

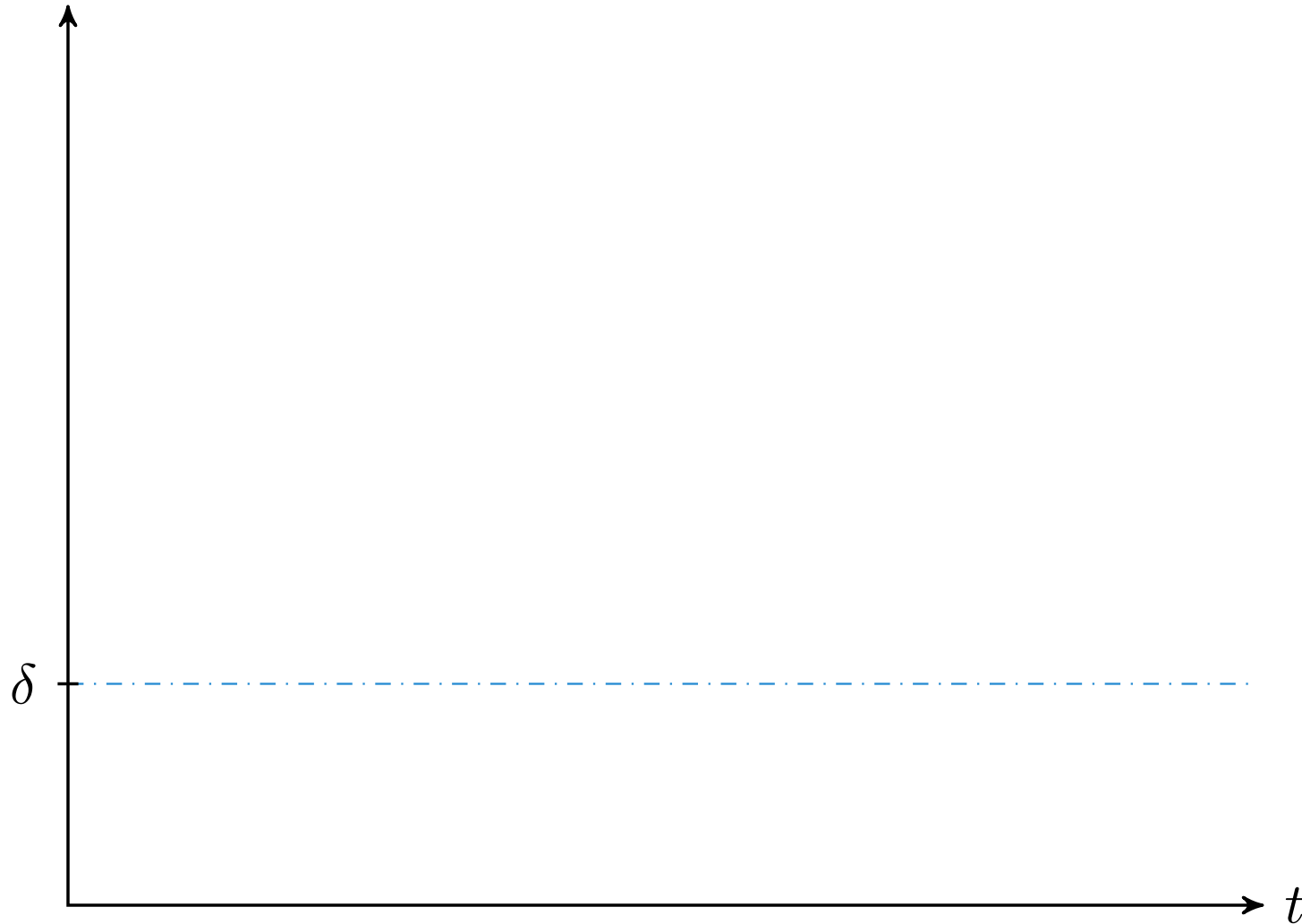
Forelesning 10

Bonusmateriale

Ting som ikke ble med i forelesningen, men som kanskje kan være av interesse

Noe av stoffet innimellom her er også
brukt i forelesningen, men er gjentatt
her for å gjøre fremstillingen mer
sammenhengende.

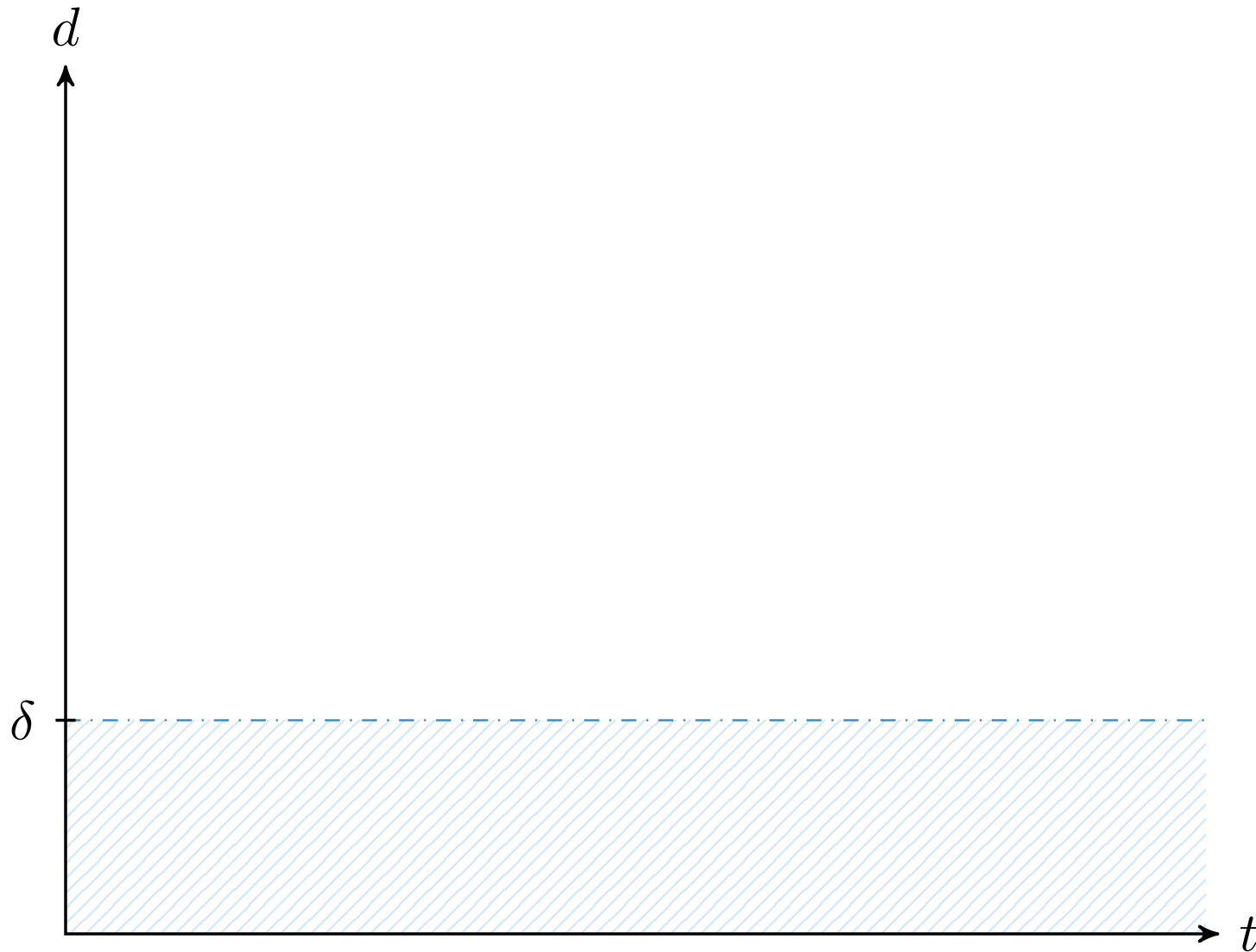
Mer om kantslakking



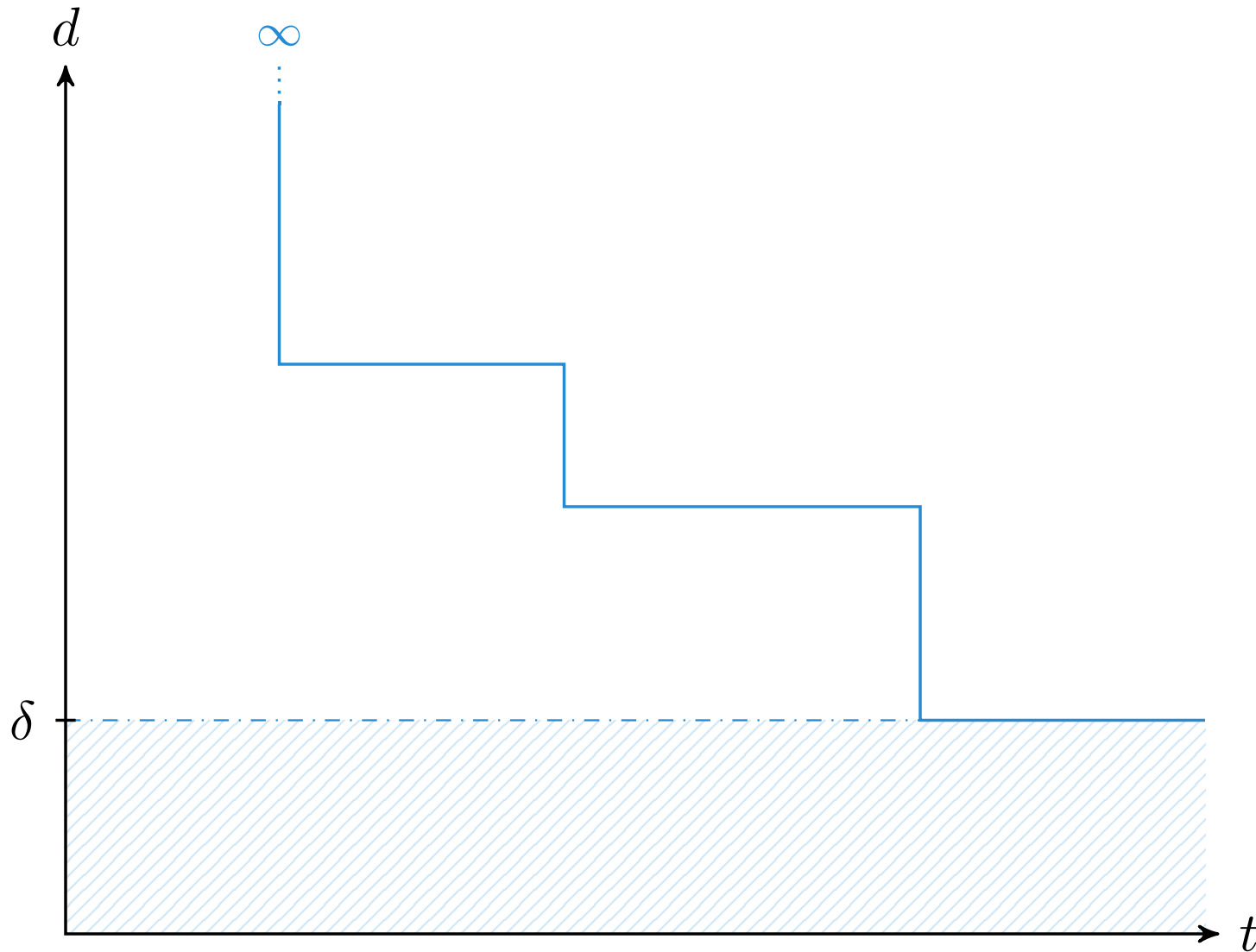
Avstanden $\delta(s, v)$ er ukjent til å begynne med



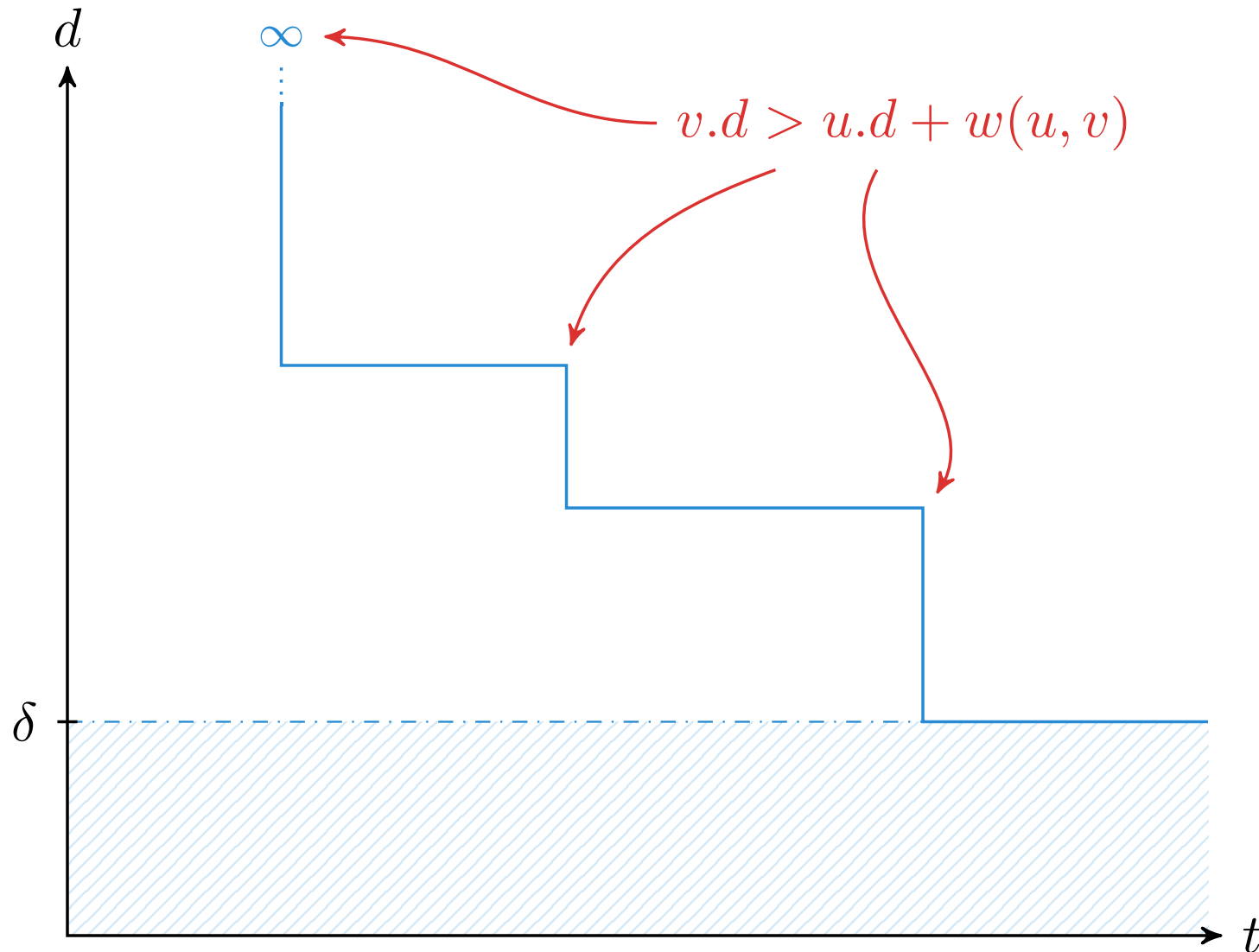
Vi leter etter bedre veier; $v.d$ er best så langt



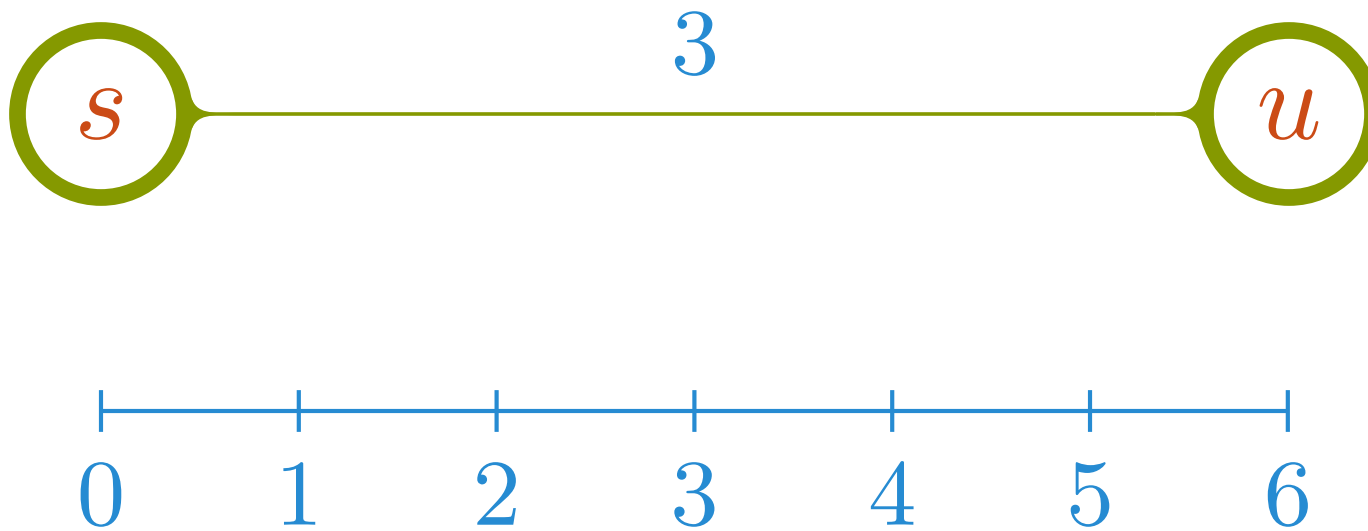
Vi kan naturligvis aldri få $v.d$ mindre enn $\delta(s, v)$



Hver gang vi finner en snarvei $s \rightsquigarrow u \rightarrow v$, synker estimatet



Hver gang vi finner en snarvei $s \rightsquigarrow u \rightarrow v$, synker estimatet



Her er s startnoden, og avstans-overestimateret $u.d$ er 6



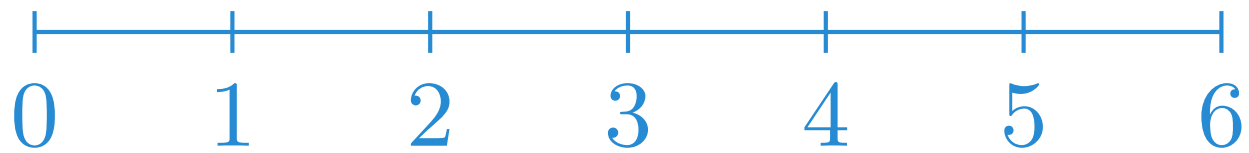
Men esimtattet her trenger ikke være mer enn 3



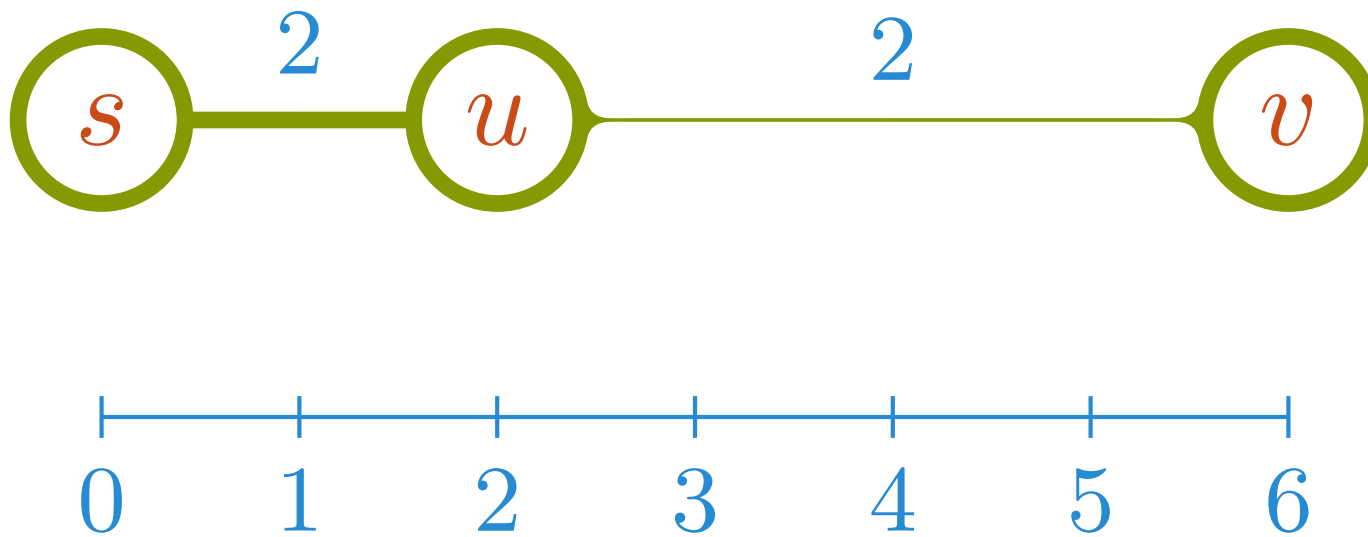
Men esimatet her trenger ikke være mer enn 3



Kanskje det finnes en kortere vei, men avstanden er maks 3



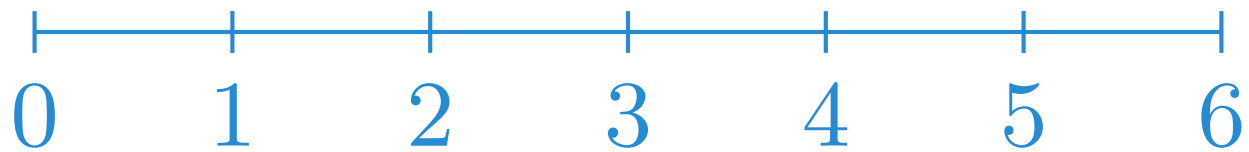
Her er $u.d$ for stor; trenger maks være 2



Men nå ser vi at $v.d$ er for stor; trenger maks være $d.u + 2 = 4$

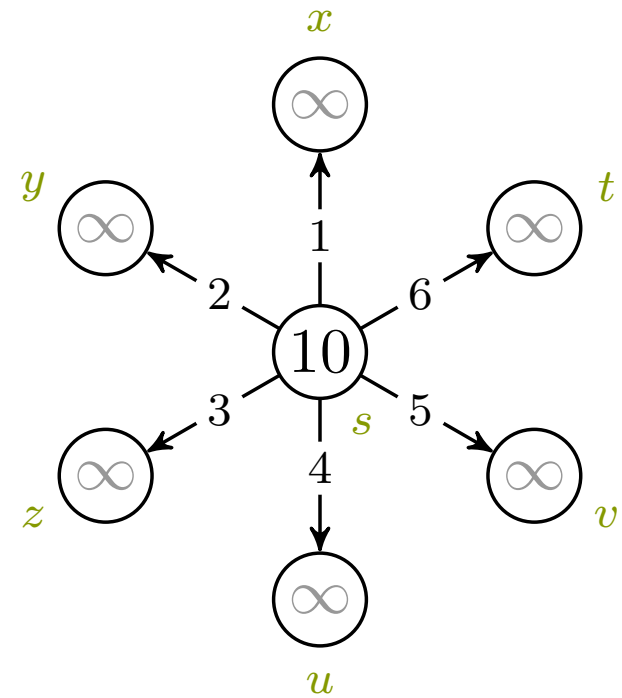


Finnes andre kanter, så kan veien være kortere; ikke lengre!

