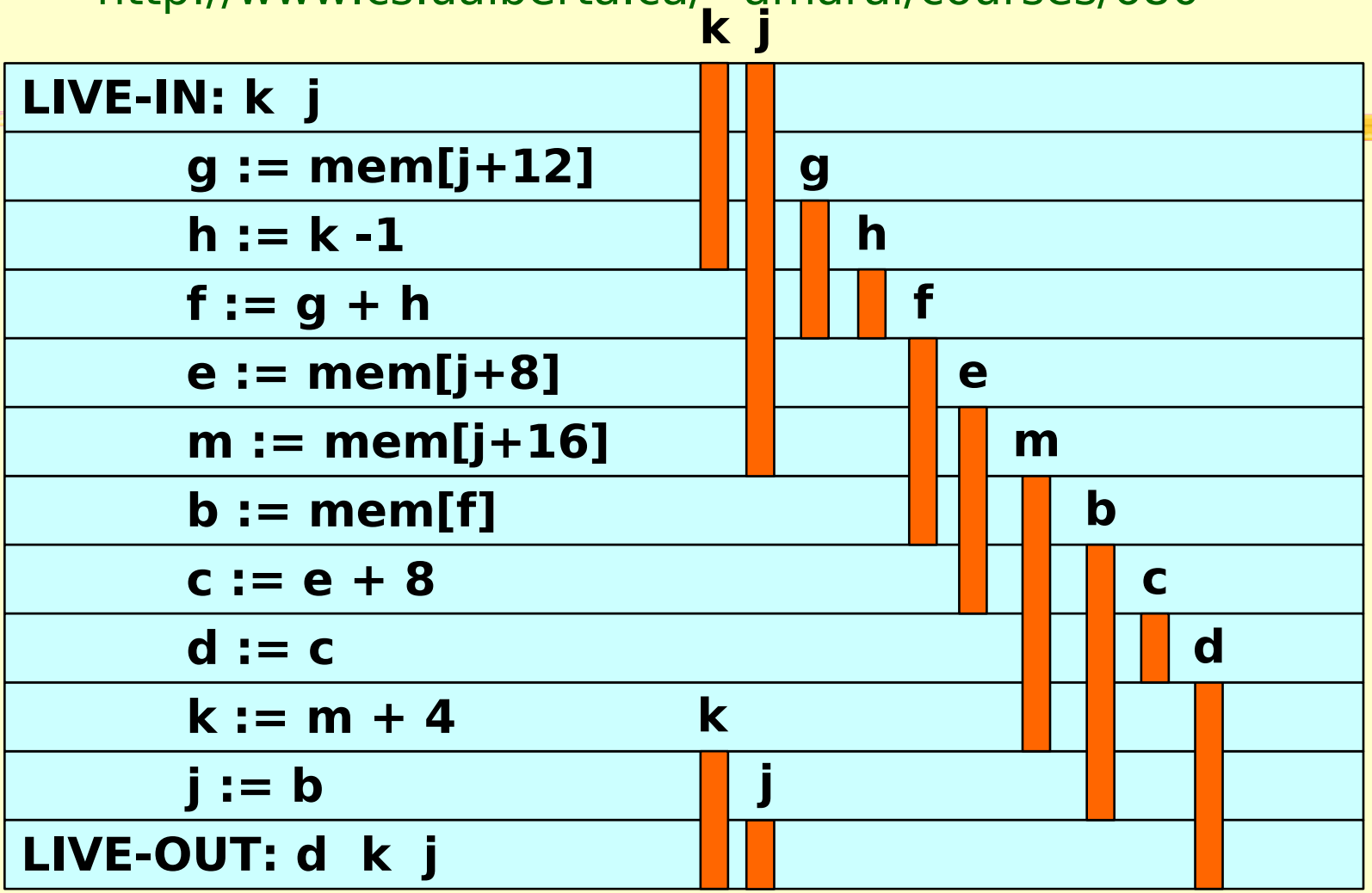
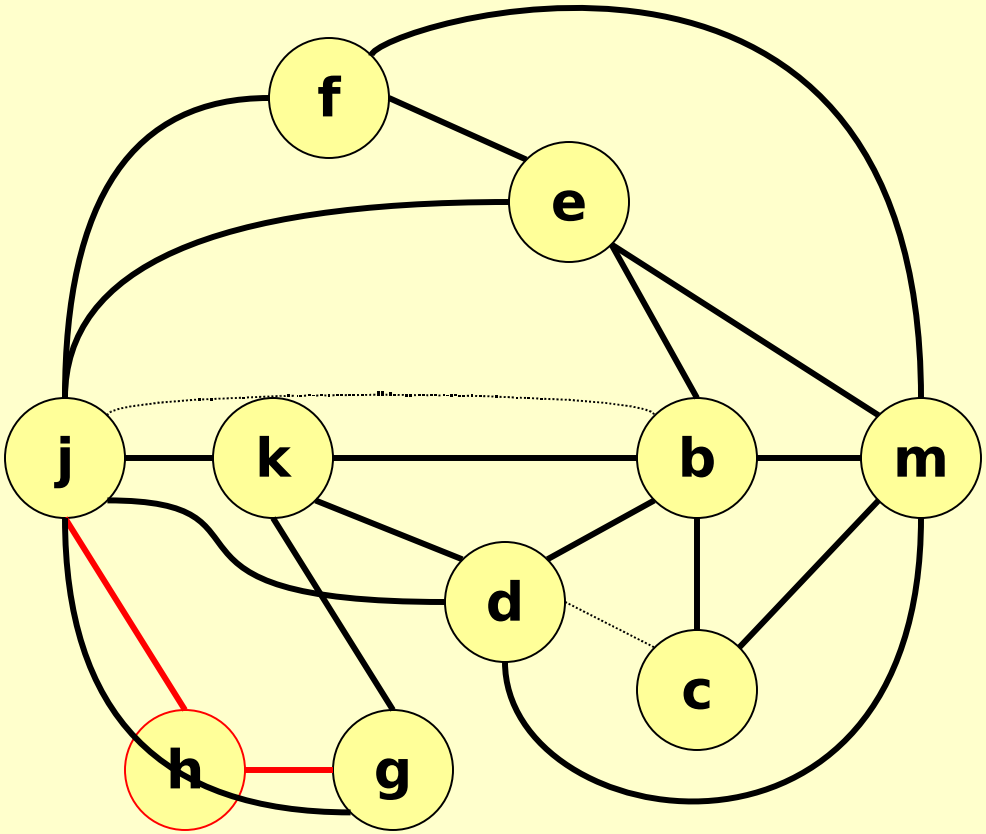
Borrowed from J. N. Amaral, slightly modified

http://www.cs.ualberta.ca/~amaral/courses/680



Example: Simplify (K=4)

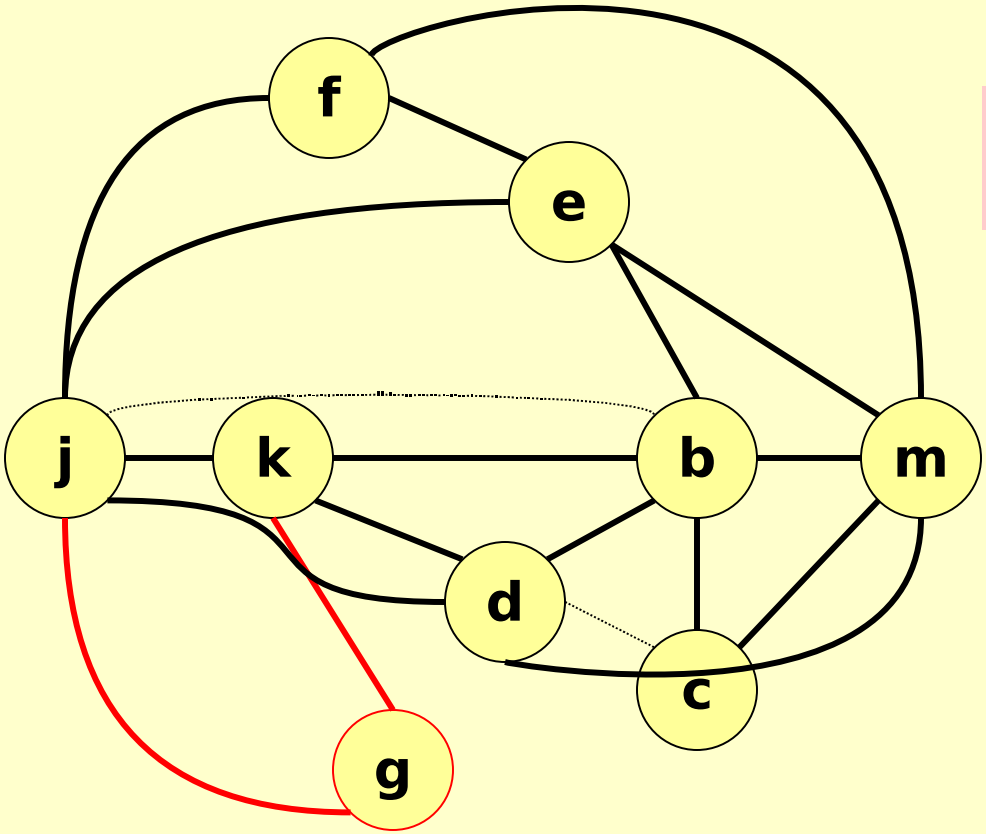


stack

(h,no-spill)

(Appel, pp. 237)

Example: Simplify (K=4)

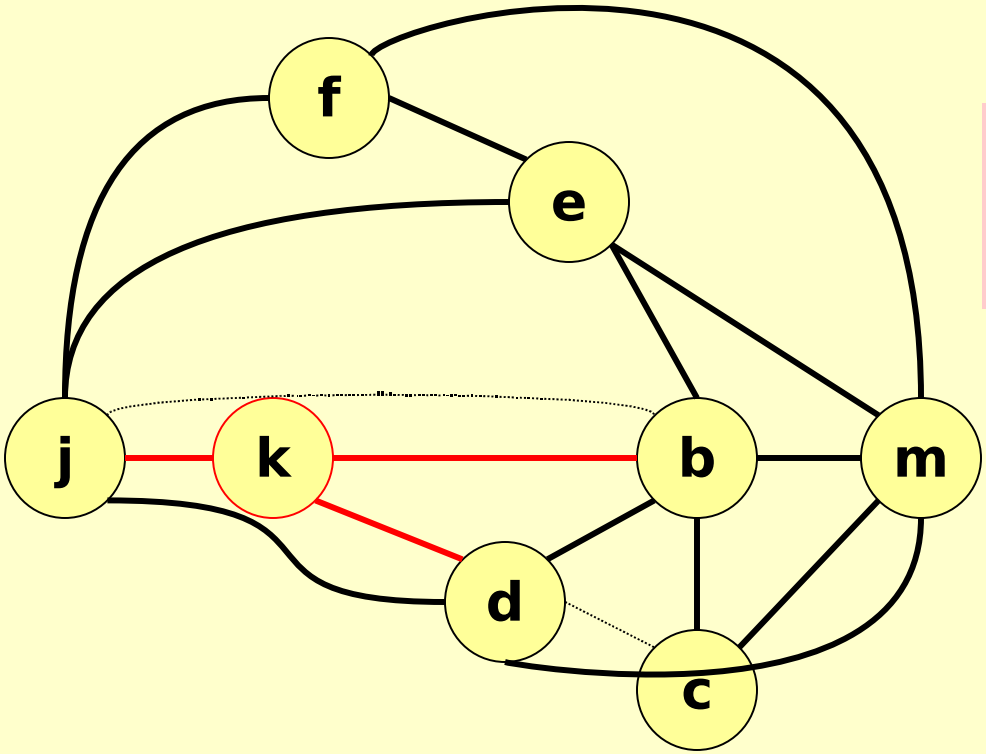


stack

(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=4)

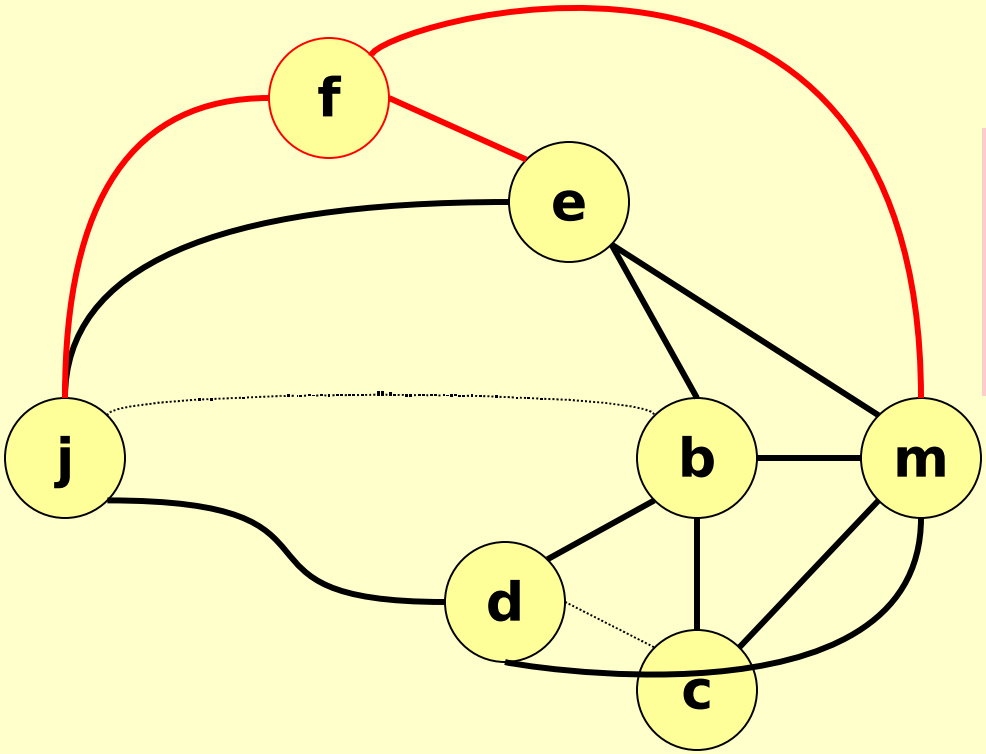


stack

(k, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=4)

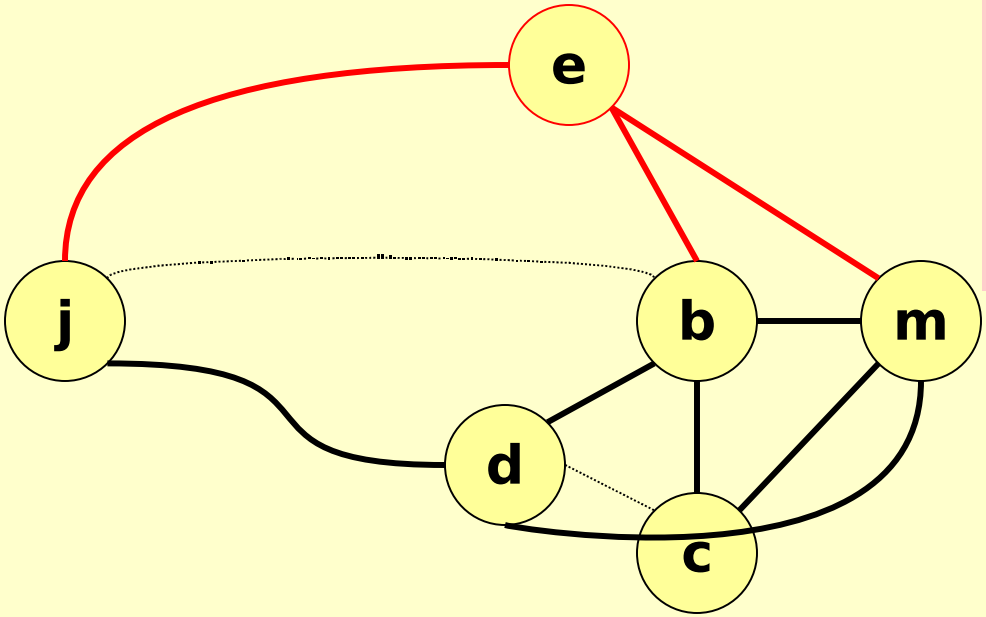


stack

(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=4)



stack

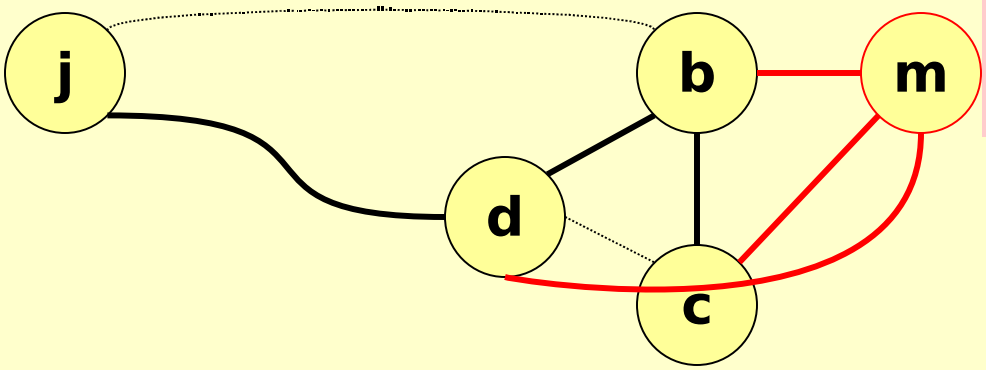
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=4)

stack

(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

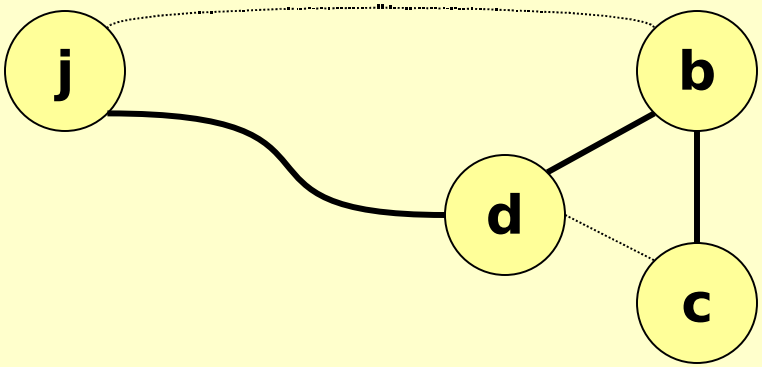


(Appel, pp. 237)

Example: Coalesce (K=4)

stack

(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)



Why can't we simplify?

