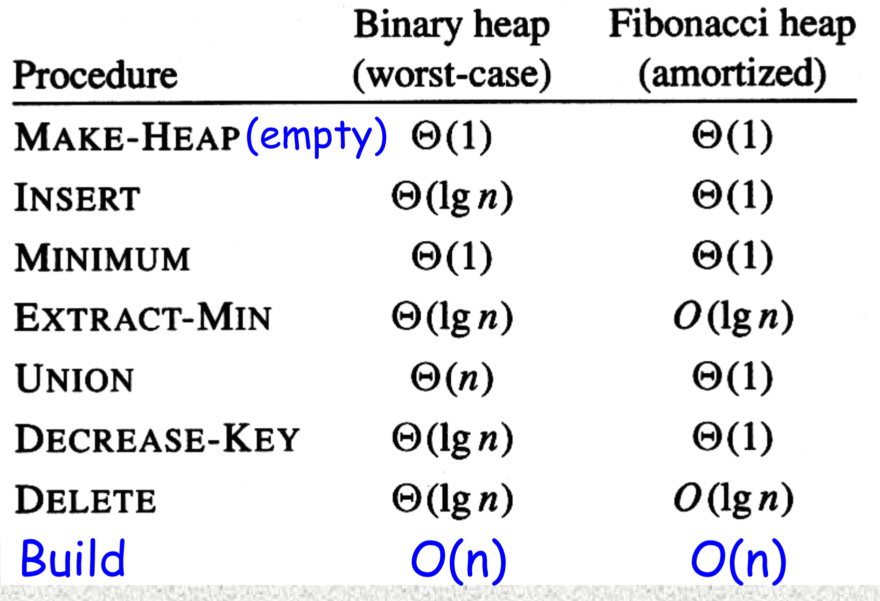


Procedure	Binary heap (worst-case)	Fibonacci heap (amortized)	array
MAKE-HEAP (empty)	Θ(1)	Θ(1)	O(1)
INSERT	Θ(lg *n*)	Θ(1)	O(1)
MINIMUM	Θ(1)	Θ(1)	O(n)
EXTRACT-MIN	Θ(lg *n*)	*O*(lg *n*)	O(n)
UNION	Θ(*n*)	Θ(1)	O(n)
DECREASE-KEY	Θ(lg *n*)	Θ(1)	O(1)
DELETE	Θ(lg *n*)	*O*(lg *n*)	O(1)
Build	O(n)	O(n)	O(n)

An array

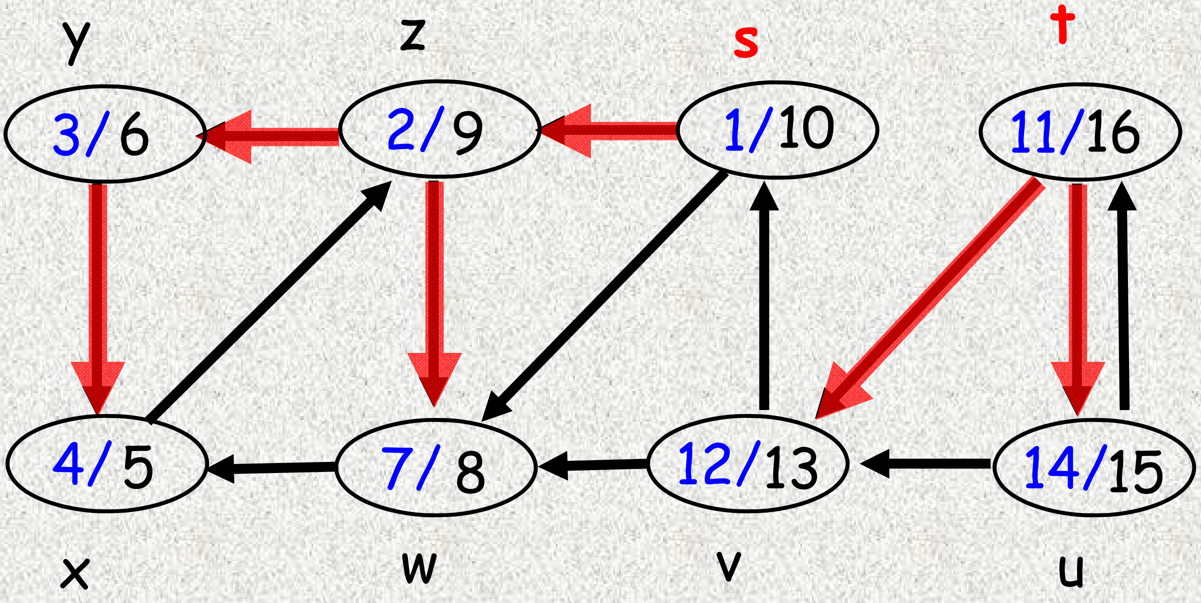
			3		☆		
(a, 4)	(b, 7)	(c, 9)	(d, ~~5~~)	(e, 8)	(f, 2)	(g, 3)	(h, 6)

