Compiling Esterel into Static Discrete-Event Code

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Presented by

Michael Halas

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CEC

- Compiles Esterel into very efficient C code
- Minimizes runtime overhead
  - Compile time
  - Runtime

An Example

Modeling a shared resource

Input I,S ;
Output O,Q;

```
every S do
   await I;
   weak abort
      sustain R
   when immediate A;
   emit O
||
loop
   pause; pause;
   present R then
      emit A
   end present
end loop
||
loop
   present R then
      pause; emit Q
   else
      pause
   end present
end loop
end every
```

Takes **I**, and passes to group two through **R**

1

```
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Responds to **R** with **A**

2

Makes **Q** delayed version of **R**

3

Takes **I**, and passes to group two through **R**

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await I;
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Responds to **R** with **A**

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```
loop
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Makes **Q** delayed version of **R**

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Takes **I**, and passes to group two through **R**

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Responds to **R** with **A**

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Makes **Q** delayed version of **R**

1. Takes **I**, and passes to group two through **R**
2. Responds to **R** with **A**
3. Makes **Q** delayed version of **R**

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The GRC Representation

Developed by Potop-Butucaru

Control Flow Graph

```
Input I,S ;
Output O,Q;
Signal R,A in

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```

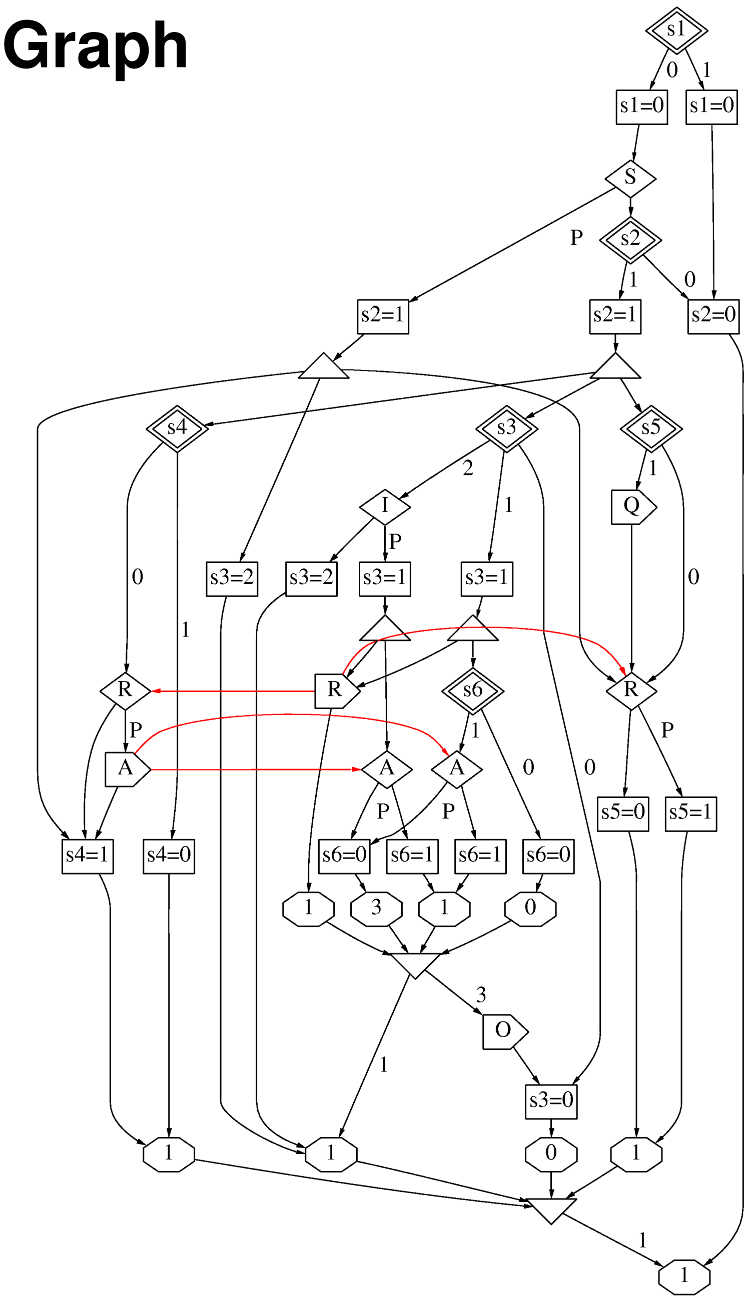

Executes once per cycle from entry to exit

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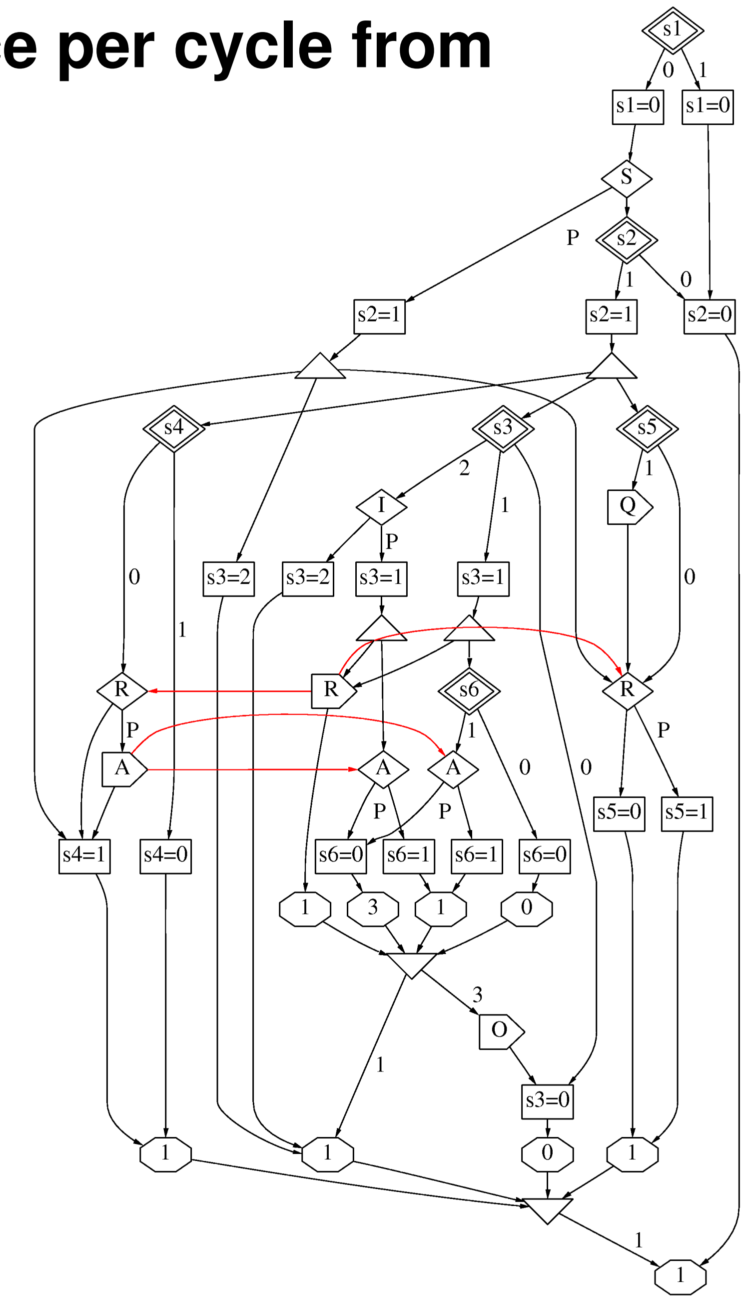

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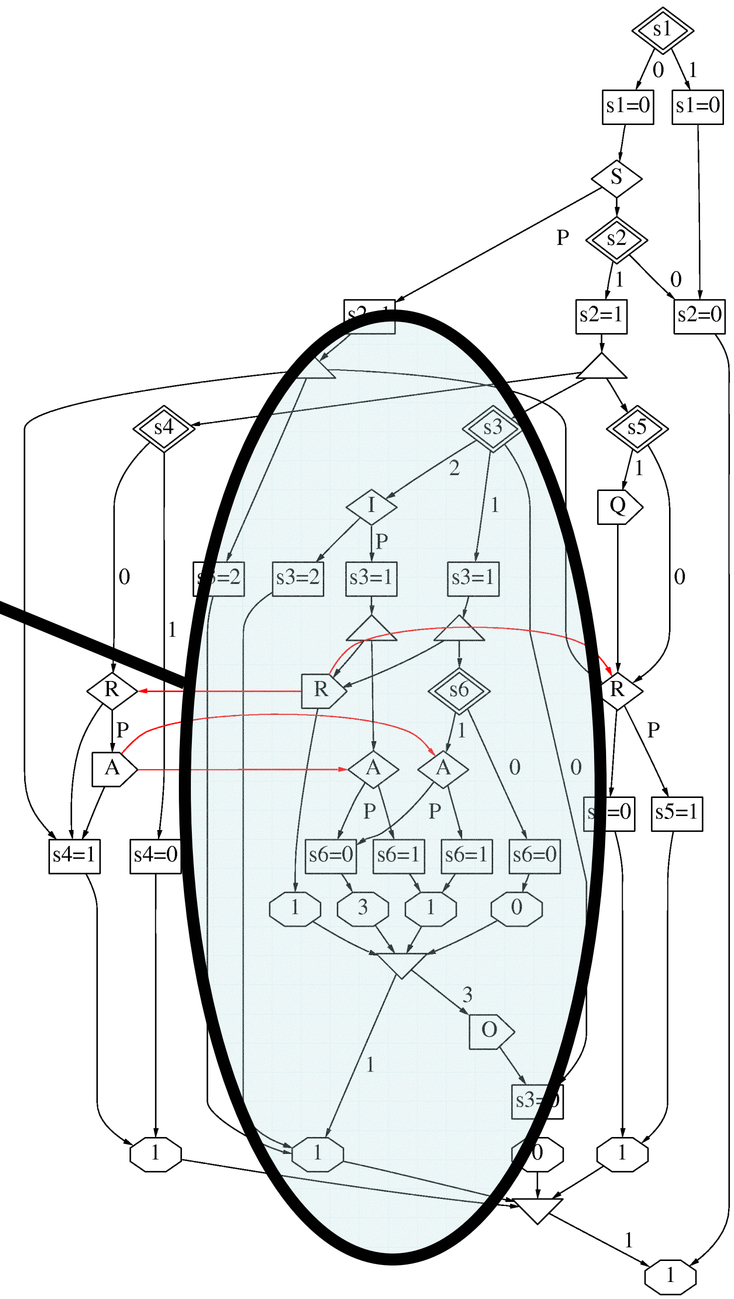

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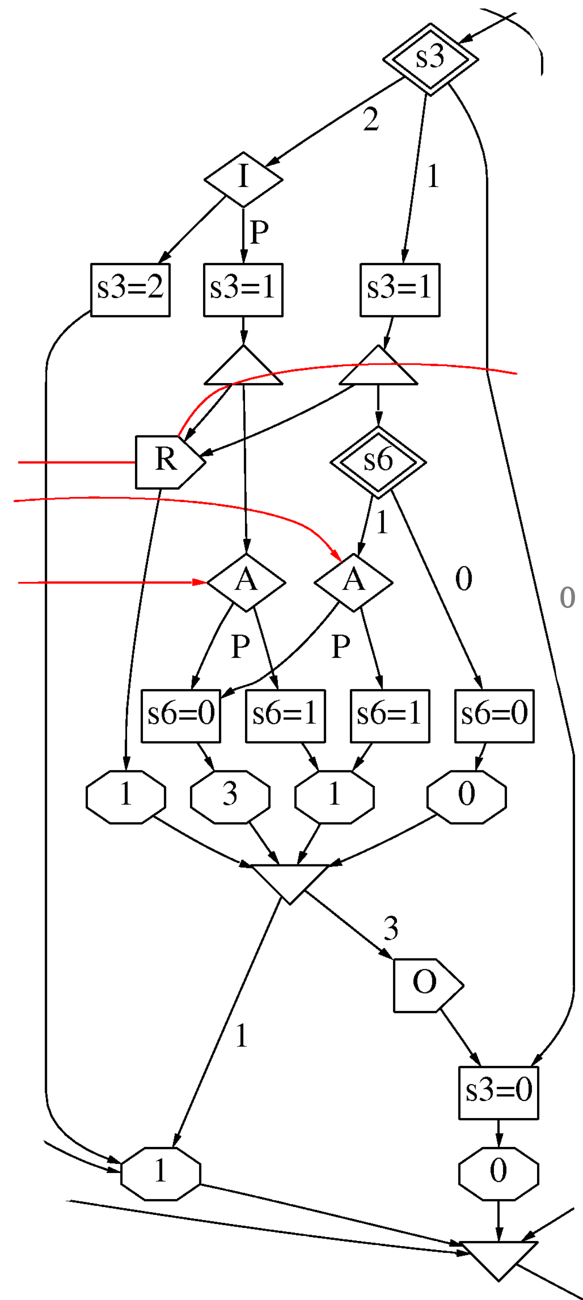

