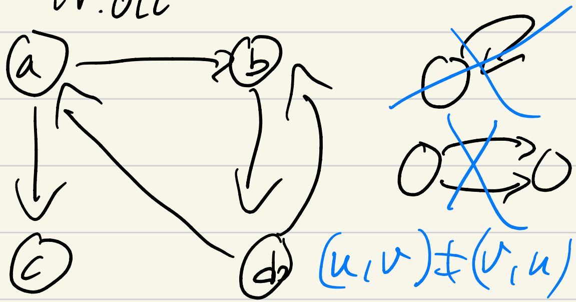
ÉLSÚLYOZATLAN (ELEMI) GRÁFOK

$G = (\underset{G.V}{V}, \underset{G.E}{E})$ $\quad E \subseteq V \times V \setminus \{(u,u) \mid u \in V\}$

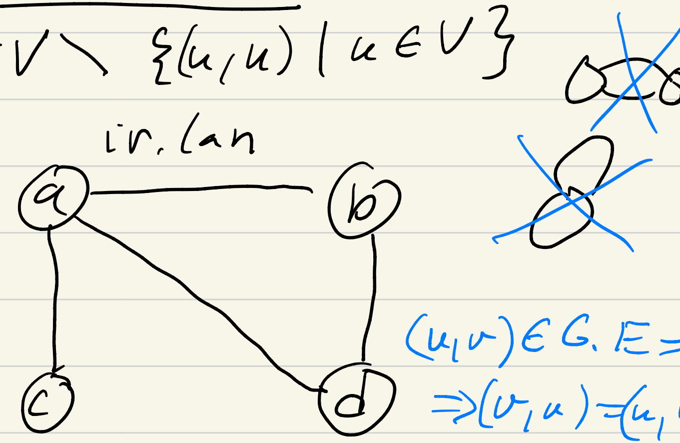
ir.ott



$(u,v) \neq (v,u)$

GRAFIKUS ÁBRÁZOLÁS

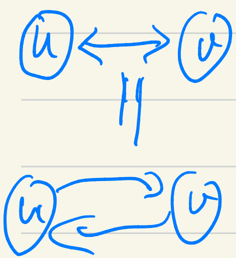
ir.lan



$(u,v) \in G.E \Rightarrow$
$\Rightarrow (v,u) = (u,v)$

$a=1, b=2, \dots, z=26$

$G.A(u) \overset{def}{=} \{v \in G.V \mid (u,v) \in G.E\}$



a → b; c.
b → d.
[c.]
d → a; b.

SZÖVEGES ÁBR.

a — b; c; d.
b — d.
[c.
d.]

$G = (\{a,b,c,d\}, \{(a,b),(a,c),(b,d),(d,a),(d,b)\})$?

Szomszédossági mtx-os repr.
(csúcsmtx.)

A/1 : $\mathbb{B}[n,n]$

$$A = \begin{array}{c|cccc} & a & b & c & d \\ \hline a & 0 & 1 & 1 & 0 \\ b & 0 & 0 & 0 & 1 \\ c & 0 & 0 & 0 & 0 \\ d & 1 & 1 & 0 & 0 \end{array}$$