Extract-Min

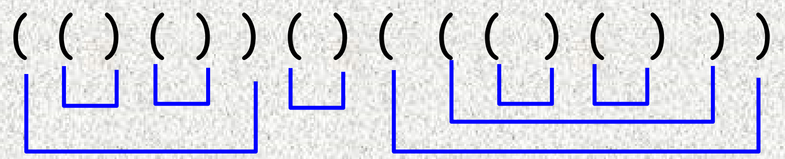
Decrease-Key (d, 5) -> (d, 3)

Delete c

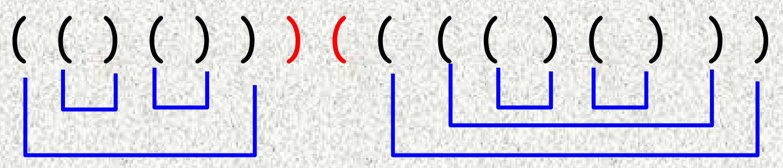
22-9 Fig



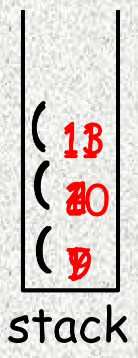
Parenthesis structure: (well-formed)



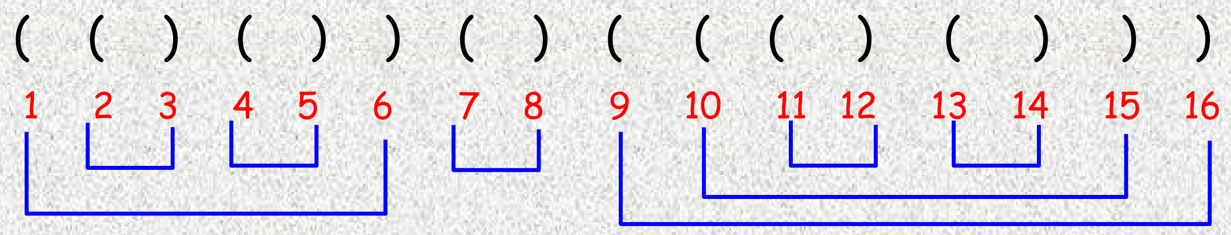
yes



no

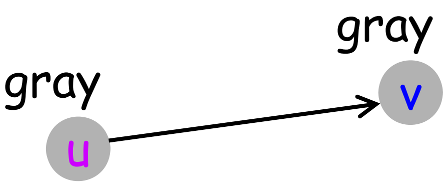


yes



Case 2:

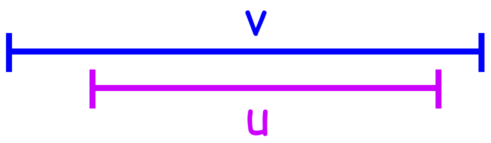
22-11a



* intervals are not disjoint

⇨ descendant – ancestor relation (nested intervals)

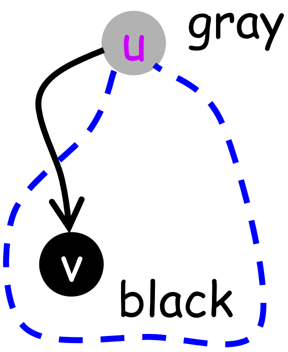
* f(u) < f(v) (* u 先結束 *)

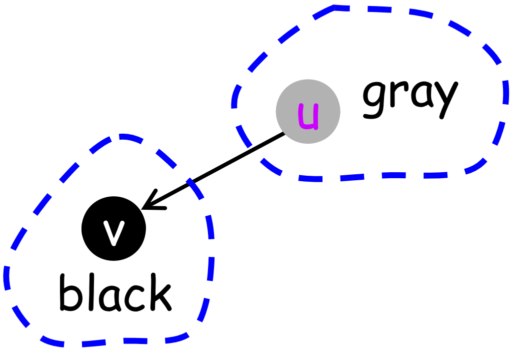
⇨ 

⇨ back edge !