Clustering

1. Group the GRC nodes into clusters that can run without interruption
2. Assign levels – Partial Ordering

   Levels execute in order

   Clusters within the same level can execute in any order

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   Levels execute in order – Compile Time

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Clustering

1. Group the GRC nodes into clusters that can run without interruption
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   Levels execute in order – Compile Time

   Clusters within the same level can execute in any order - Runtime

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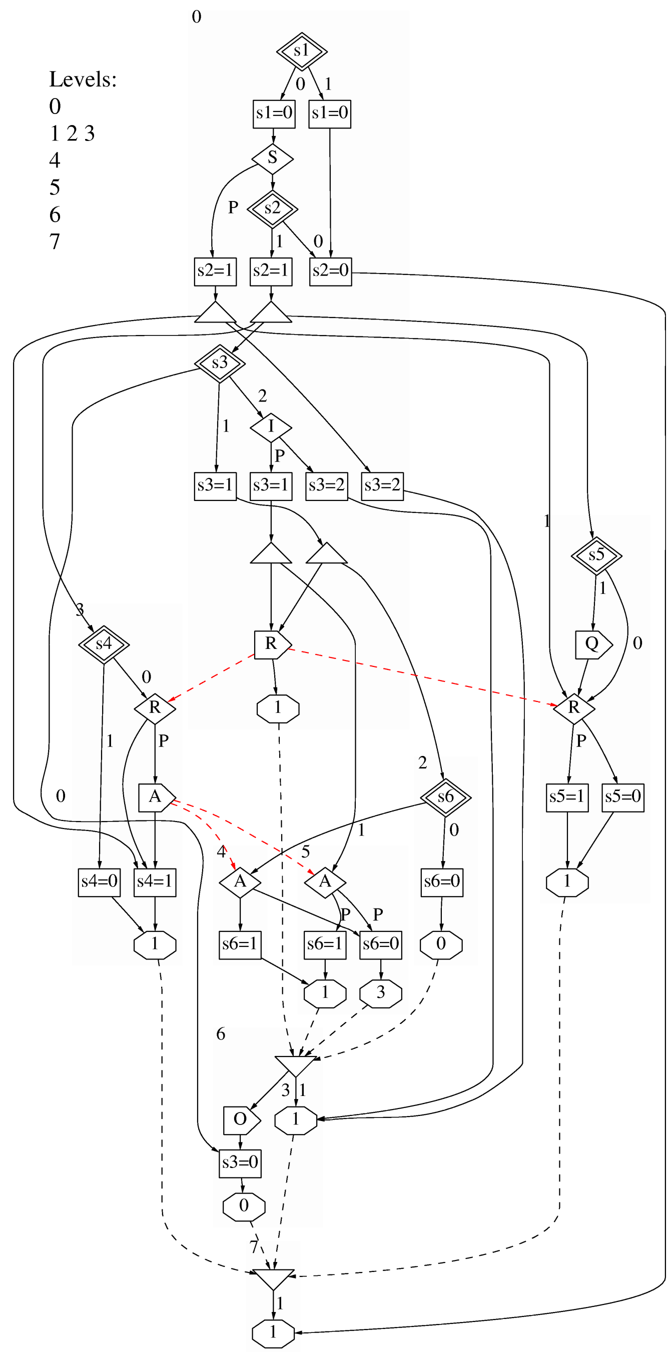

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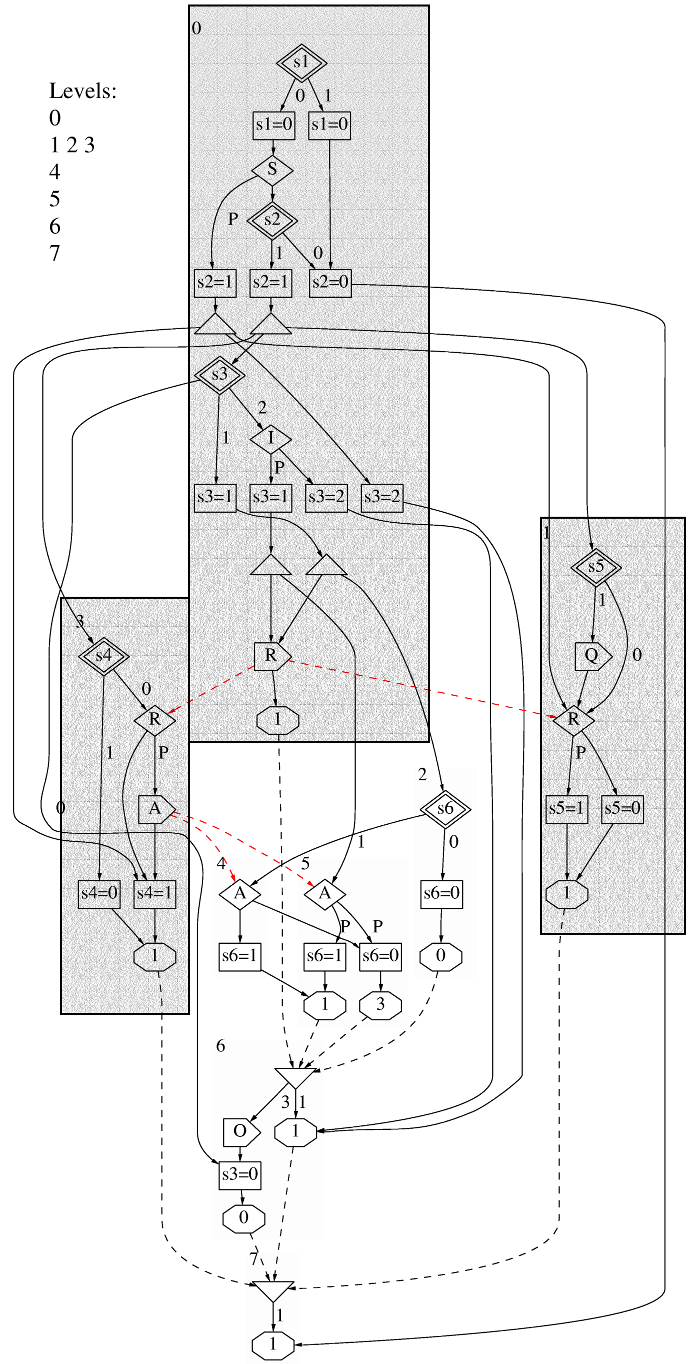

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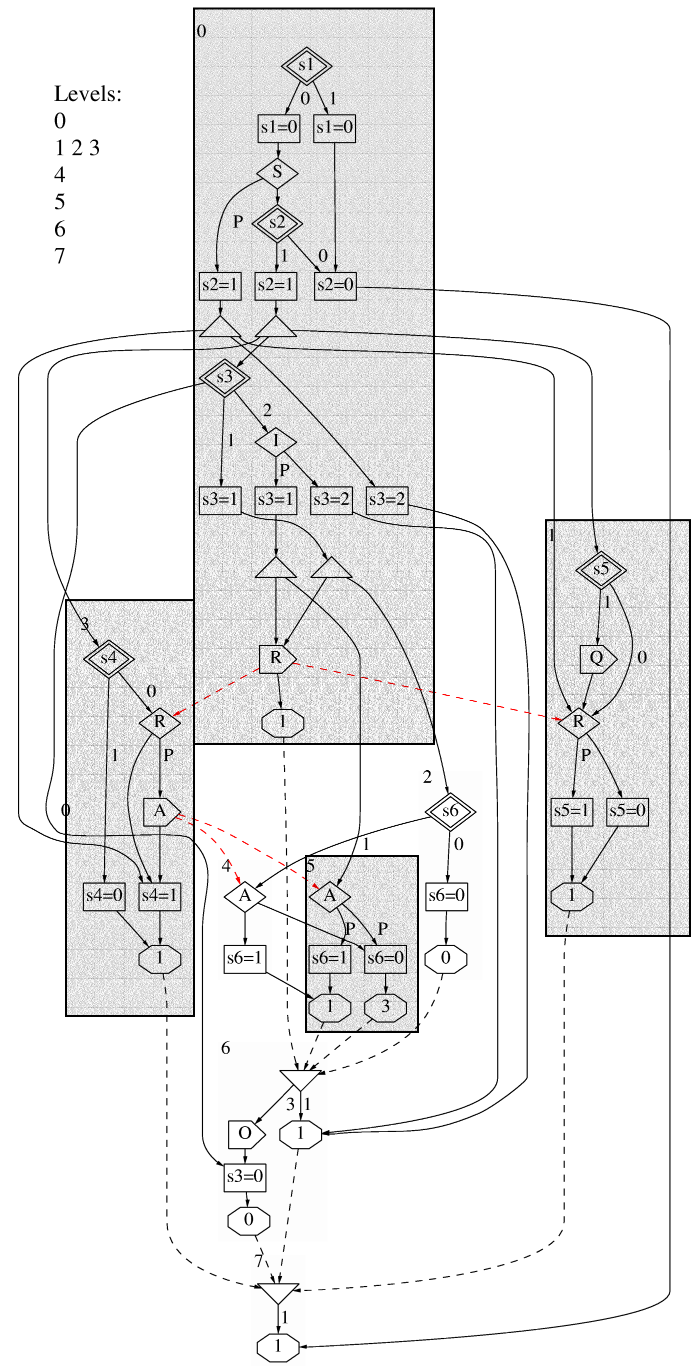