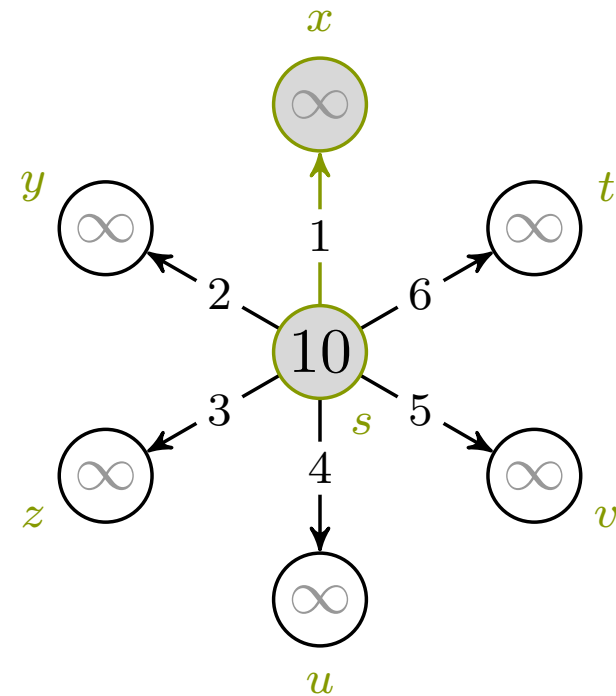


Er dette den korteste stien, så er $u.d$ og $v.d$ nå korrekte

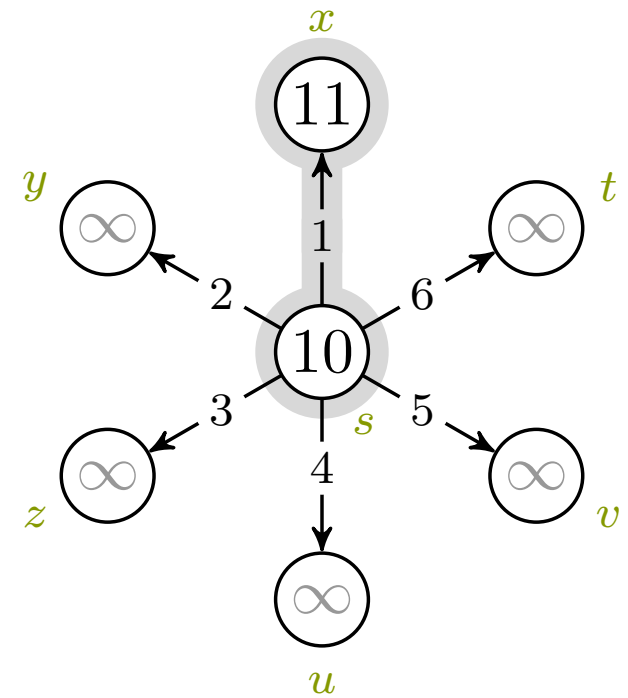
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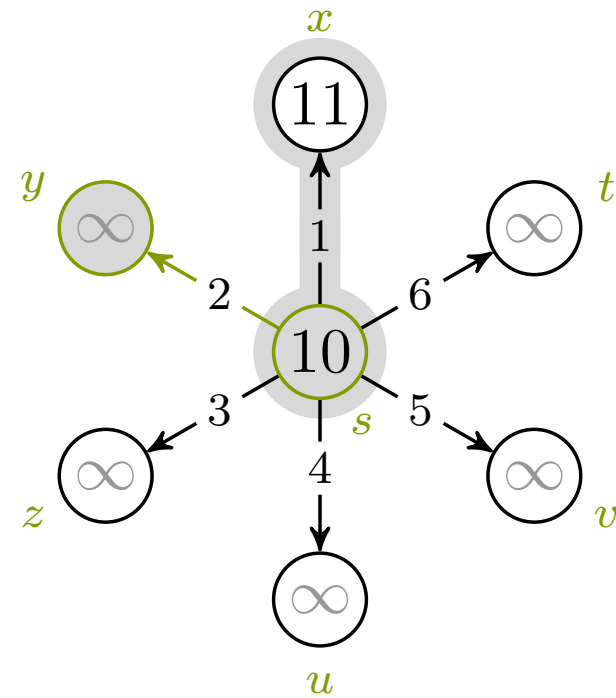
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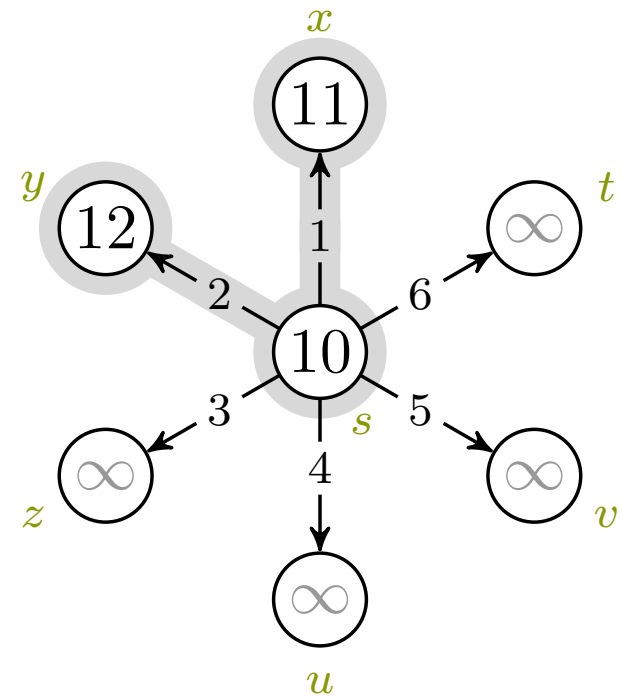
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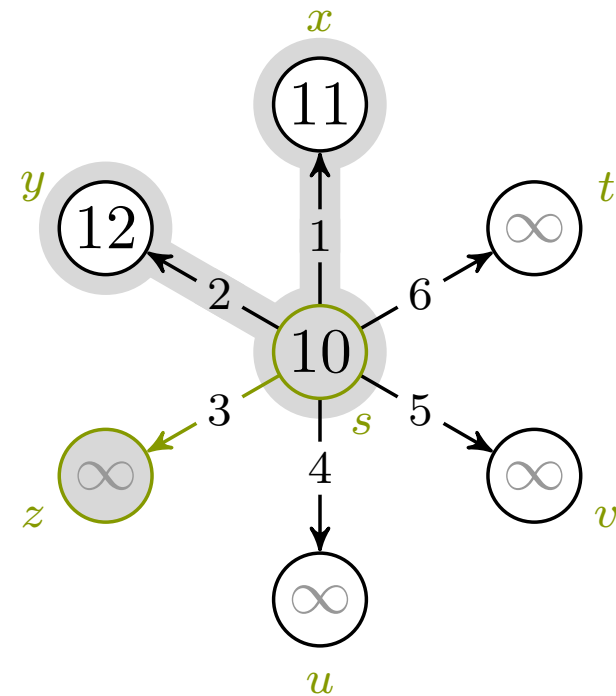
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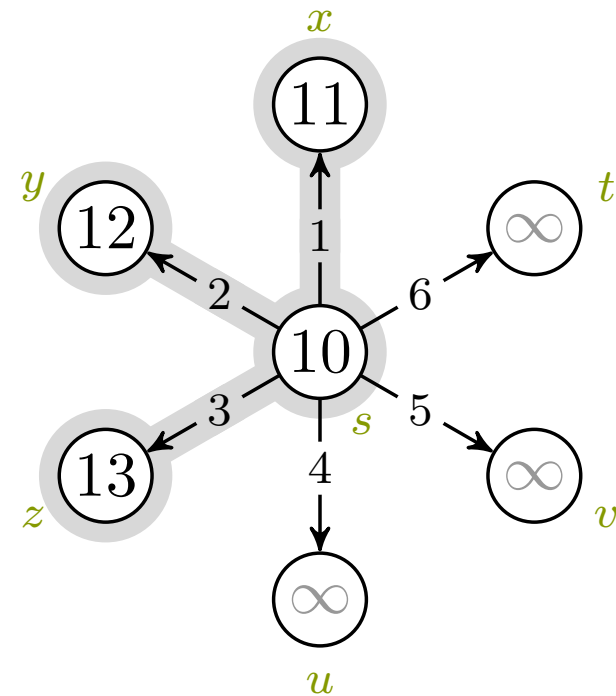
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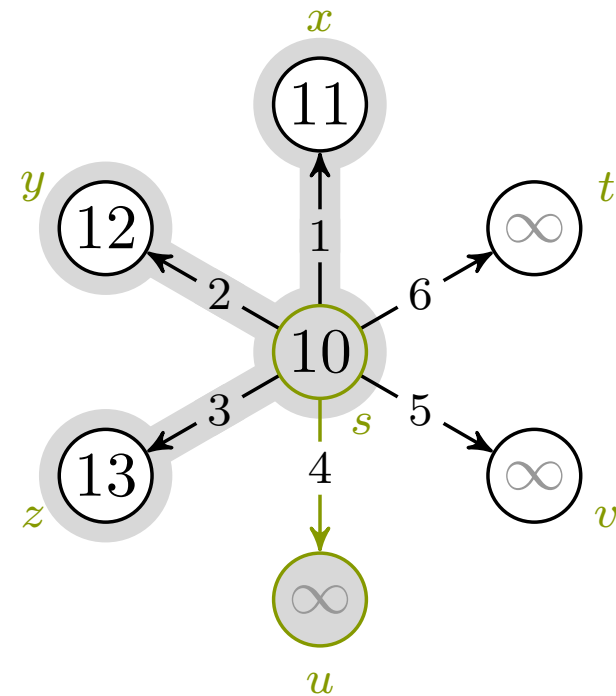
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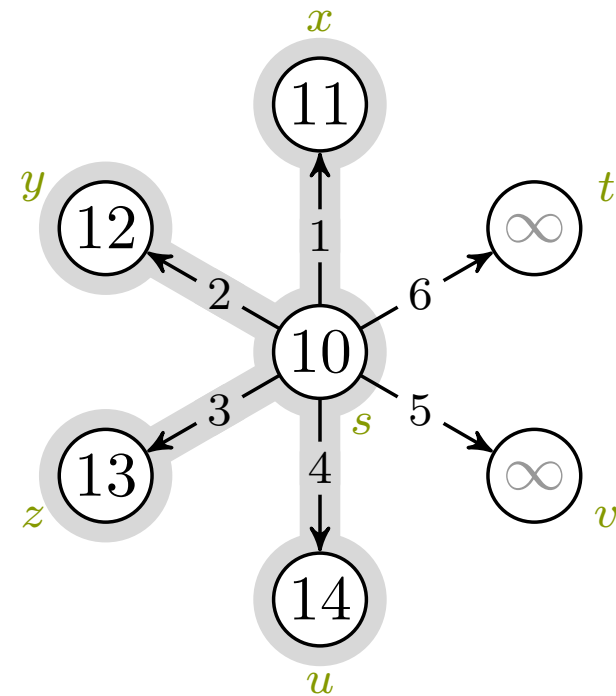
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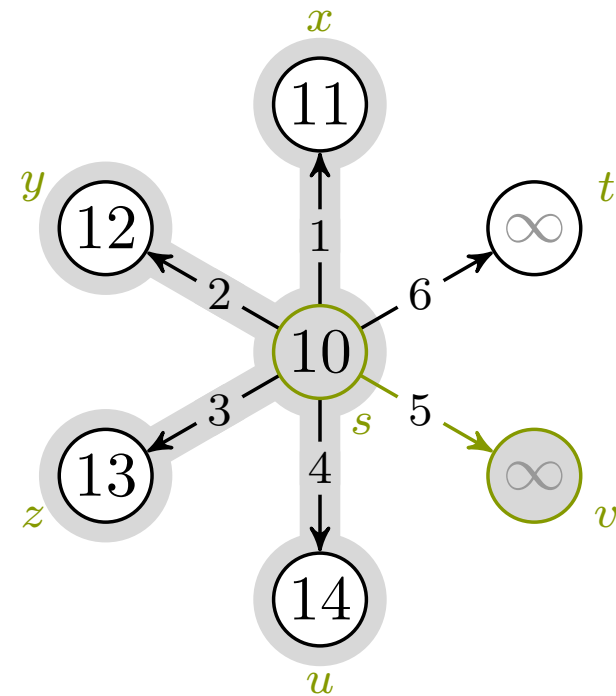
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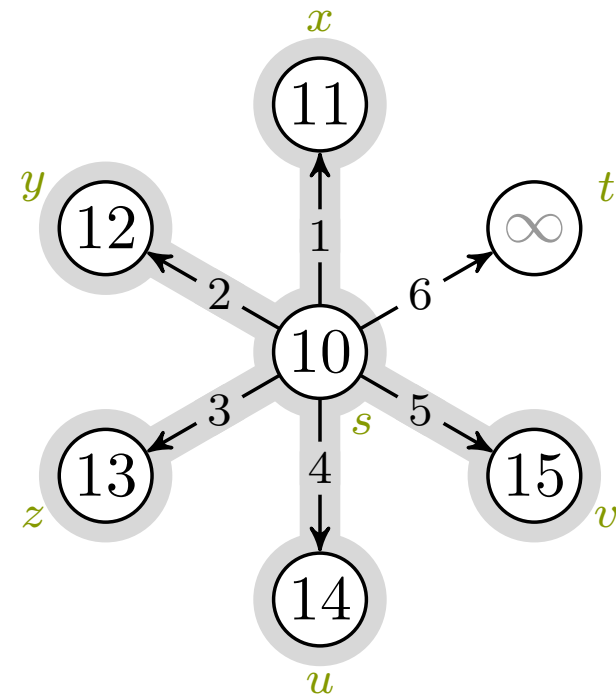
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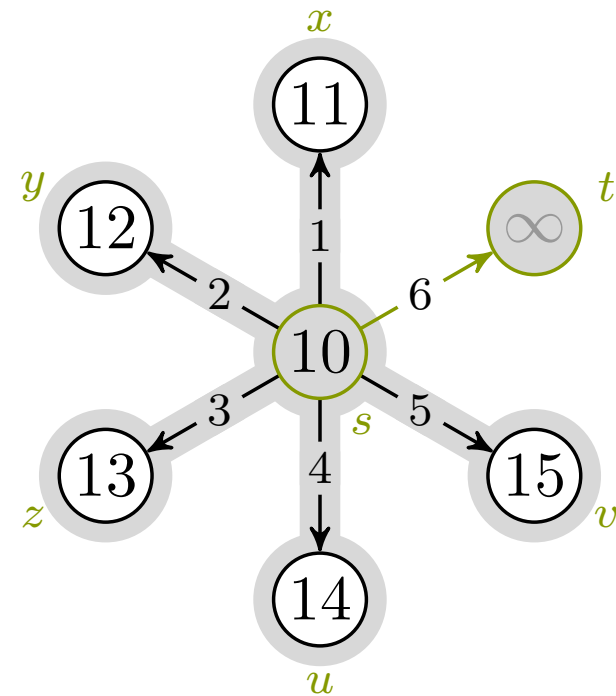
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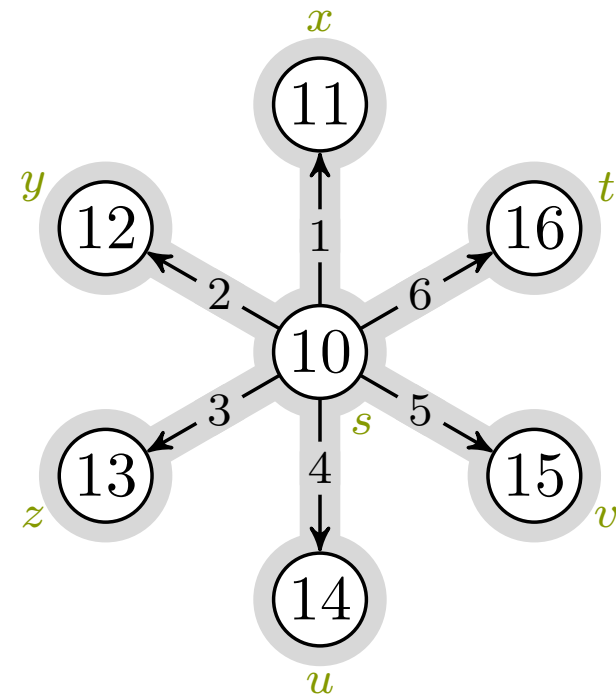
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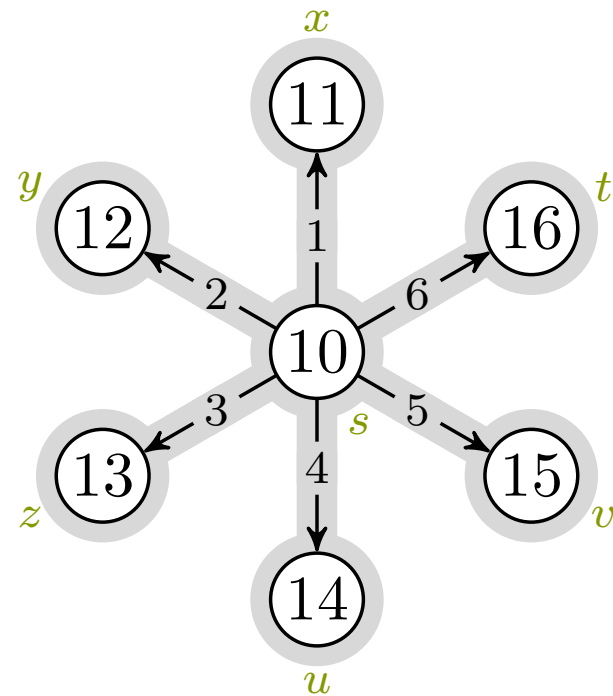
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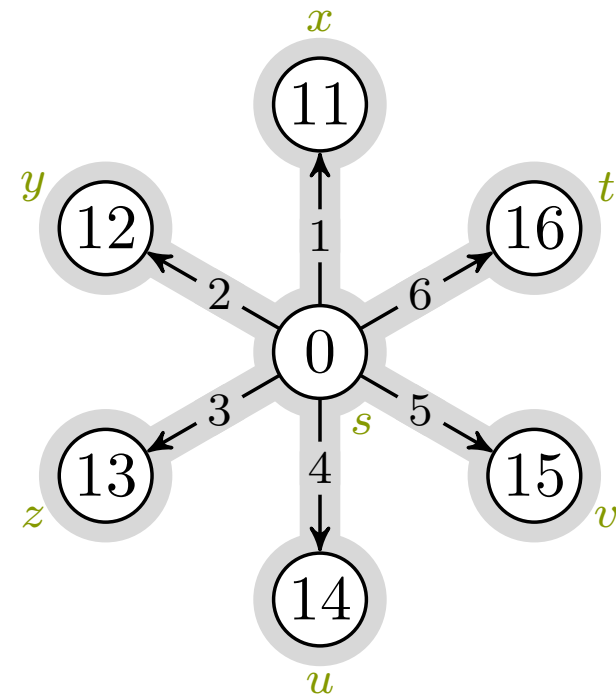


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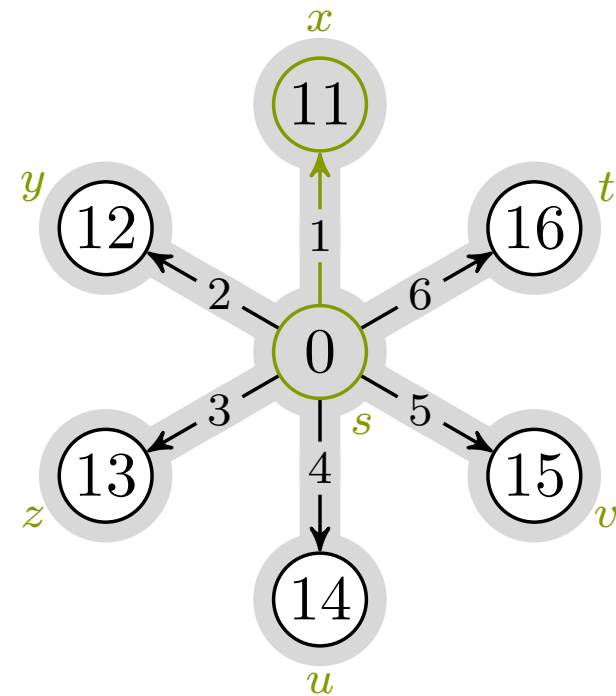
Ferdig...