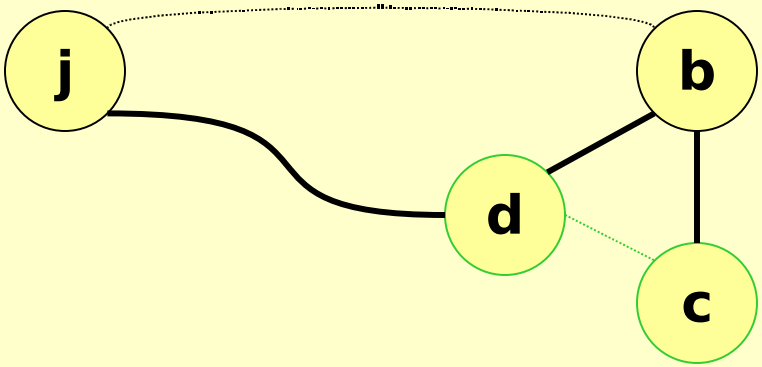
Cannot simplify move-related nodes.

(Appel, pp. 237)

Example: Coalesce (K=4)

stack

(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

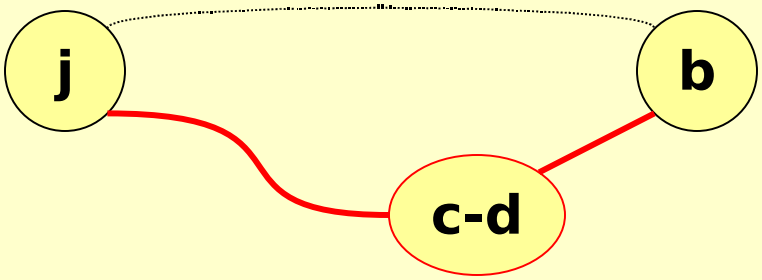


(Appel, pp. 237)

Example: Simplify (K=4)

stack

(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)



(Appel, pp. 237)

Example: Coalesce (K=4)

stack

(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=4) greedy-4-colorable

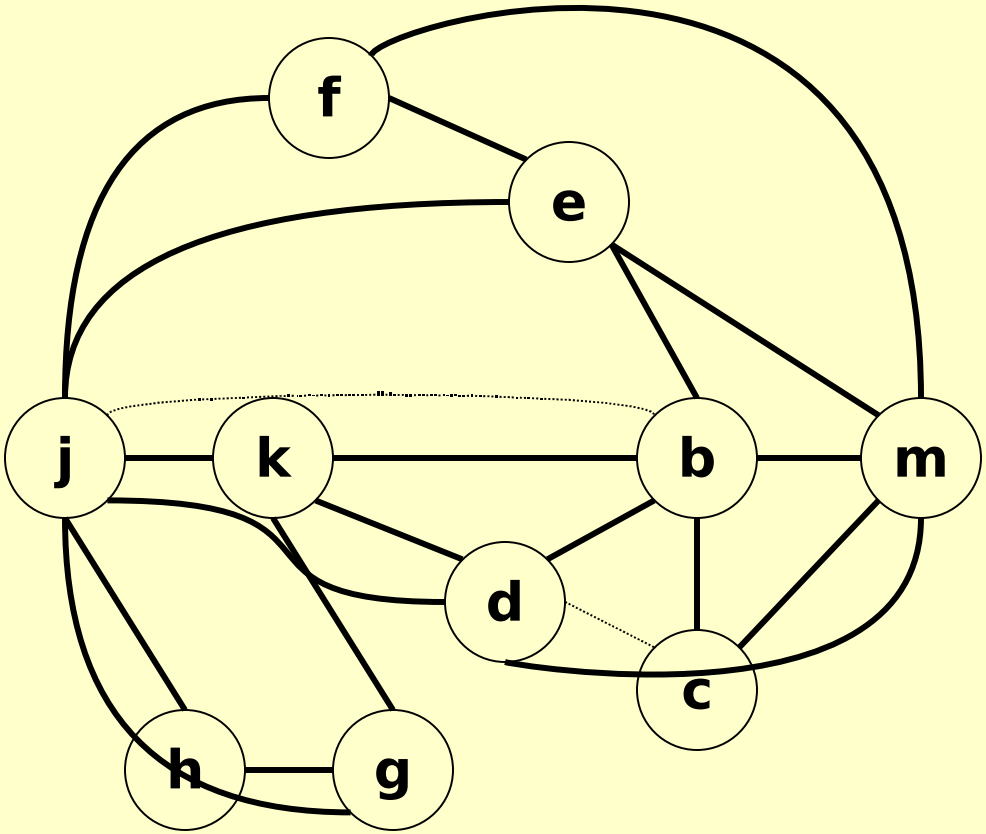
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

b-j

(Appel, pp. 237)

Example: Select (K=4)



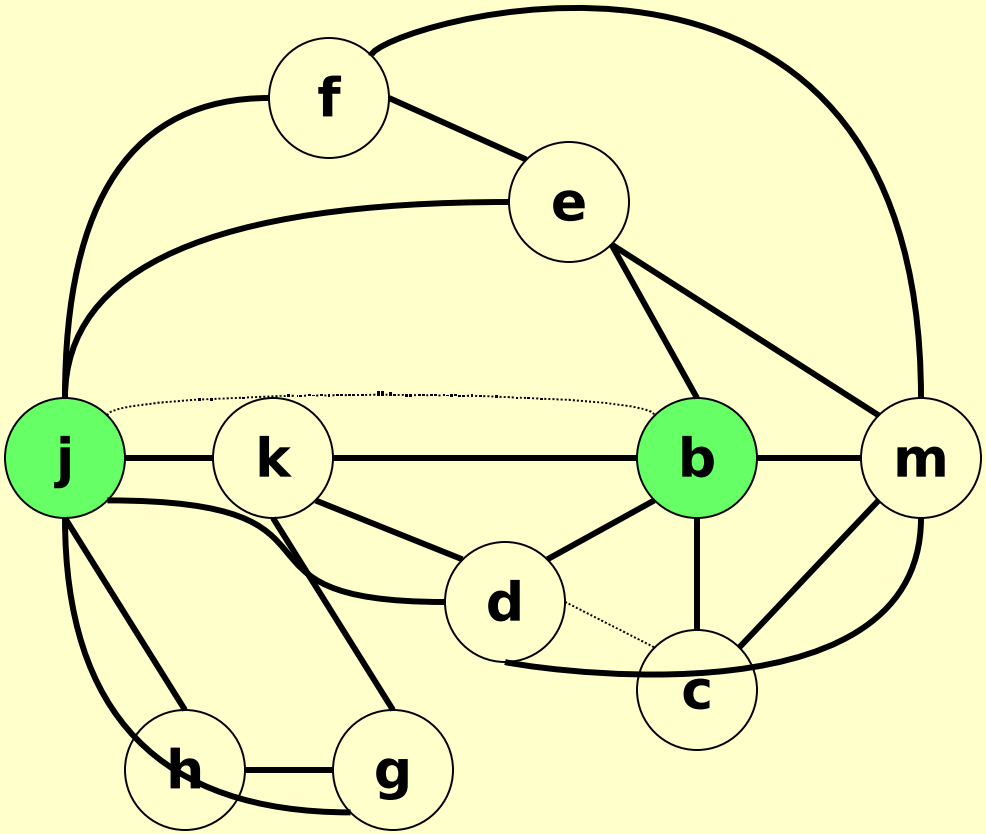
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



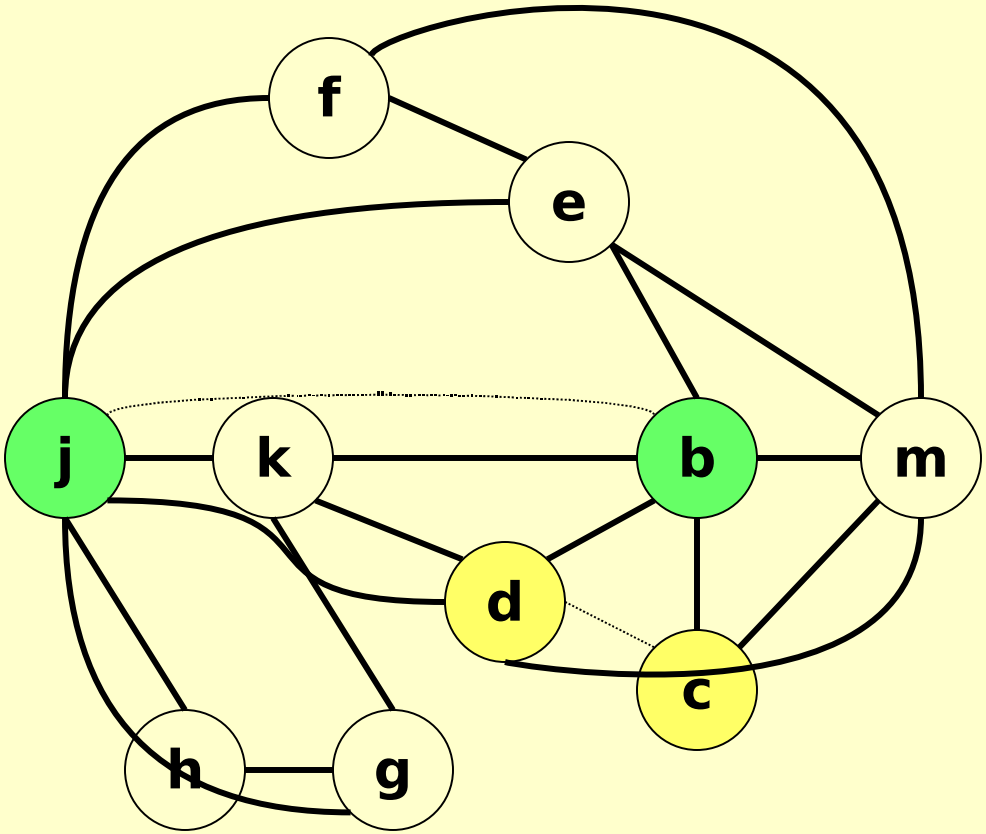
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



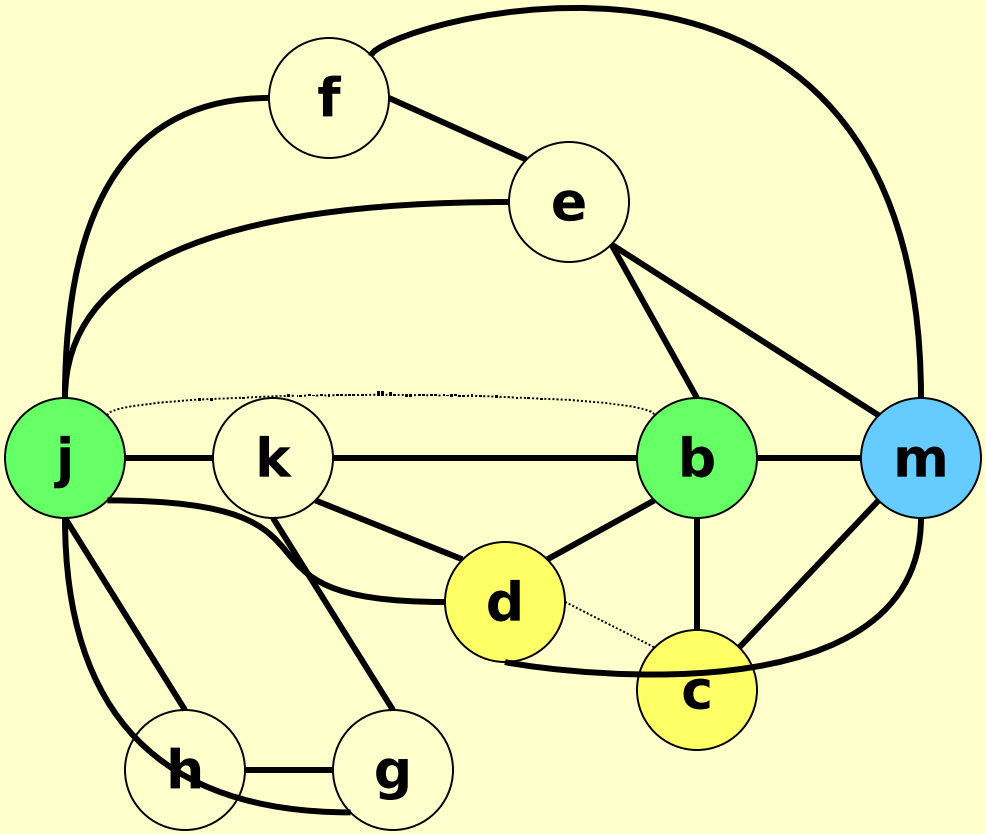
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



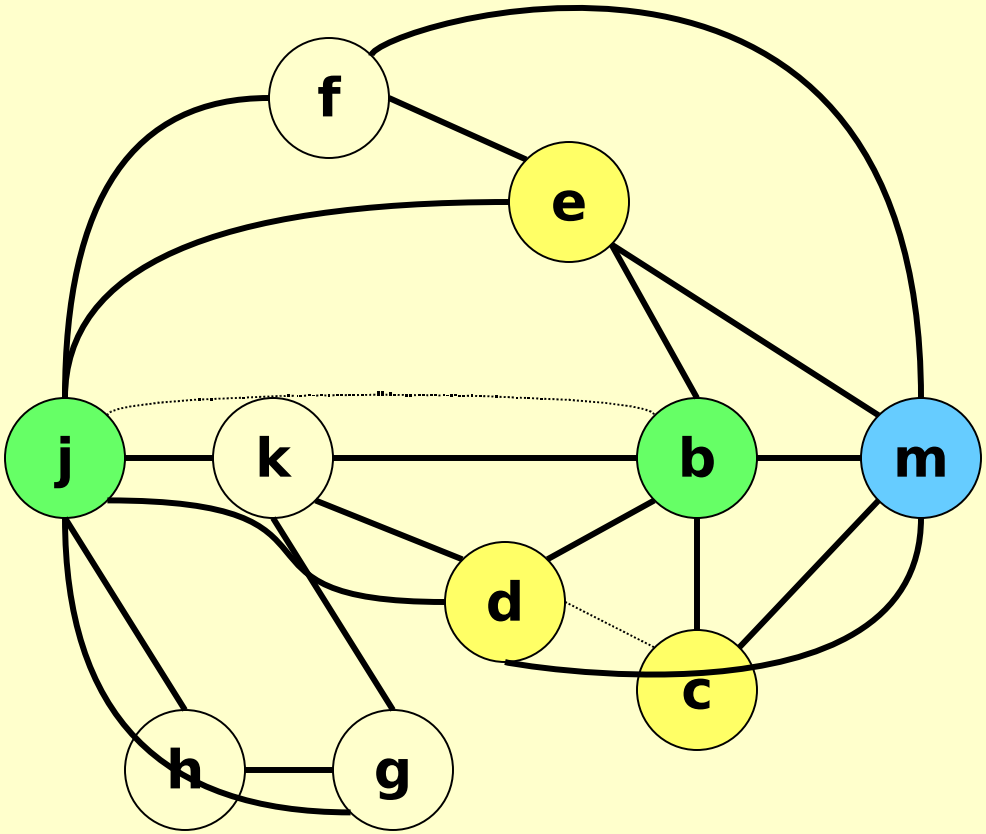
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