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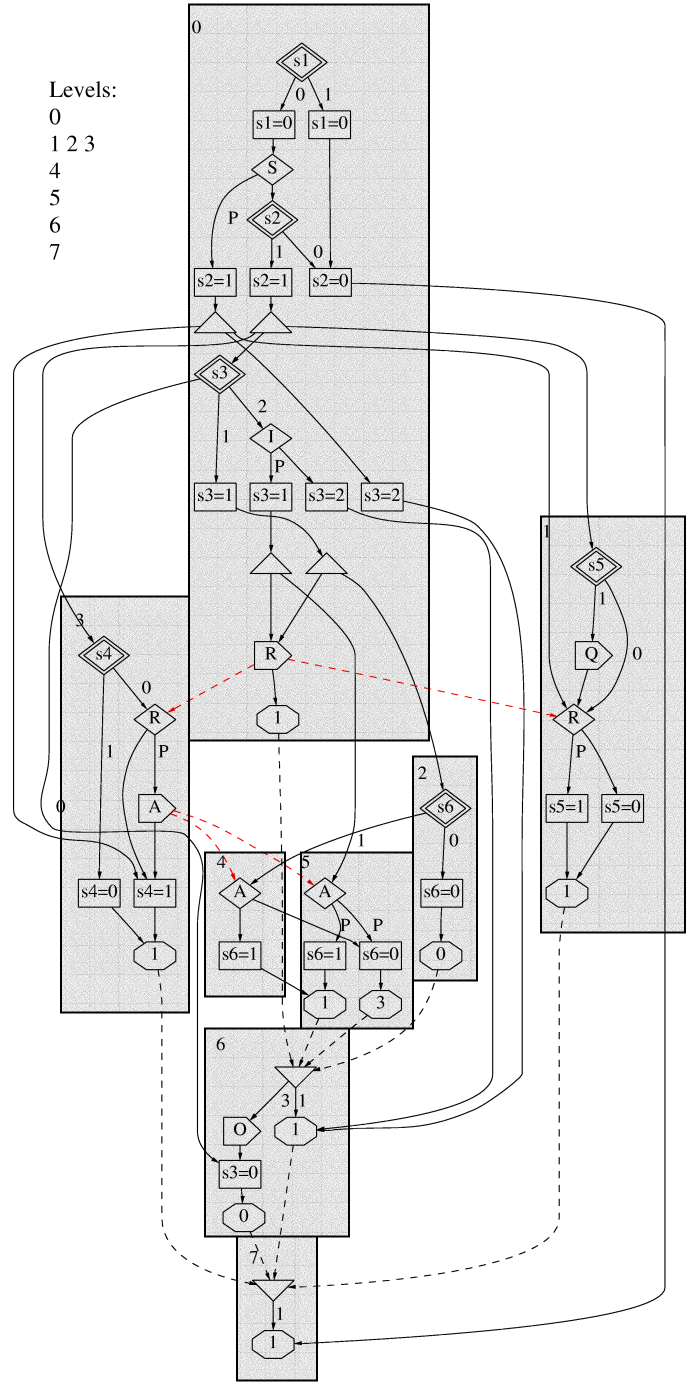
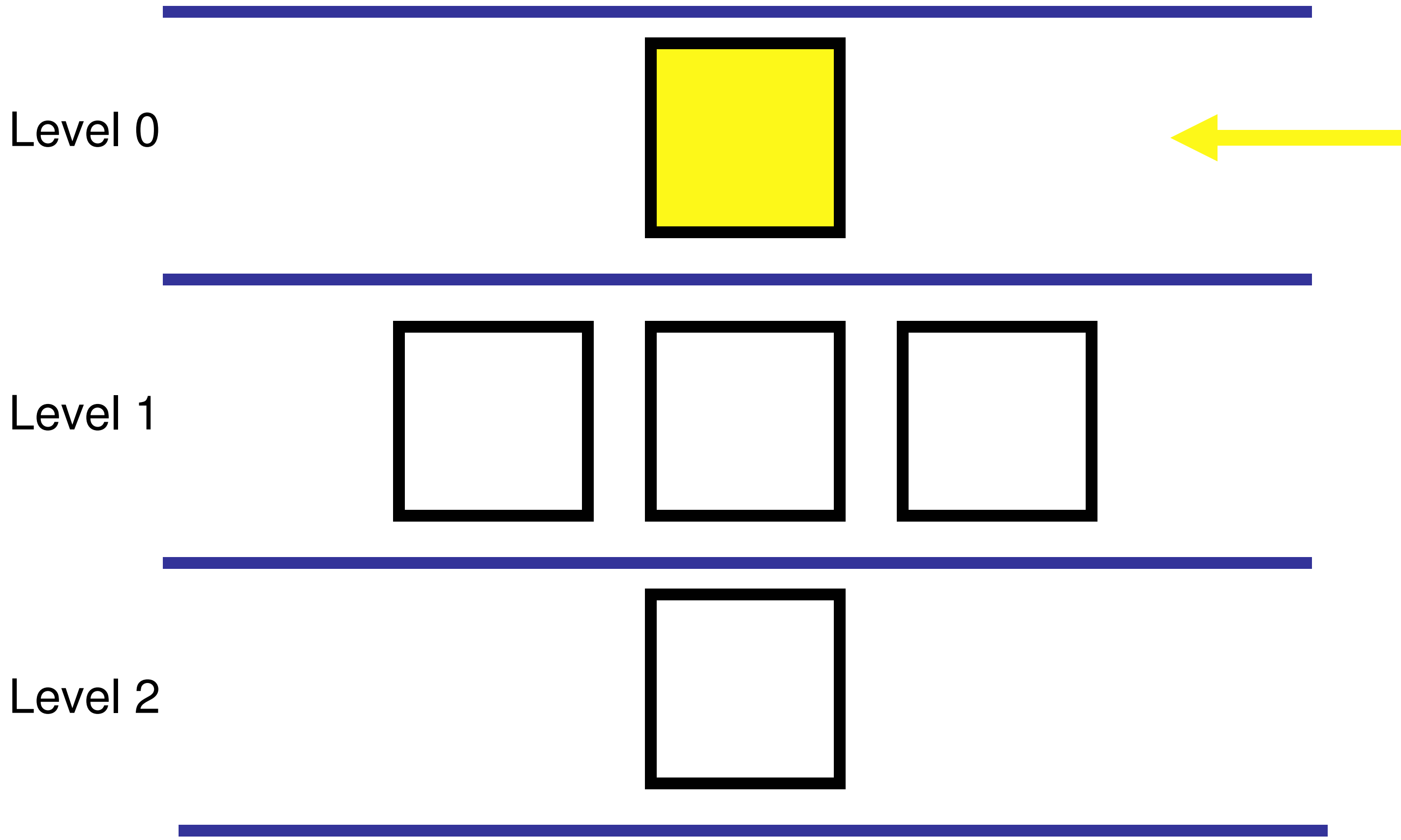


Running A Cycle



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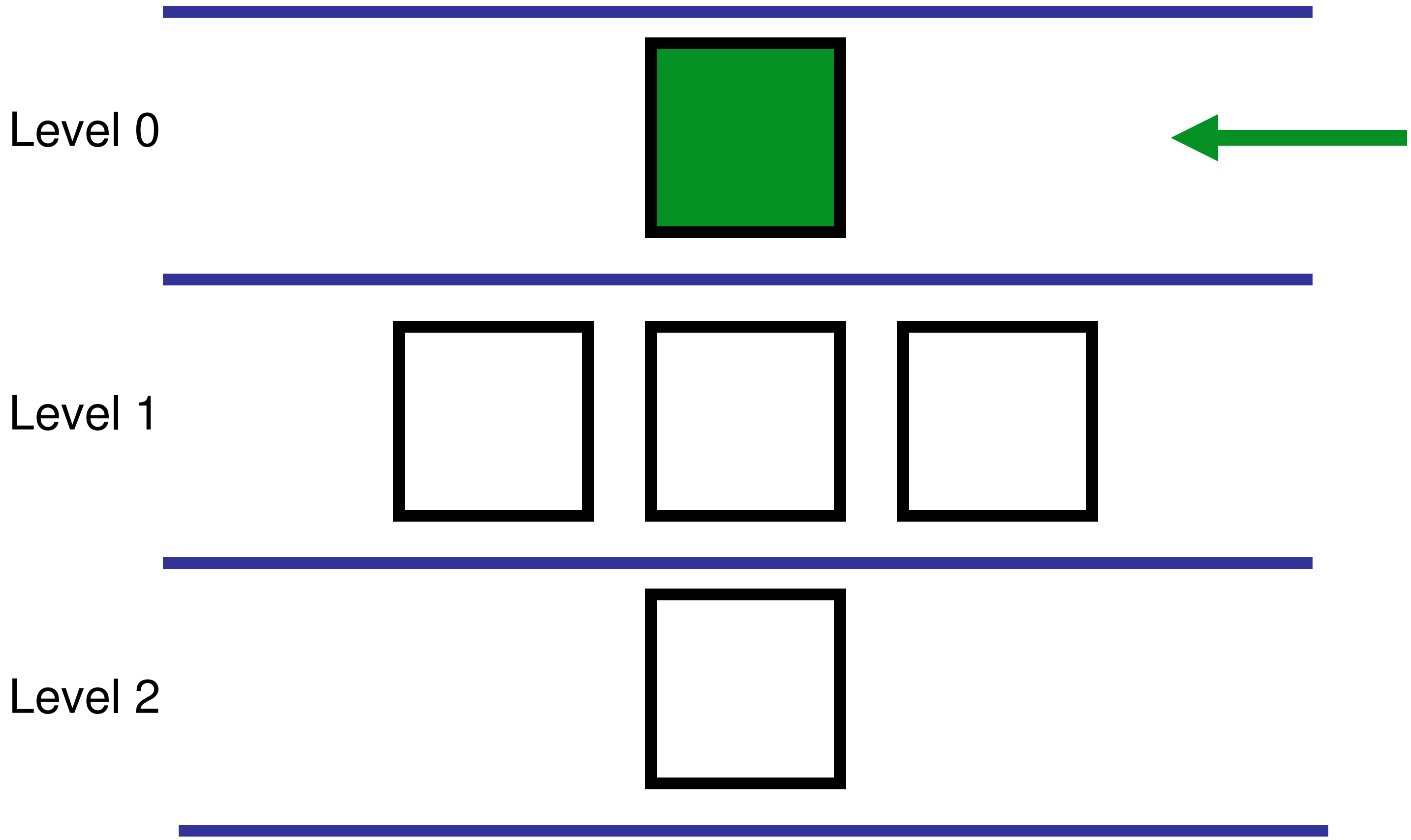

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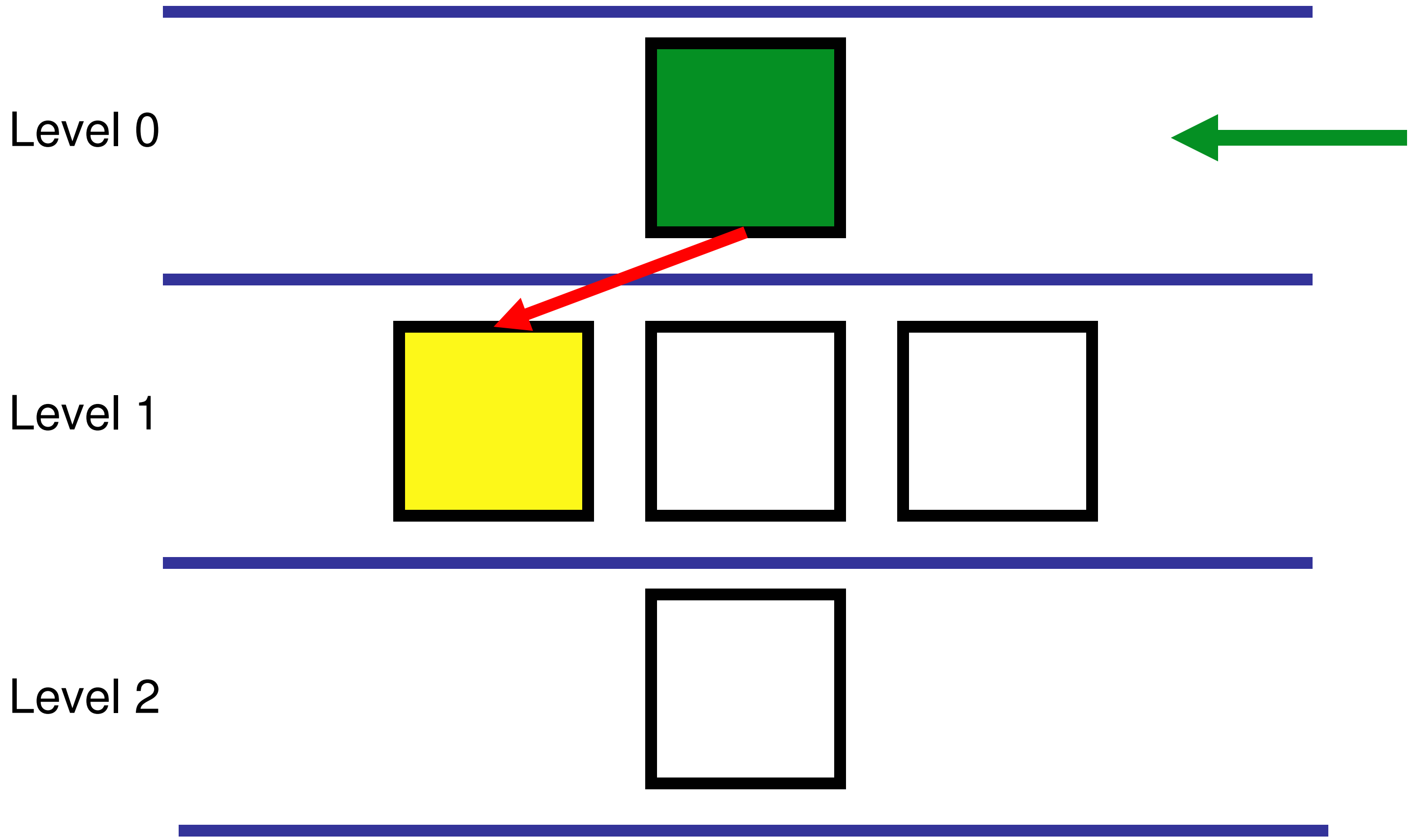