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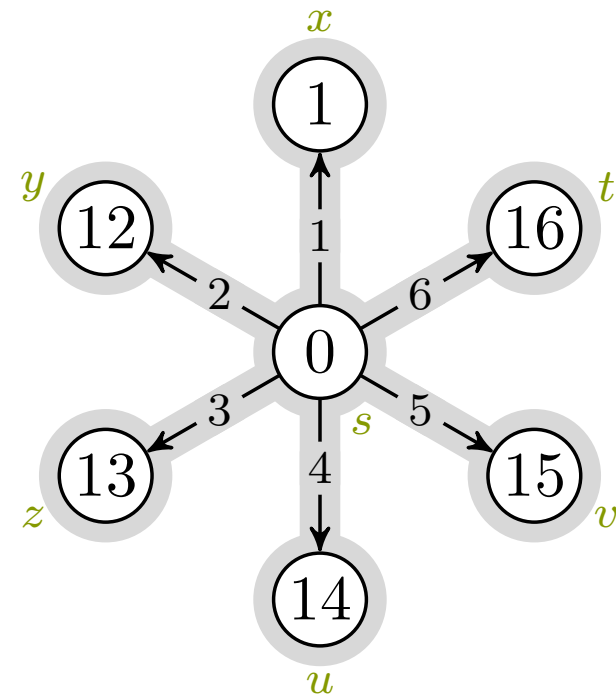


...med mindre $s.d$ endres!