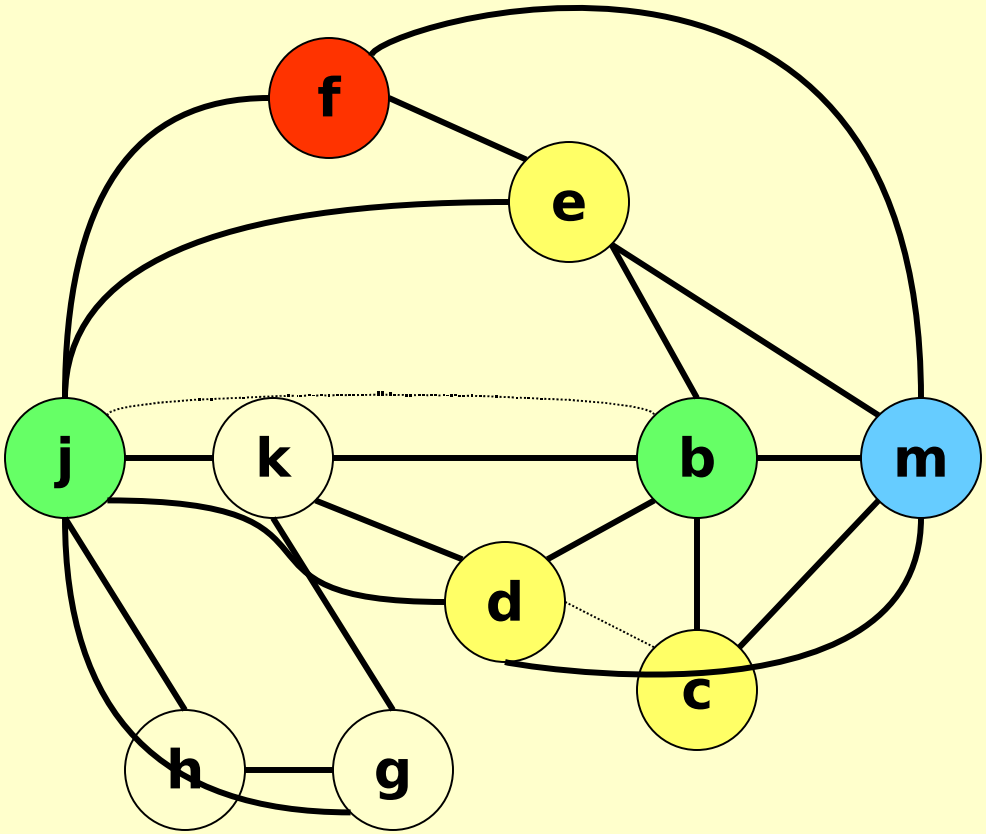
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



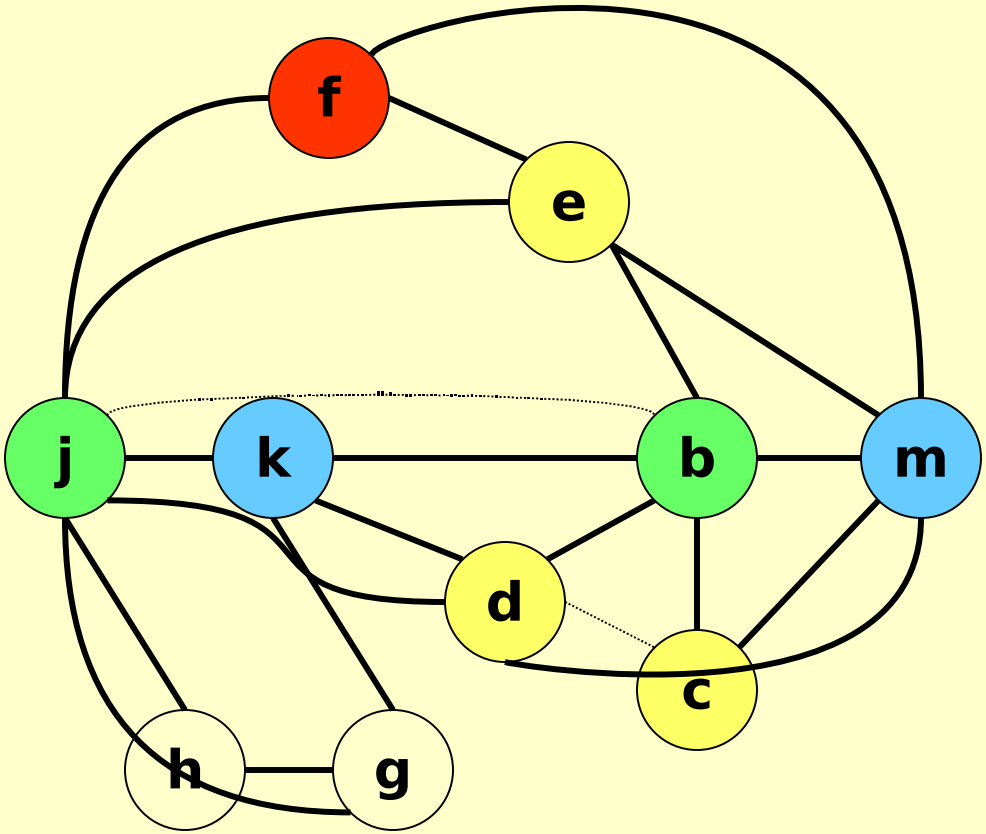
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



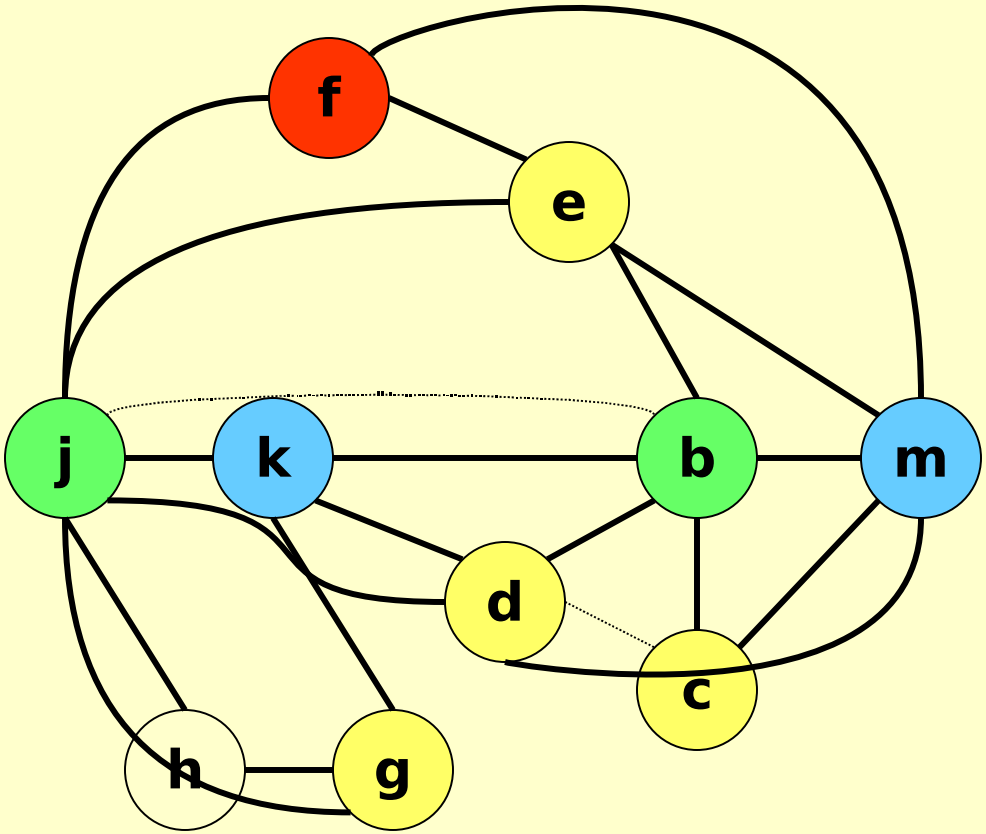
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



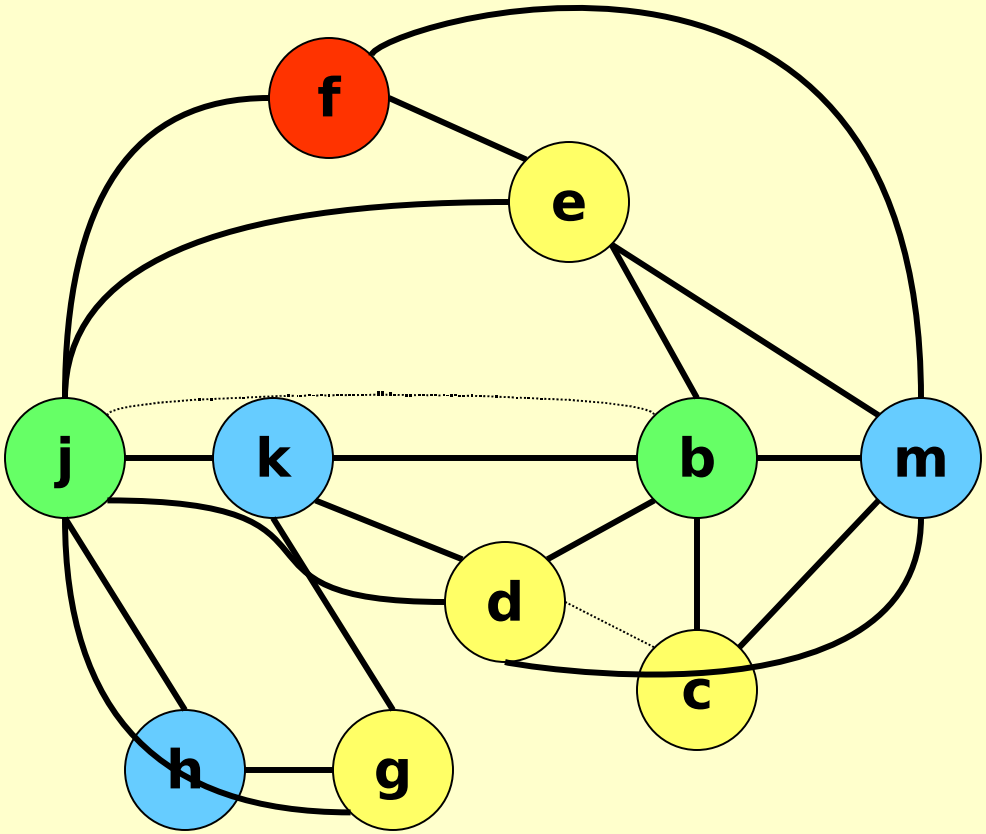
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

R1
R2
R3
R4

(Appel, pp. 237)

Example: Select (K=4)



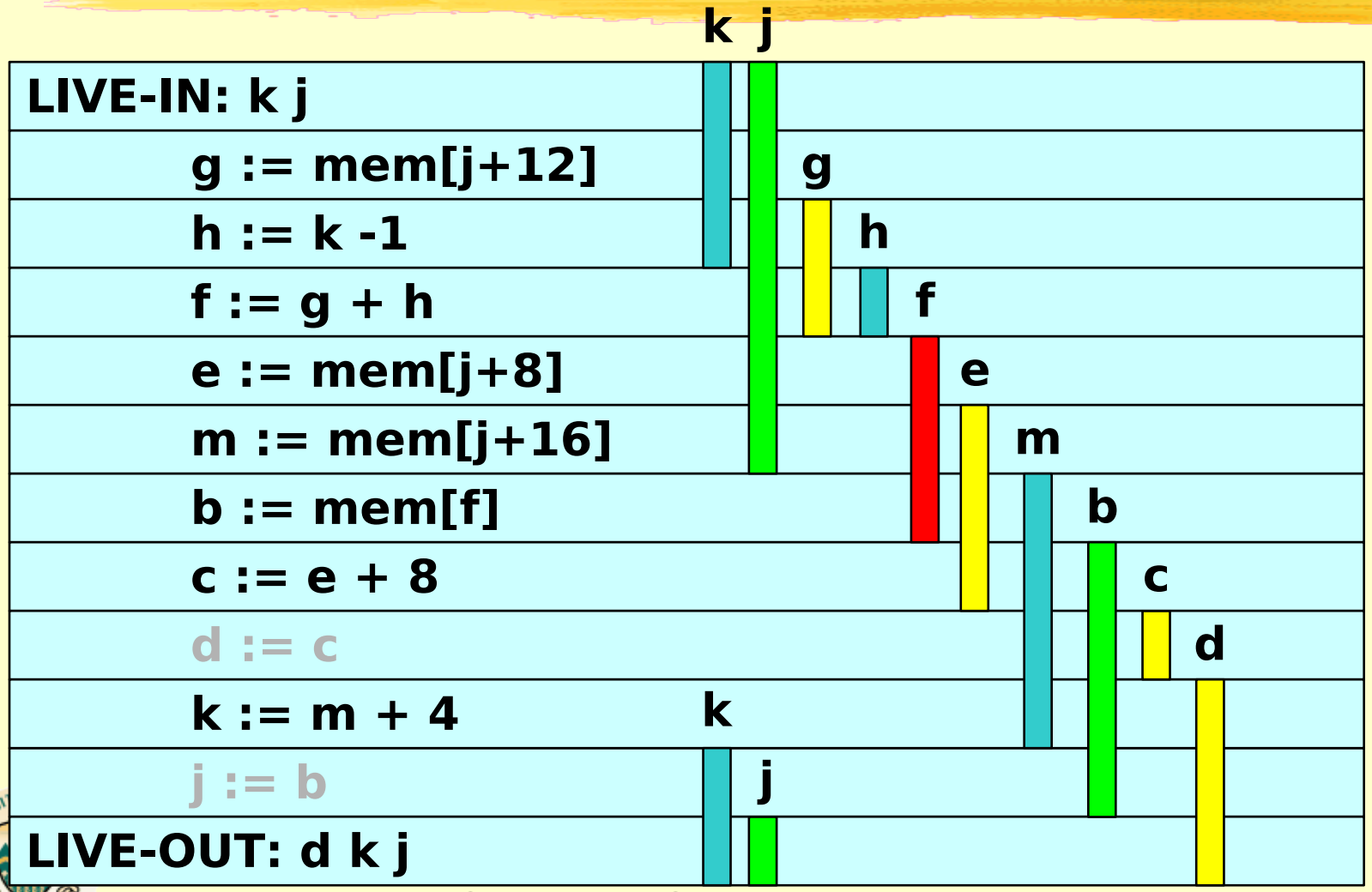
stack

(b-j, no-spill)
(c-d, no-spill)
(m, no-spill)
(e, no-spill)
(f, no-spill)
(k, no-spill)
(g, no-spill)
(h, no-spill)