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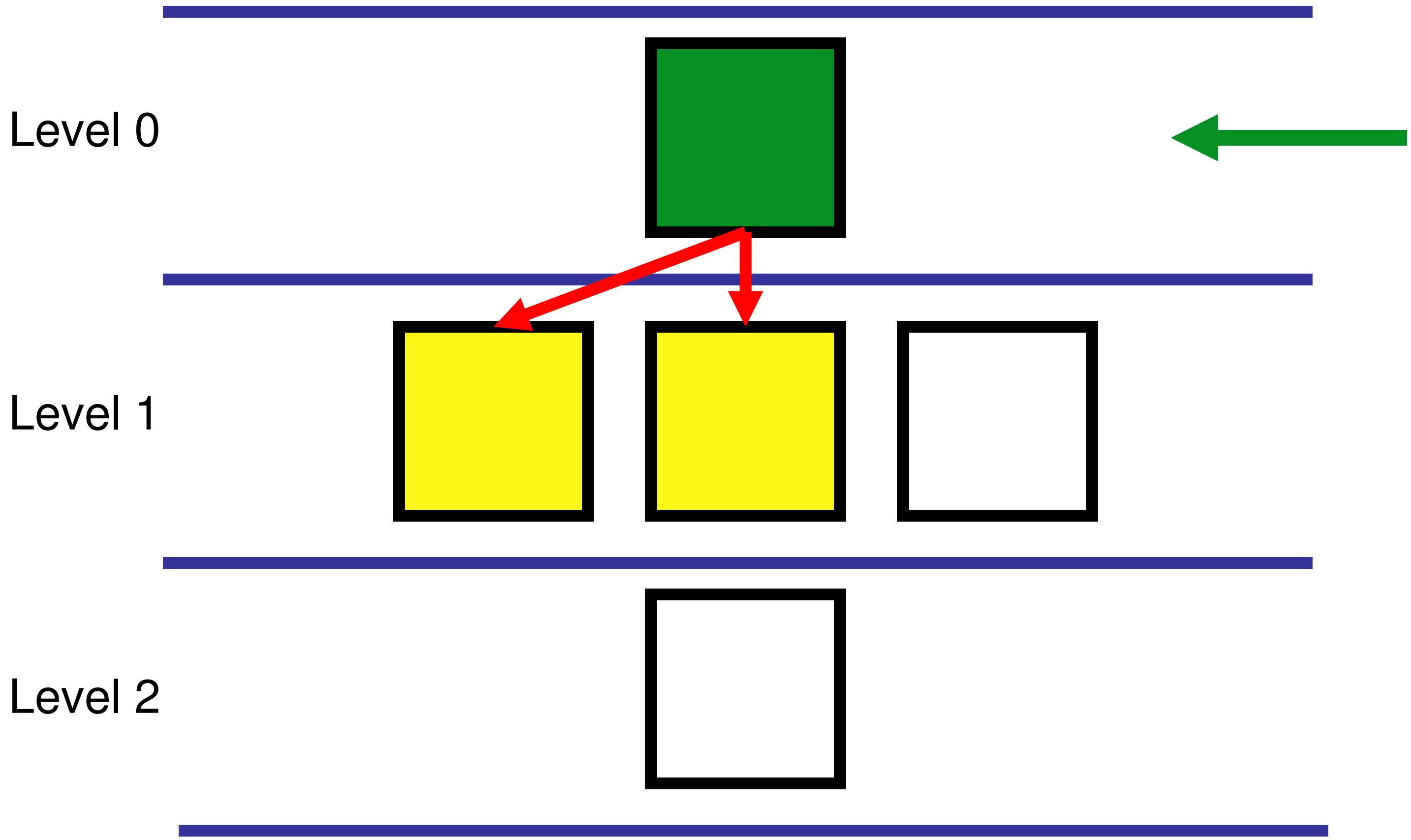

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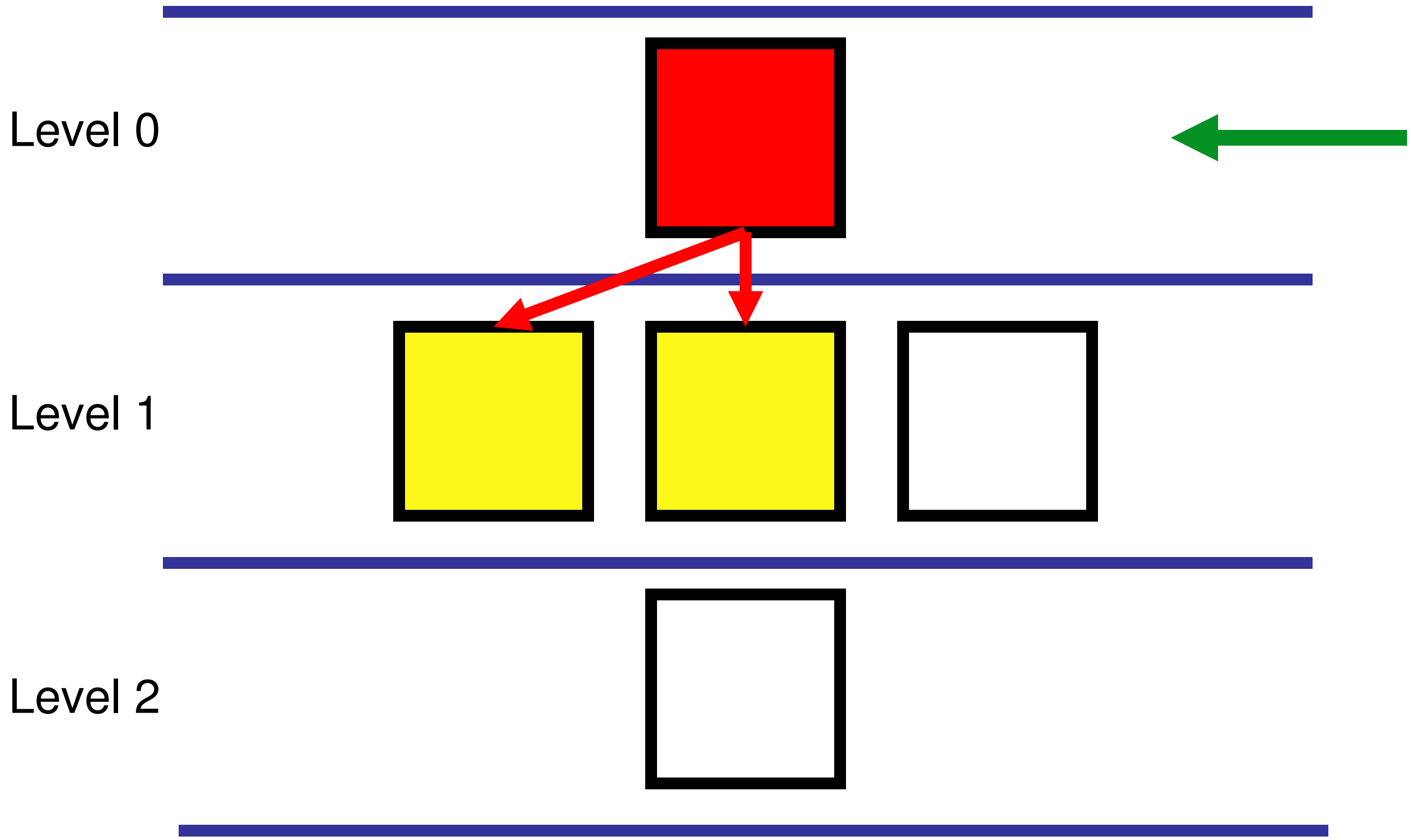

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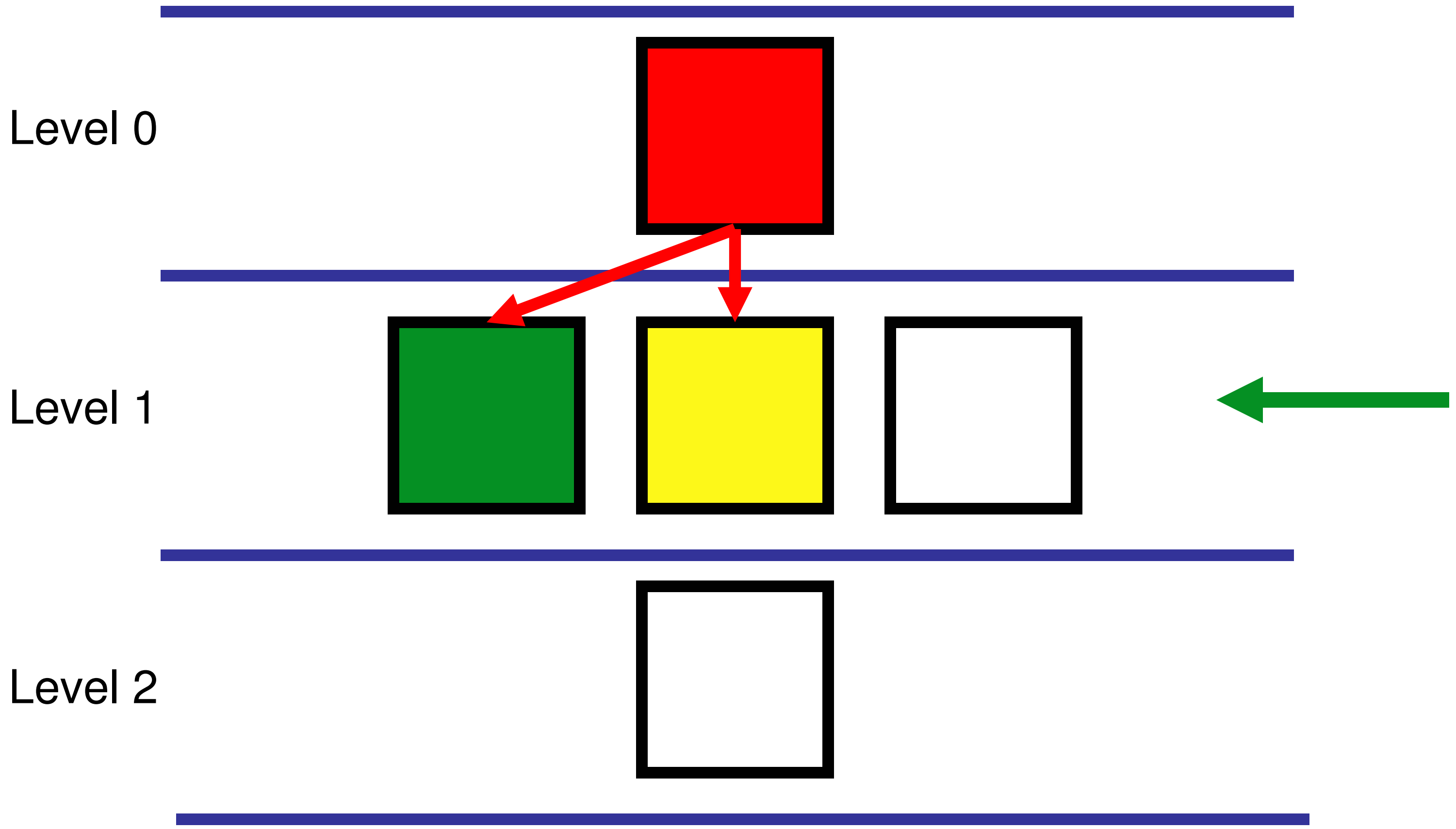

