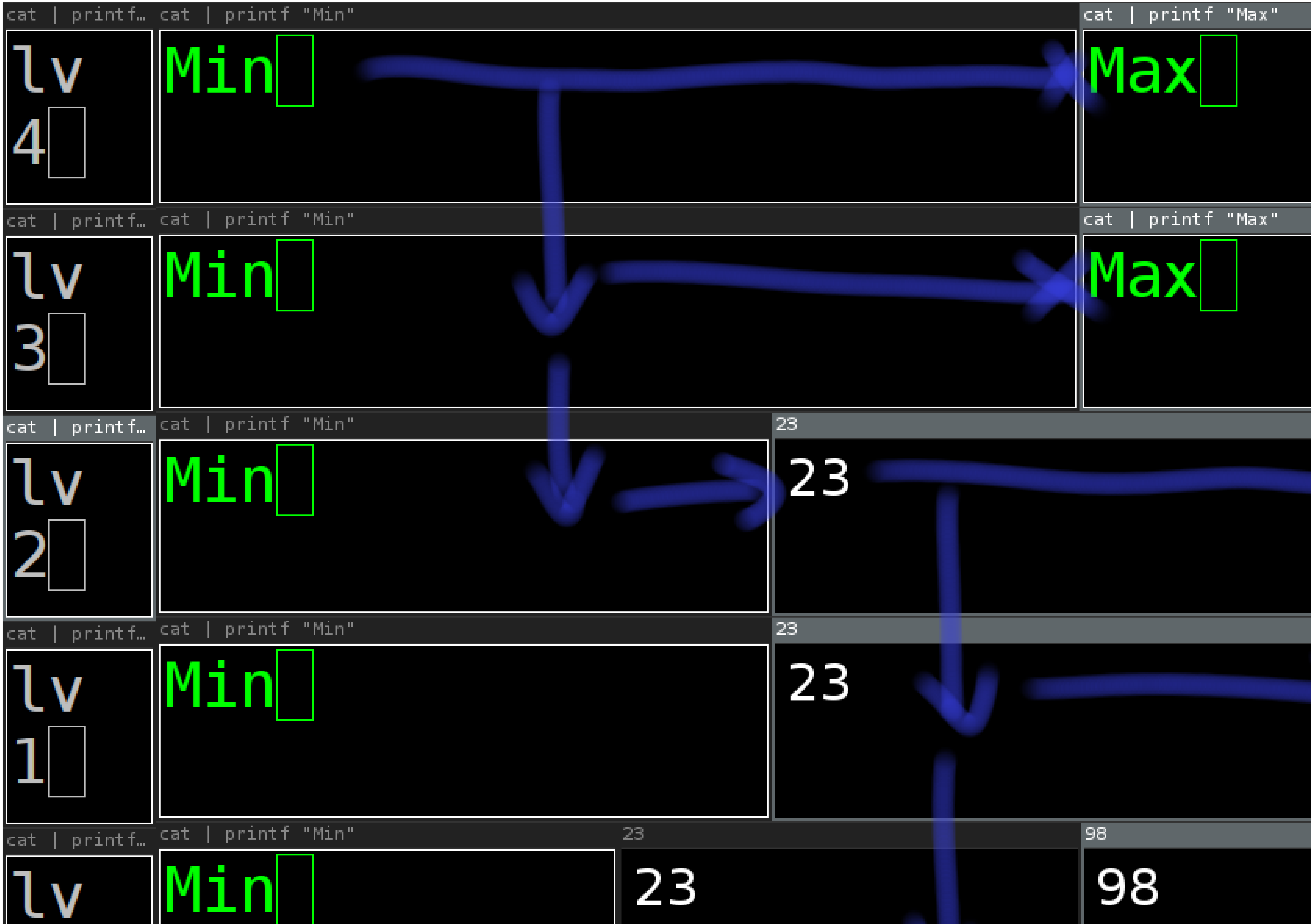
```
cat | printf "Min"
Min
```

```
23
23
```

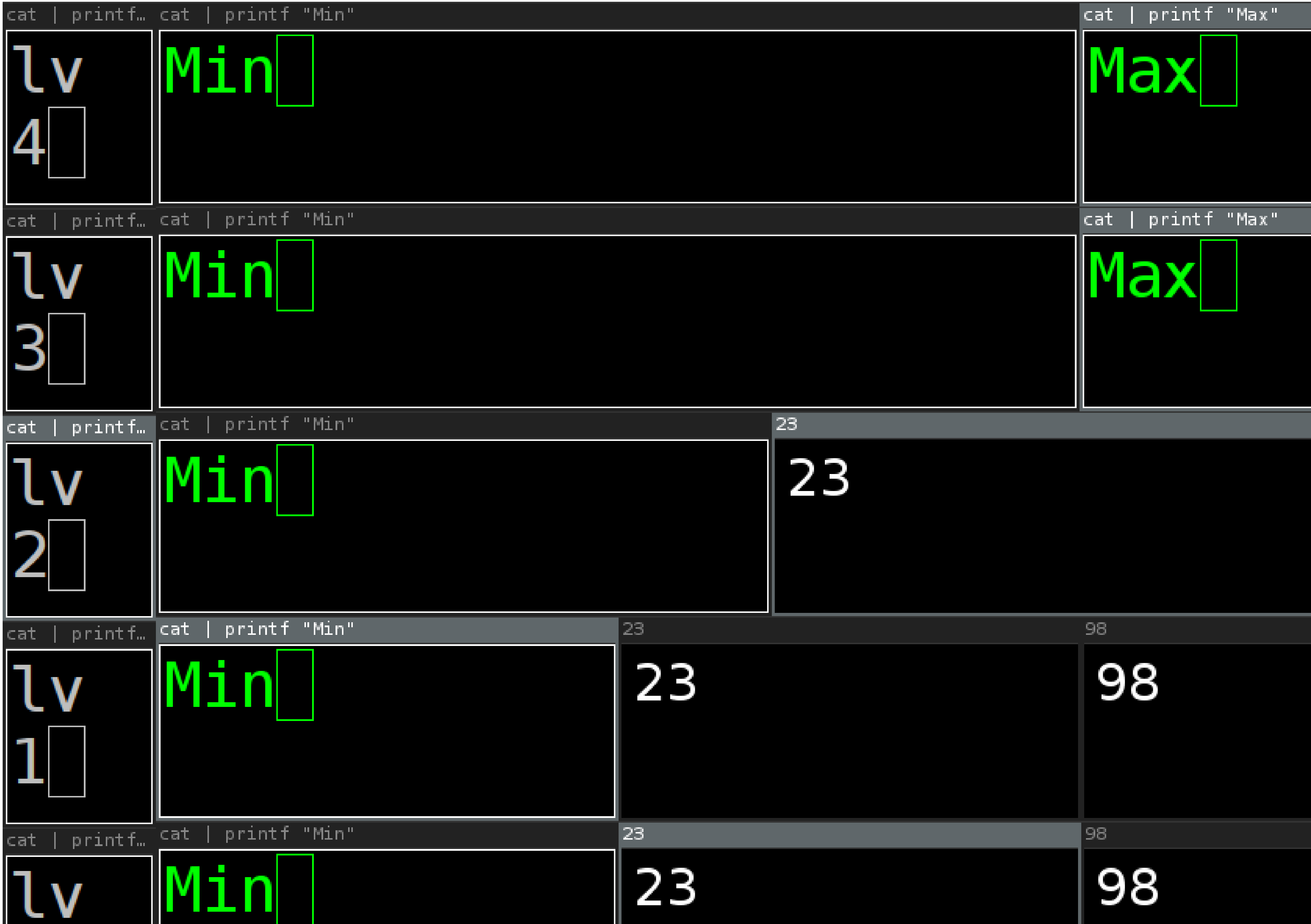
```
cat | printf…
lv
```

```
cat | printf "Min"
Min
```

```
23
23
```



```
cat | printf…
lv
4

cat | printf "Min"
Min

cat | printf "Max"
Max

cat | printf…
lv
3

cat | printf "Min"
Min

cat | printf "Max"
Max

cat | printf…
lv
2

cat | printf "Min"
Min

23
23

cat | printf…
lv
1

cat | printf "Min"
Min

23
23

cat | printf…
lv

cat | printf "Min"
Min

23
23

98
98
```



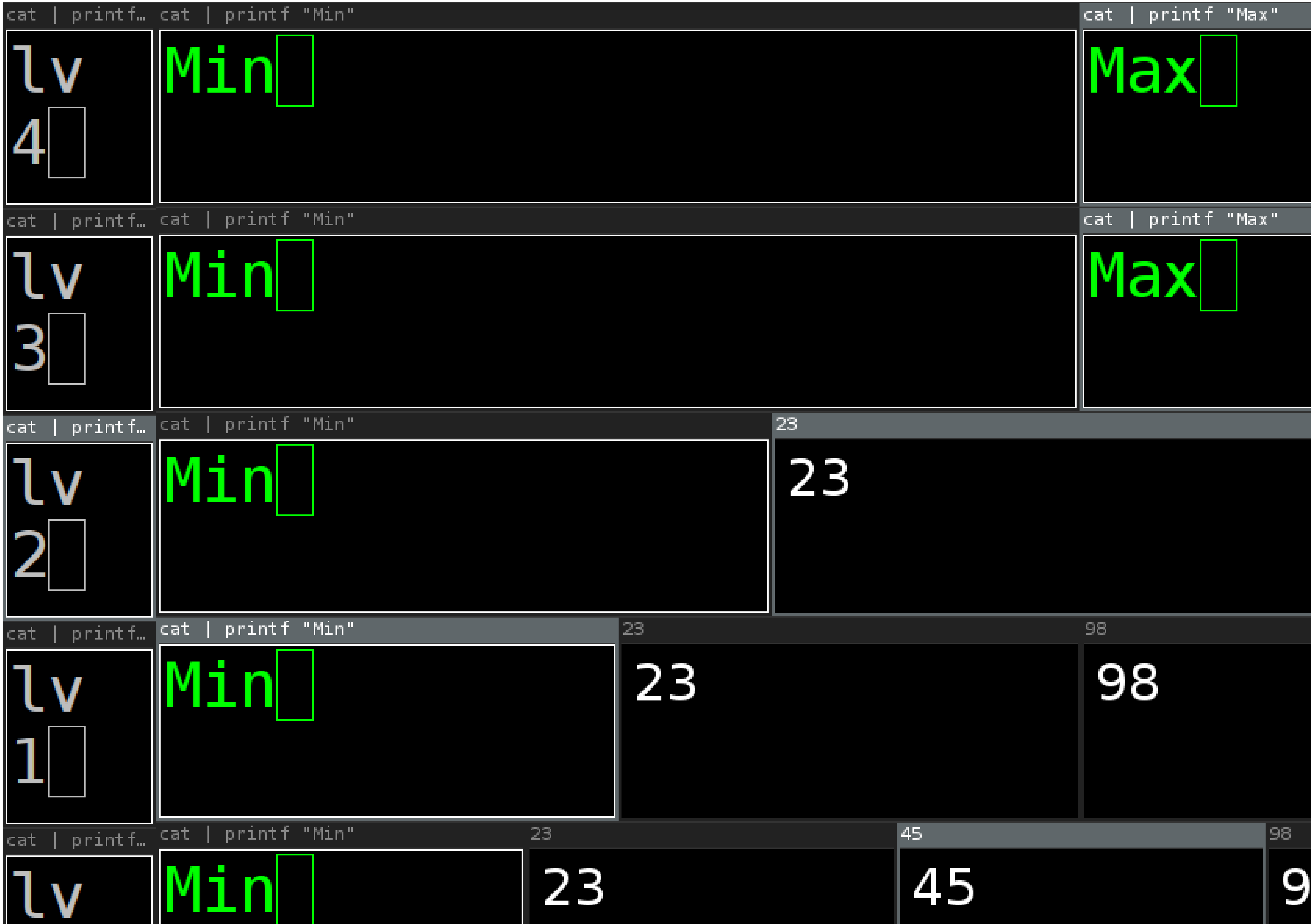
```
cat | printf…   cat | printf "Min"                         cat | printf "Max"