Case 3:

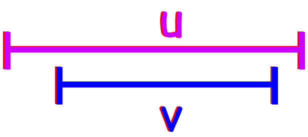
22-11b





f(v) < f(u)

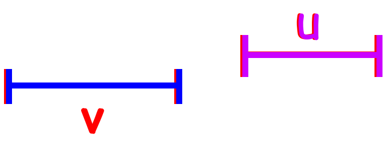
* d(u) < d(v)



⇨ nested

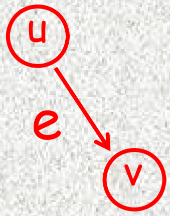
⇨ forward edge!

* d(u) > d(v)

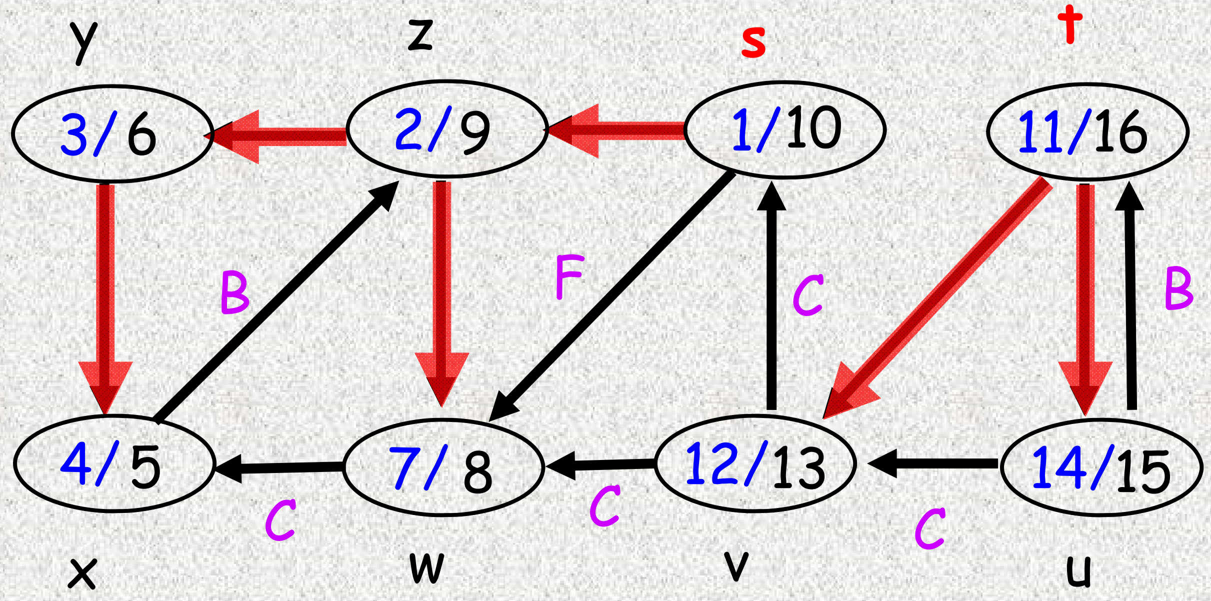


⇨ disjoint

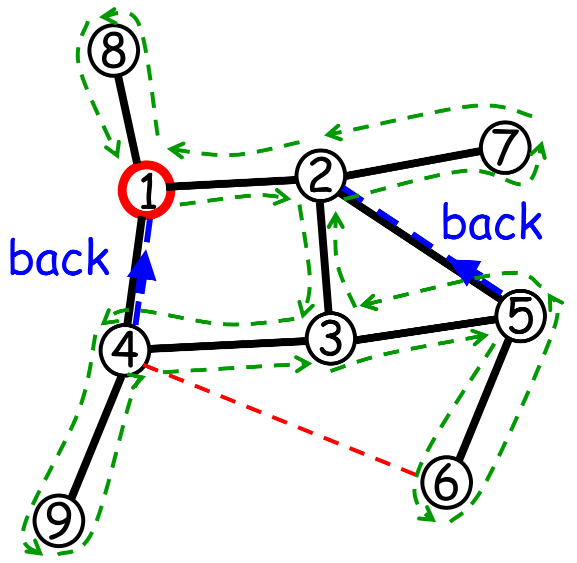
⇨ cross edge!