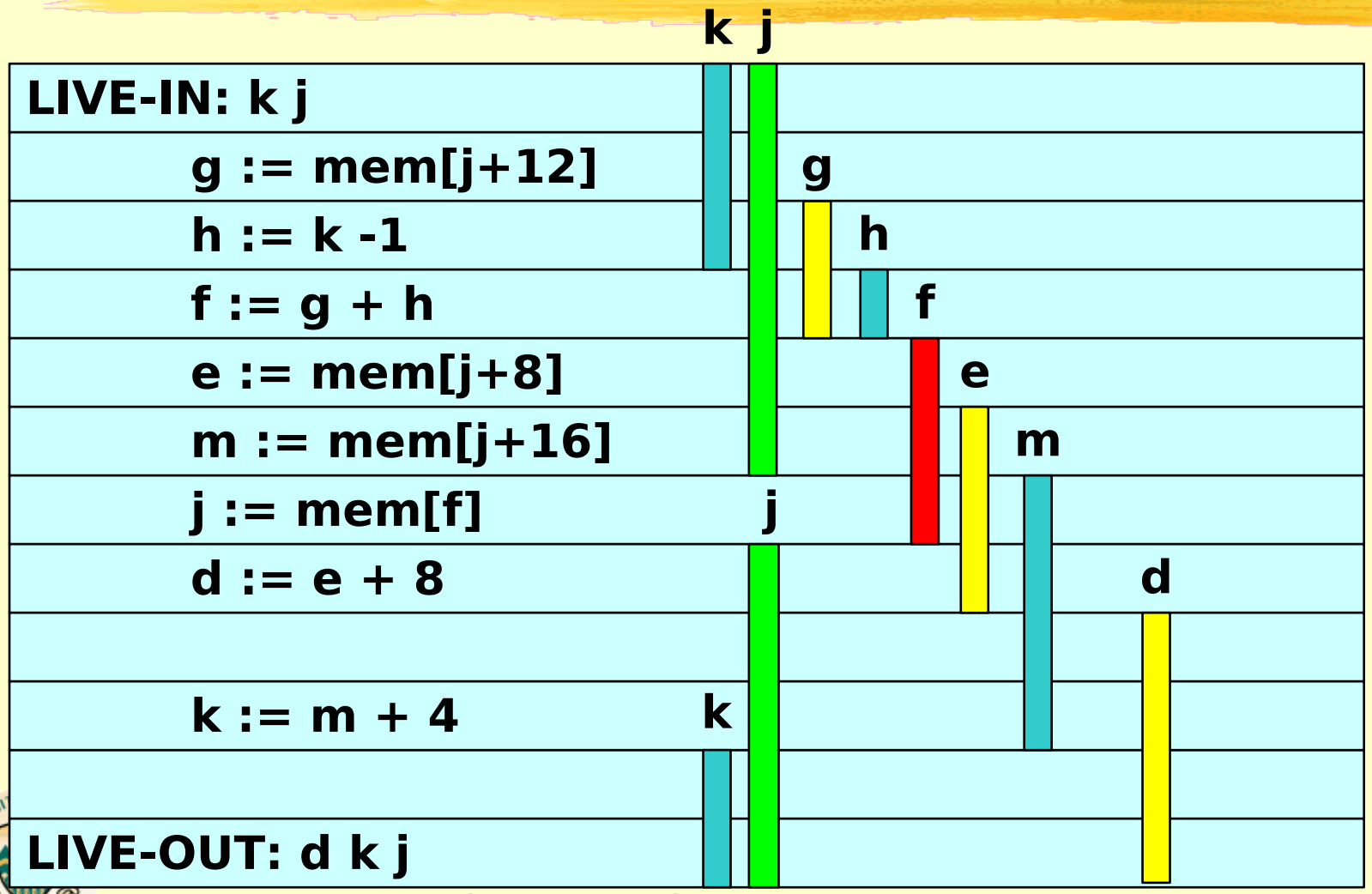
R1
R2
R3
R4

(Appel, pp. 237)

Example: Allocation with 4 registers

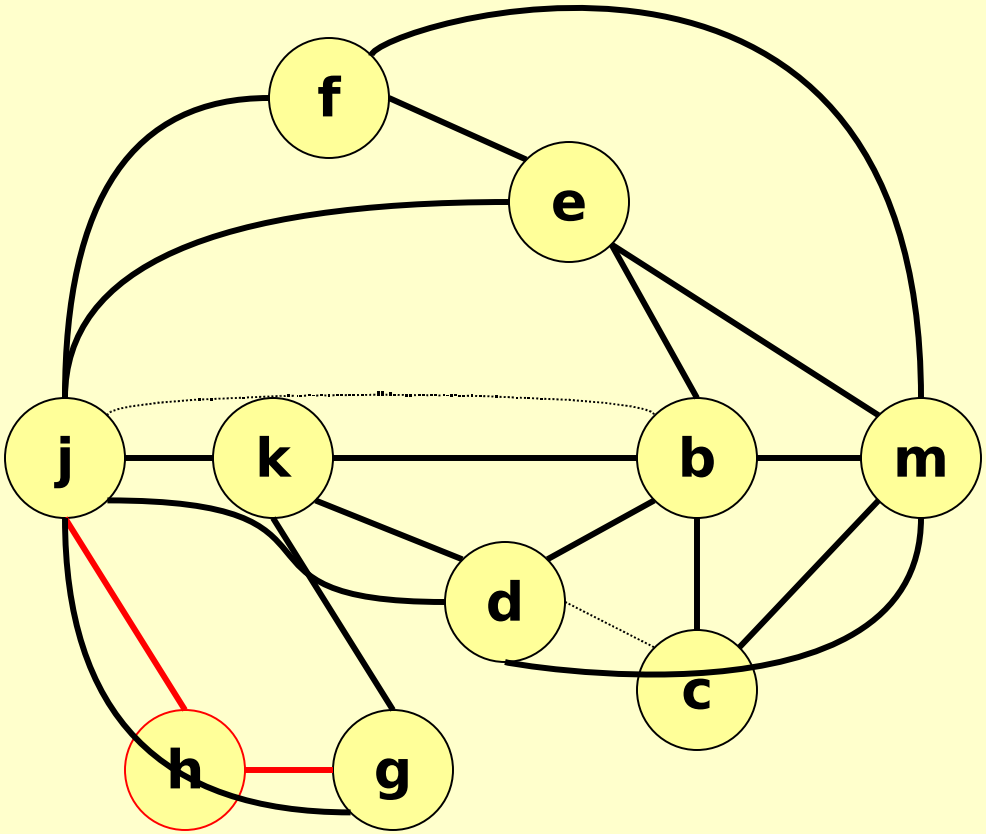


Example: Allocation with 4 registers



Could we do the allocation in the previous example with 3 registers?

Example: Simplify (K=3)

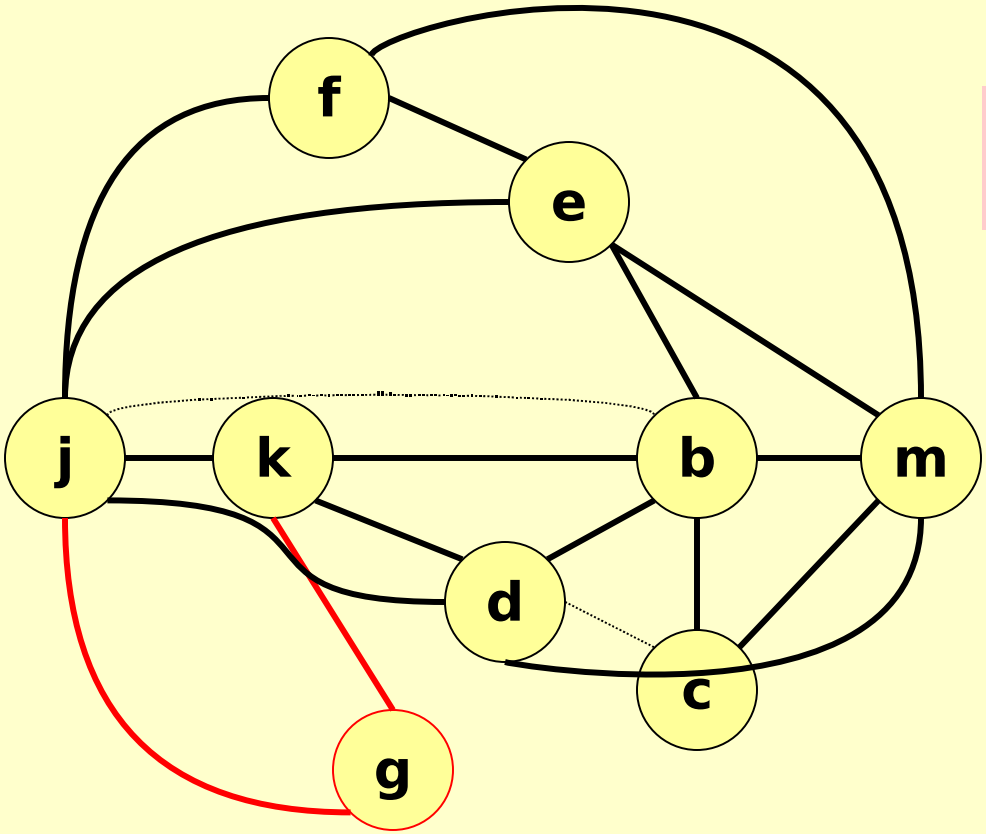


stack

(h,no-spill)

(Appel, pp. 237)

Example: Simplify (K=3)

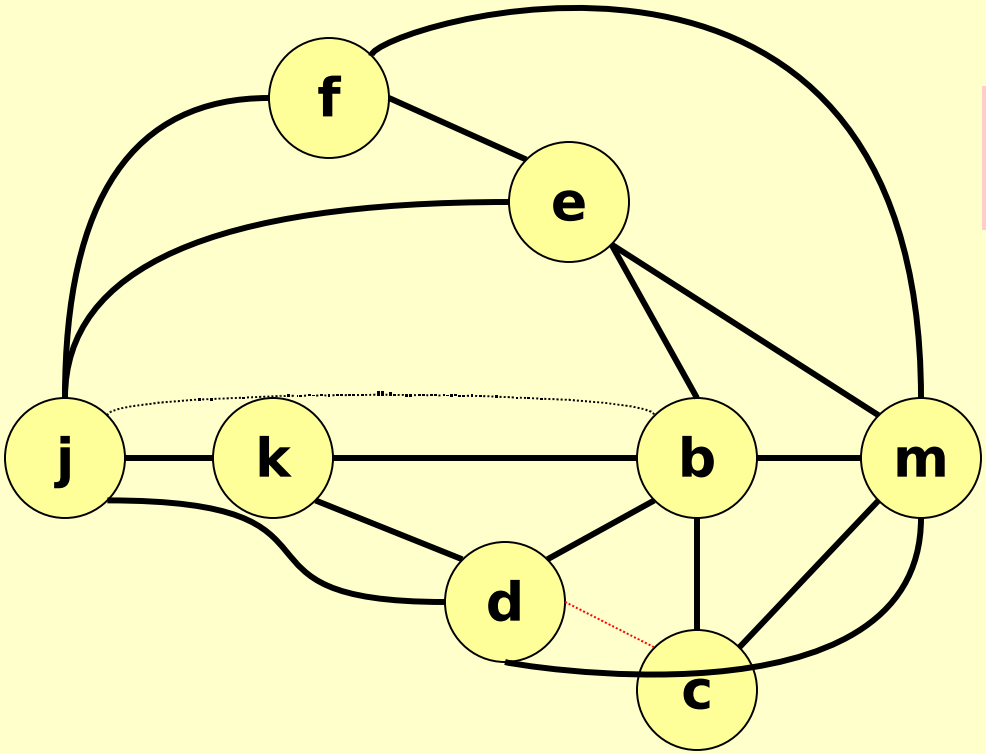


stack

(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Freeze (K=3)



stack

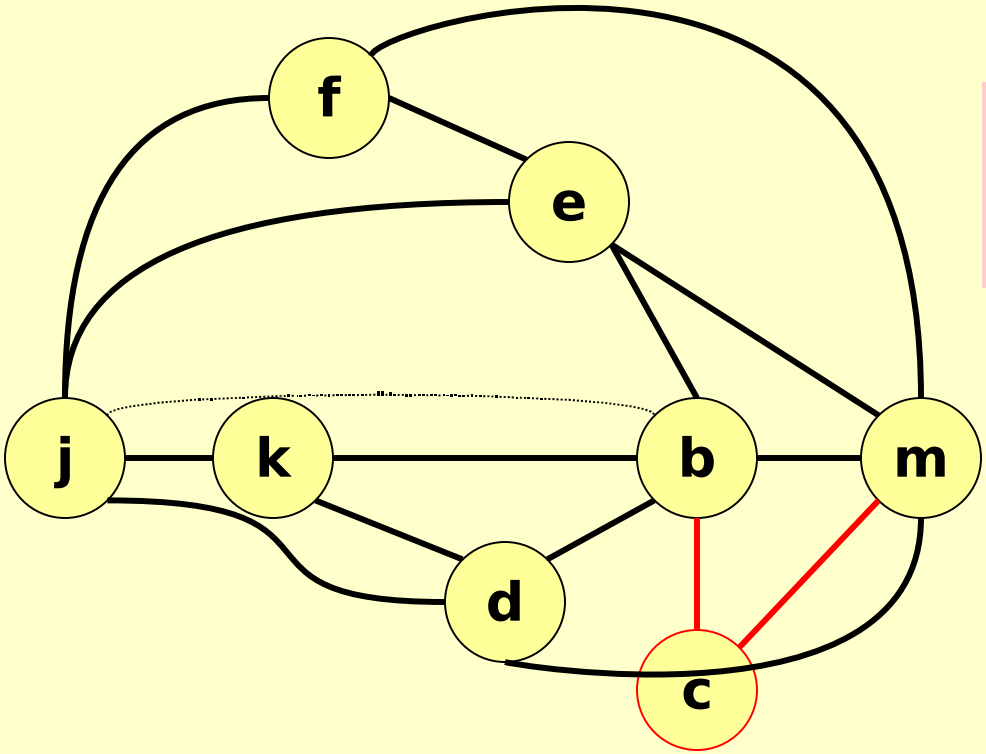
(g, no-spill)
(h, no-spill)

Coalescing may make things worse (not always).

George's rule would coalesce the move d-c, Briggs' rule would freeze.