lv              Min                                        Max
4
```

```
cat | printf…   cat | printf "Min"                         cat | printf "Max"
lv              Min                                        Max
3
```

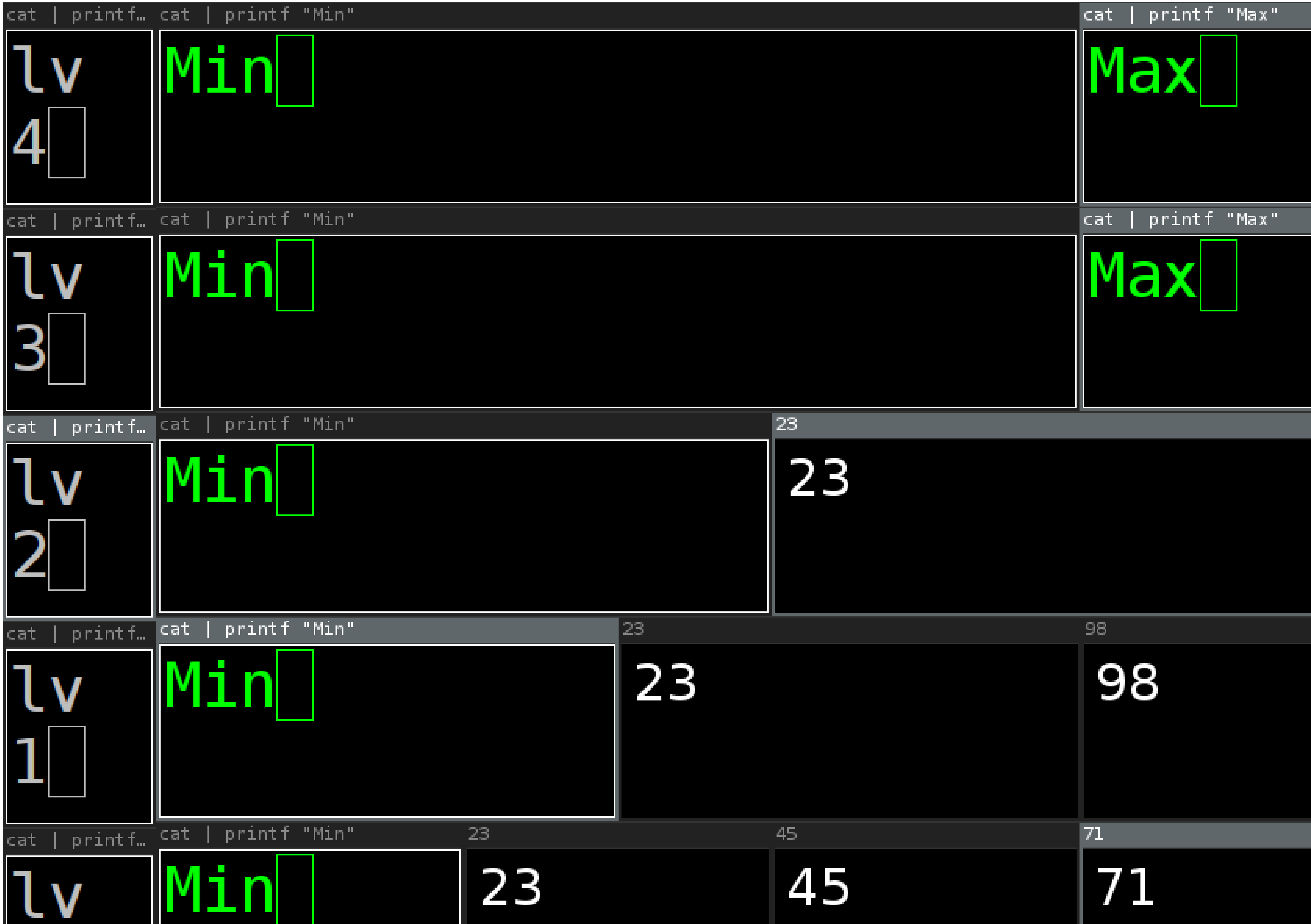
```
cat | printf…   cat | printf "Min"             23
lv              Min                            23
2
```

```
cat | printf…   cat | printf "Min"   23                    98
lv              Min                  23                    98
1
```

```
cat | printf…   cat | printf "Min"   23                    98
lv              Min                  23                    98
```



```
cat | printf…   cat | printf "Min"   cat | printf "Max"
lv              Min                  Max
4

cat | printf…   cat | printf "Min"   cat | printf "Max"
lv              Min                  Max
3

cat | printf…   cat | printf "Min"   23
lv              Min                  23
2

cat | printf…   cat | printf "Min"   23   98
lv              Min                  23   98
1

cat | printf…   cat | printf "Min"   23   45   98
lv              Min                  23   45   9
```



```
cat | printf…   cat | printf "Min"                      cat | printf "Max"
lv              Min                                     Max
4
```

```
cat | printf…   cat | printf "Min"                      cat | printf "Max"
lv              Min                                     Max
3
```

```
cat | printf…   cat | printf "Min"              23
lv              Min                             23
2
```

```
cat | printf…   cat | printf "Min"      23                  98
lv              Min                     23                  98
1
```

```
cat | printf…   cat | printf "Min"   23        45        71
lv              Min                  23        45        71
```