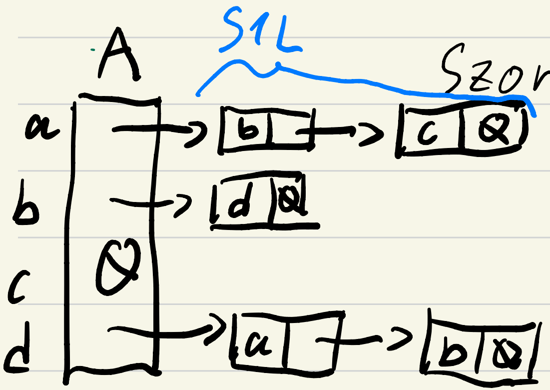
$$A[i,j]=1 \iff (i,j) \in G.E$$

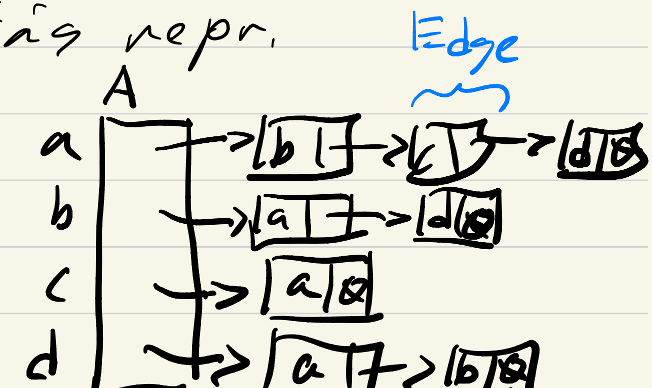
$$A = \begin{array}{c|cccc} & a & b & c & d \\ \hline a & 0 & 1 & 1 & 1 \\ b & 1 & 0 & 0 & 1 \\ c & 1 & 0 & 0 & 0 \\ d & 1 & 1 & 0 & 0 \end{array}$$

A/1 : Edge*[n]

Edge
+ v : N + next : Edge*

Szomszédossági listás repr.

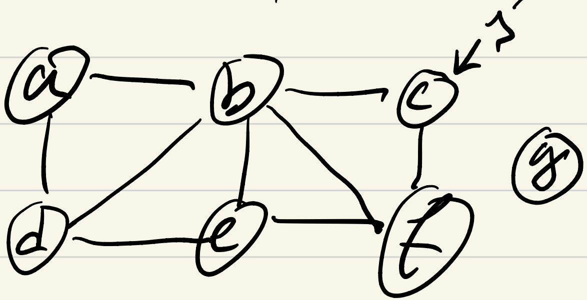




$(u,v) \in G.E \iff v \in A[u]$ lista

Szélességi gráfkeresés (BFS) Breadth-first search

(Adott csúcsból legröv. utakat ker...)



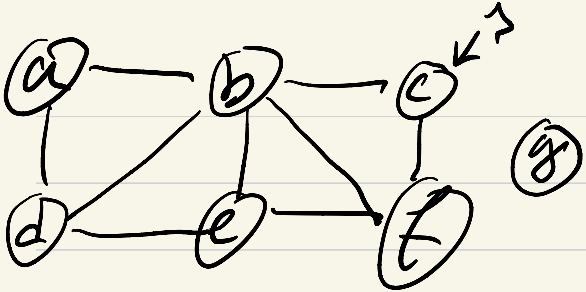
$$d(u) = \overbrace{s \xrightarrow[\text{opt}]{} u}^{\text{hossza}}$$

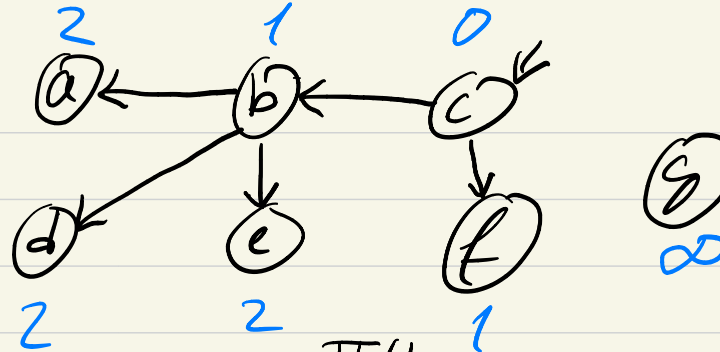
$$\pi(u) \qquad \overbrace{s \longrightarrow \circ \longrightarrow u}^{\text{opt}}$$

$$d(s) = 0$$
$$\pi(s) = \emptyset$$

$\nexists\ s \rightsquigarrow u$ út!