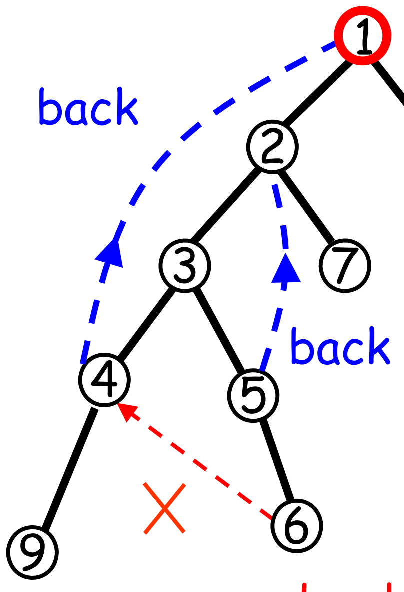


1. v is white → tree
2. v is gray → back
3. v is black → forward if d[u] < d[v]
cross if d[u] > d[v]



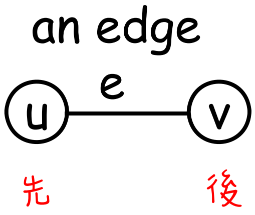
Theorem 22.10

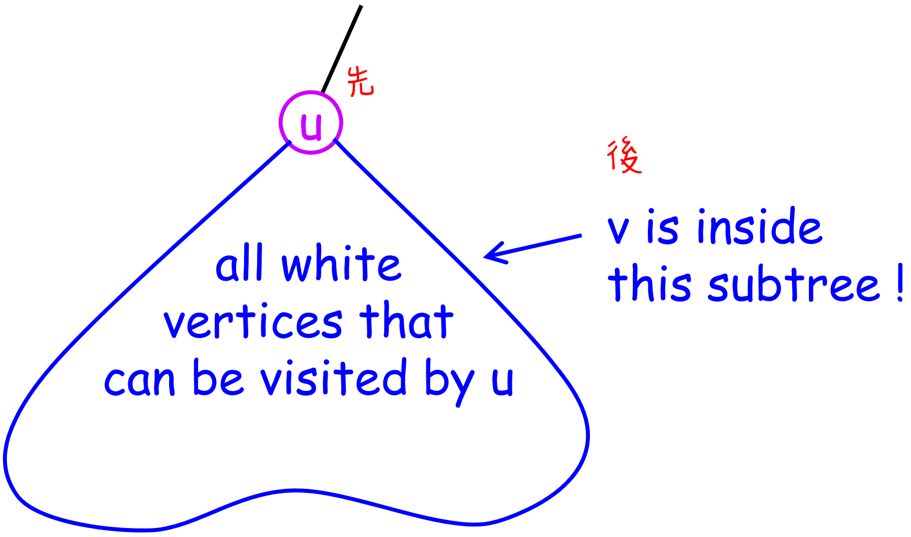




no cross edges!

Theorem 22.10

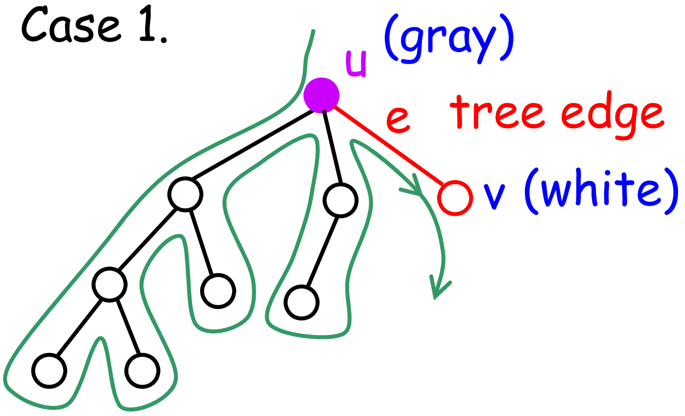



u
先
後
all white vertices that can be visited by u
v is inside this subtree !