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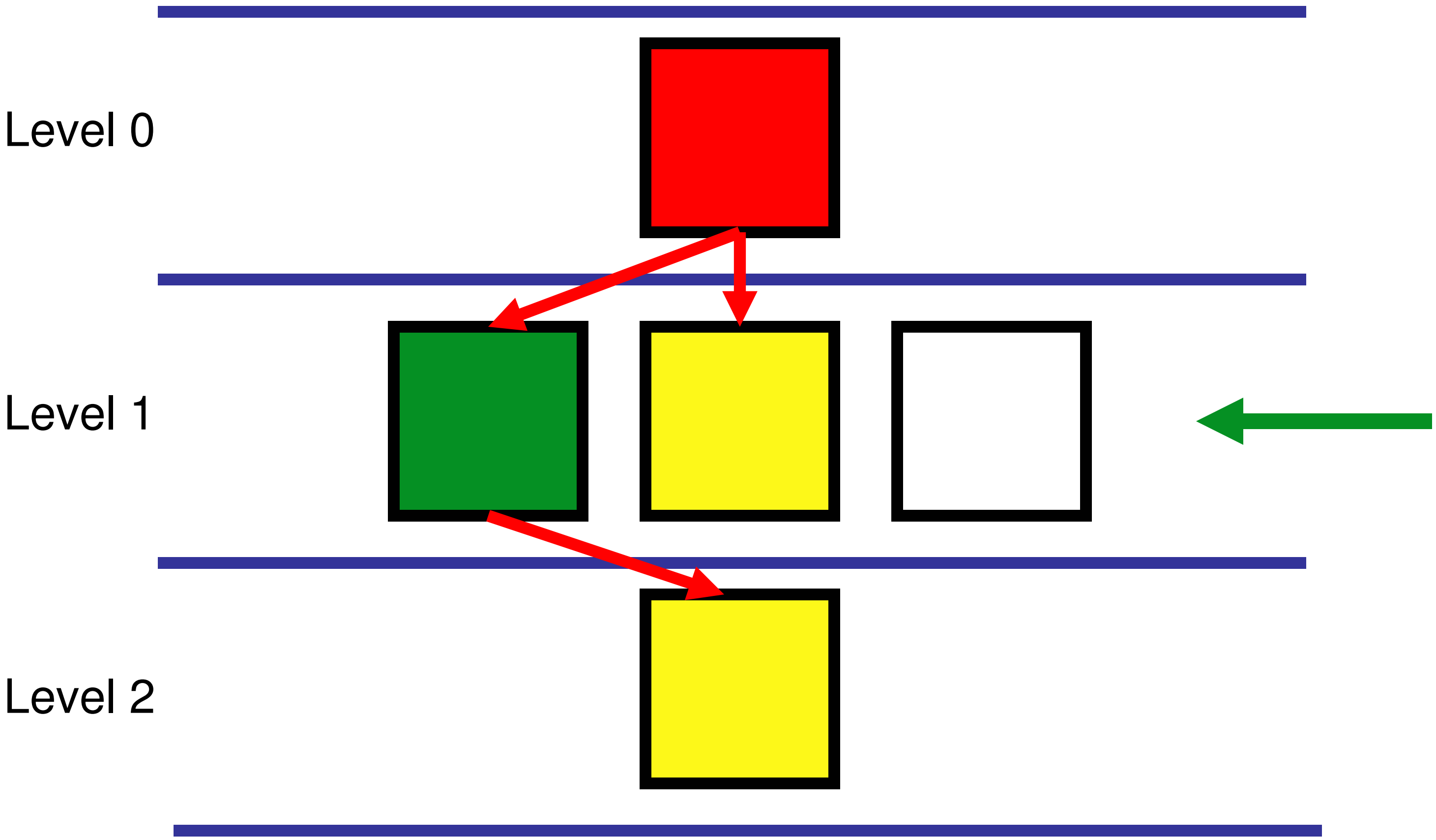

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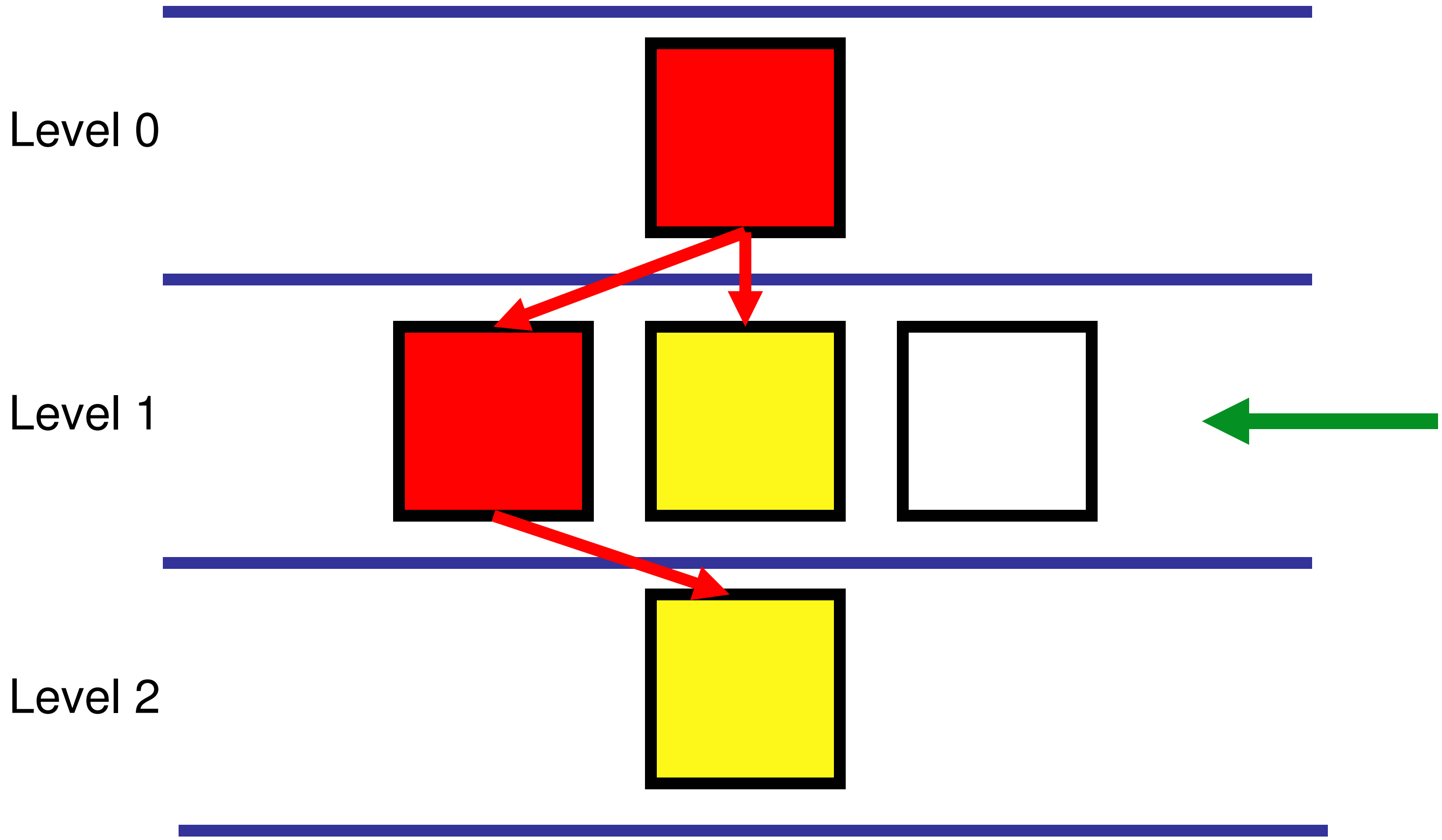

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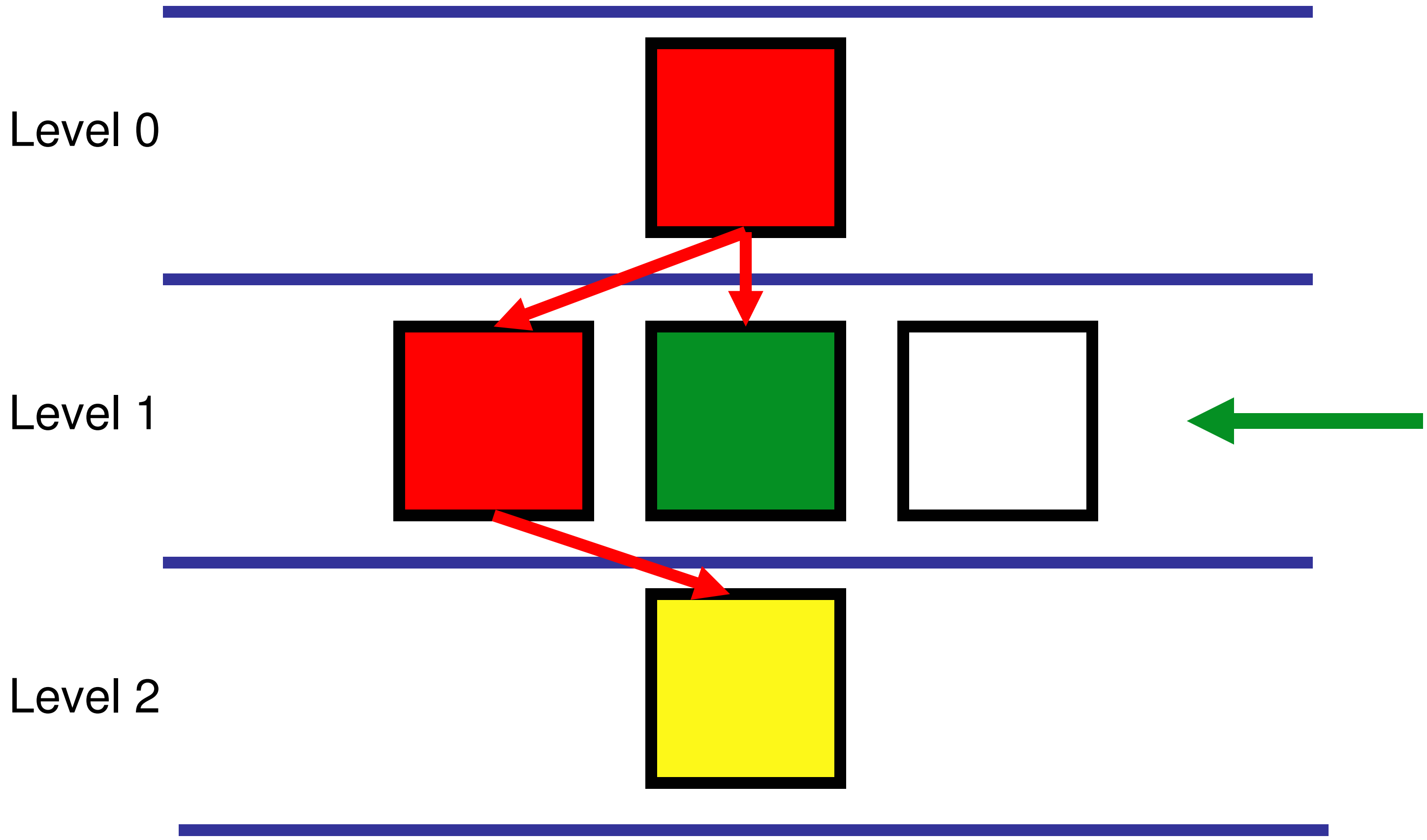