$$d(u) = \infty$$
$$\pi(u) = \emptyset$$





d() π()

a	b	c	d	e	f	g	kiterjeszt :d()	Queue	a	b	c	d	e	f	g
∞	∞	0	∞	∞	∞	∞		⟨c⟩	Ø	Ø	Ø	Ø	Ø	Ø	Ø
	1				1		c : 0	⟨b, f⟩		c				c	
2			2	2			b : 1	⟨f, a, d, e⟩	b			b	b		
							f : 1	⟨a, d, e⟩							
							a : 2	⟨d, e⟩							
							d : 2	⟨e⟩							
							e : 2	⟨⟩							
2	1	0	2	2	1	∞	eredmény		b	c	Ø	b	b	c	Ø
a	b	c	d	e	f	g			a	b	c	d	e	f	g

repr.

```
BFS(A/1 : Edge*[n] ; s : 1..n ; d/1, π/1 : ℕ[n])        ∞ ~ n
                                                        0 ~ 0
i := 1 to n
    d[i] := n ; π[i] := 0
d[s] := 0 ; Q : Queue ; Q.add(s)
¬Q.isEmpty()
    u := Q.rem() ; p := A[u]
    p ≠ 0
        v := p->v ; p := p->next
        d[v] = n
        d[v] := d[u]+1        | X
        π[v] := u             |
        Q.add(v)              |
```

$MT(n,m) \in \Theta(n+m)$

$mT(n) \in \Theta(n)$

$$MT(n,m) = \underset{\geq\; n+m}{\overset{2(n+m)\;\geq}{2n+m}}$$

$\Downarrow$

$MT(n,m) \in \Theta(n+m)$

$MS(n) \in \Theta(n)$

$mS(n) \in \Theta(1)$

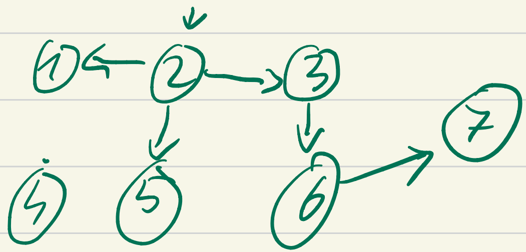
HF Adott a BFS eredményeként kapott π tömb és az s start csúcs. Írjuk meg az
$print\_opt\_path(\pi/1:\mathbb{N}[n];\ s,u:1..n)$
eljárás struktogramját, ami kiírja az $s \leadsto u$ optimális utat, vagy ha $\nexists\ s \leadsto u$ út, akkor azt, hogy "s-ből u nem érhető el." (s és u helyett a megfelelő indexekkel.)

Pl ha π:

1	2	3	4	5	6	7
2	0	2	0	2	3	6

, $s=2$, $u=7$, akkor az output:

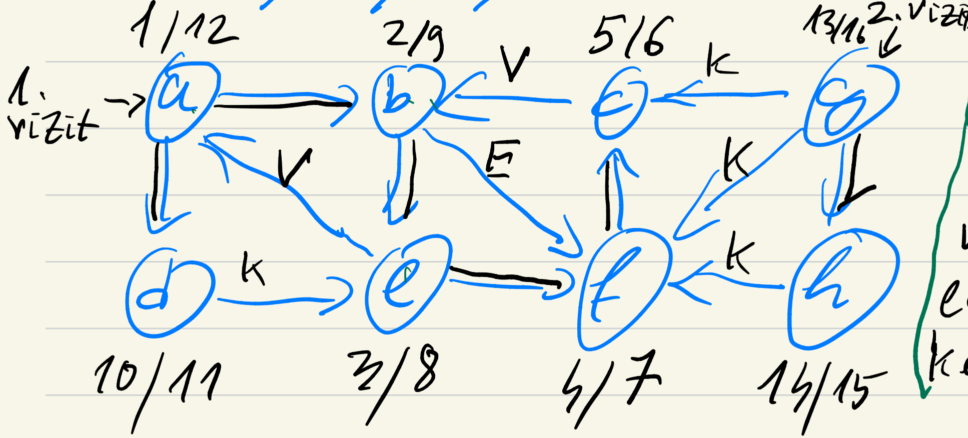
„$2 \to 3 \to 6 \to 7$."