(Appel, pp. 237)

Example: Simplify (K=3)

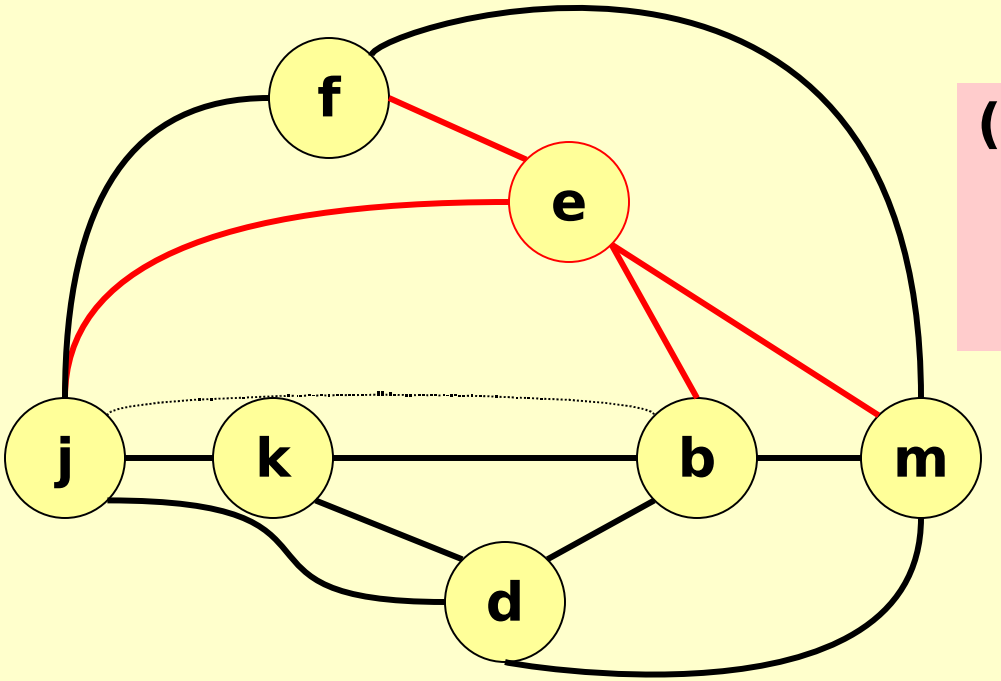


stack

(c, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Potential Spill (K=3)



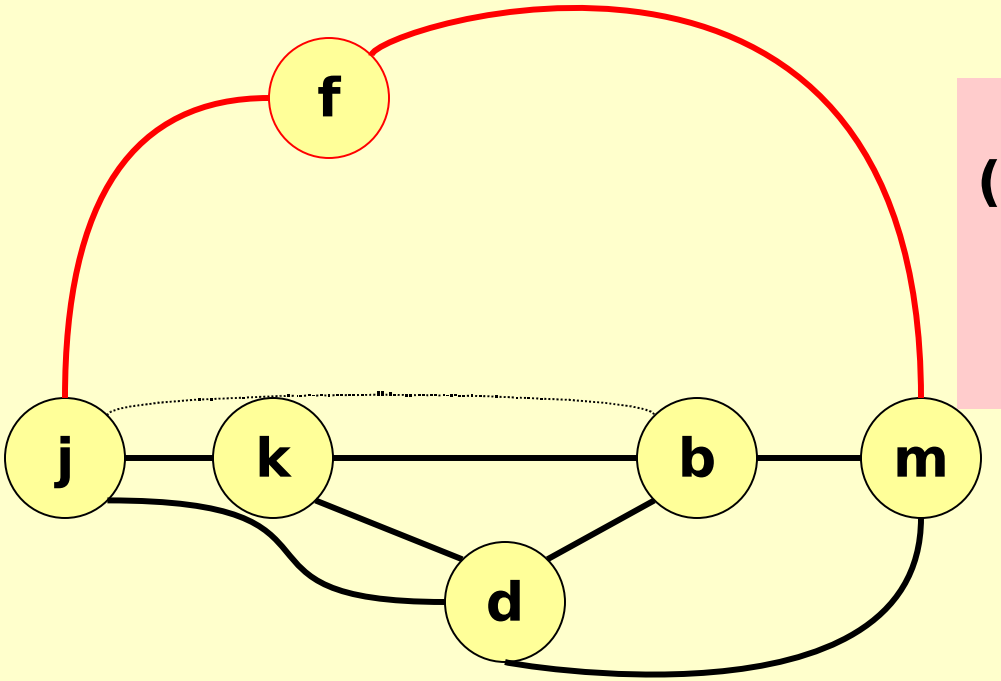
stack

(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

Neither coalescing nor freezing help us.
At this point we should use some profitability analysis to choose a node as *may-spill*.

(Appel, pp. 237)

Example: Simplify (K=3)

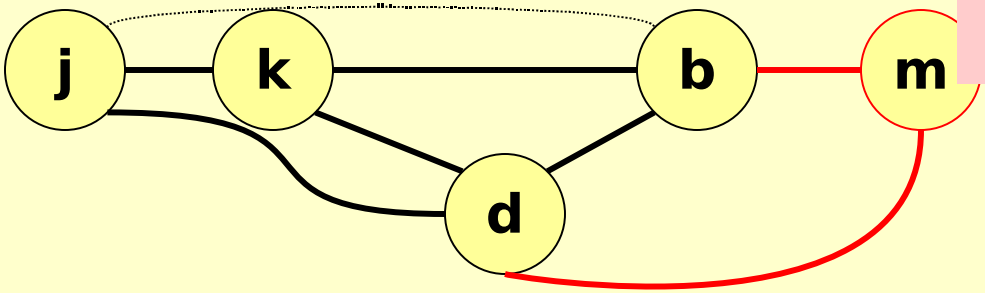


stack

(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Simplify (K=3)



stack

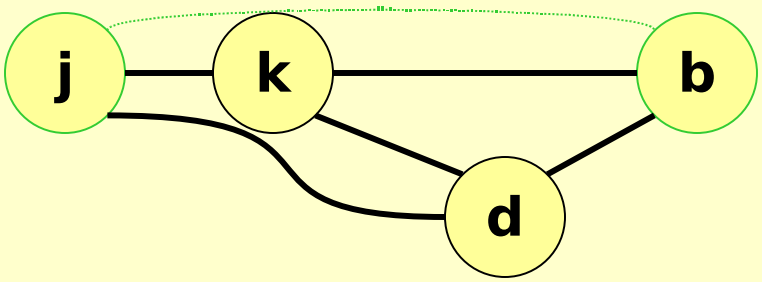
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Coalesce (K=3)

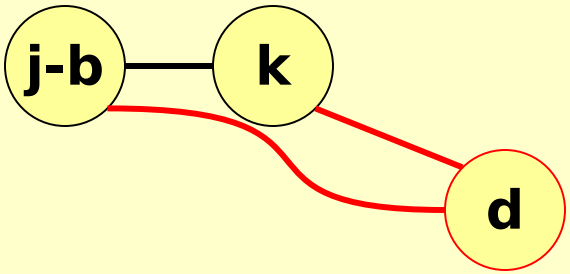
stack

(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)



(Appel, pp. 237)

Example: Coalesce (K=3)

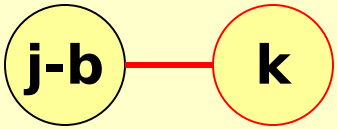


stack

(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Coalesce (K=3)



stack

(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

(Appel, pp. 237)

Example: Coalesce (K=3)

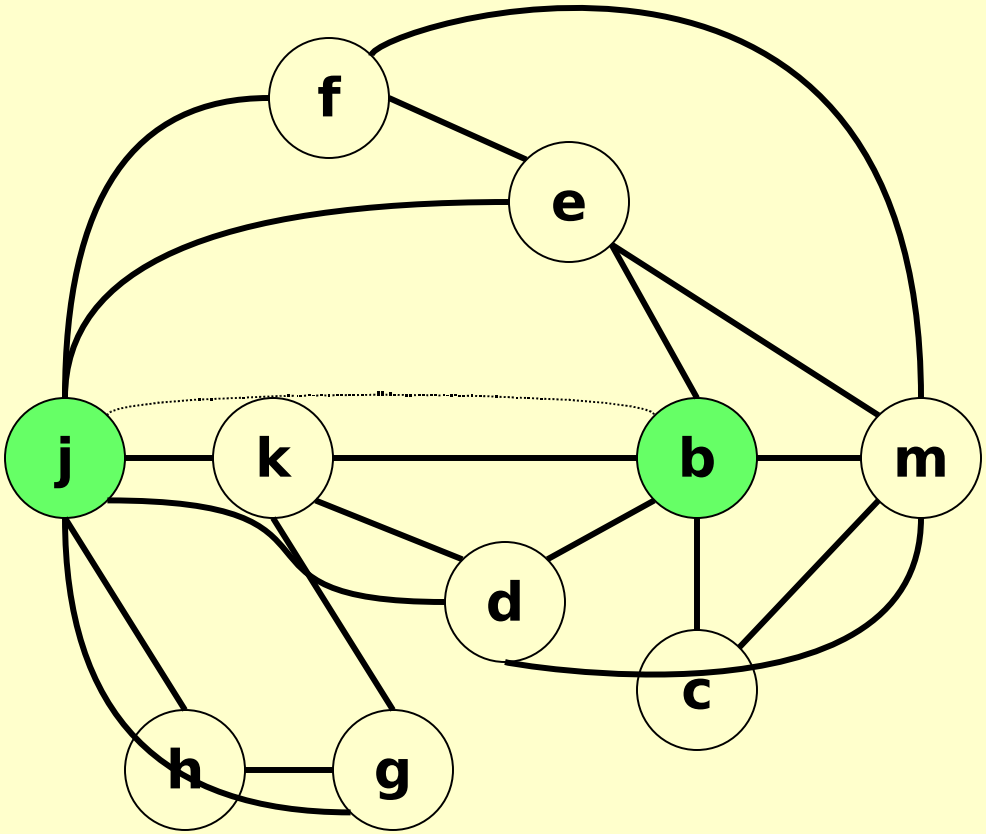
stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

j-b

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

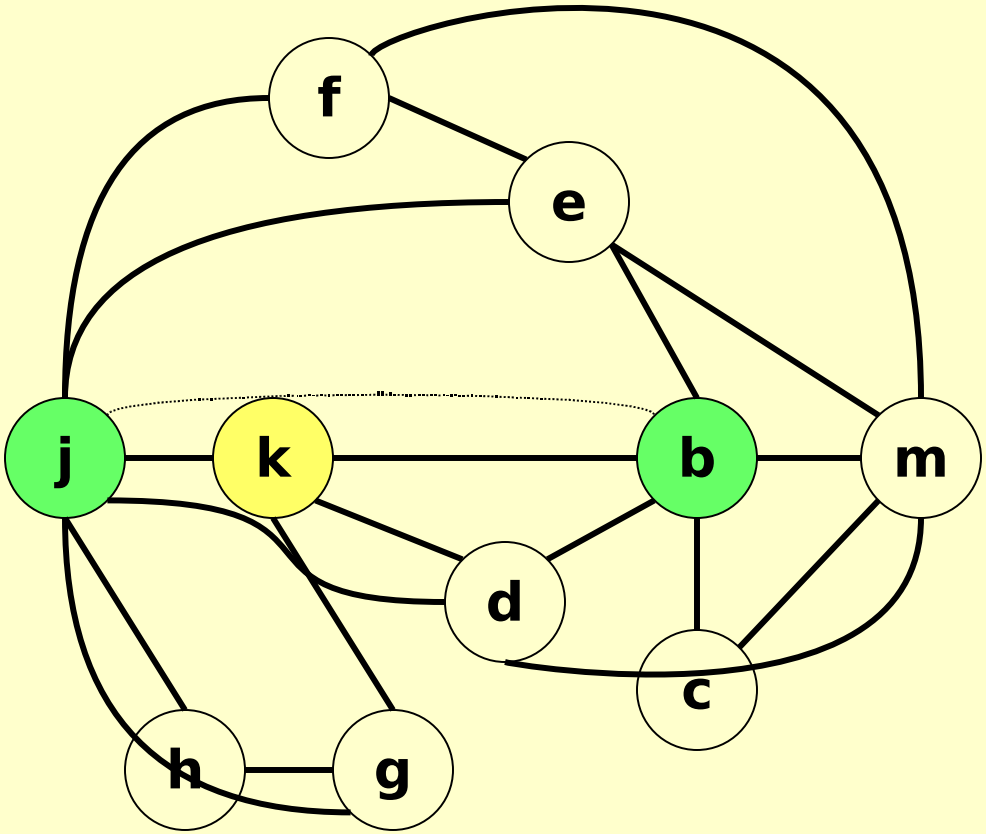
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

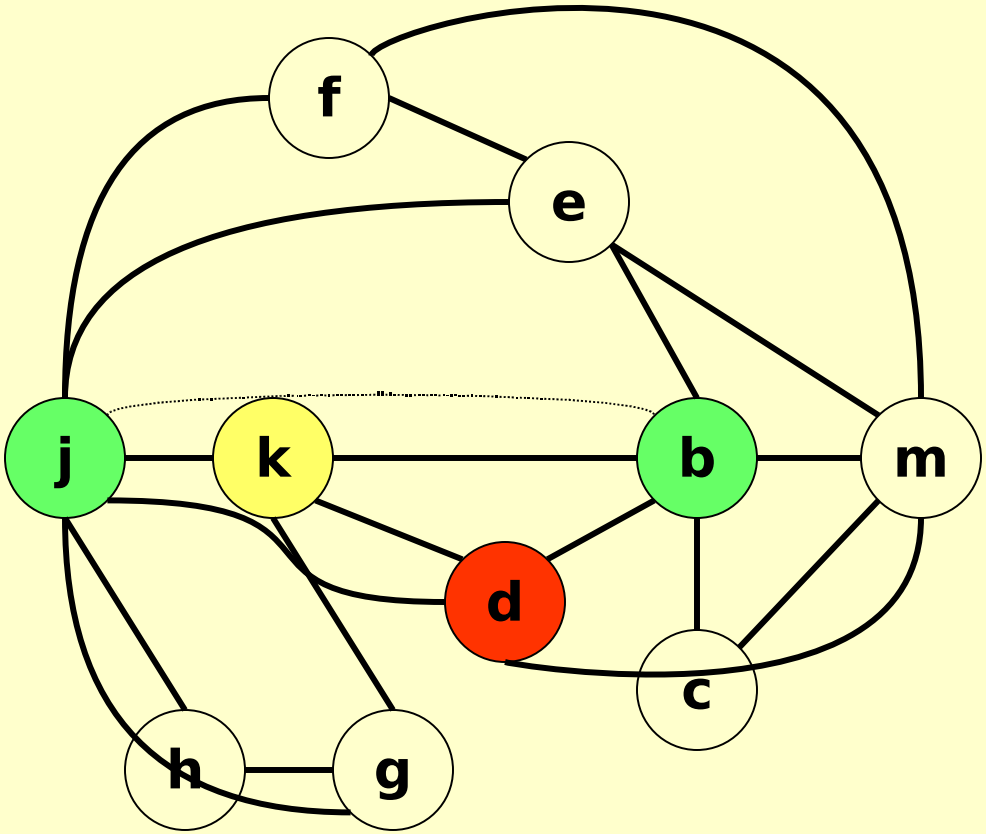
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

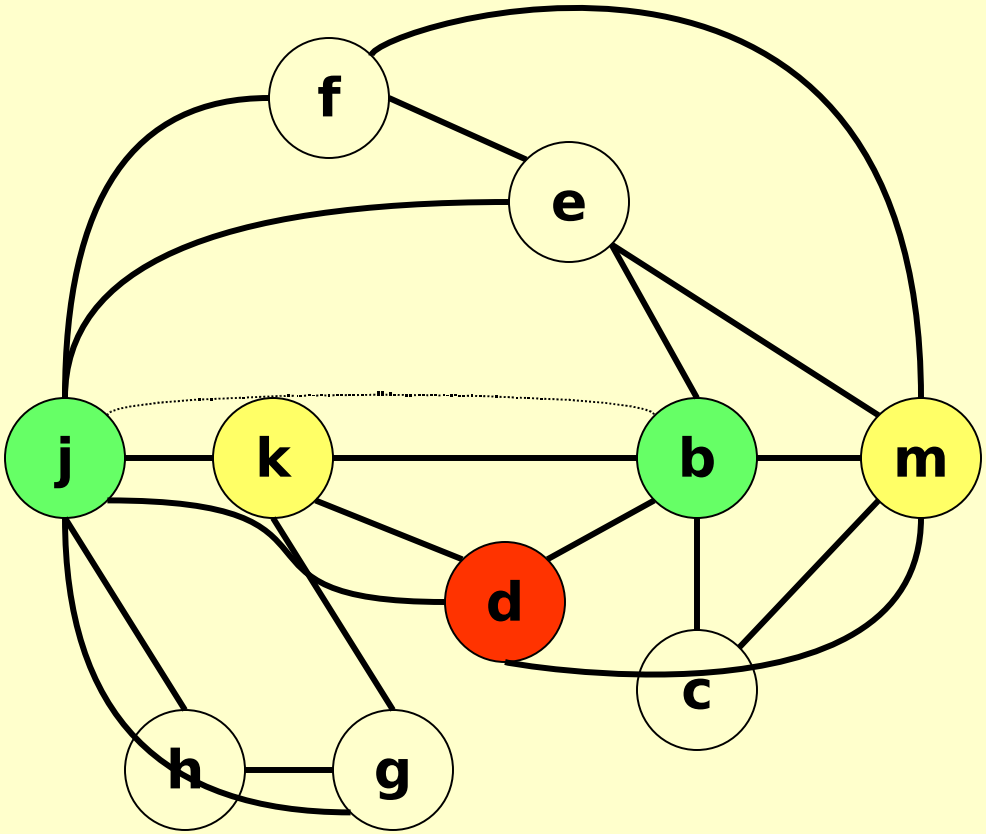
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