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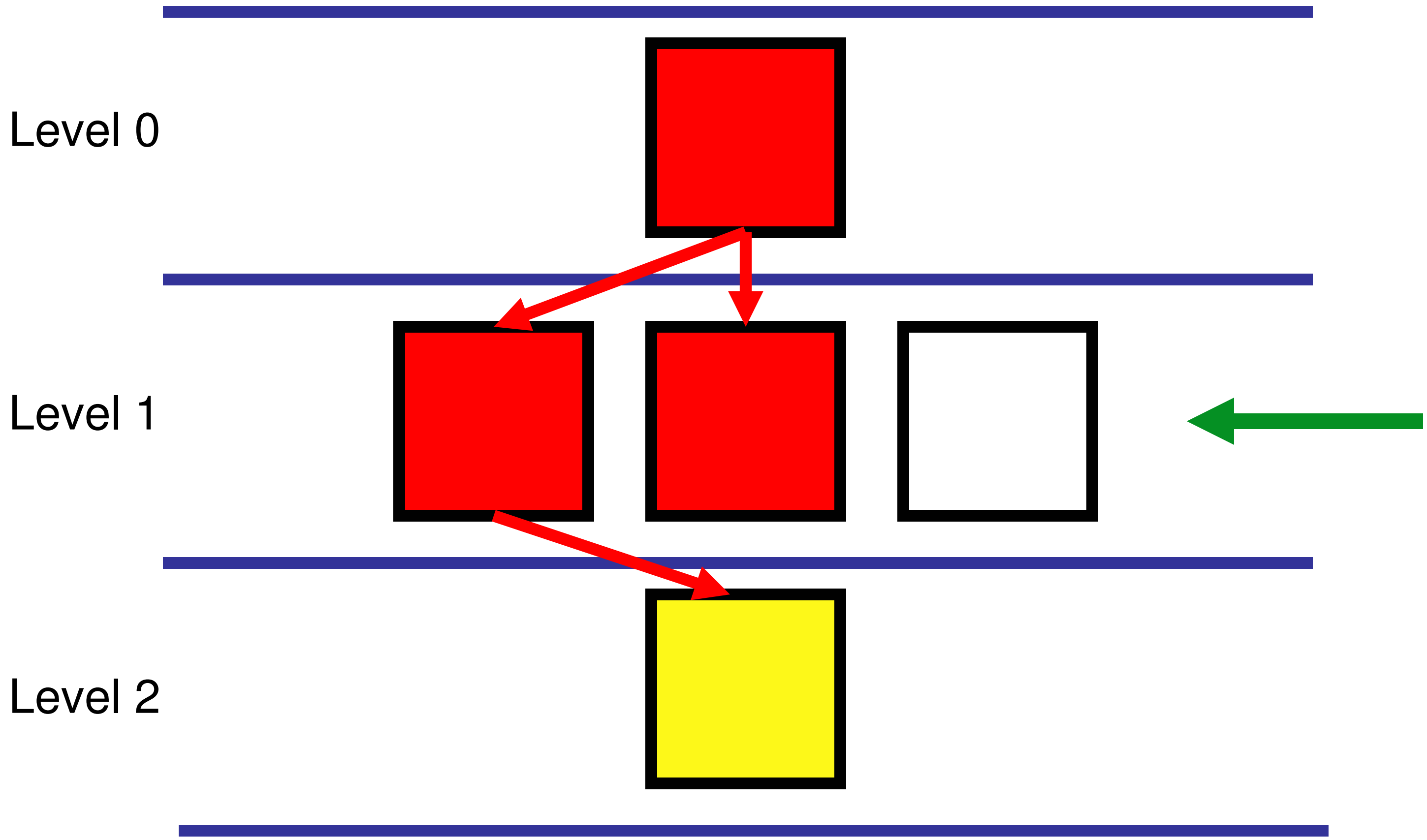

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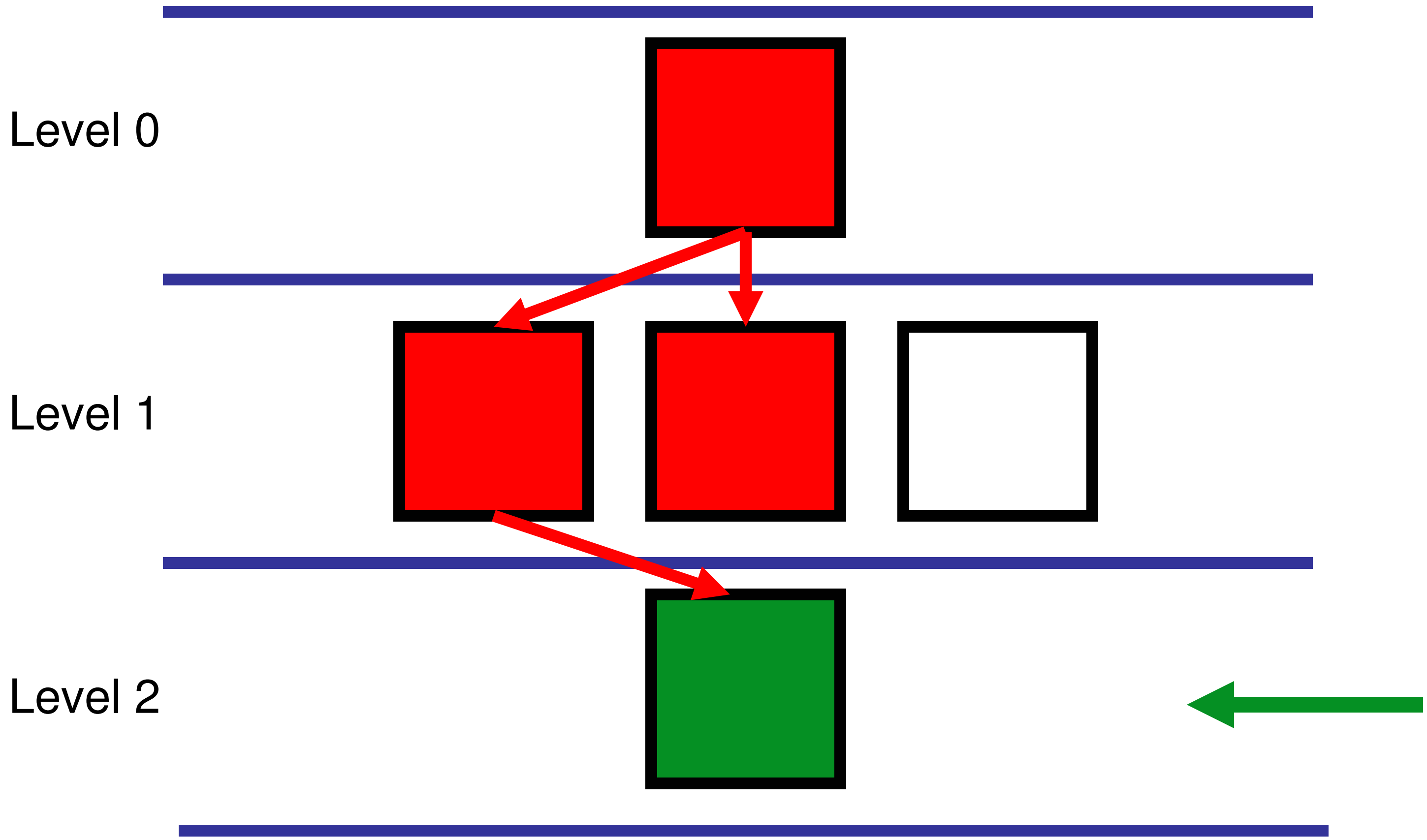

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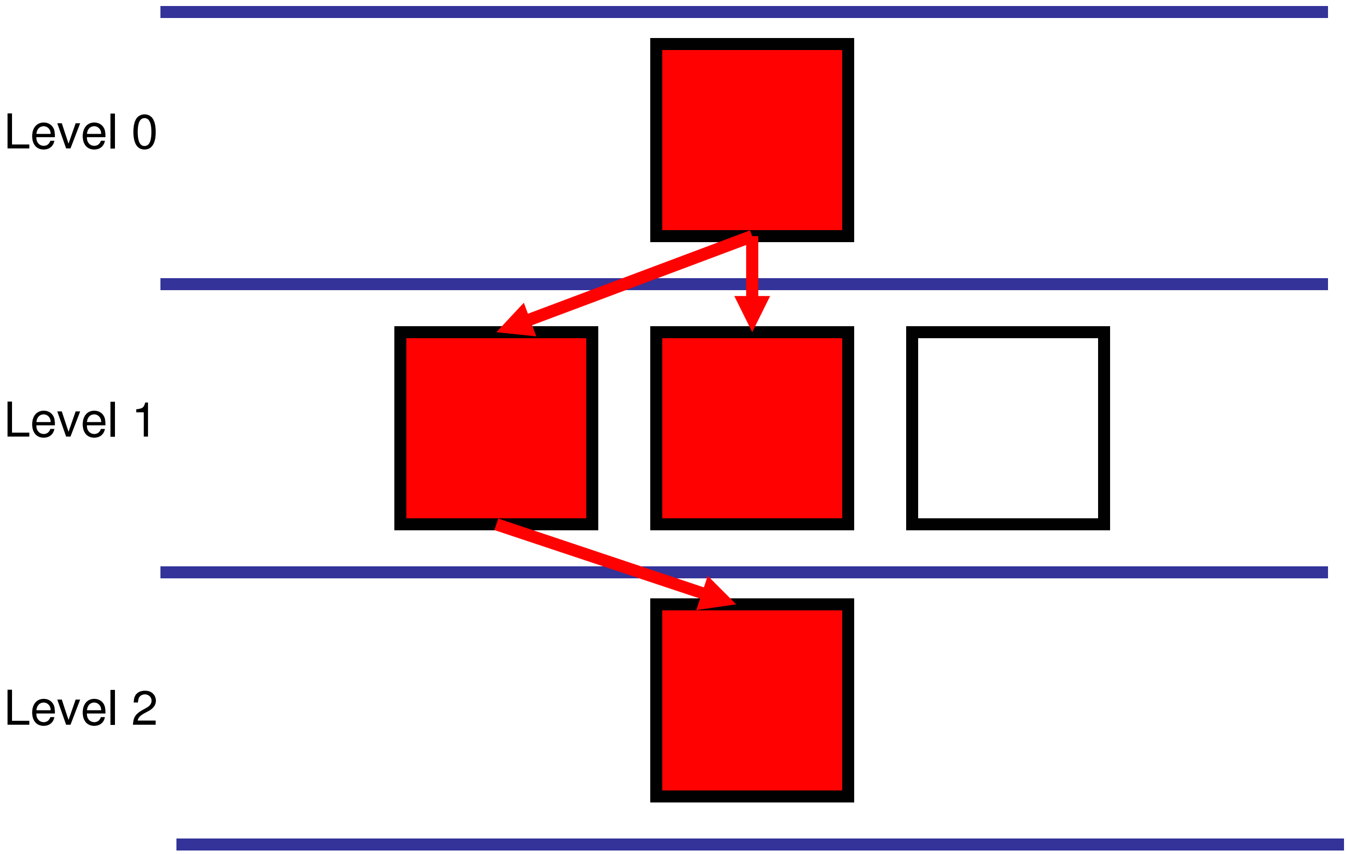
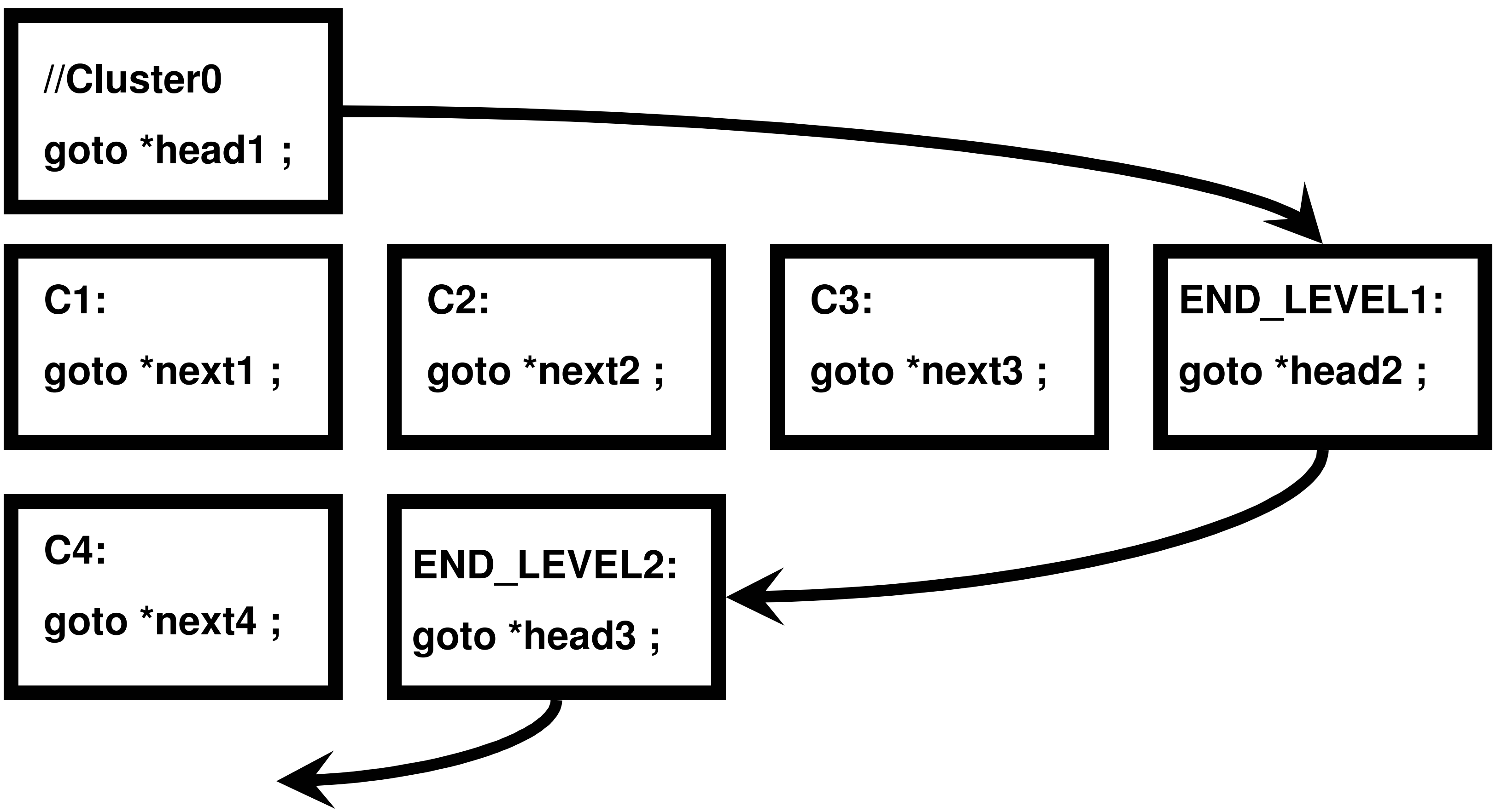