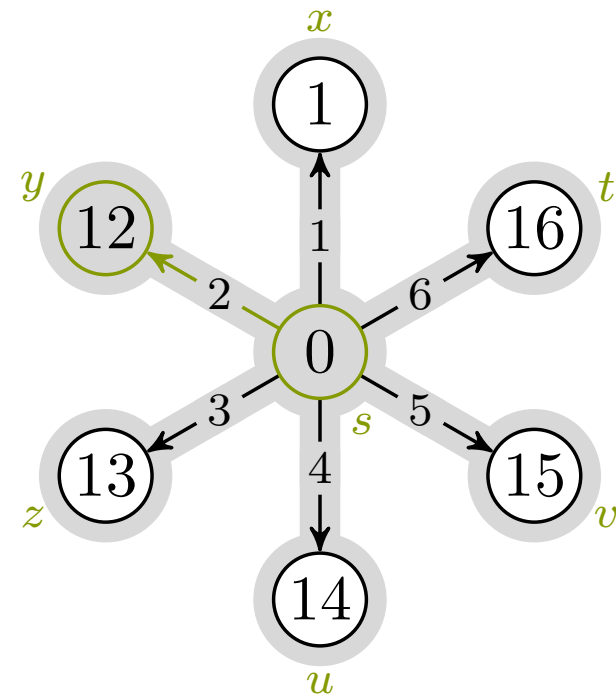
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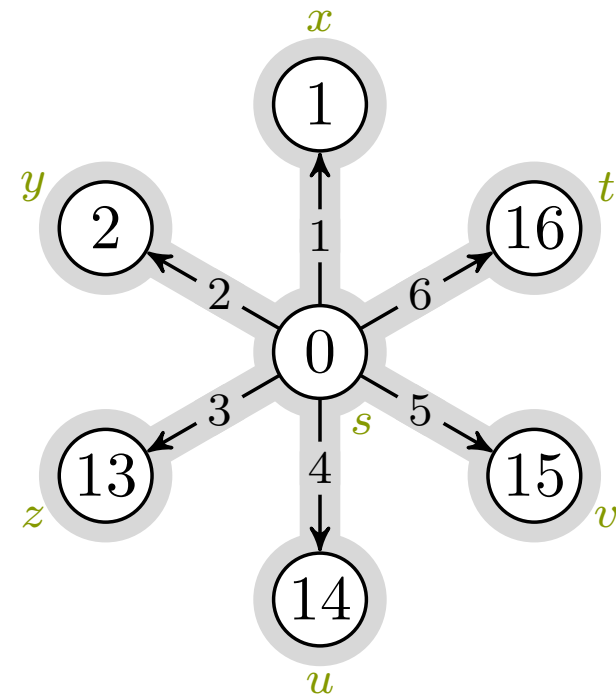
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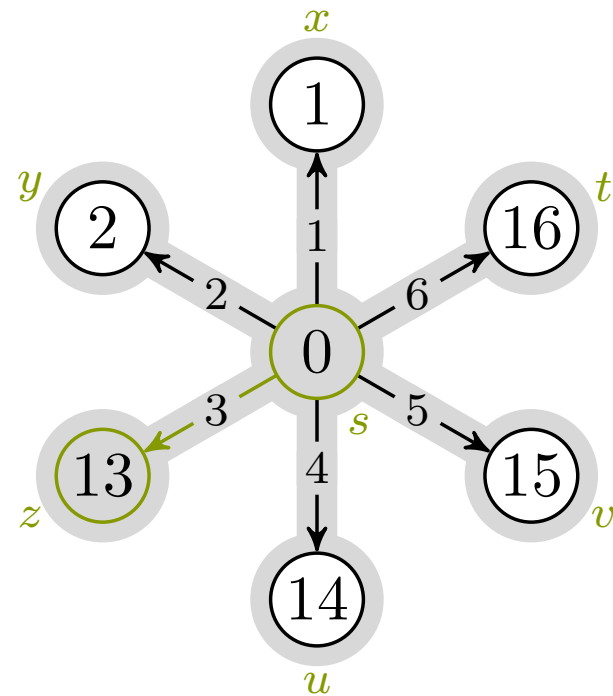
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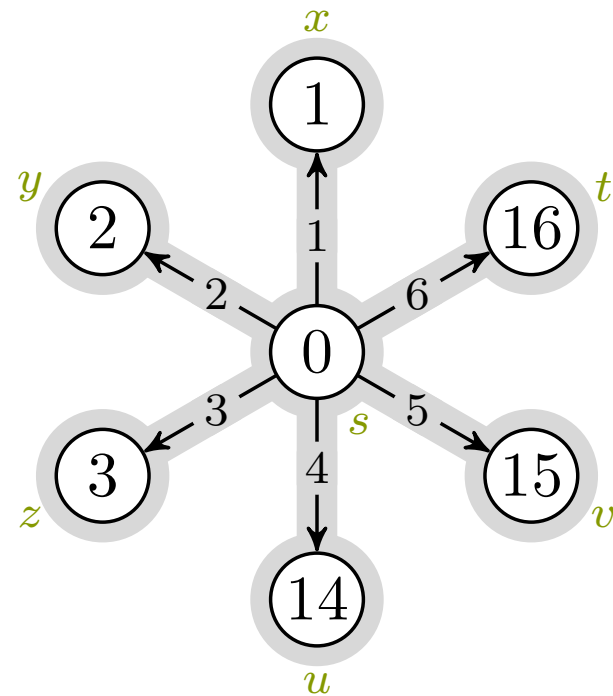
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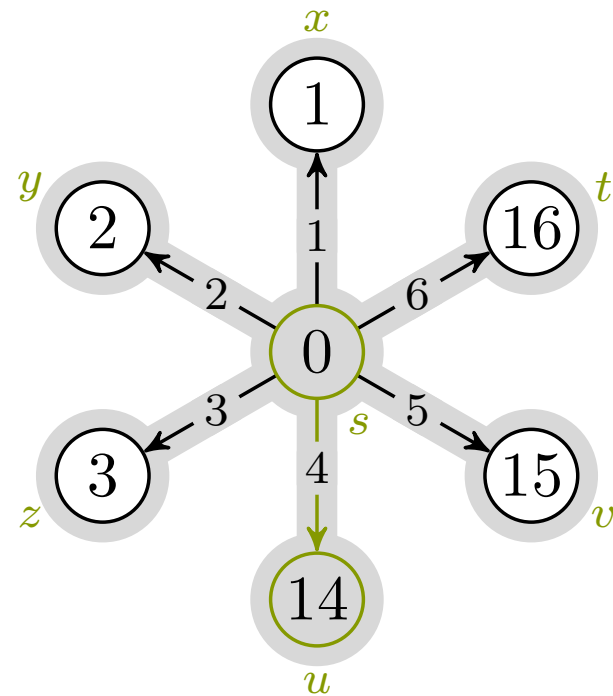
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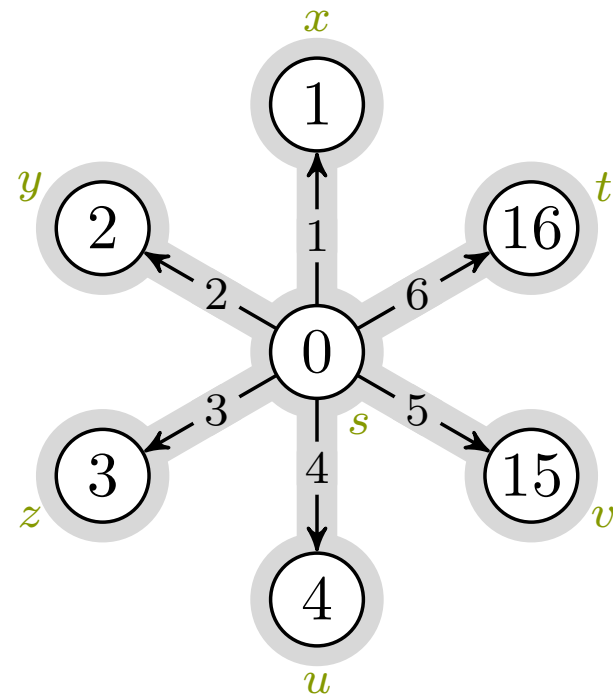
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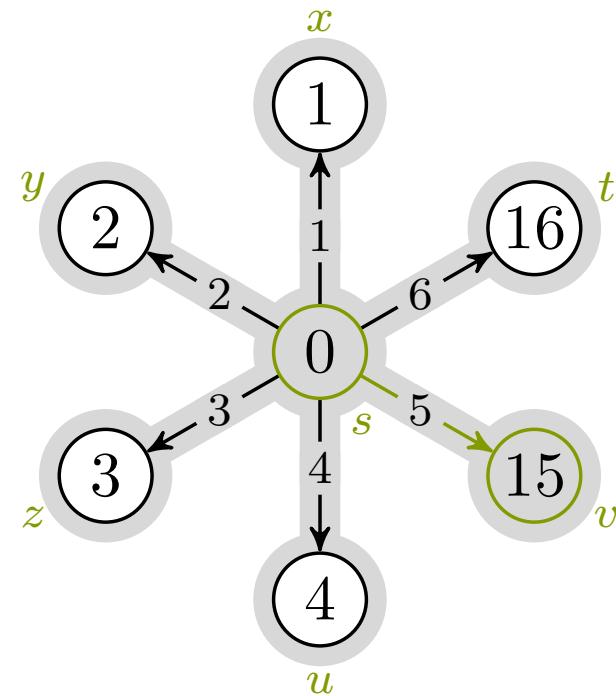
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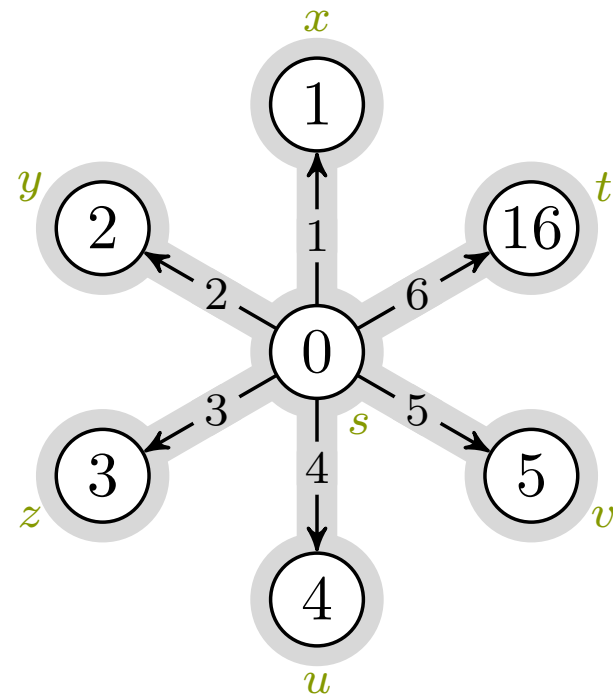
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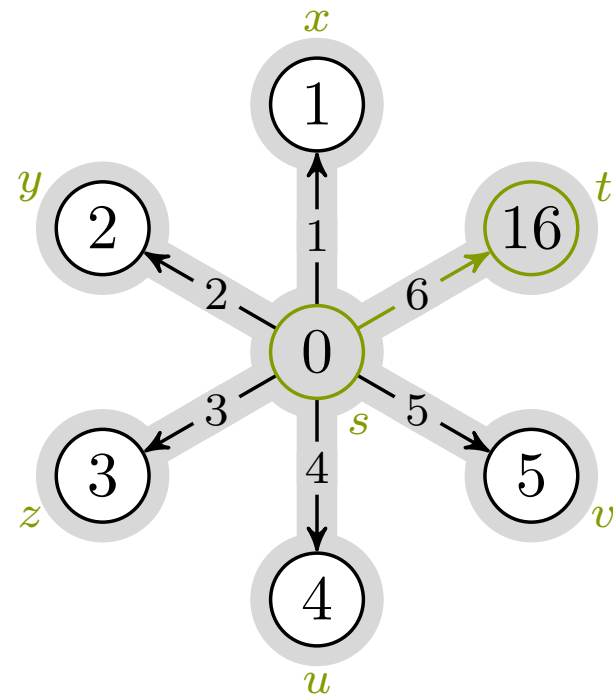
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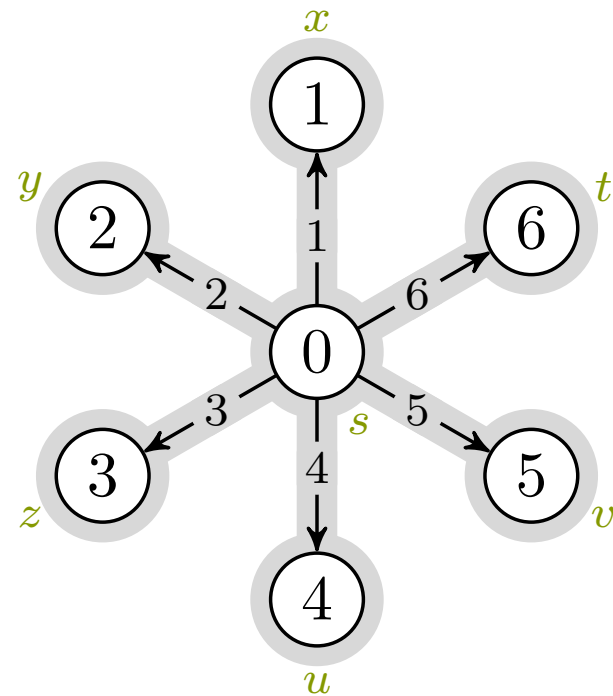
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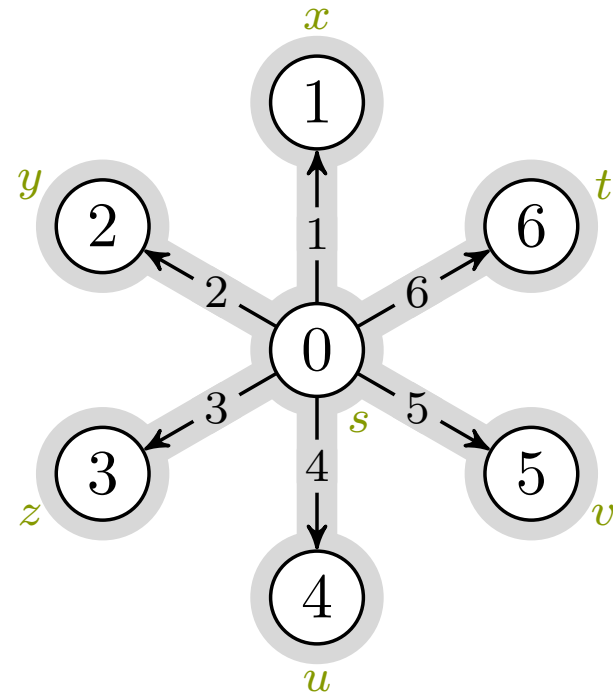
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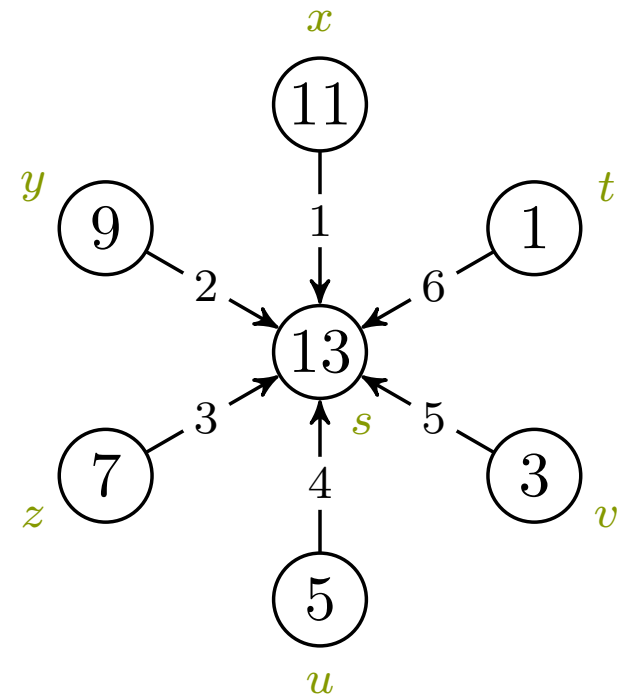
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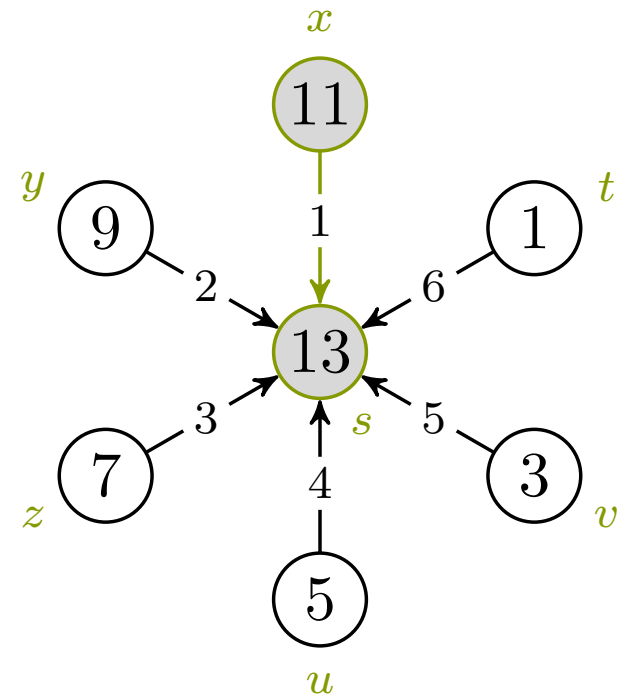
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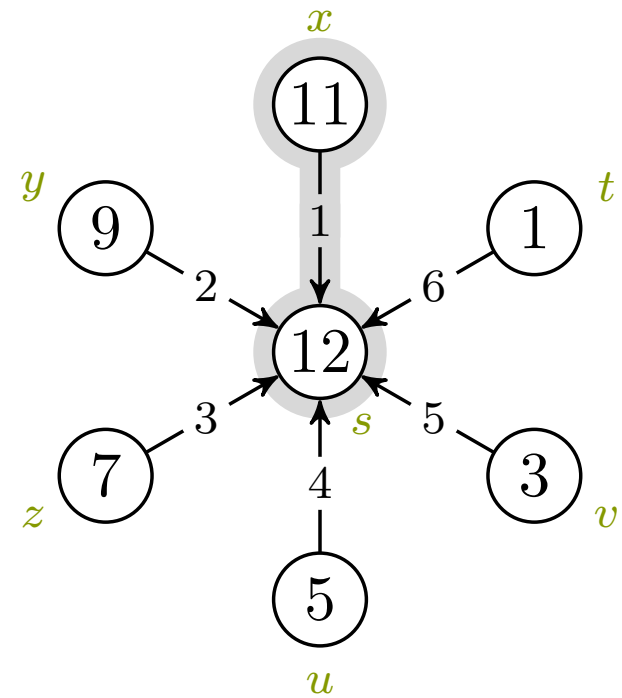
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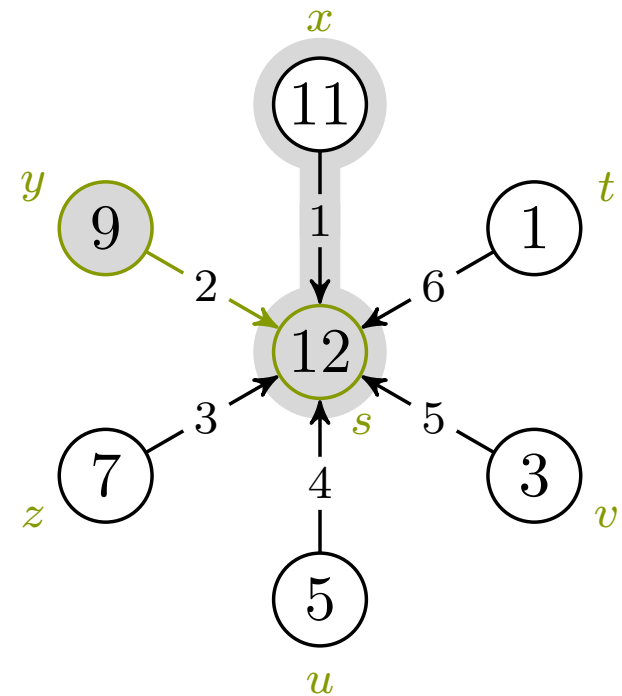
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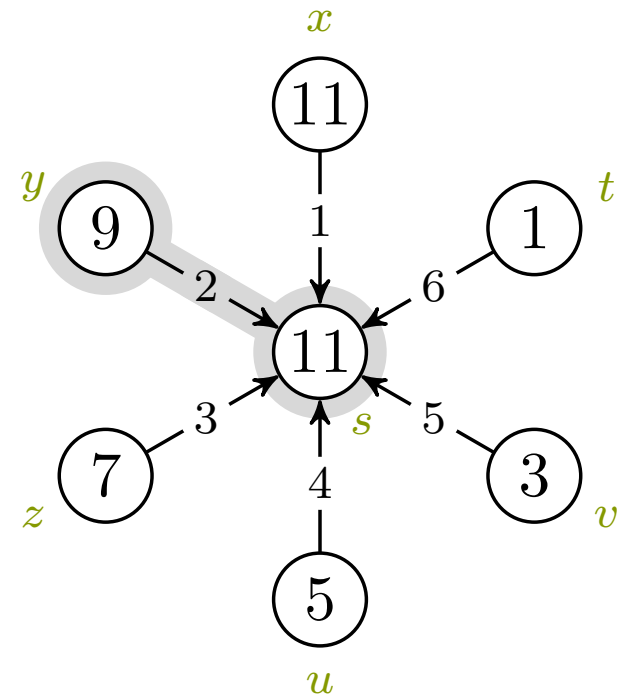
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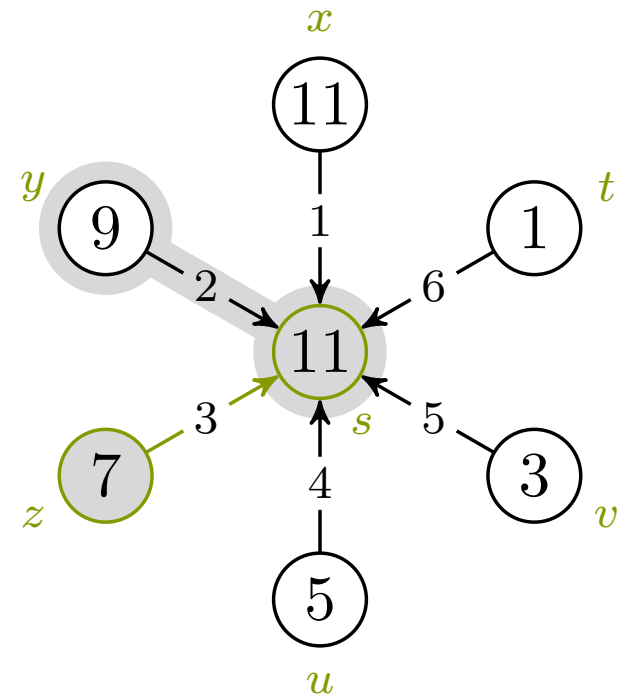
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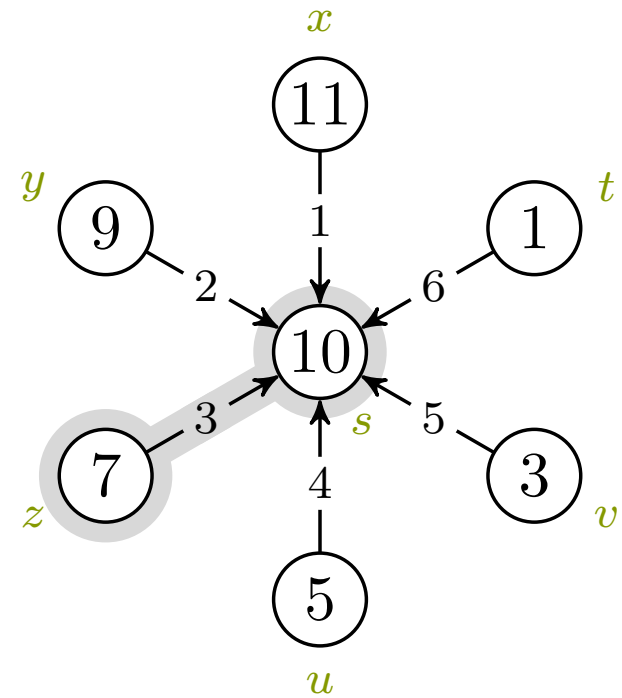
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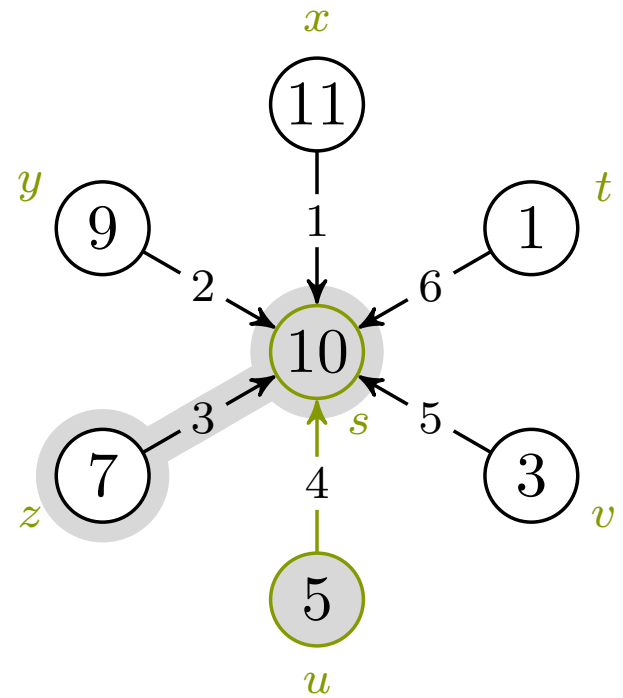
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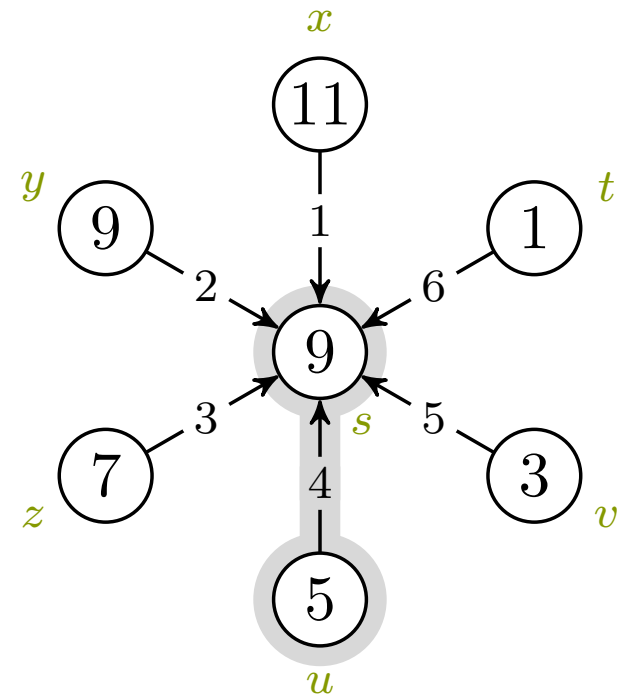
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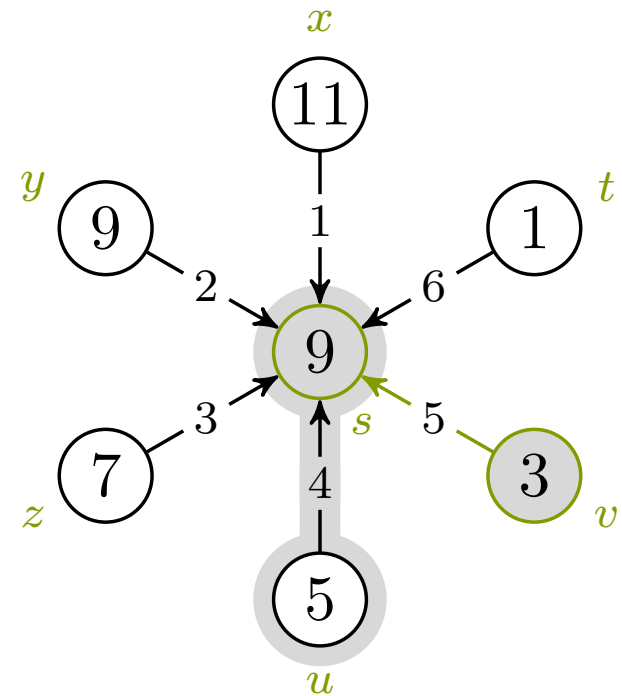
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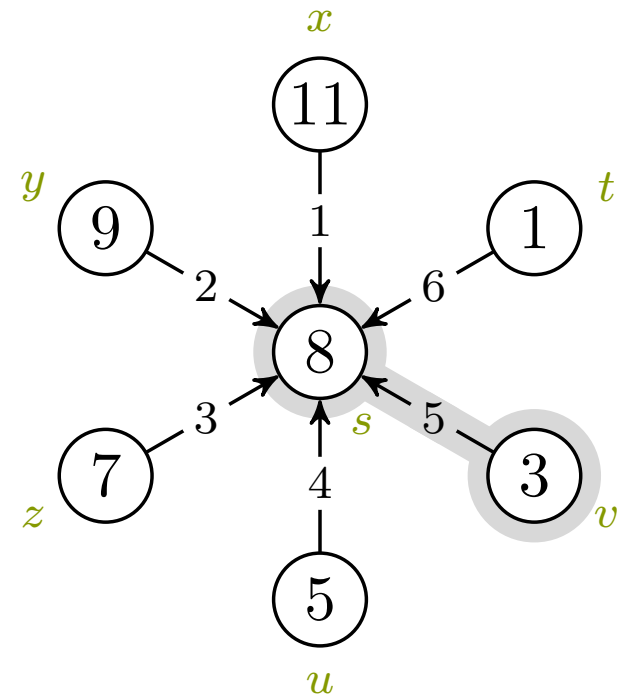
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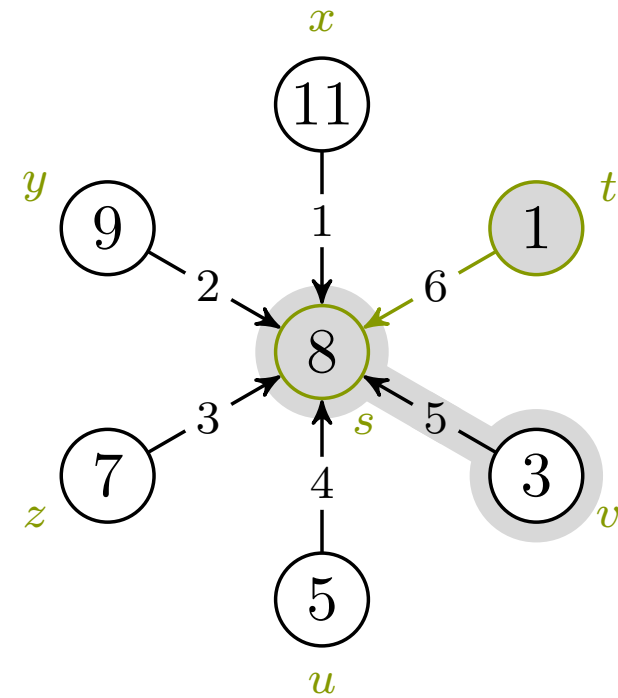
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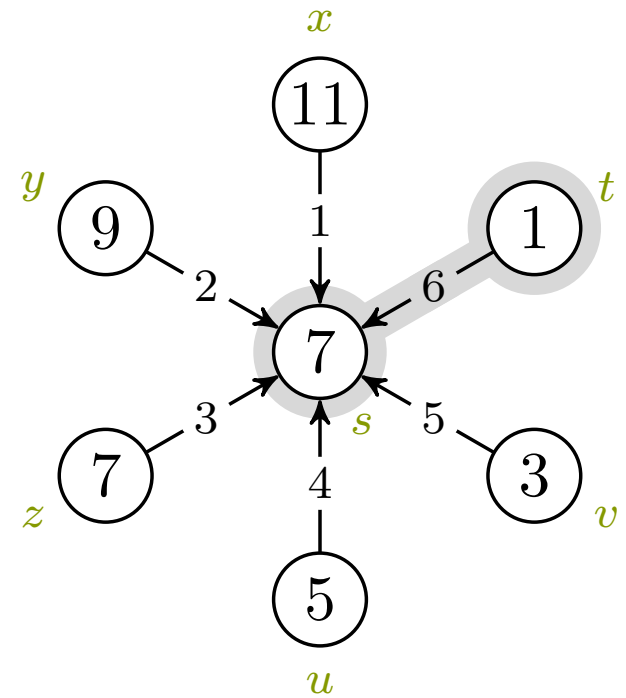
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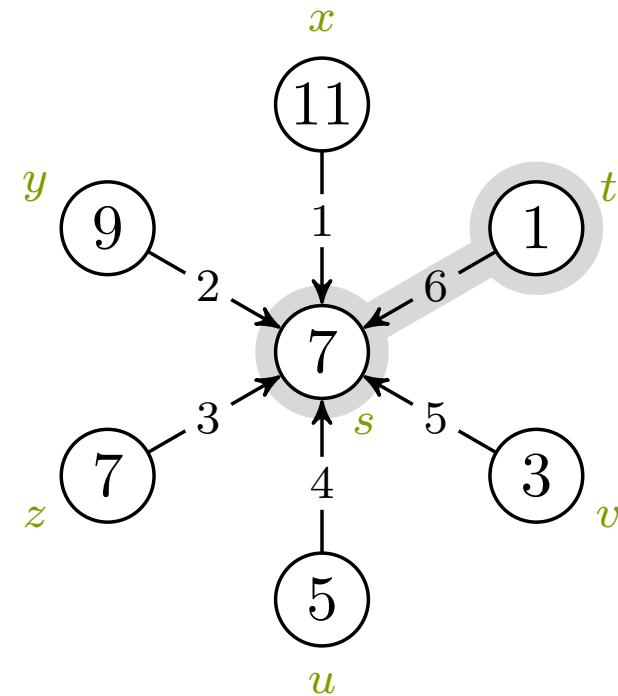
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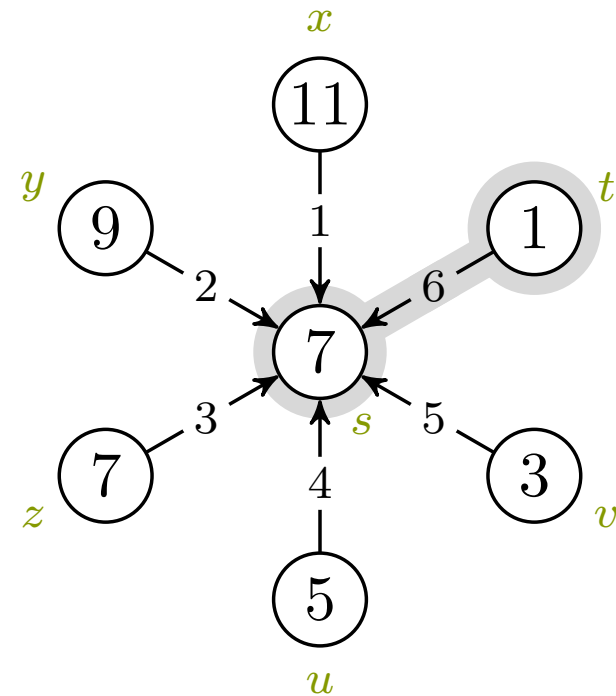