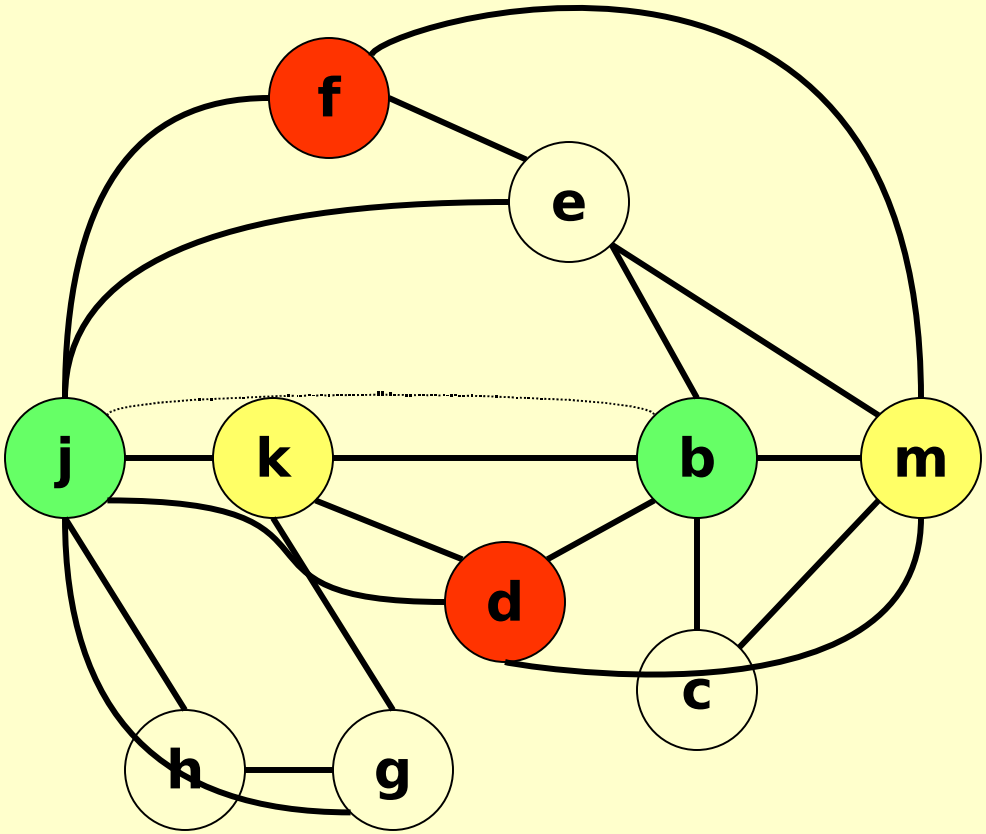
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

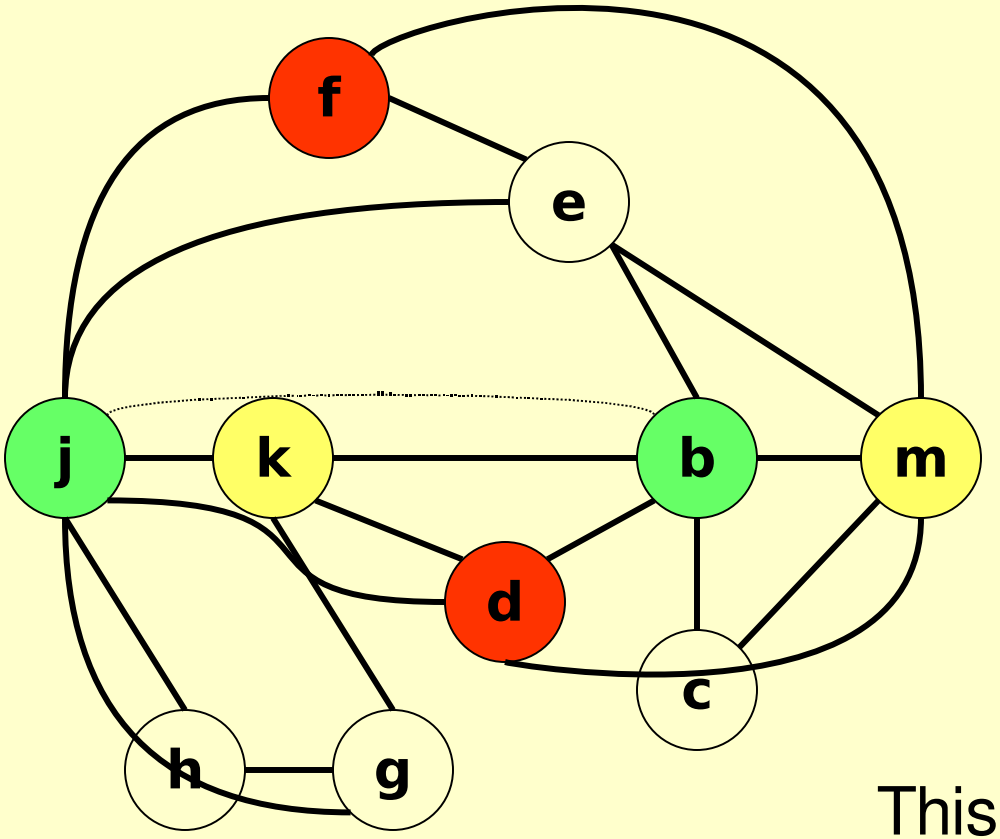
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

R1

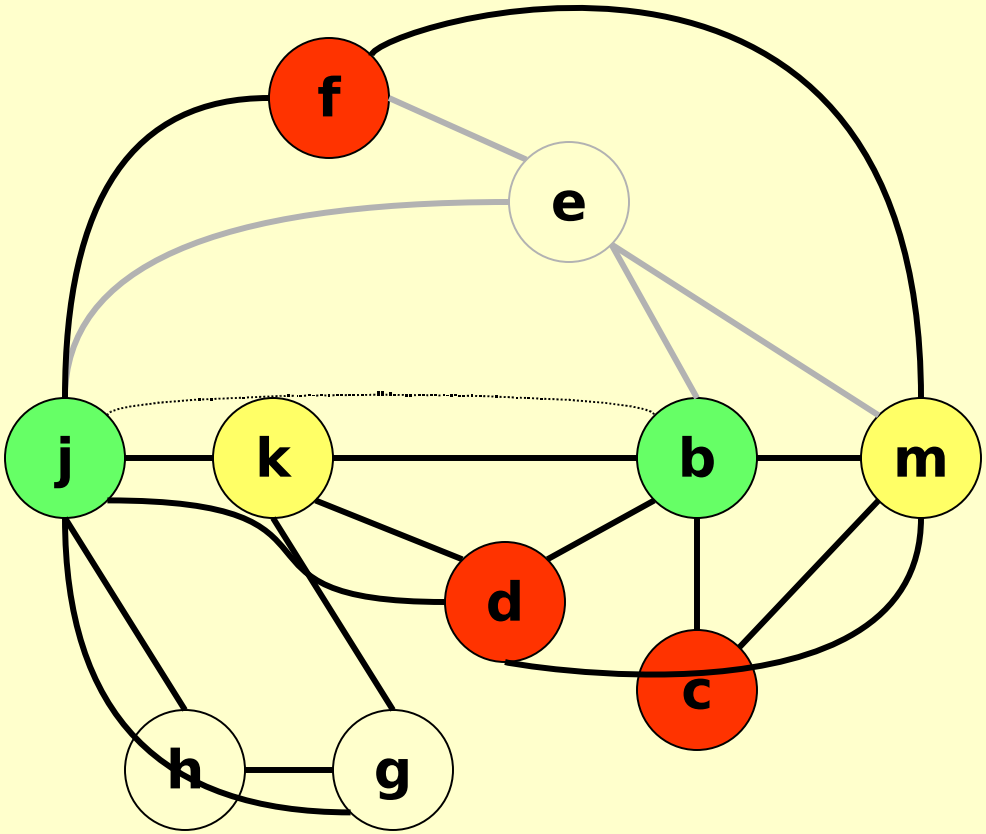
R2

R3

This is when our optimism could have paid off.

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

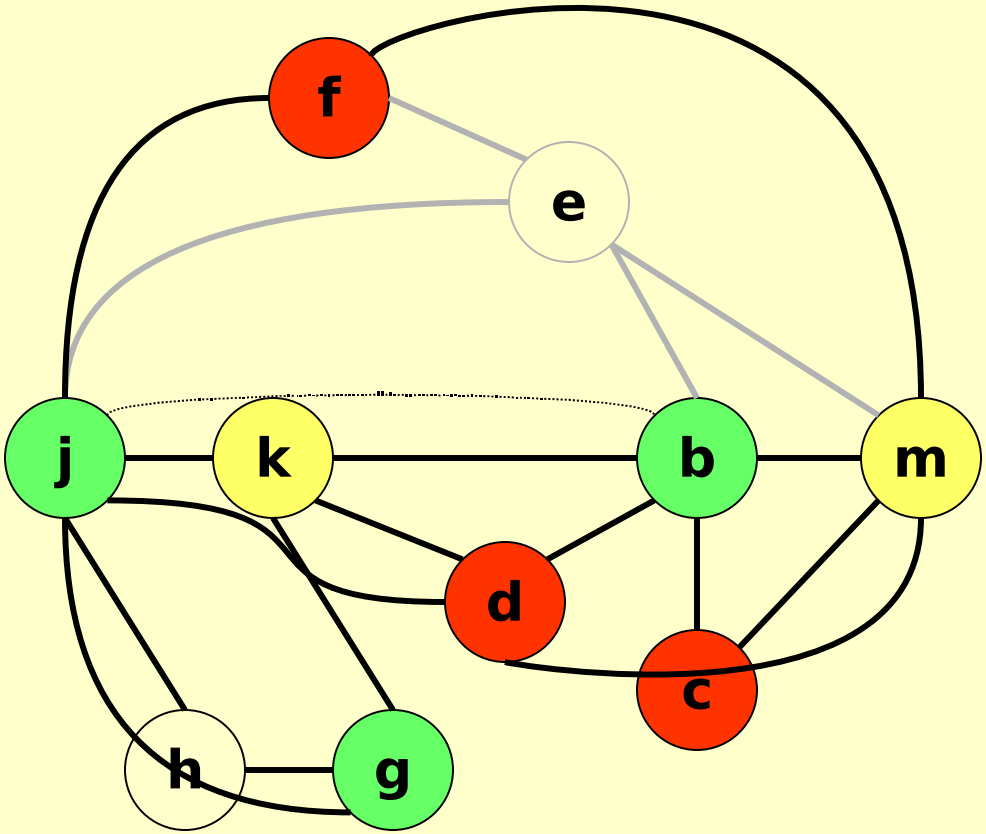
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

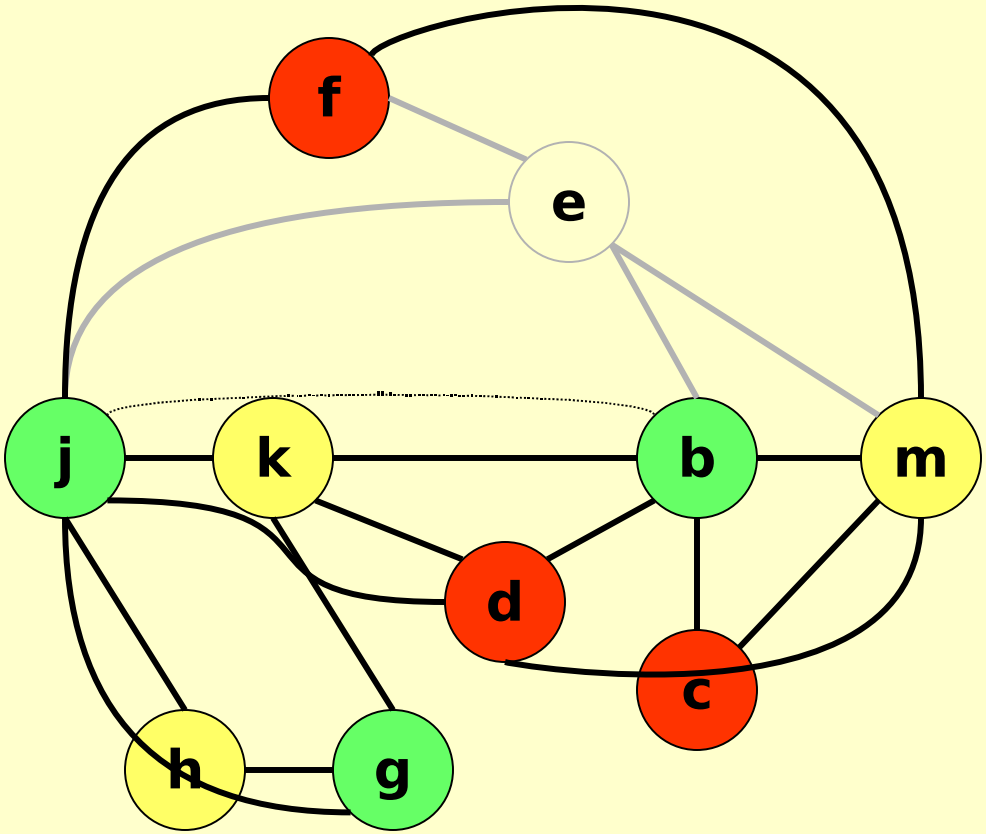
R1

R2

R3

(Appel, pp. 237)

Example: Select (K=3)



stack

(j-b, no-spill)
(k, no-spill)
(d, no-spill)
(m, no-spill)
(f, no-spill)
(e, may-spill)
(c, no-spill)
(g, no-spill)
(h, no-spill)

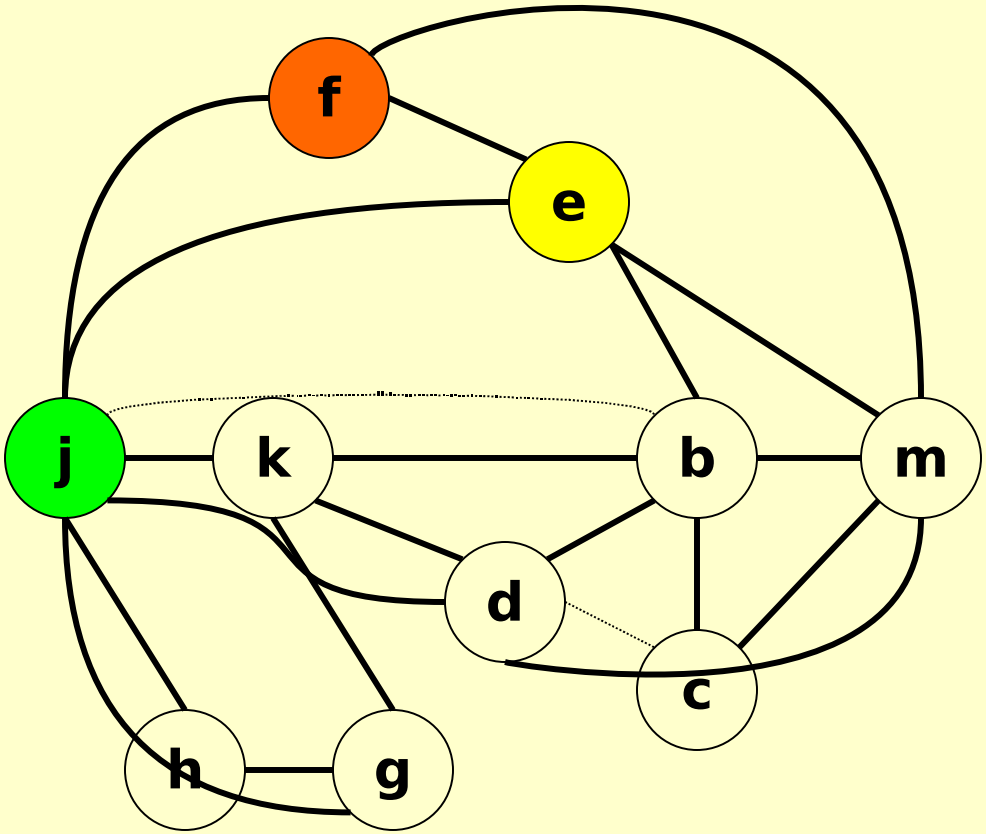
R1

R2

R3

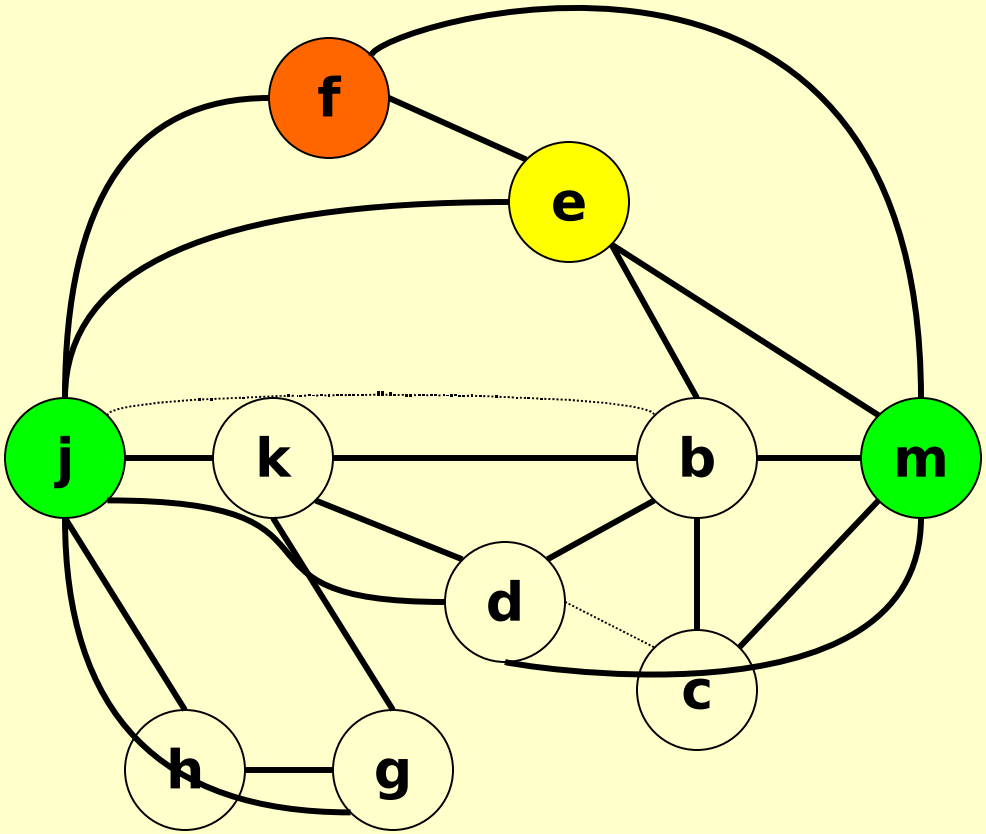
(Appel, pp. 237)

So, is it possible for K=3?