Running A Cycle

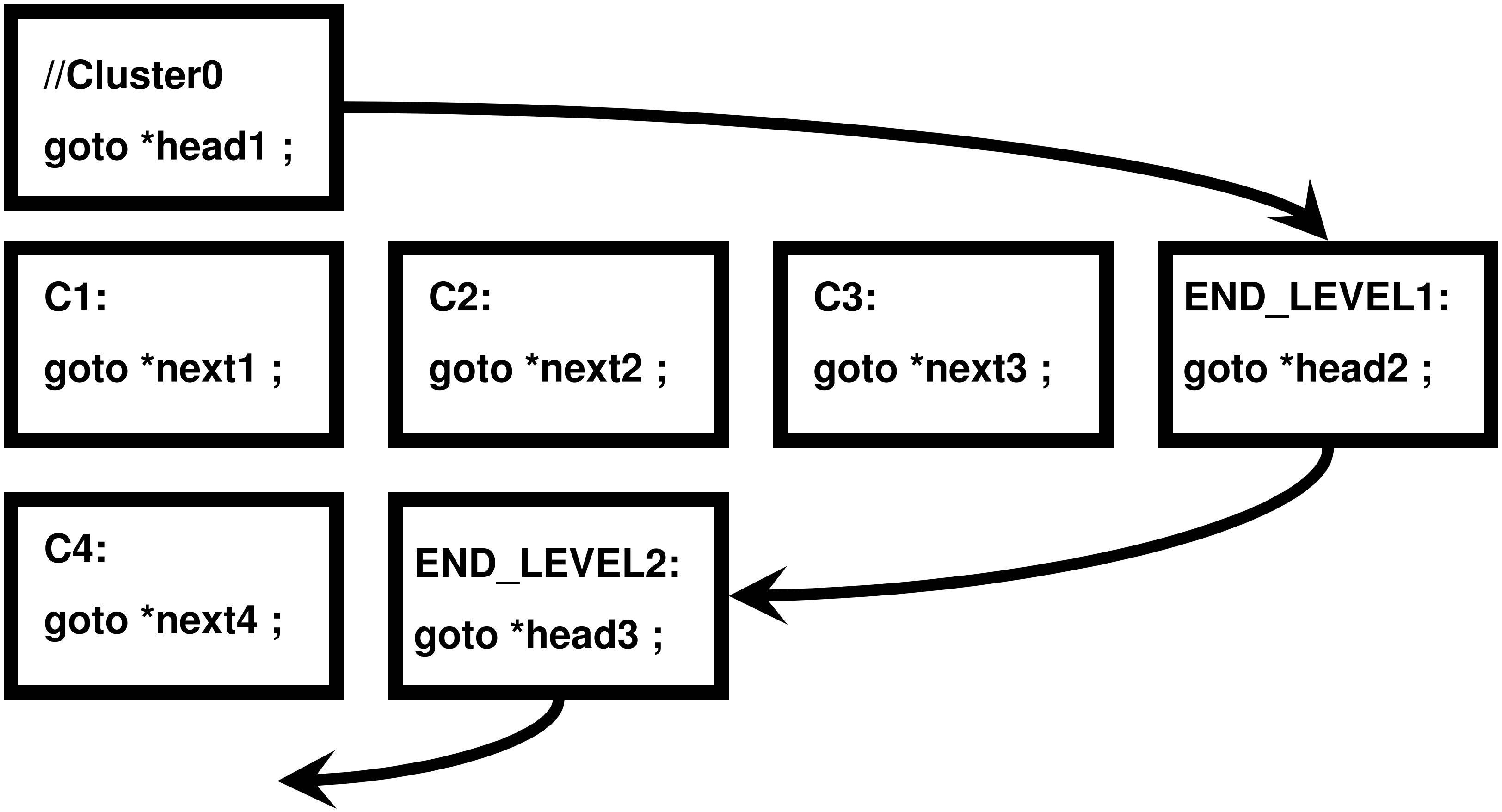
Linked list structure with nothing scheduled



Only have to run cluster 0 and jump to each level

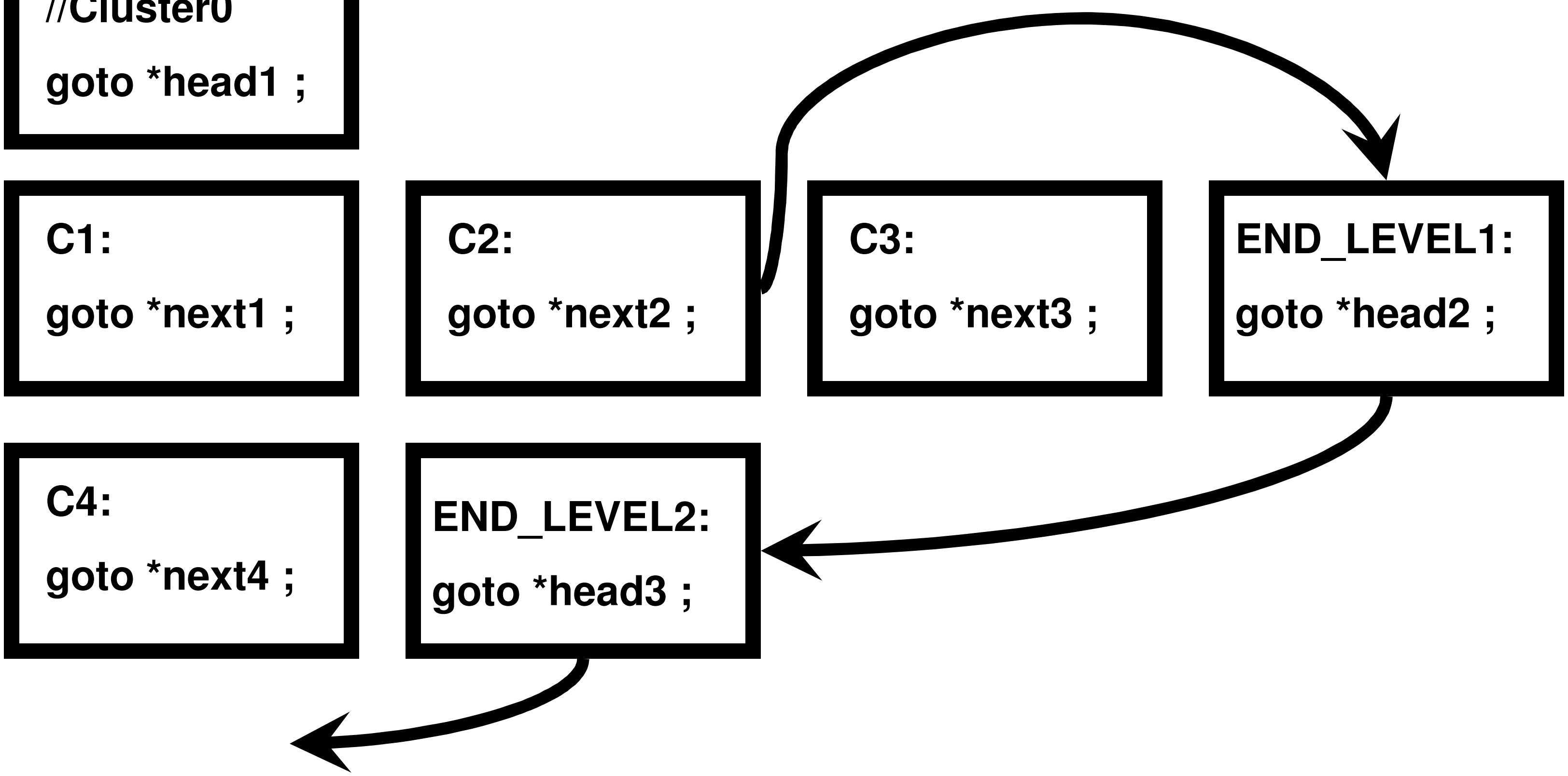
Schedule cluster 2 in the empty structure