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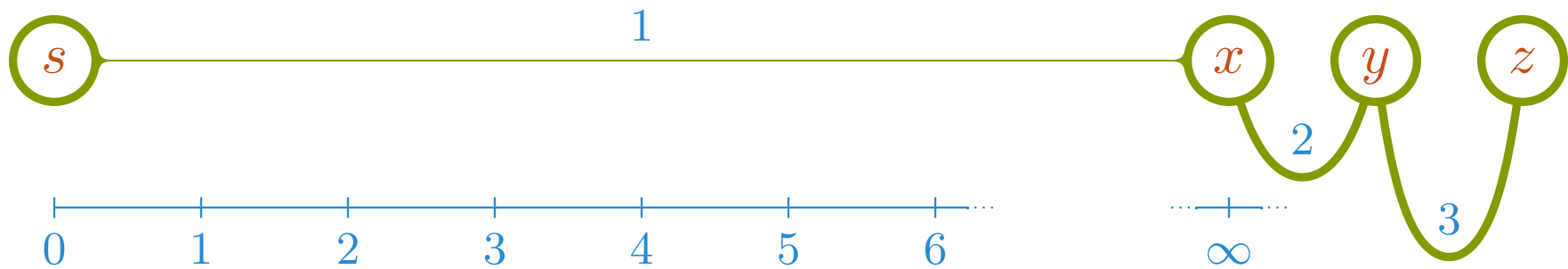


$s.d$ er min. over inn-kanter

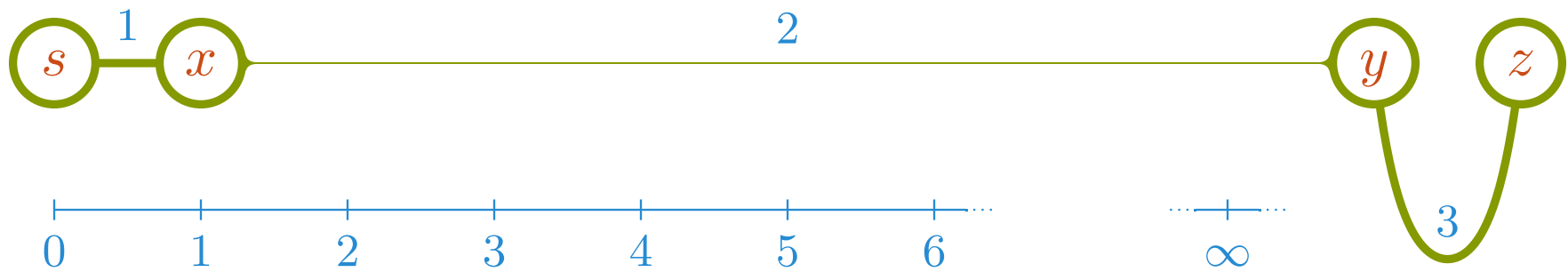
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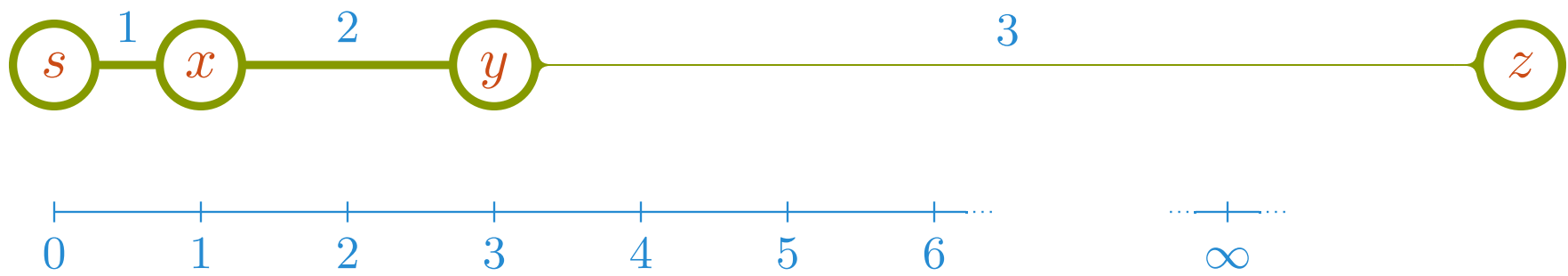
$x.d, y.d \dots$ rett $\implies s.d$ rett

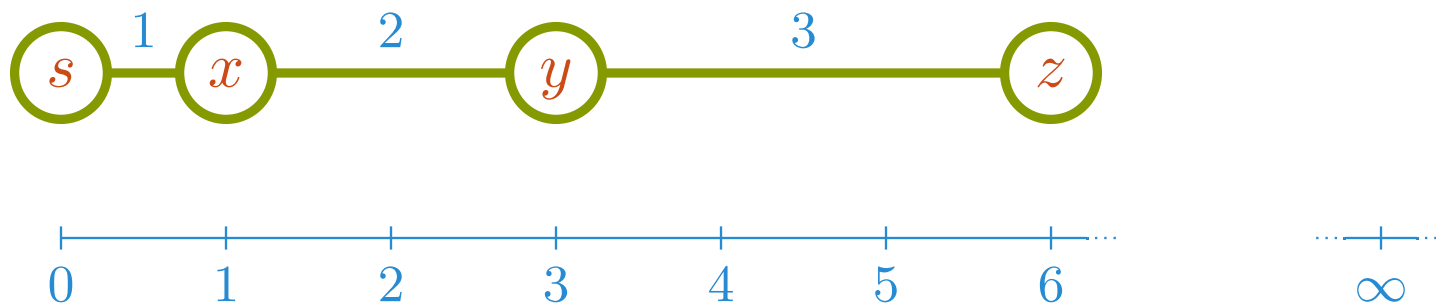


For å sikre oss mot «juks» starter vi med uendelige estimater



Vi «reparerer» så ett og ett estimat...





...helt til alle er korrekte

Sti-slakkings-egenskapen

Sti-slakkings-egenskapen

Om p er en kortest vei fra s til v

Sti-slakkings-egenskapen

Om p er en kortest vei fra s til v og vi slakker kantene til p i rekkefølge,

Sti-slakkings-egenskapen

Om p er en kortest vei fra s til v og vi slakker kantene til p i rekkefølge, så vil v få riktig avstandsestimat.

Sti-slakkings-egenskapen

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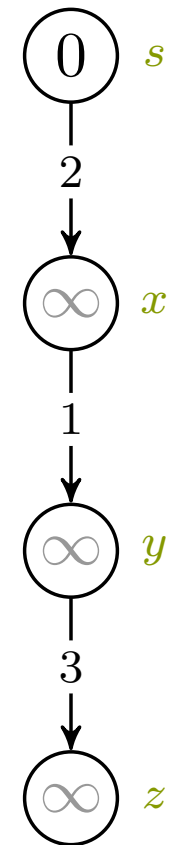
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Sti-slakkings-egenskapen

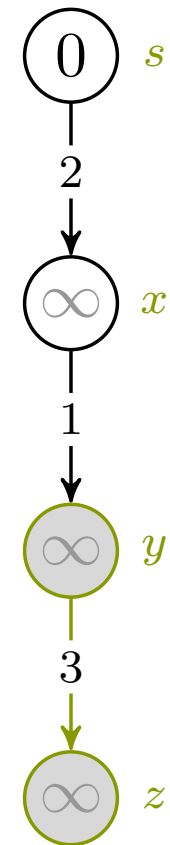
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«The path-relaxation property»; flere slektninger på s. 650

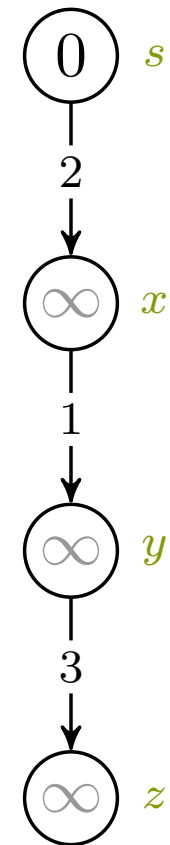
- 1 RELAX(y, z)
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- 3 RELAX(s, x)
- 4 RELAX(y, z)
- 5 RELAX(x, y)
- 6 RELAX(y, z)
- 7 RELAX(s, x)



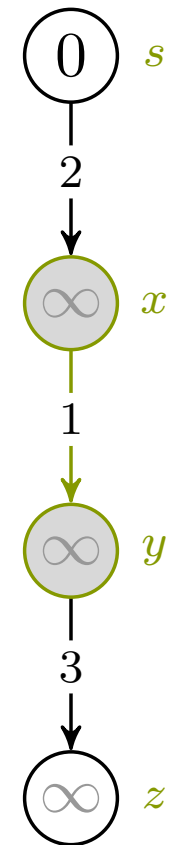
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- 6 RELAX(y, z)
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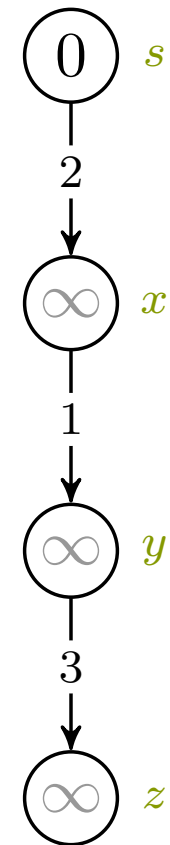
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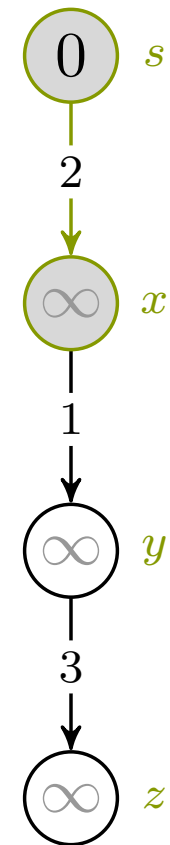
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- 6 RELAX(y, z)
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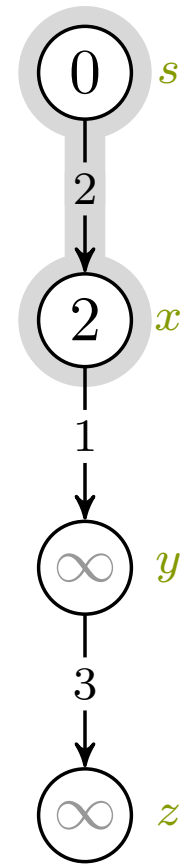
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- 6 RELAX(y, z)
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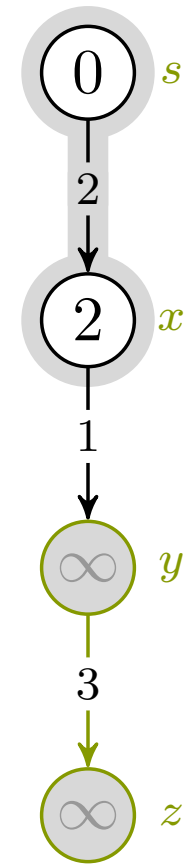
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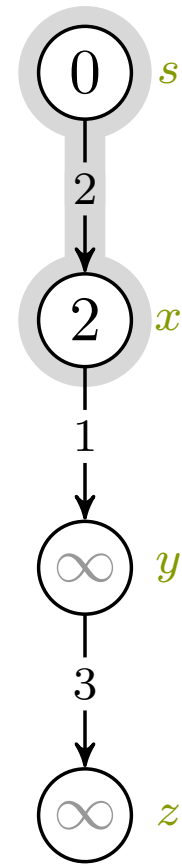
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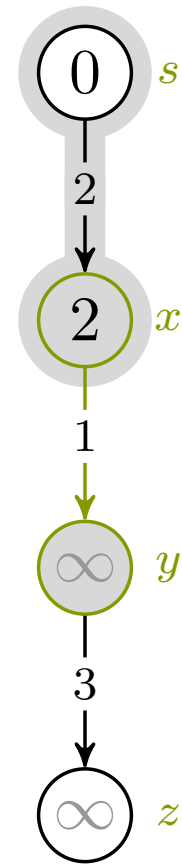
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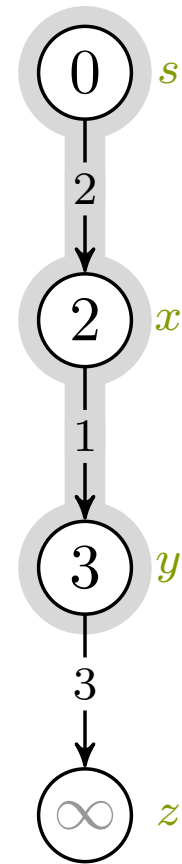
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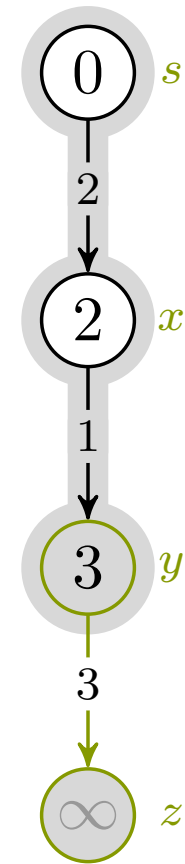
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- 3 RELAX(s, x)
- 4 RELAX(y, z)
- 5 RELAX(x, y)
- 6 RELAX(y, z)
- 7 RELAX(s, x)



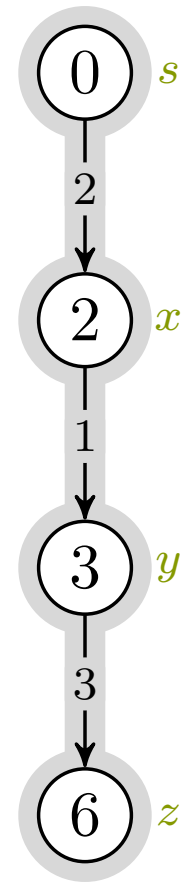
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- 6 RELAX(y, z)
- 7 RELAX(s, x)



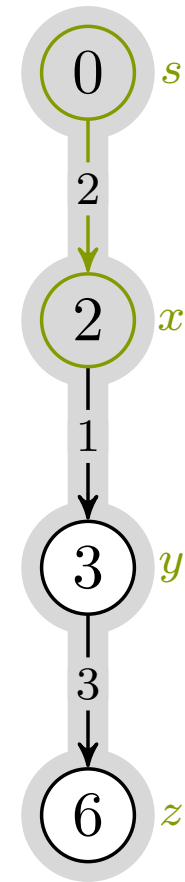
- 1 RELAX(y, z)
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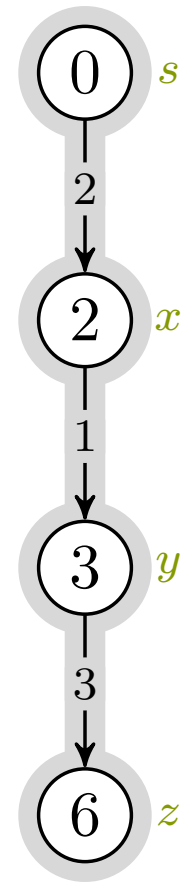
- 1 RELAX(y, z)
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- 5 RELAX(x, y)
- 6 RELAX(y, z)
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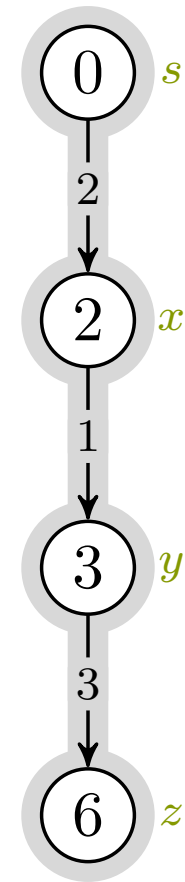
- 1 RELAX(y, z)
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- 4 RELAX(y, z)
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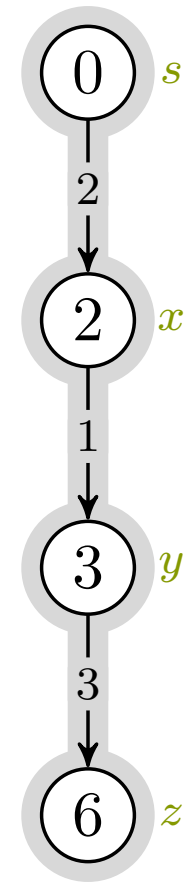


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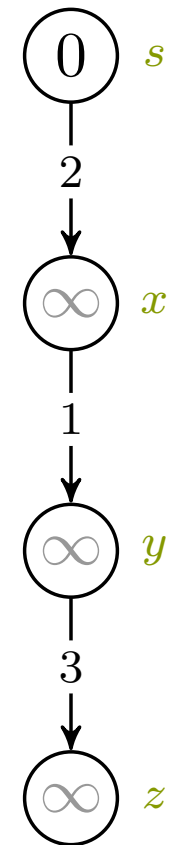
Flere kall var bortkastet

- 1 RELAX(y, z)
- 2 RELAX(x, y)
- 3 RELAX(s, x)
- 4 RELAX(y, z)
- 5 RELAX(x, y)
- 6 RELAX(y, z)
- 7 RELAX(s, x)

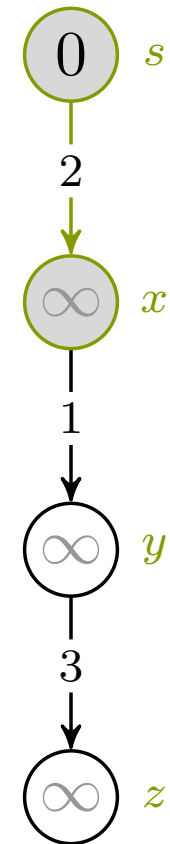


La oss droppe dem!

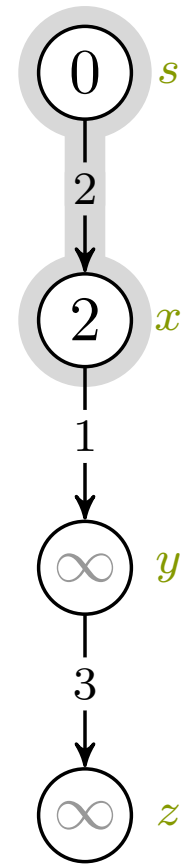
- 1 ~~RELAX~~(y, z)
- 2 ~~RELAX~~(x, y)
- 3 RELAX(s, x)
- 4 ~~RELAX~~(y, z)
- 5 RELAX(x, y)
- 6 RELAX(y, z)
- 7 ~~RELAX~~(s, x)



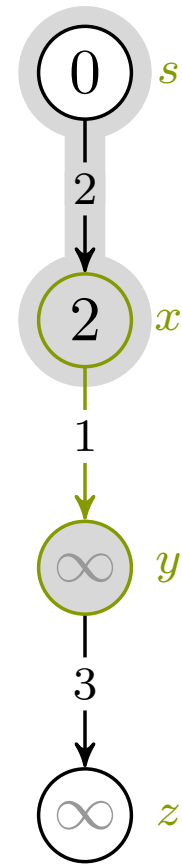
- 1 ~~RELAX~~(y, z)
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- 3 RELAX(s, x)
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- 5 RELAX(x, y)
- 6 RELAX(y, z)
- 7 ~~RELAX~~(s, x)



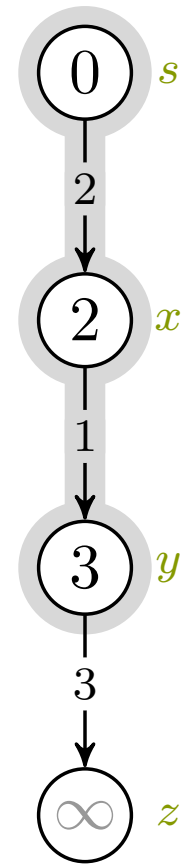
- 1 ~~RELAX~~(y, z)
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- 5 RELAX(x, y)
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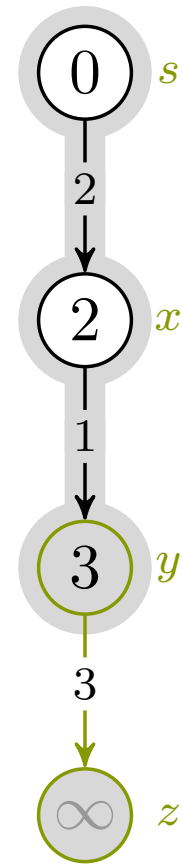
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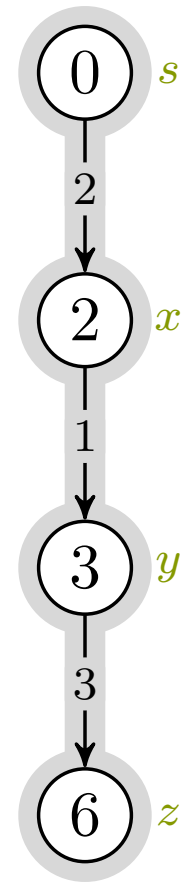
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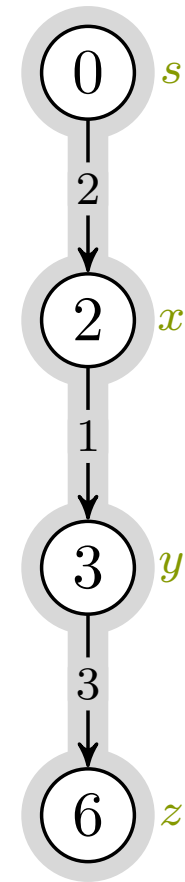
- 1 ~~RELAX~~(y, z)
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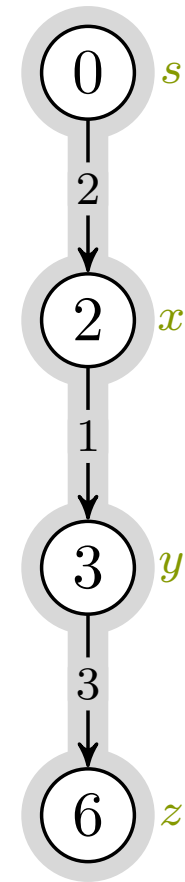
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- 1 ~~RELAX~~(y, z)
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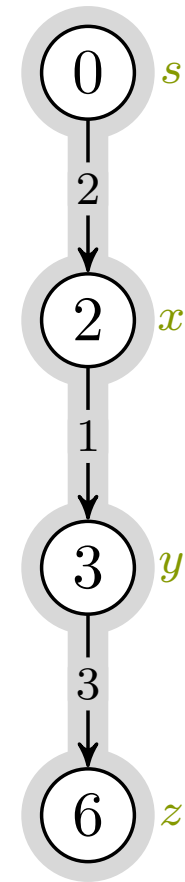