$MT(n) \in \Theta(n)$

$MS(n) \in \Theta(n)$

Mélységi gráfker (bejárás) [ir.ott gráfokon]



(u,v) él feldolgozása:

fa-él: fehér csúcsba mutat (amikor feld.)

vissza-él: szürkébe

előre-él: feketében $\wedge\ d(u) < d(v)$

kereszt-él: —||— $\wedge\ d(u) > d(v)$

$\pi(b) = a,\ \pi(d) = a,\ \pi(e) = b, \dots$

v ↑ a b e | verem: a, b, e | e out | b, e | e → a output | e | e → a → b | | e → a → b → e output

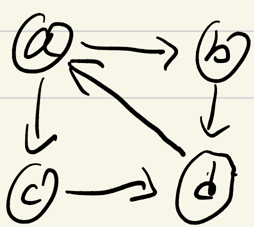
struktúra: StHF

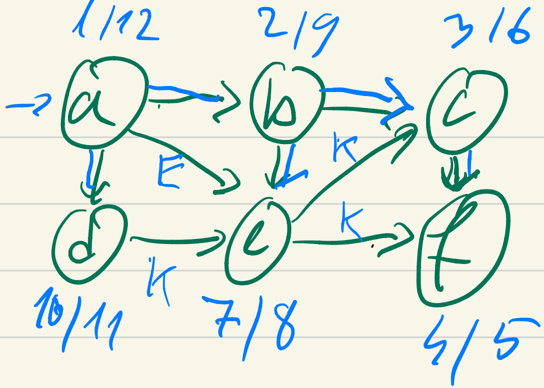
Körkiíró 2p

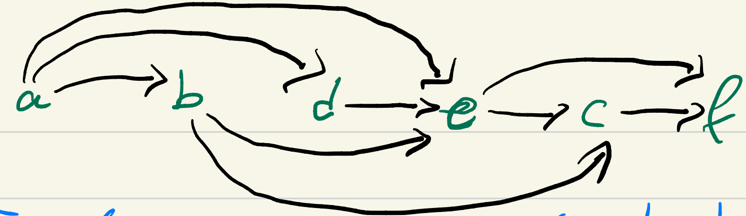
$(\pi/1{:}N[n];$

$u, v: 1..n)$

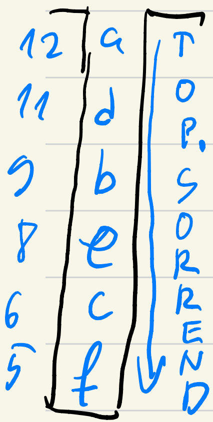
vissza-él







Topologikus sorrend: $\langle a, b, d, e, c, f \rangle$



Stack

Alg Topologikus rendezés: $MT(n,m) \in \Theta(n+m)$

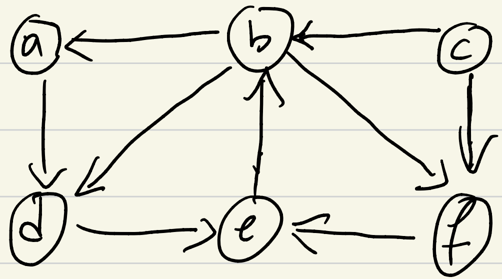
SzHF → szomszédossági listás repr.-ra 5p

csúcsmtx: 4p

stuki vagy C program papíron

XOR

HW2



textual representation of the graph

$a \to d.$ $b \to a; d; f.$ $c \to b; f.$
$d \to e.$ $e \to b.$ $f \to e.$

3p

a) Illustrate DFS on this graph.

b) When does it turn out that this graph does not have topological order?

c) Delete a single edge so that the remaining graph has a topological ordering.

d) Illustrate the process of topological sorting of the remaining graph.