next2 = head1, head1 = &&C2



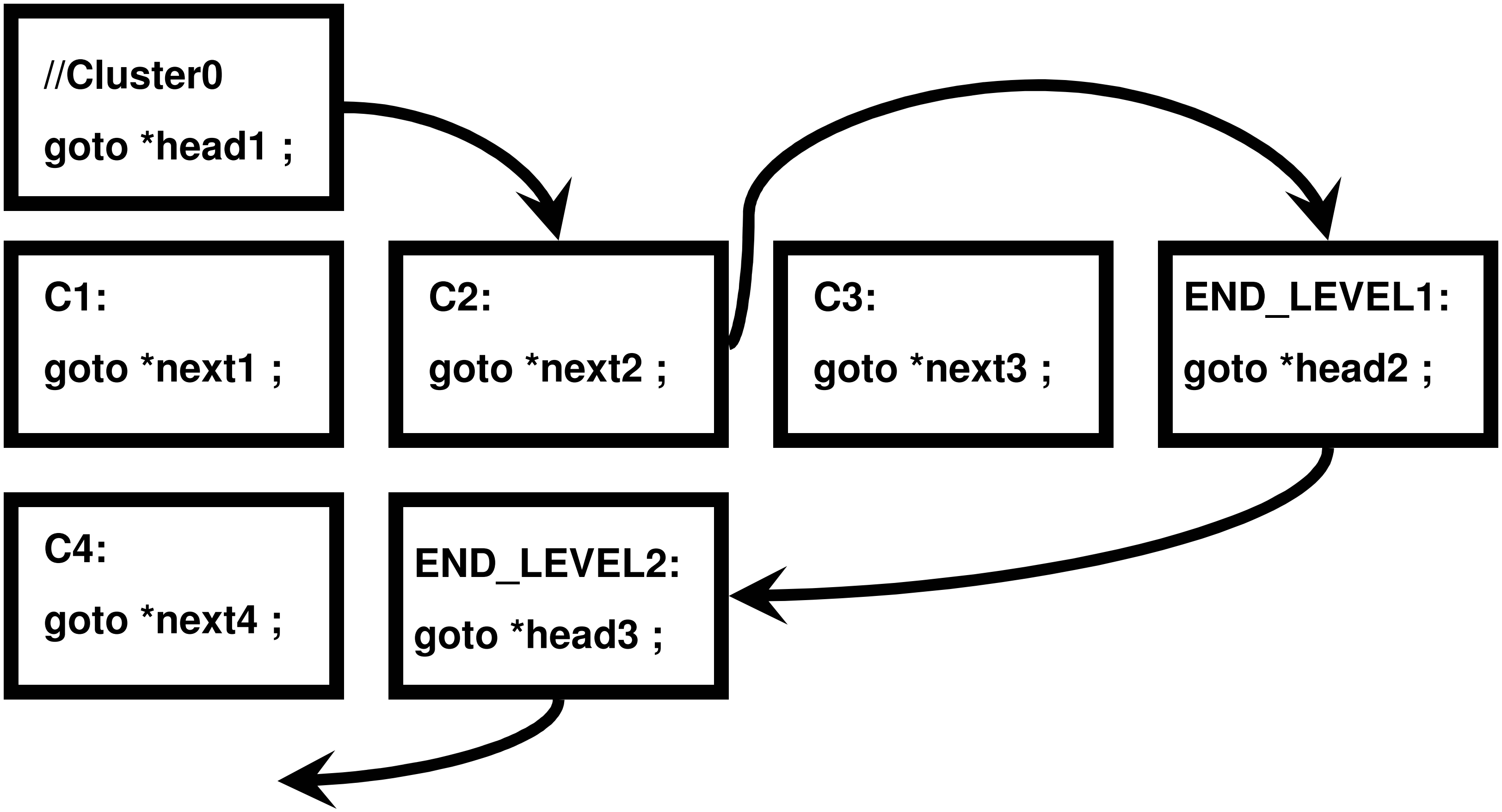
Schedule cluster 2 to the empty structure

next2 = head1, *head1 = &&C2*



Schedule cluster 2 to the empty structure

next2 = head1, ***head1 = &&C2***



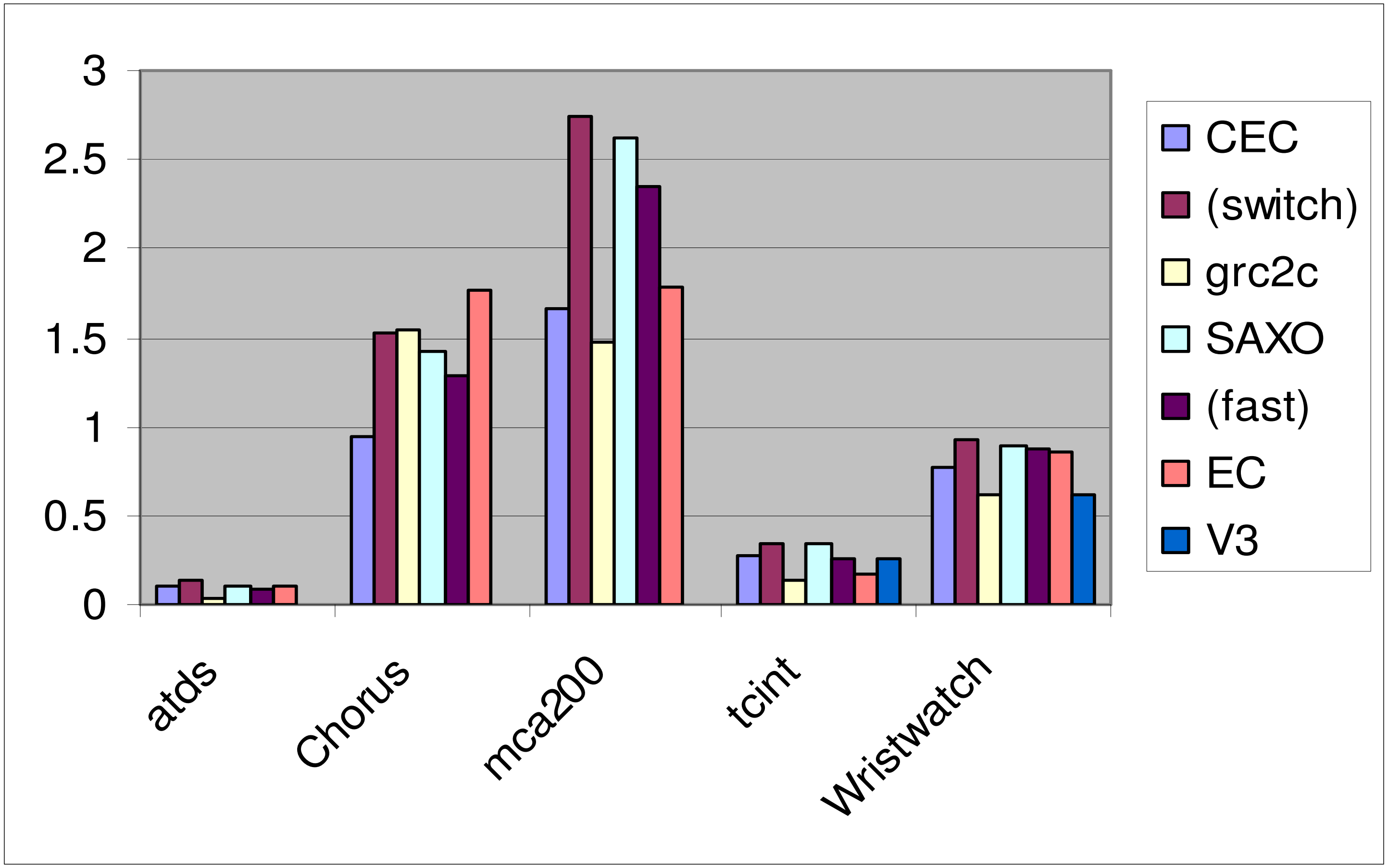
Experimental Results

Five medium sized examples

- Potop-Butucaru's grc2c
  - Beats us on four of the five examples
  - We are substantially faster on the largest example
- SAXO-RT compiler
  - We are faster on the three largest examples

- Most closely resembles SAXO-RT
  - Basic blocks
    - Sorted topologically
    - Executed based on run-time scheduling decisions
  - Two main differences:
    - Only schedule blocks within the current cycle
    - Linked list that eliminates conditional test instead of a scoreboard

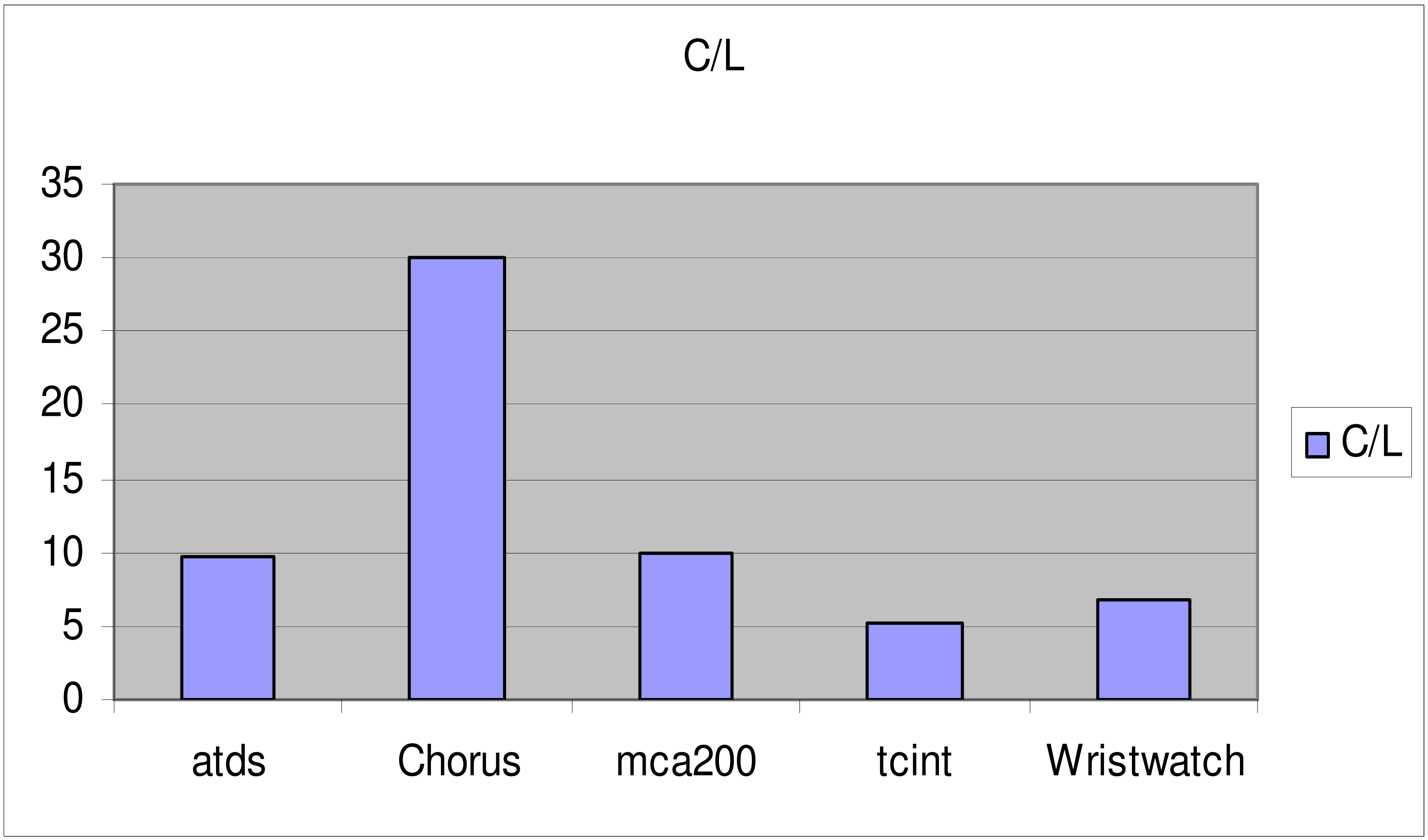
Time in seconds to execute 1 000 000 iterations of the generated code on a 1.7 GHz Pentium 4.



The height of the bars indicates the time in seconds. (Shorter is better)

C/L: Clusters Per Level

The higher C/L the better



Conclusion

- Results in improved running times over an existing compiler that uses a similar technique (SAXO-RT)
- Faster than the fastest-known compiler in the largest example (Potop-Butucaru's)

Source and object code for the compiler described in this presentation is freely available as part of the Columbia Esterel Compiler distribution available from:

http://www.cs.columbia.edu/~sedwards/cec/