- 1 ~~RELAX~~(y, z)
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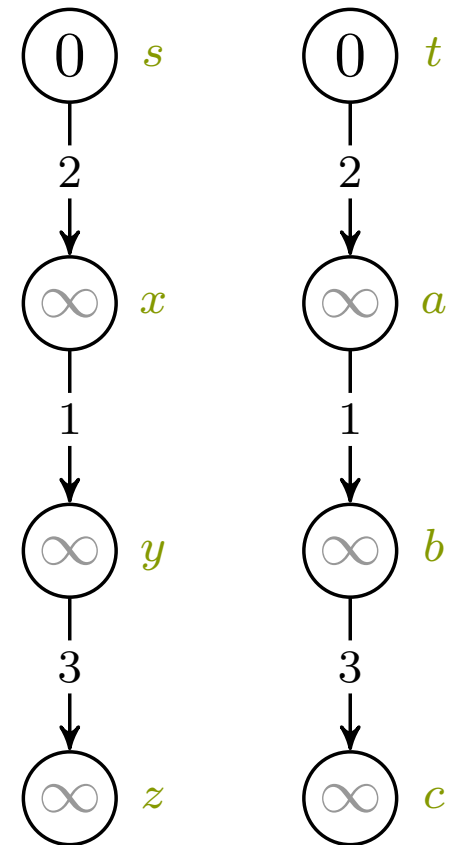
Samme utvikling; samme svar

- 1 ~~RELAX~~(y, z)
- 2 ~~RELAX~~(x, y)
- 3 RELAX(s, x)
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- 5 RELAX(x, y)
- 6 RELAX(y, z)
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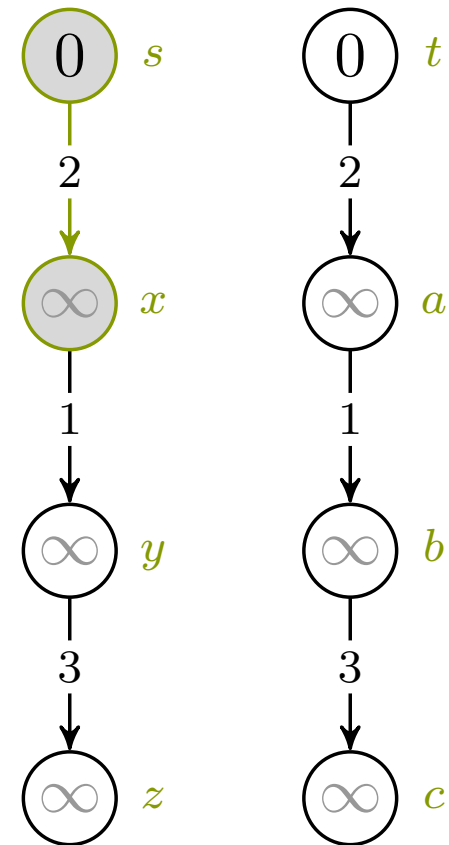
Følger rekkefølgen langs stien!

- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)

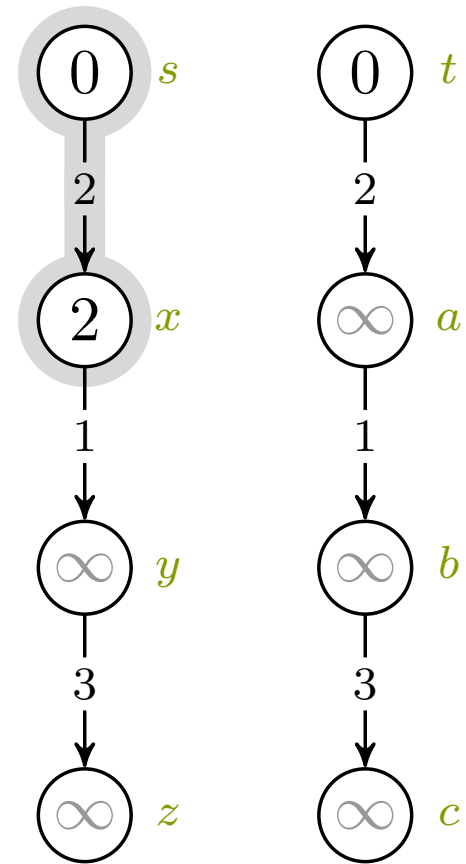


Slakk alle kanter én gang

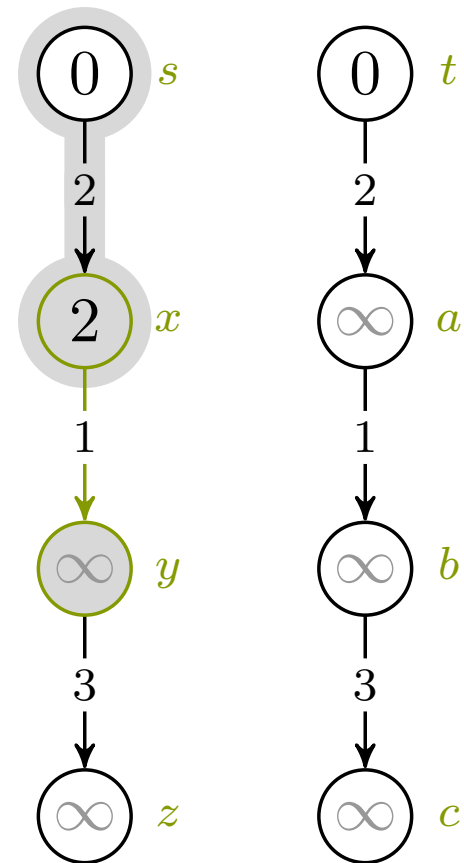
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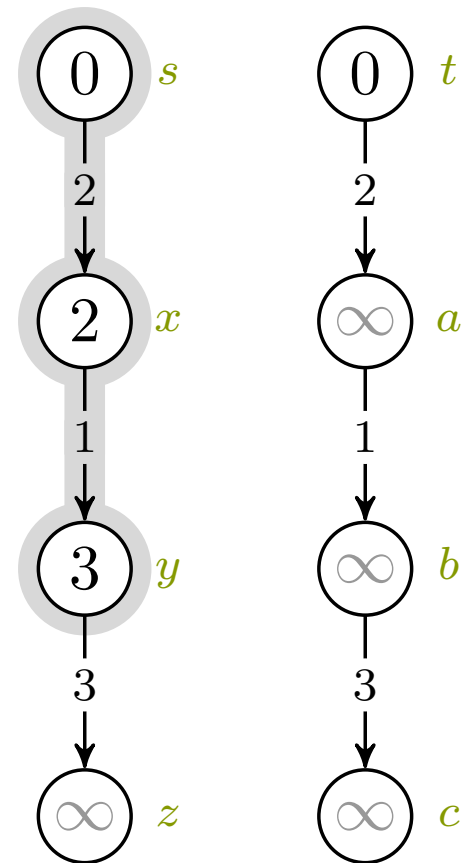
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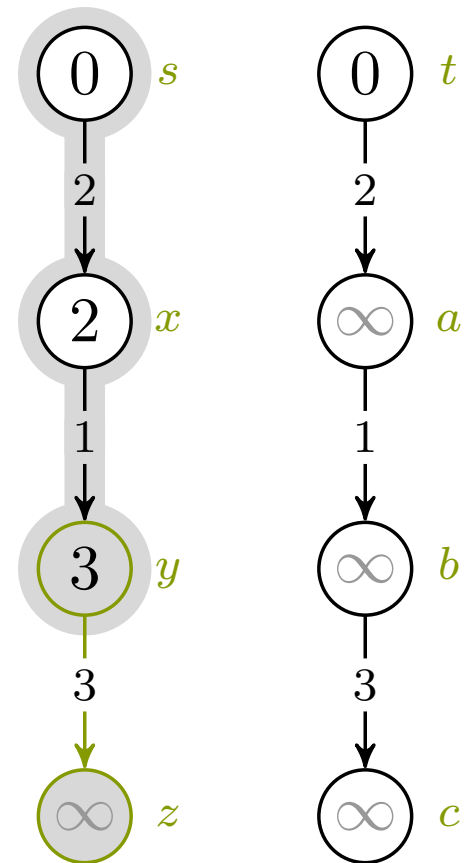
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



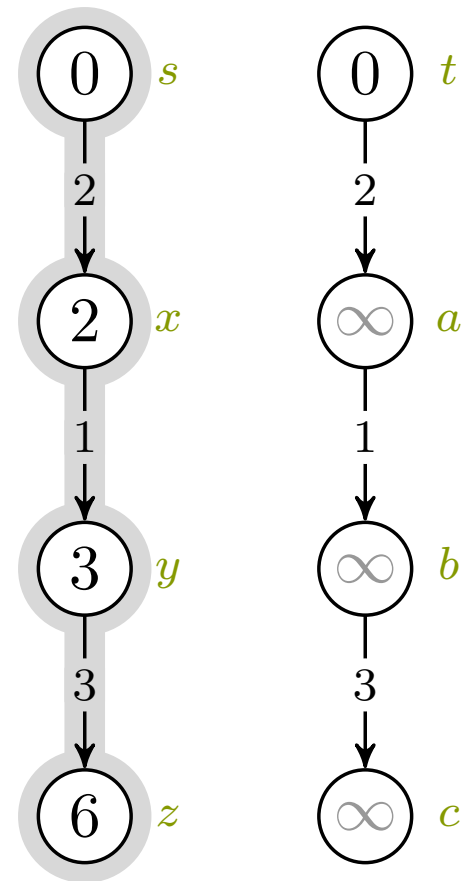
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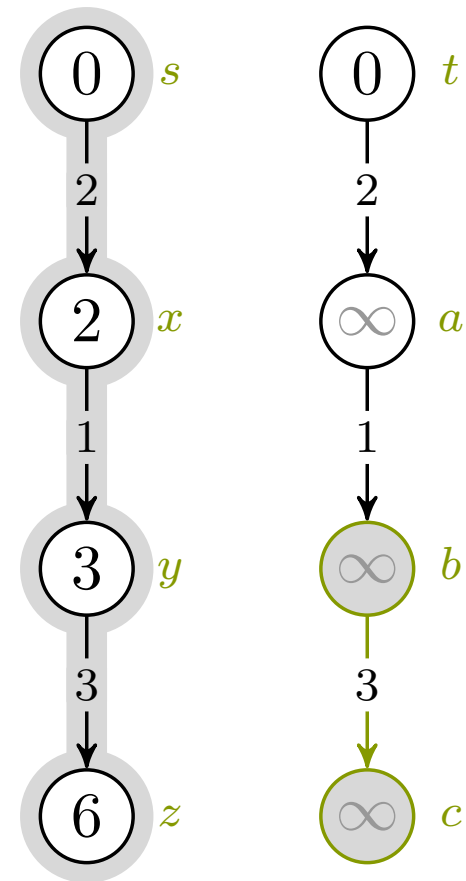
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



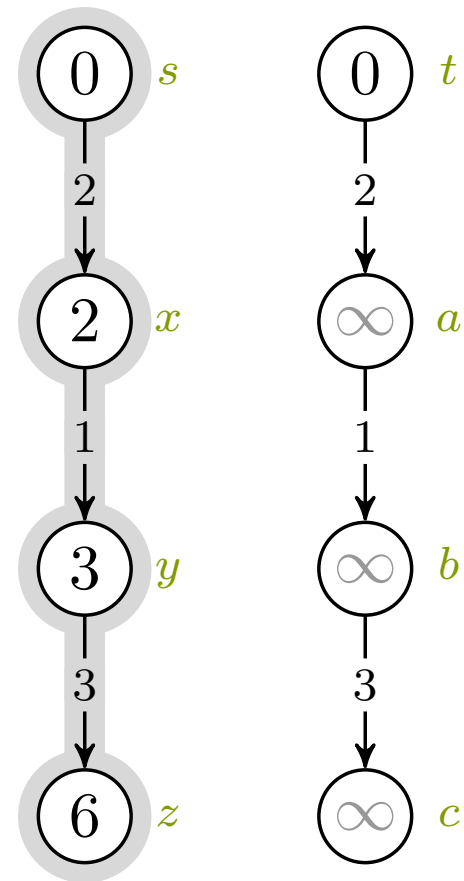
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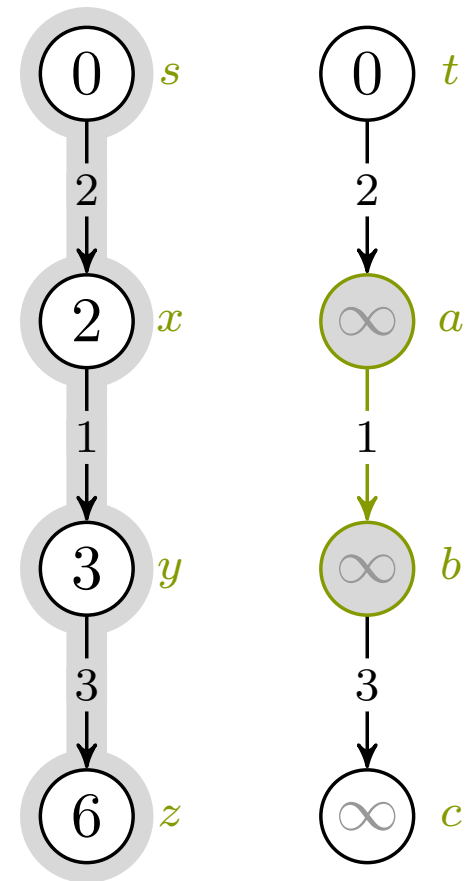
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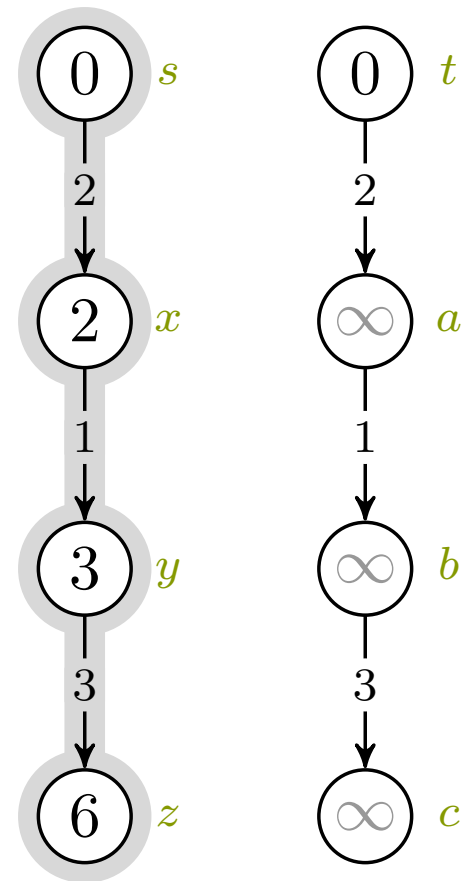
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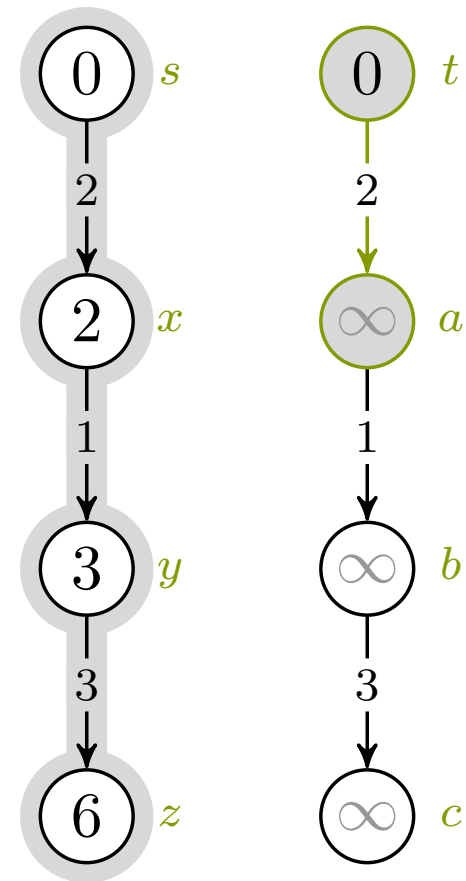
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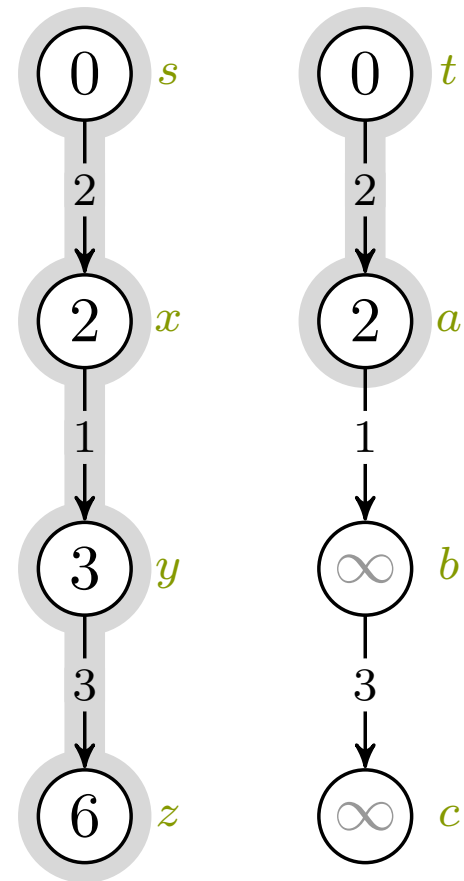
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- 6 RELAX(t, a)



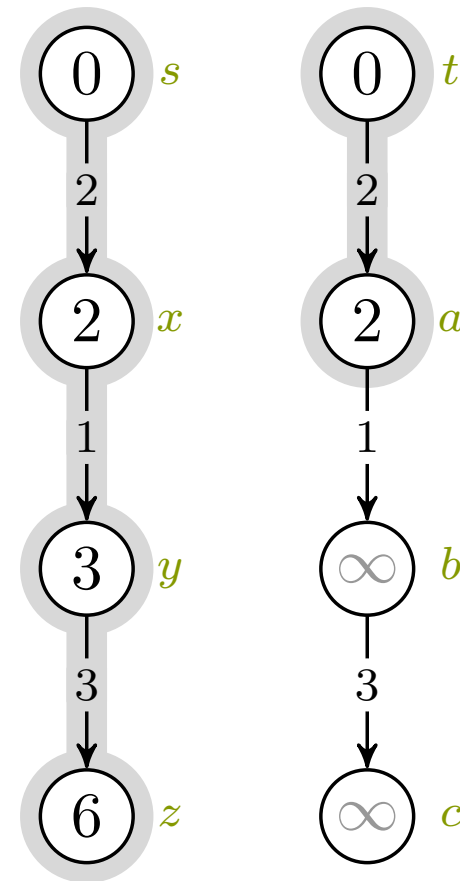
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



- 1 RELAX(s, x)
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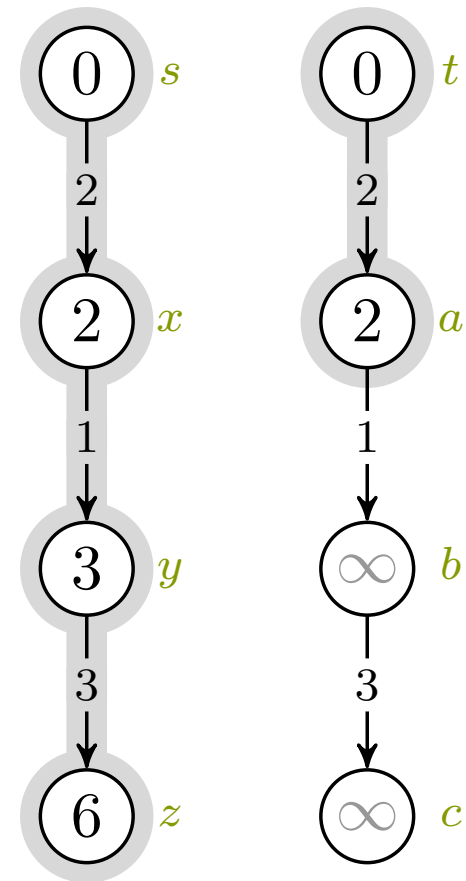


- 1 RELAX(s, x)
- 2 RELAX(x, y)
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



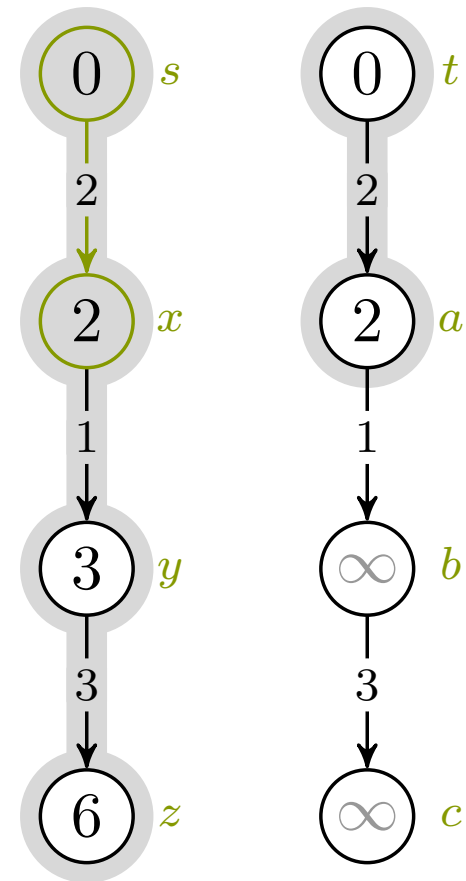
Flaks? Ferdig!