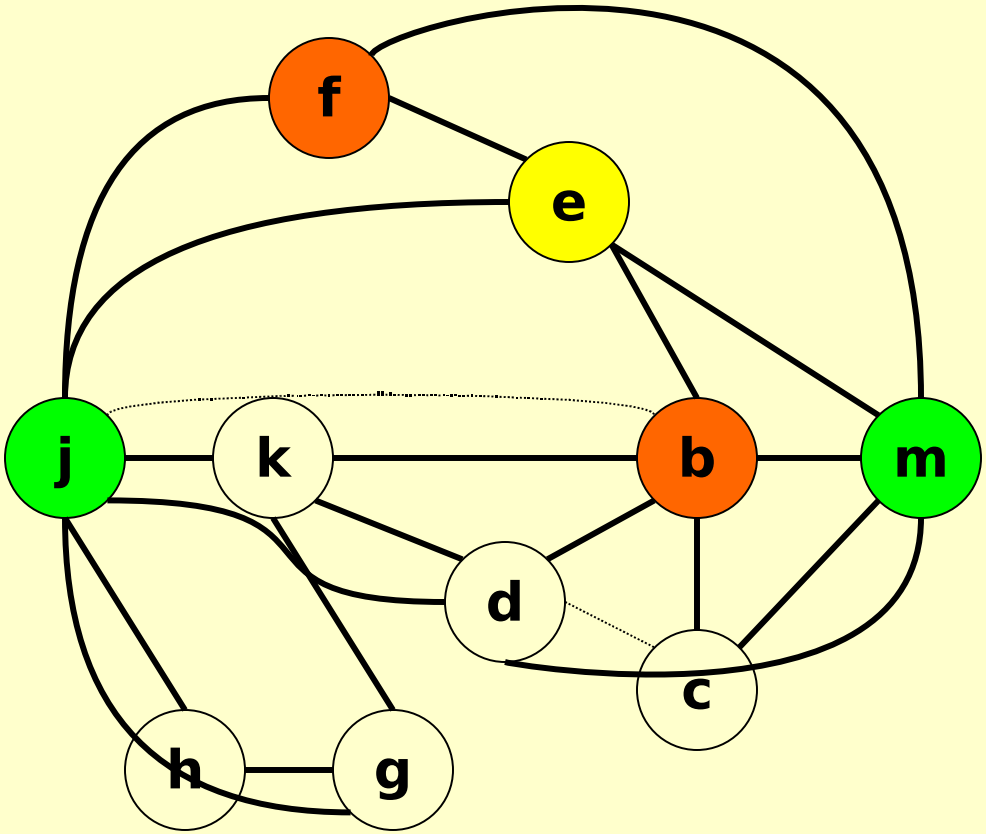
(Appel, pp. 237)

Example: Simplify (K=3)



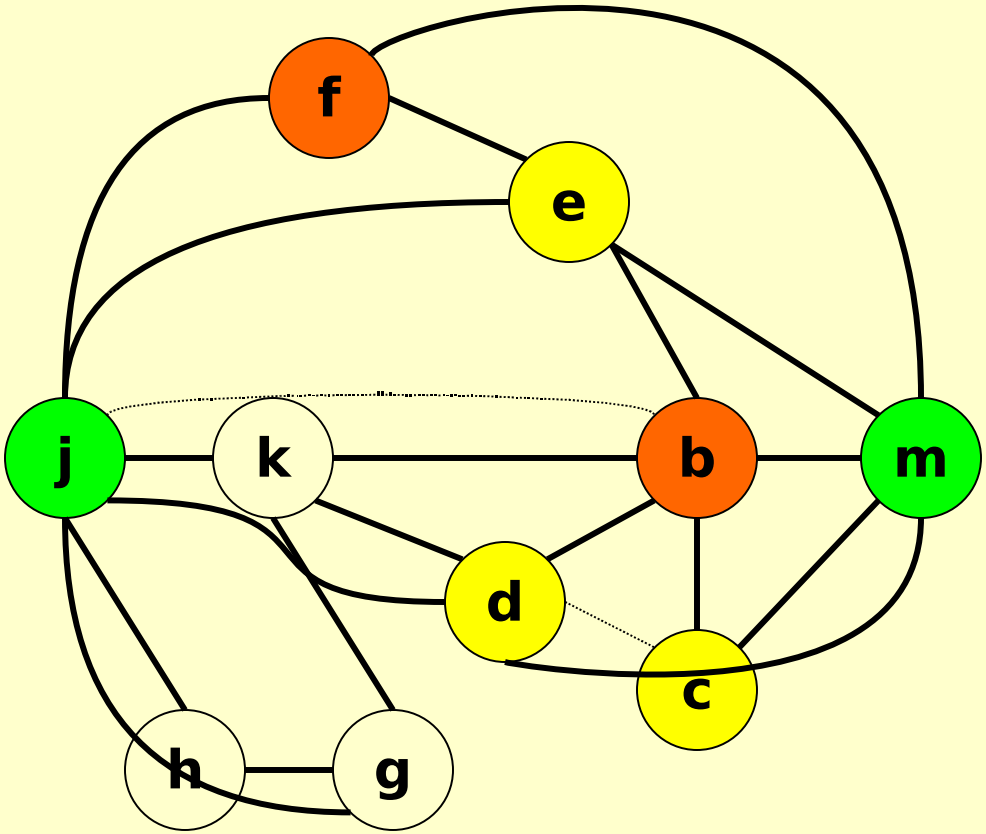
(Appel, pp. 237)

Example: Simplify (K=3)



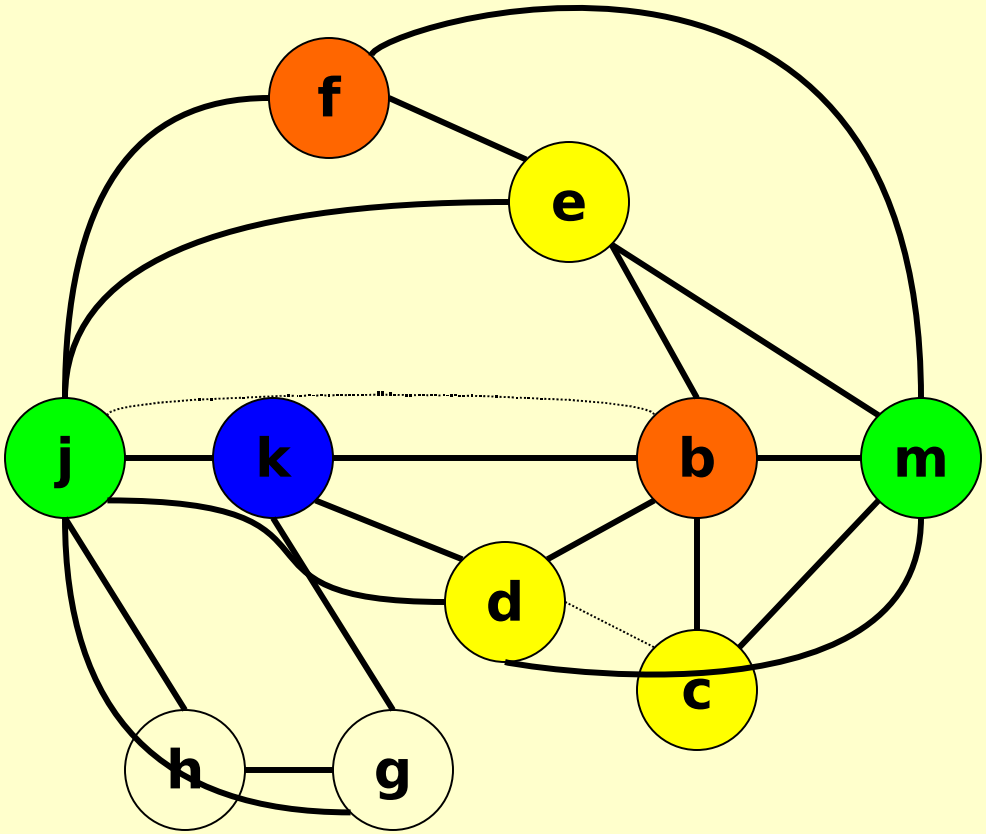
(Appel, pp. 237)

Example: Simplify (K=3)



(Appel, pp. 237)

Example: Simplify (K=3)

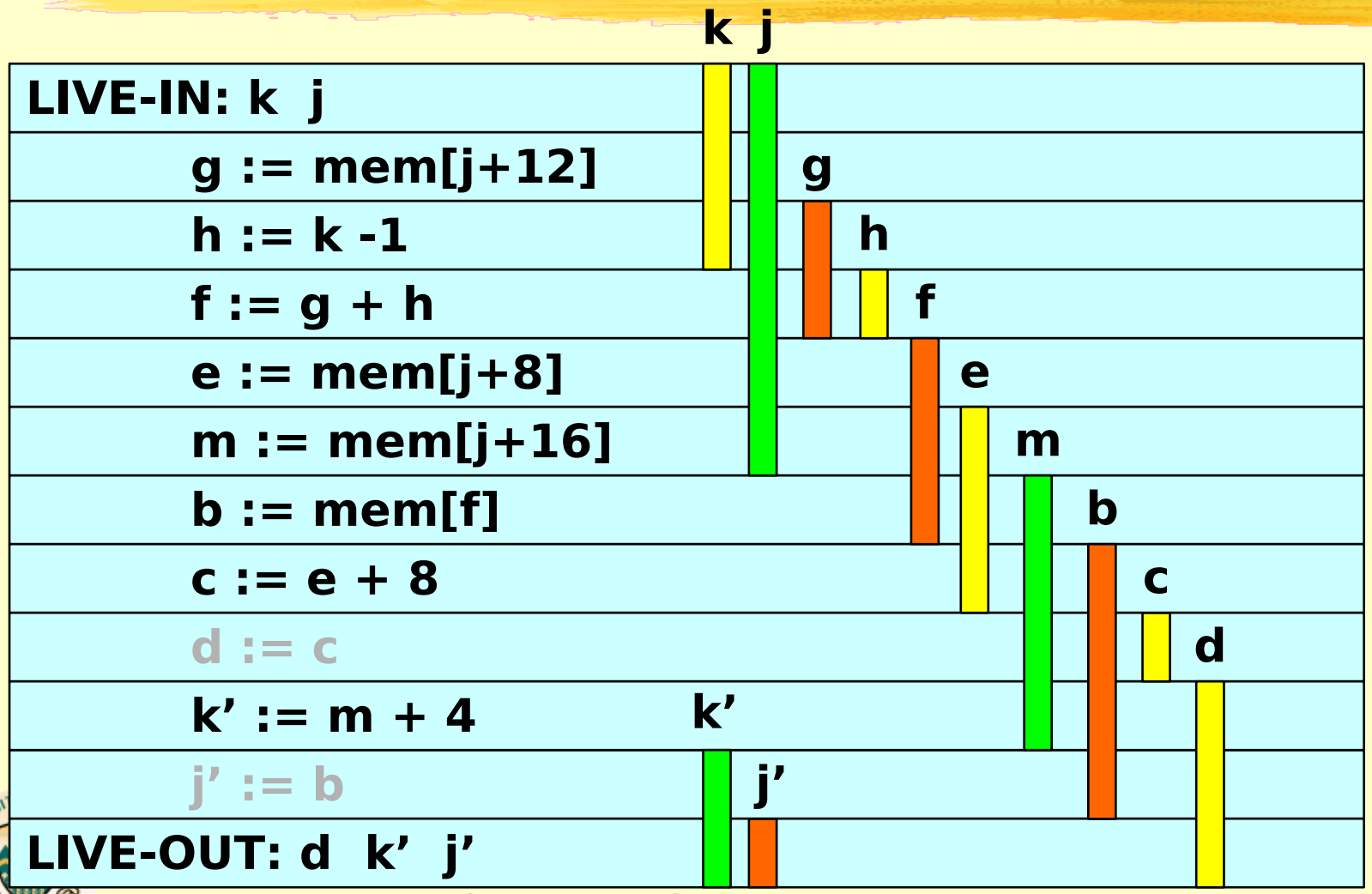


Impossible!

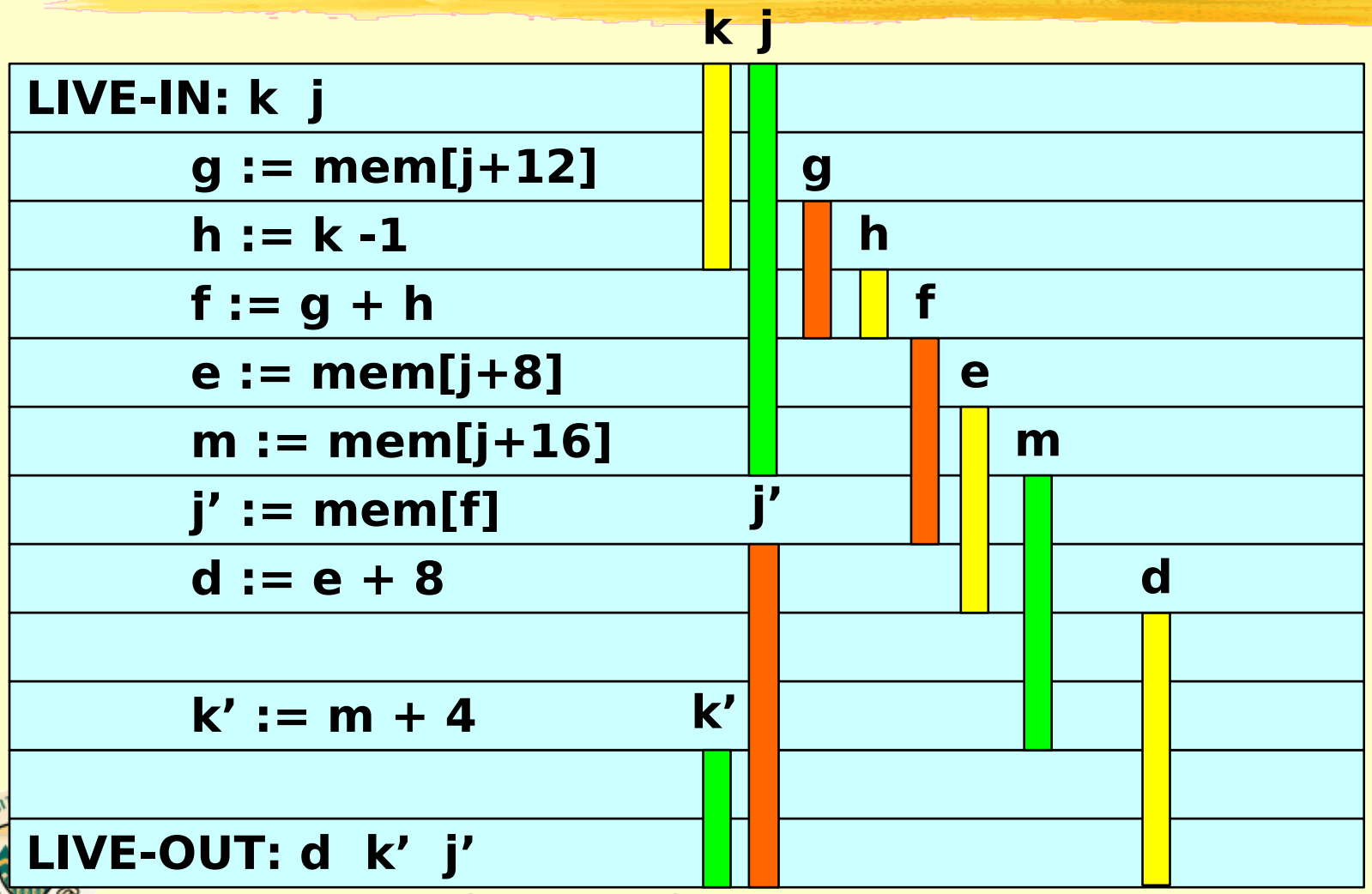
But only 3 variables are live at any time… there may be a way?