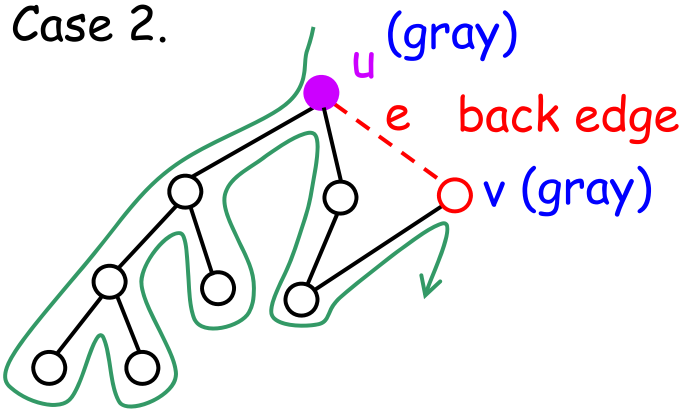
⇨ v is a descendant of u

* 在 u finish 前 , v 必 會 被 visit !!

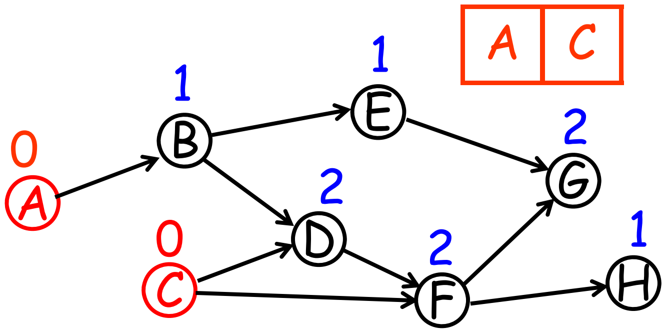
Case 1.



Case 2.