- 1 RELAX(s, x)
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- 3 RELAX(y, z)
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- 5 RELAX(a, b)
- 6 RELAX(t, a)

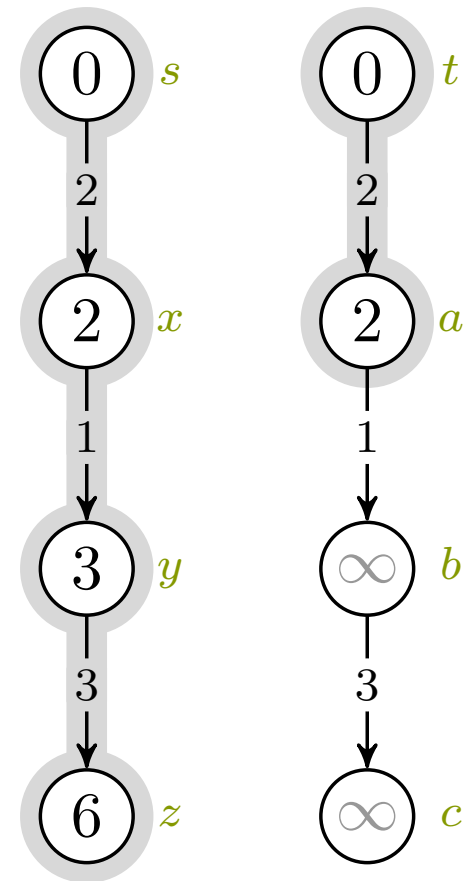


Uflaks? Ett hakk videre

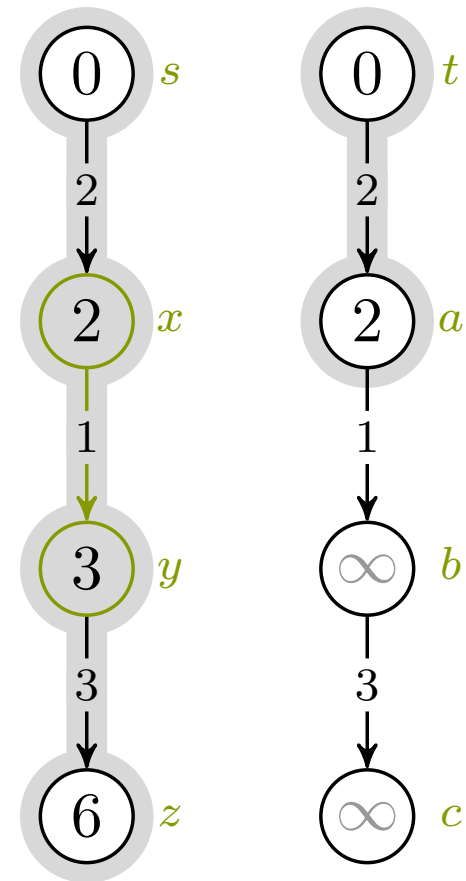
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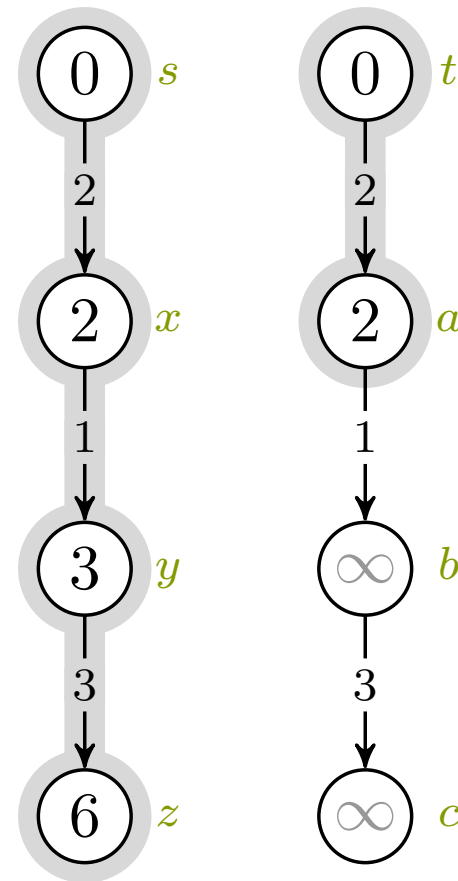
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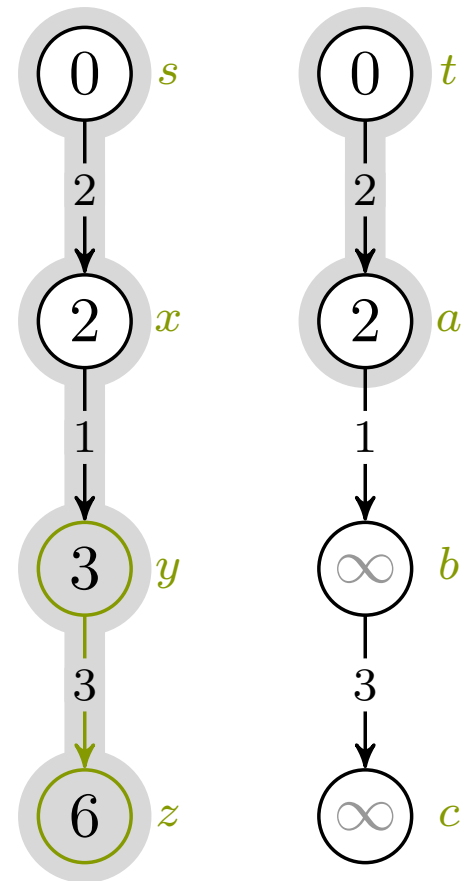
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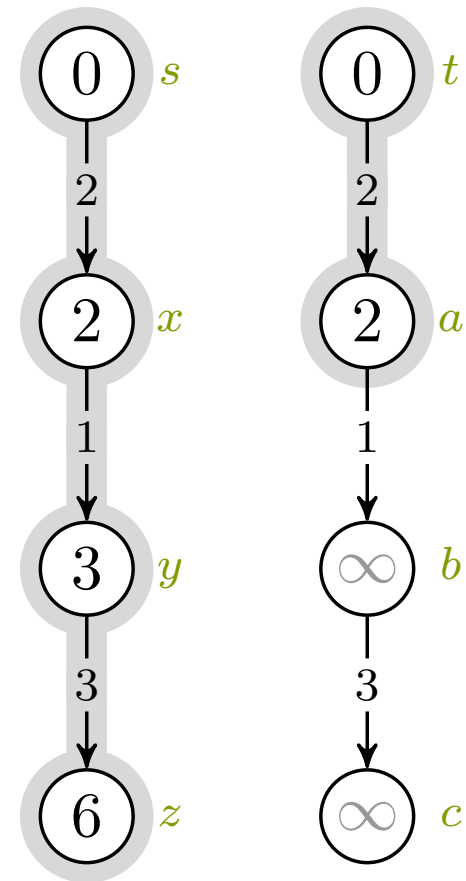
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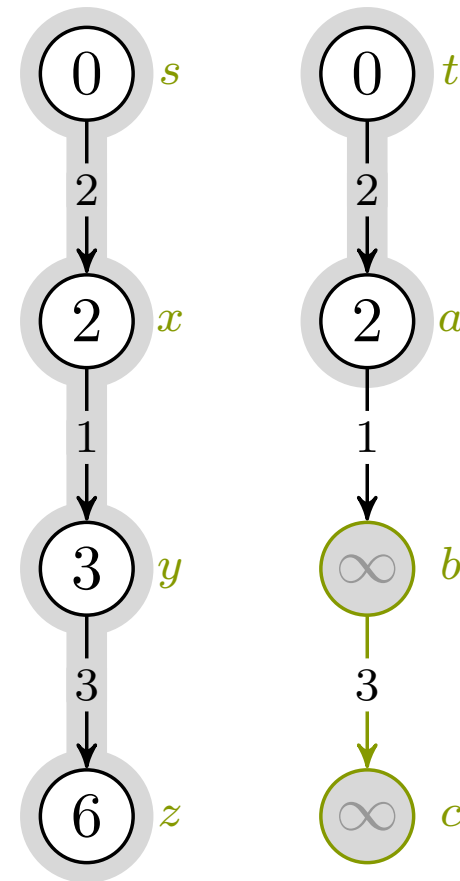
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



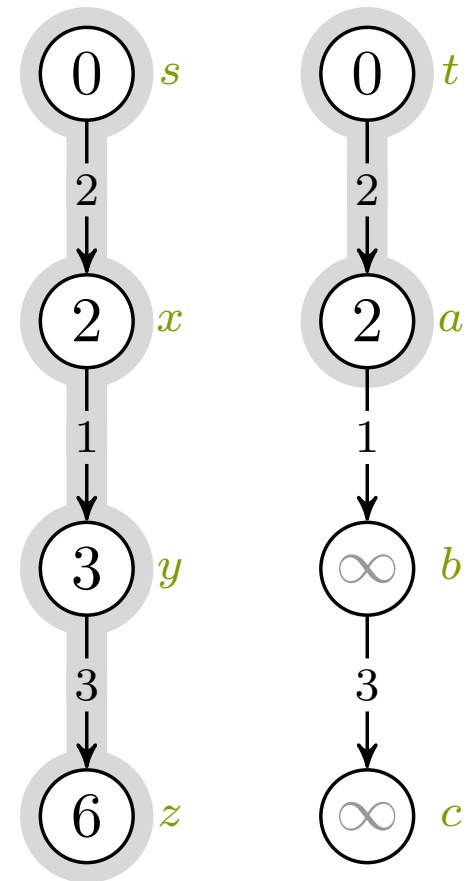
- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



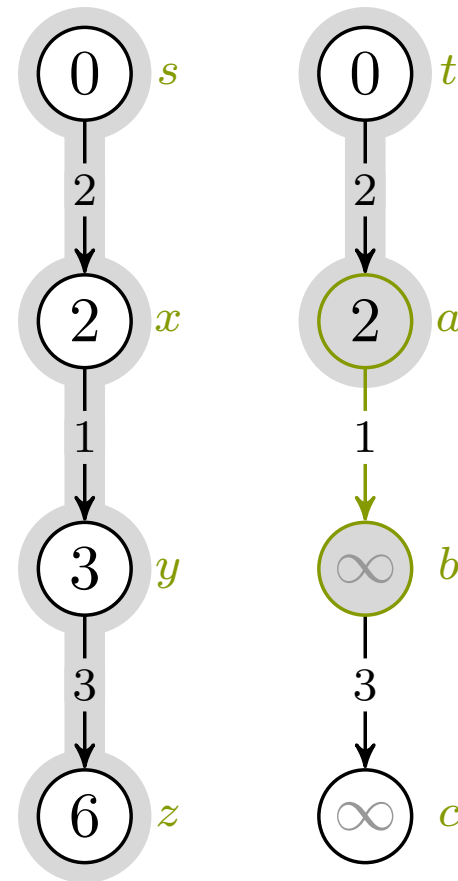
- 1 RELAX(s, x)
- 2 RELAX(x, y)
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- 6 RELAX(t, a)



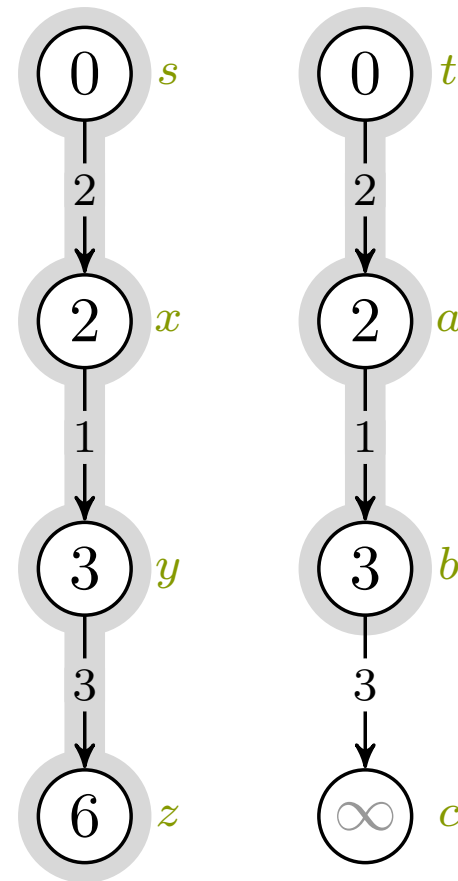
- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



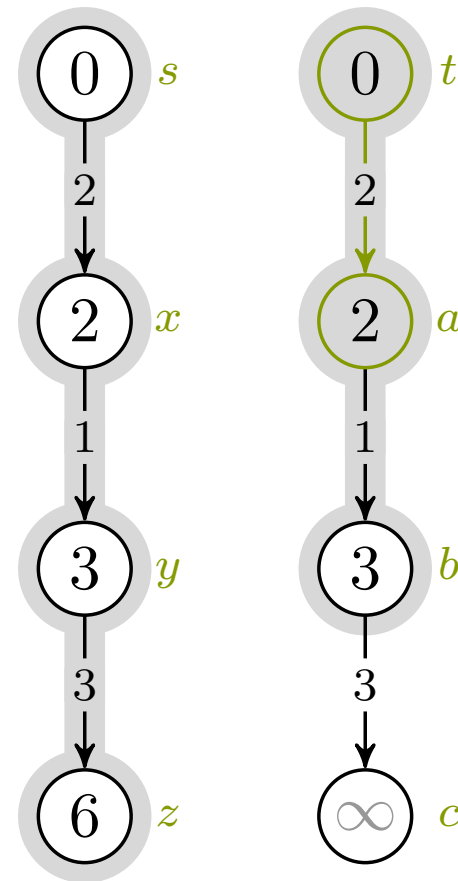
- 1 RELAX(s, x)
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- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



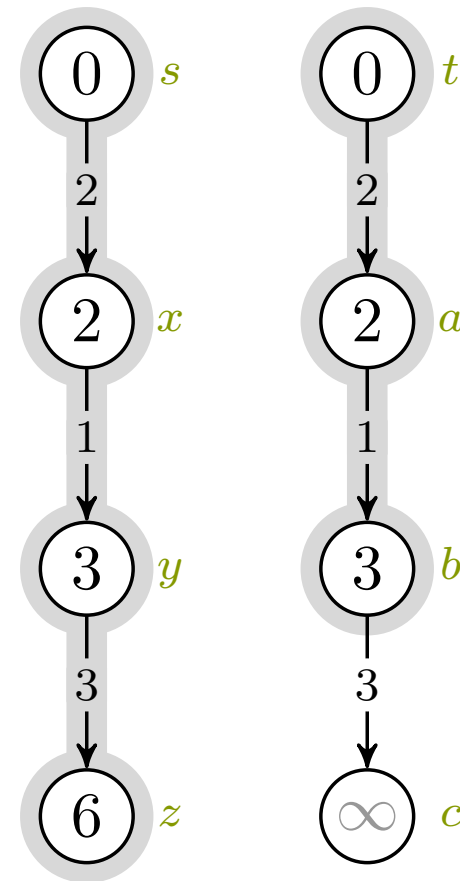
- 1 RELAX(s, x)
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



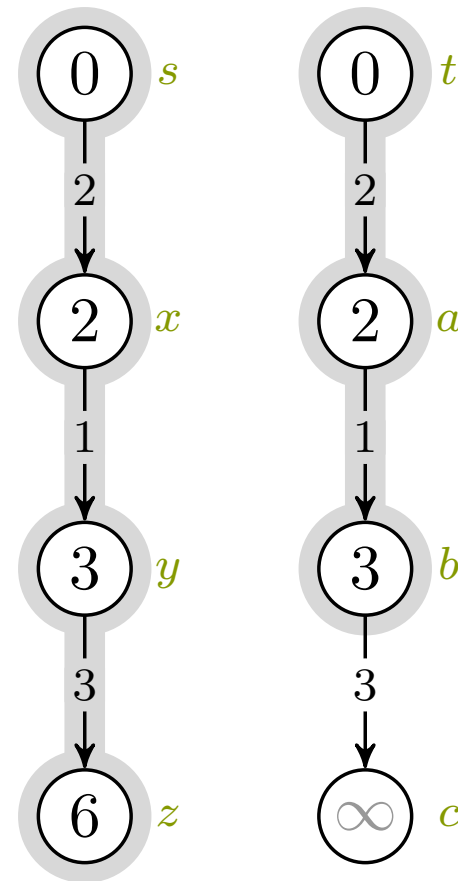
- 1 RELAX(s, x)
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- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



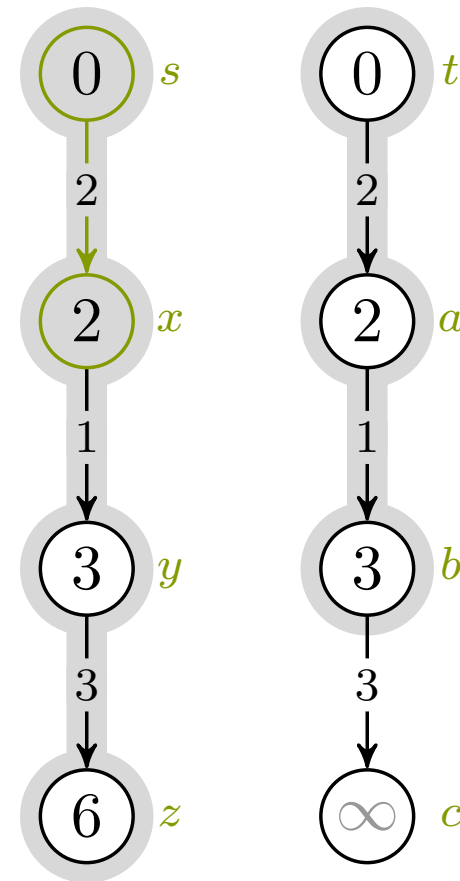
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- 6 RELAX(t, a)