(Appel, pp. 237)

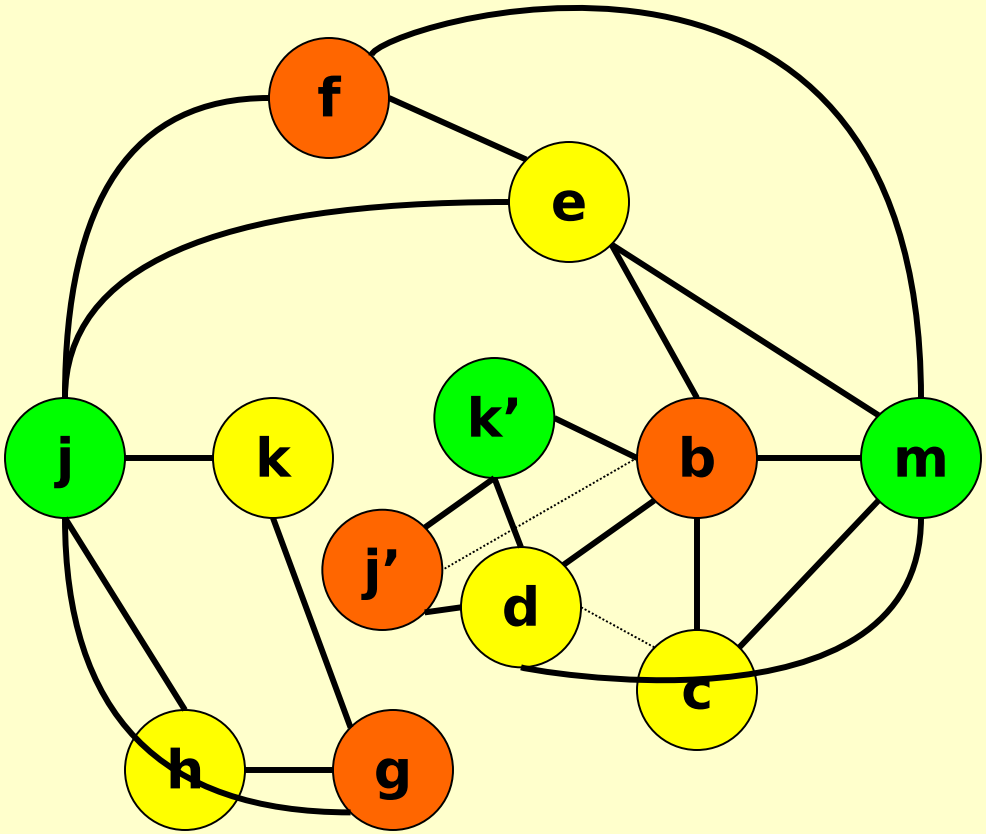
Example as basic block: 3 Registers by renaming k & j



Example as basic block: 3 Registers by renaming k & j



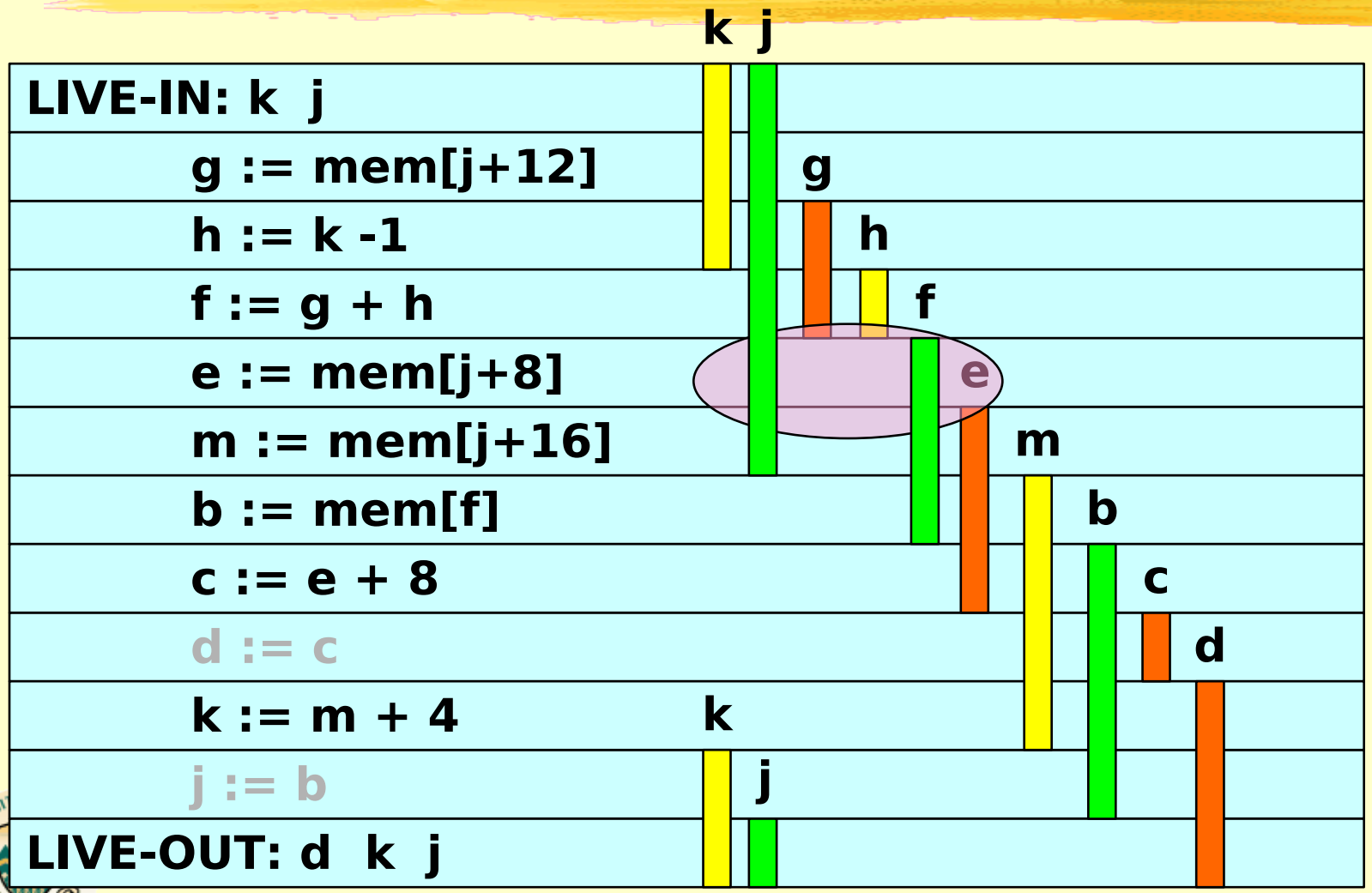
Example as basic block: A 3-coloring of the graph



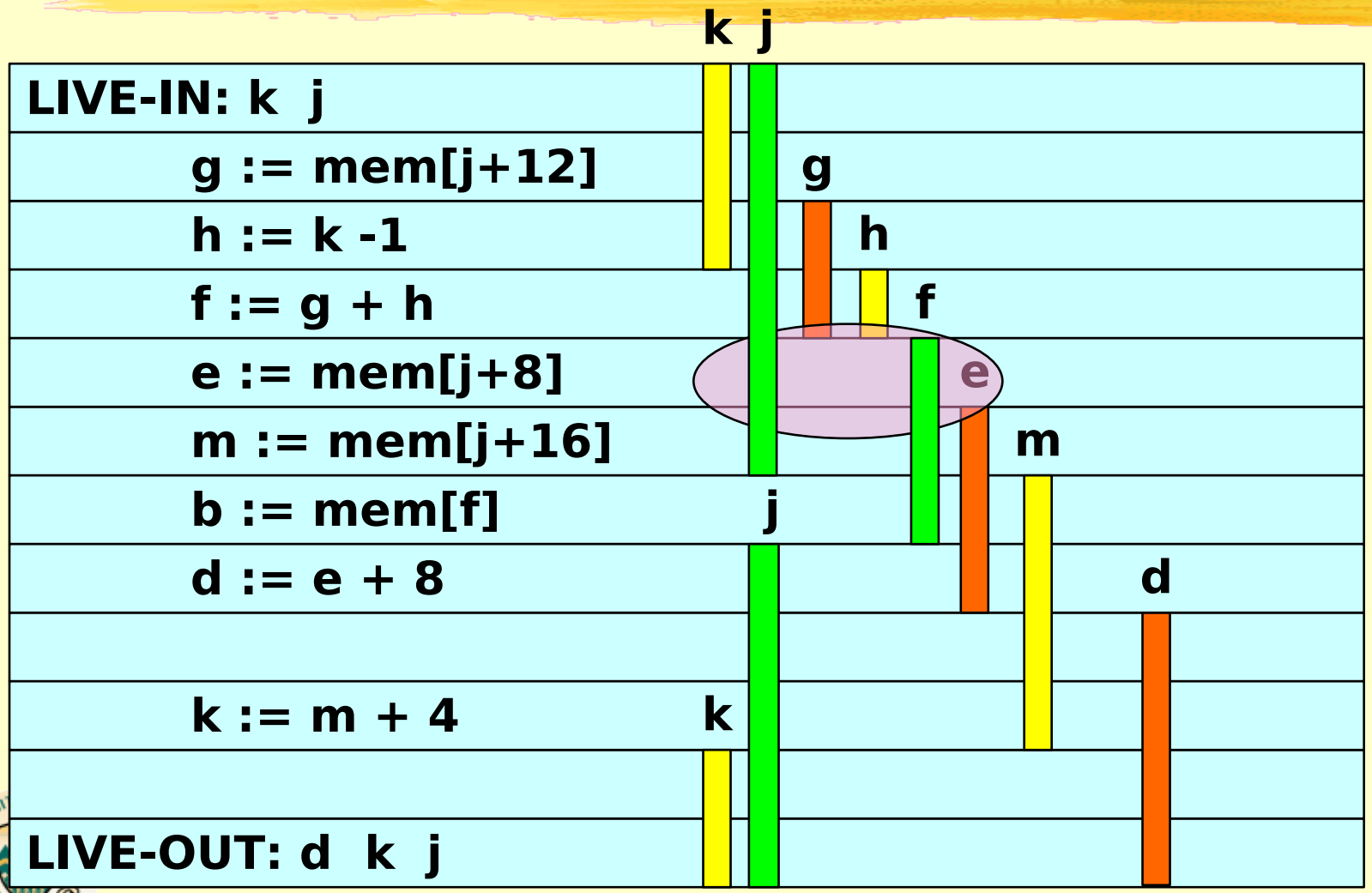
The two assignments of k (resp. j) can be placed in two different registers.

(Appel, pp. 237)

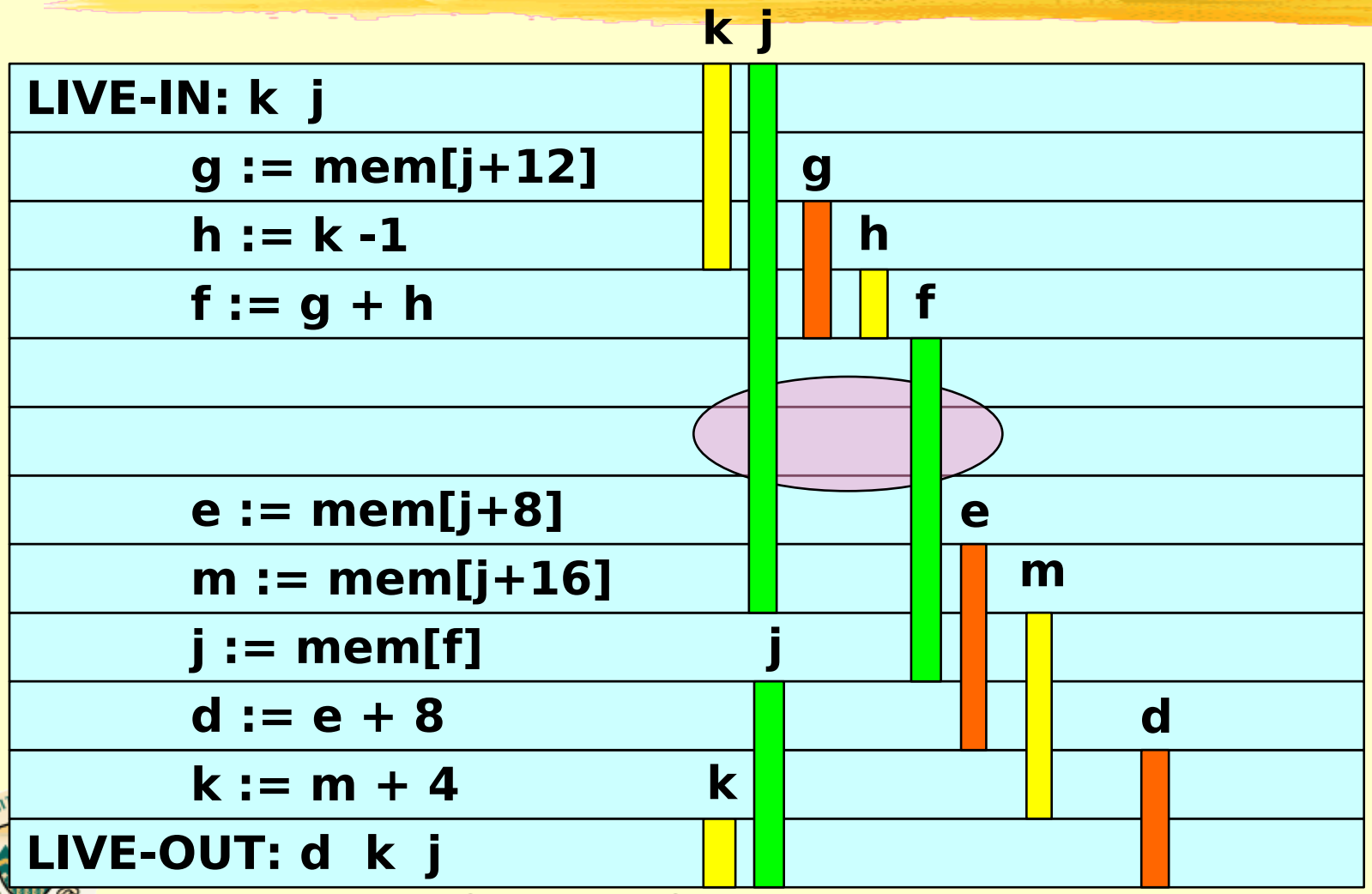
Example as a loop: 3 Registers are enough!



Example as a loop: 3 Registers are enough!



Example as a loop: 3 Registers are enough!



Example as a loop: 3 Registers are enough!