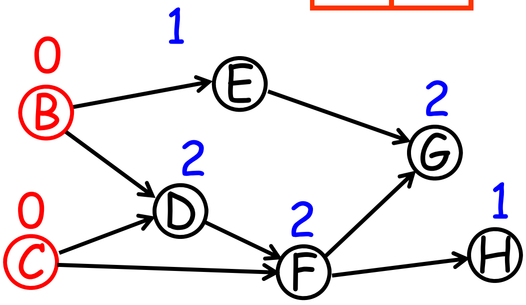


22-12a



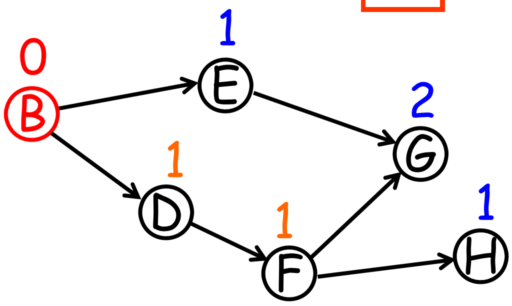
(1) A

C B



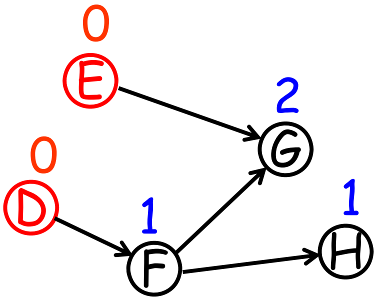
(2) AC

B



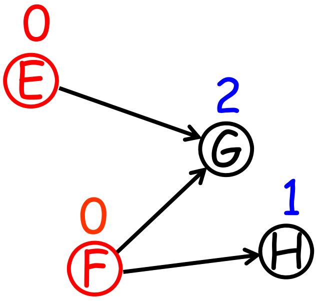
(3) ACB

D E



(4) ACBD

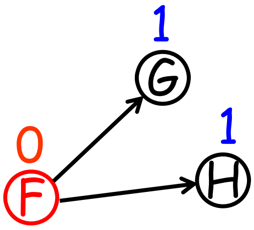
E F



(5) ACBDE

F

22-12b



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•

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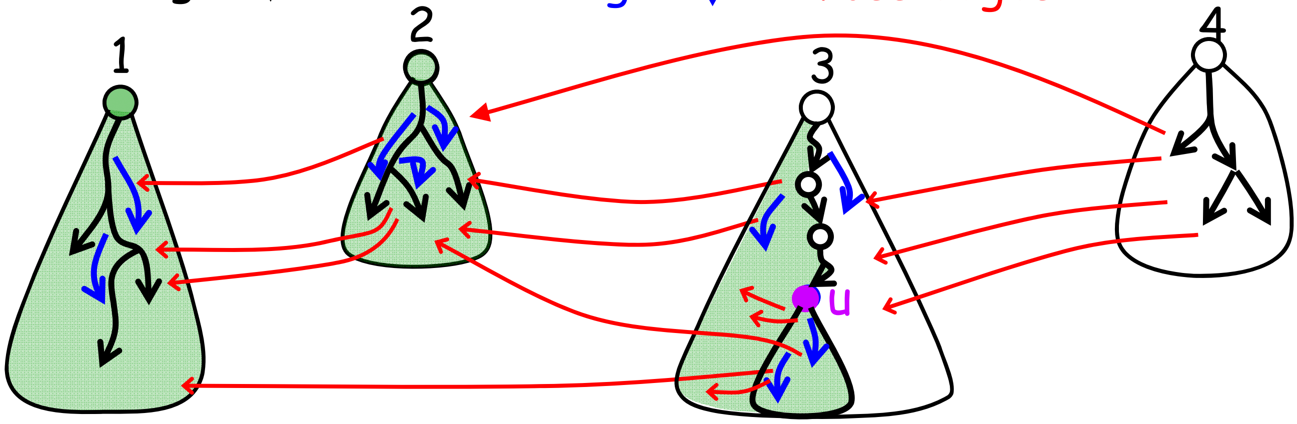
(8) ACBDEFGH

Topological sort - Correctness

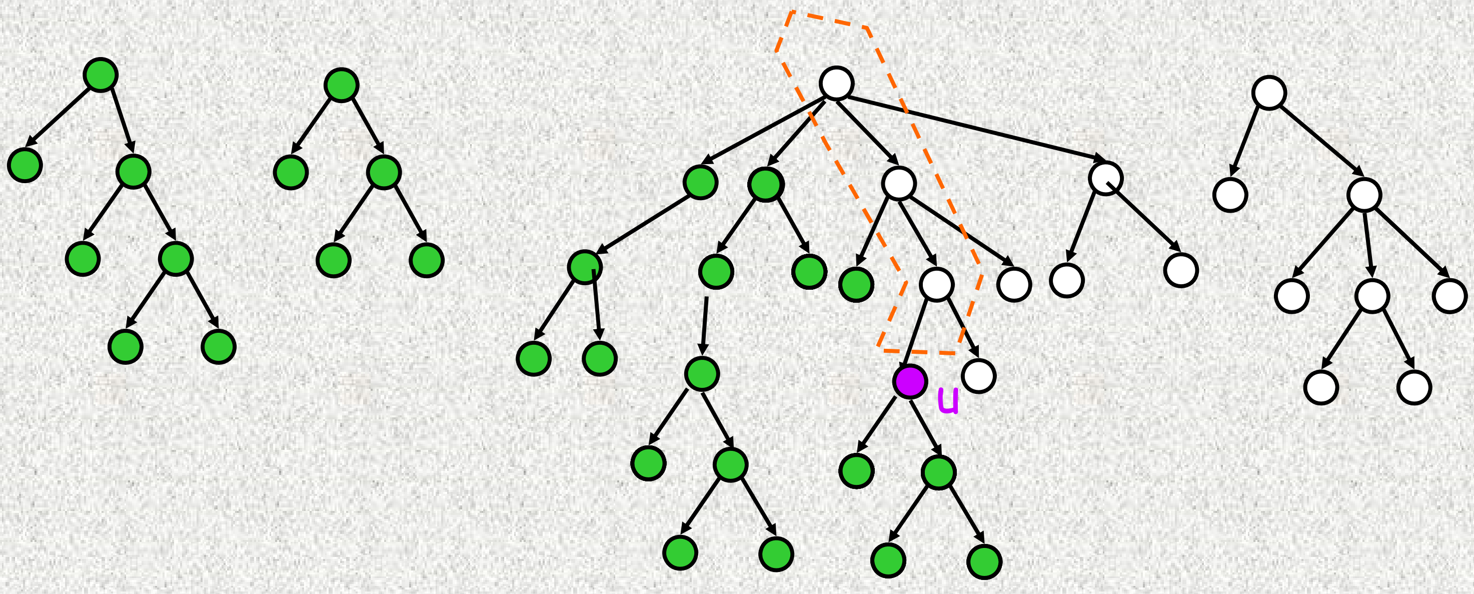
22-12c

All edges are:

tree edges ↓ Forward edges ↓ Cross edges ←



DFS Forest of G



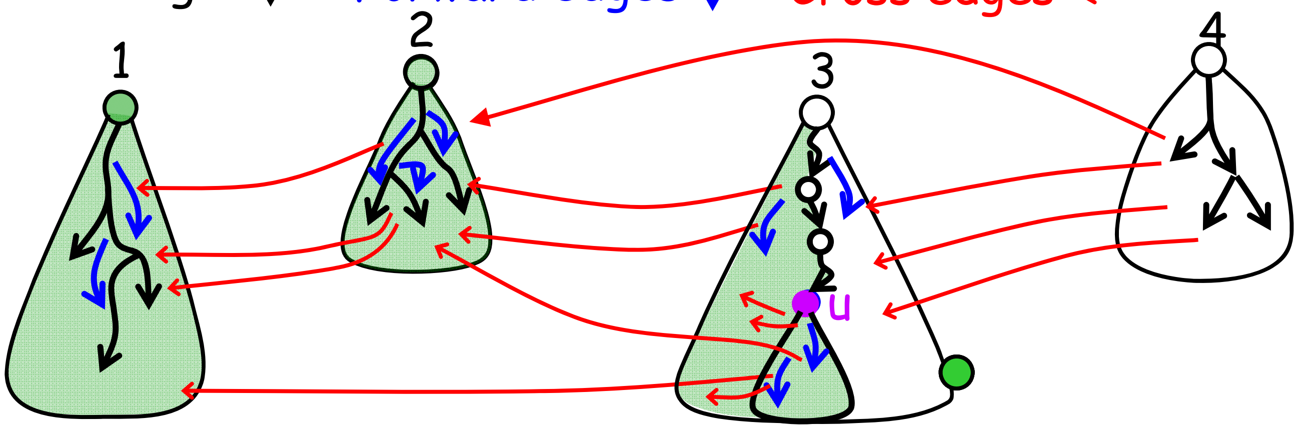
🟩 : f(🟩) < f(u) ⇨ may be arrived from u

□ : f(□) > f(u) ⇨ can not be arrived from u

22-12x

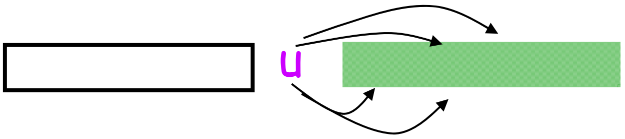
Topological sort - Correctness

All edges are:
tree edges ↓ Forward edges ↓ Cross edges ←



🟩 : f(🟩) < f(u) ⇨ may be arrived from u

□ : f(□) > f(u) ⇨ can not be arrived from u

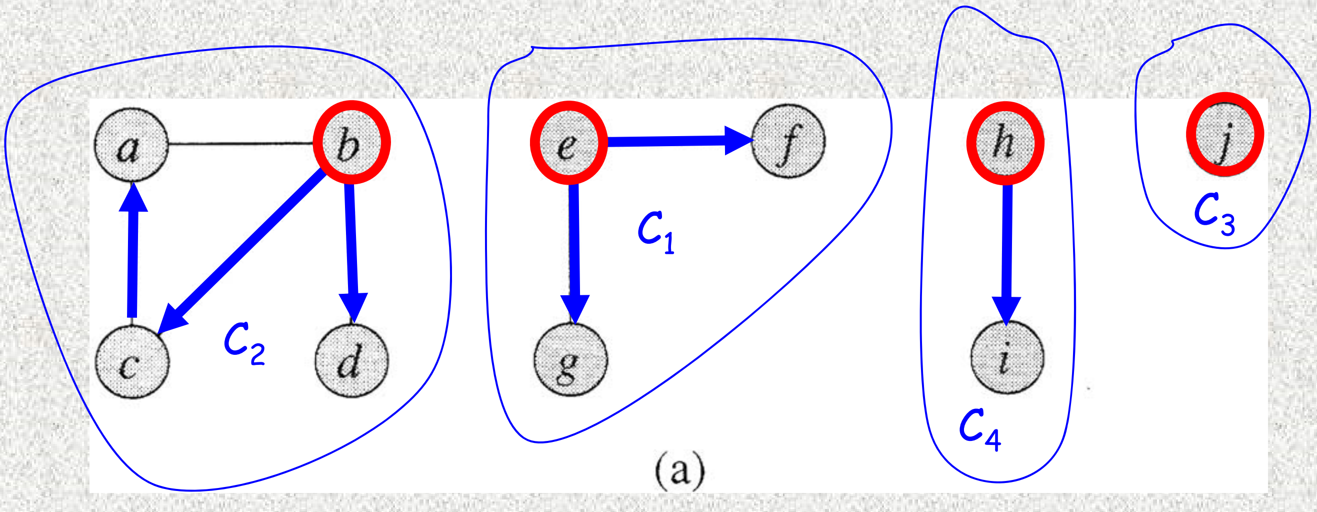
⇨


(in order of decreasing f(u))

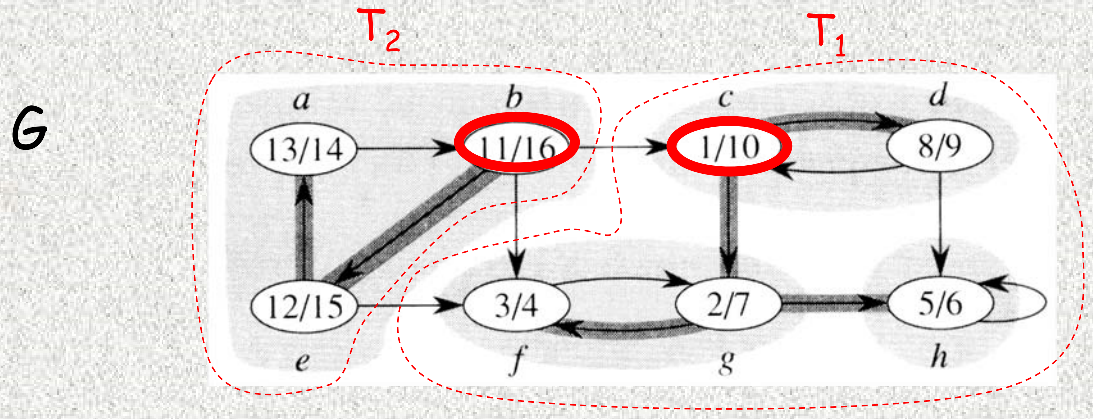
(all edges starting at u are from left to right)

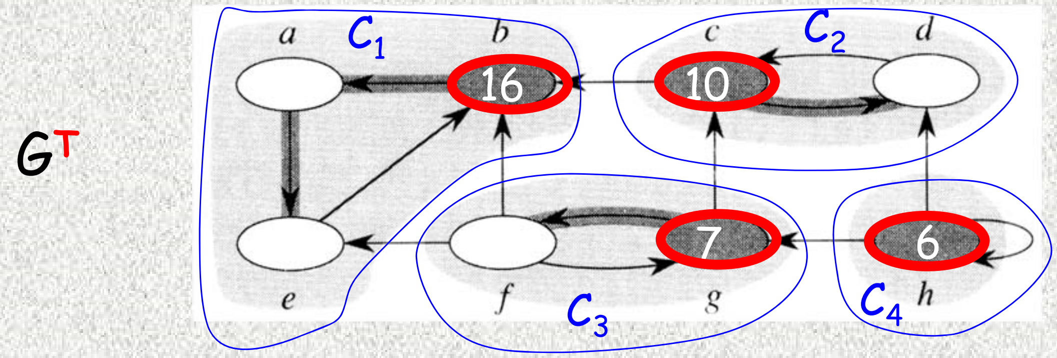
(all edges are from left to right)

Connected components of an undirected graph



(See 21-2 Fig., application of disjoint set)


G
T2
T1
a
b
c
d
13/14
11/16
1/10
8/9
12/15
3/4
2/7
5/6
e
f
g
h


G^T
a
C1
b
c
C2
d
16
10
7
6
e
f
C3
g
C4
h