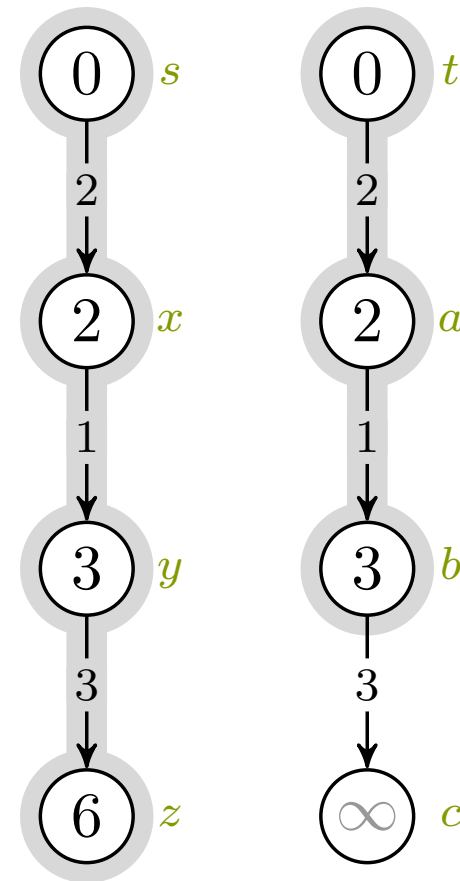
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- 6 RELAX(t, a)



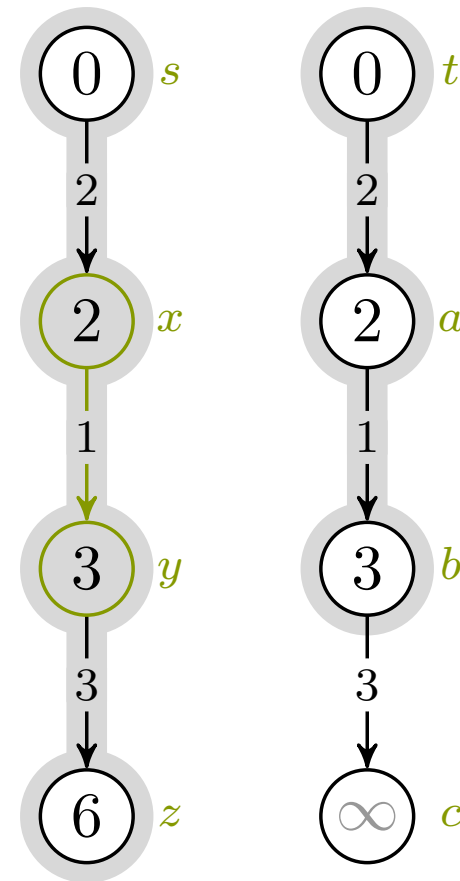
- 1 RELAX(s, x)
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- 5 RELAX(a, b)
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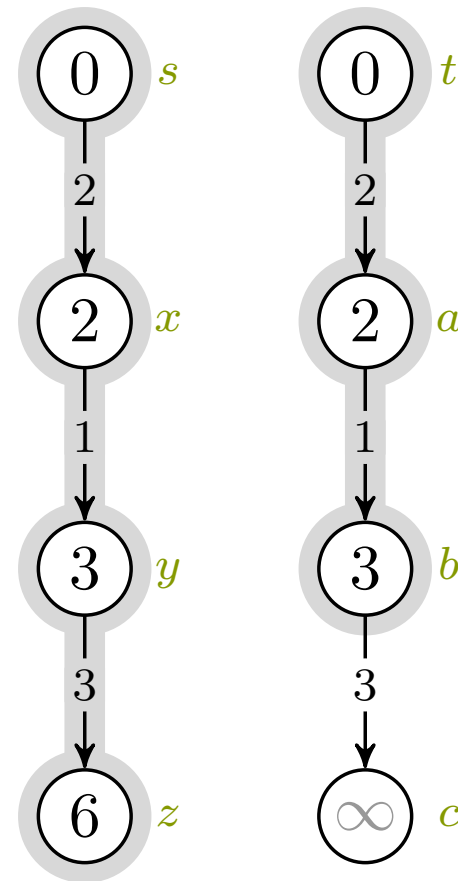
- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



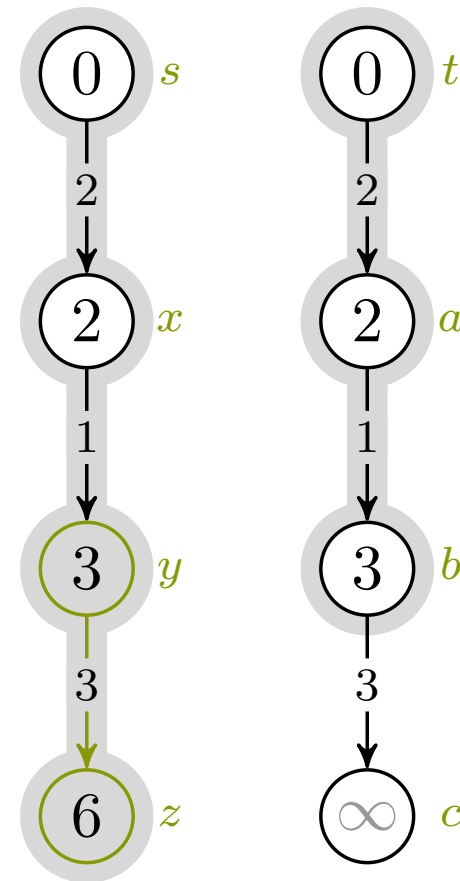
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- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



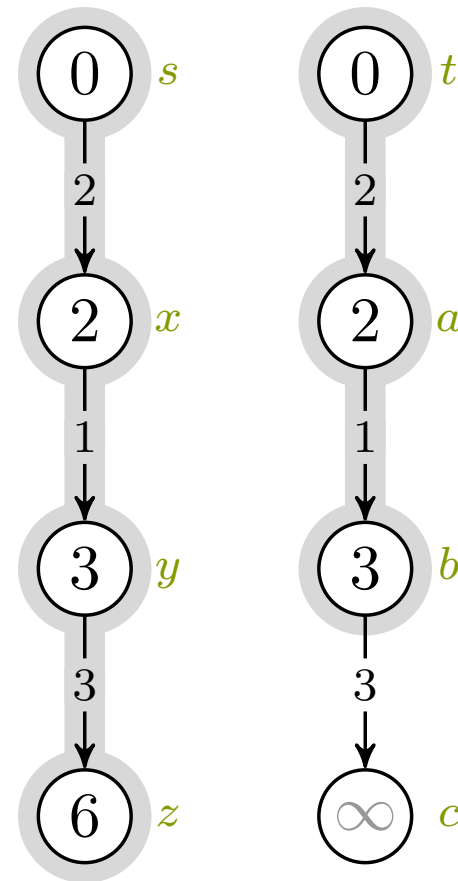
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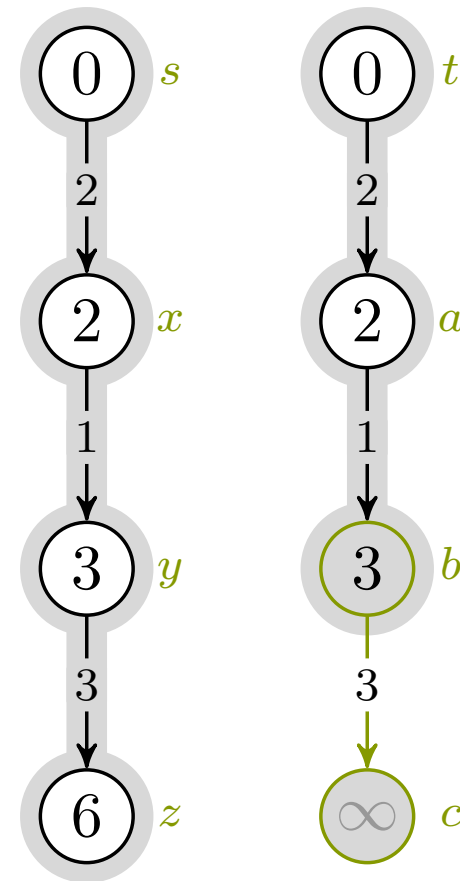
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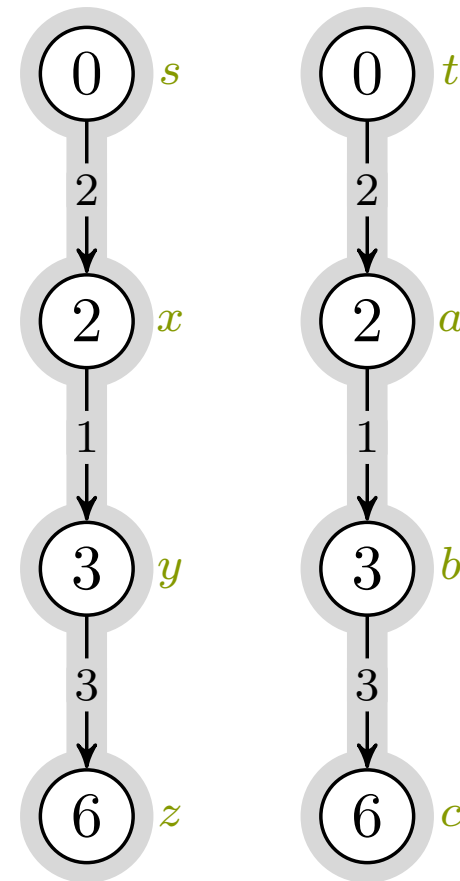
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- 6 RELAX(t, a)



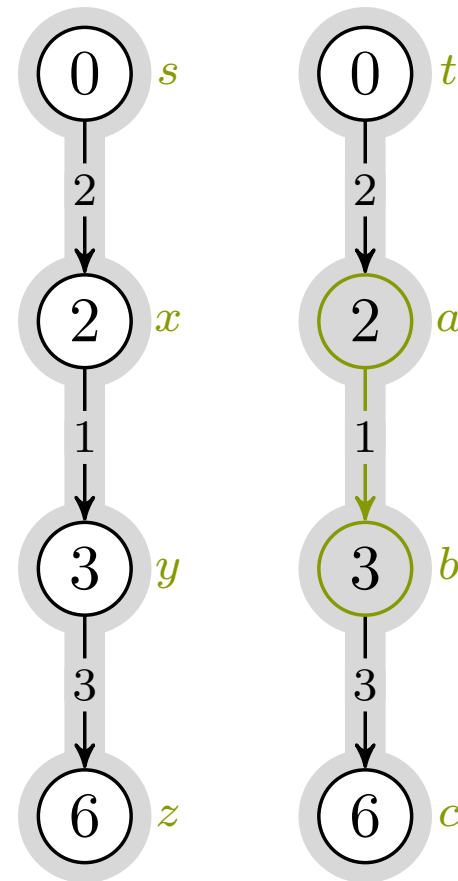
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- 5 RELAX(a, b)
- 6 RELAX(t, a)



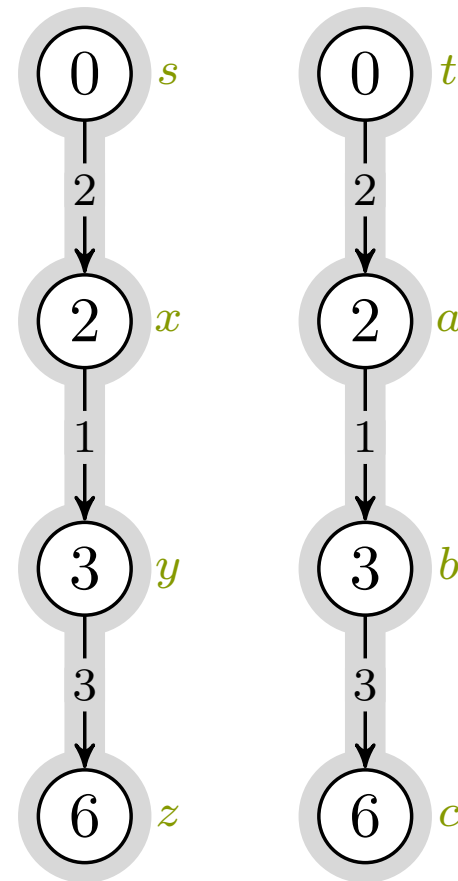
- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



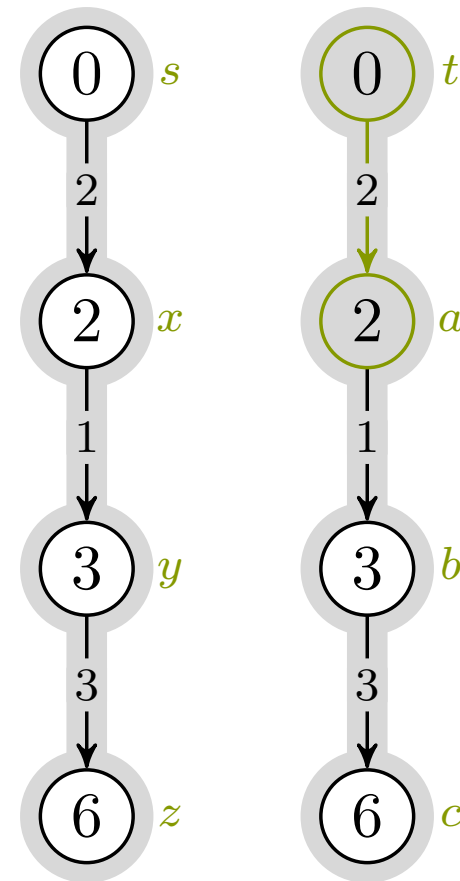
- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



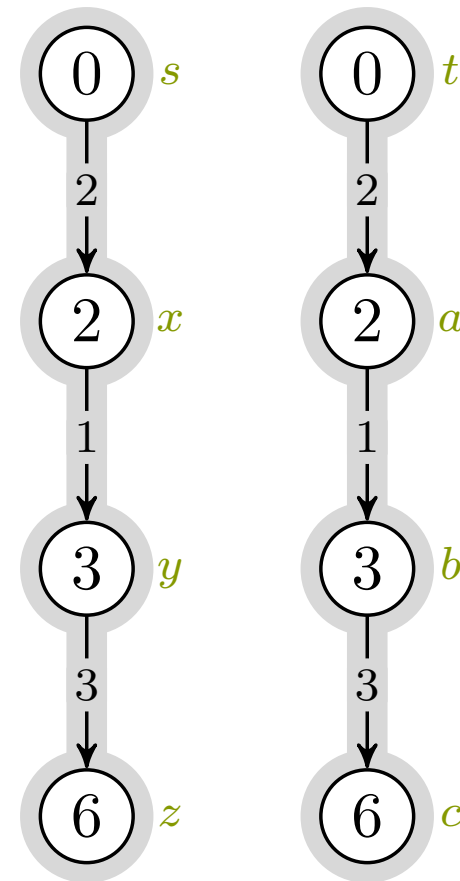
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- 6 RELAX(t, a)



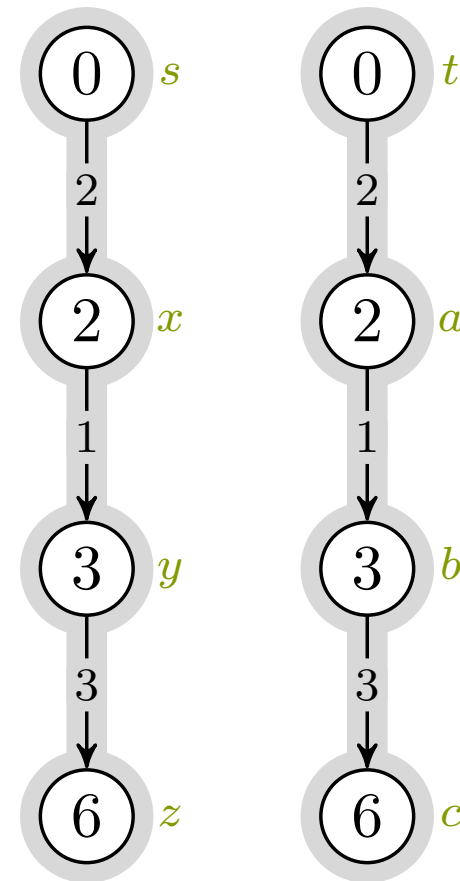
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- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



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- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)

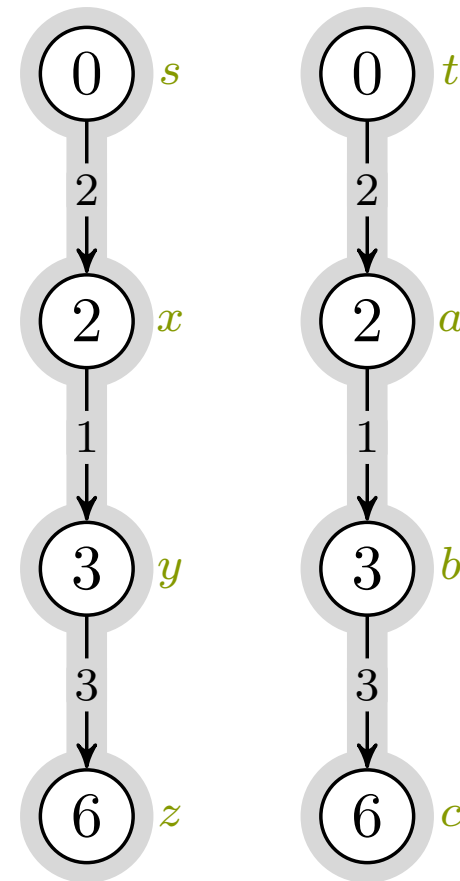


- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



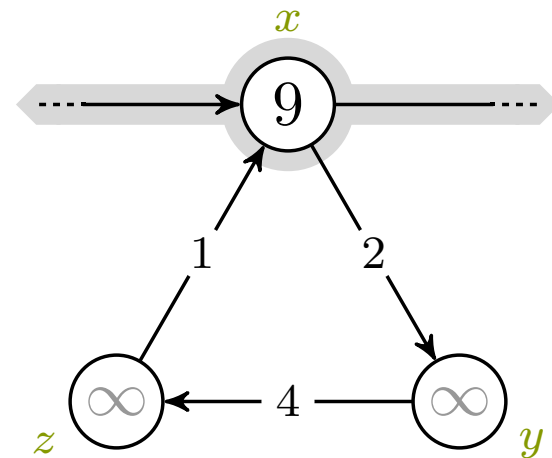
Tre pass: Garantert ferdig

- 1 RELAX(s, x)
- 2 RELAX(x, y)
- 3 RELAX(y, z)
- 4 RELAX(b, c)
- 5 RELAX(a, b)
- 6 RELAX(t, a)



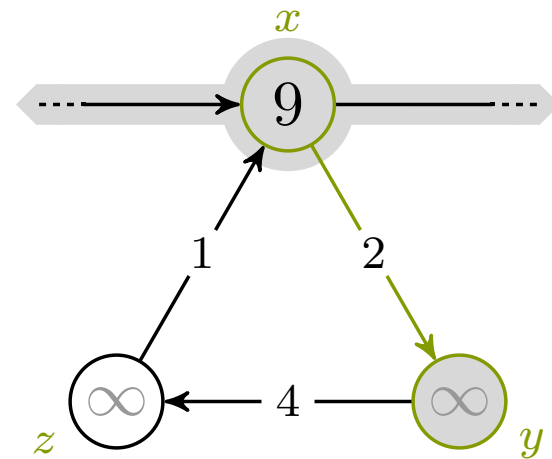
Hvorfor akkurat tre?

- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)

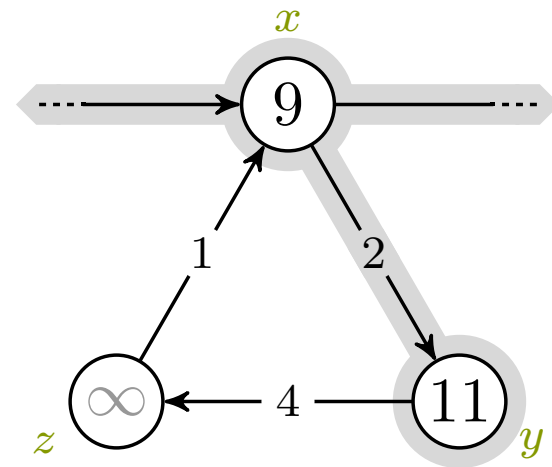


Positiv sykel

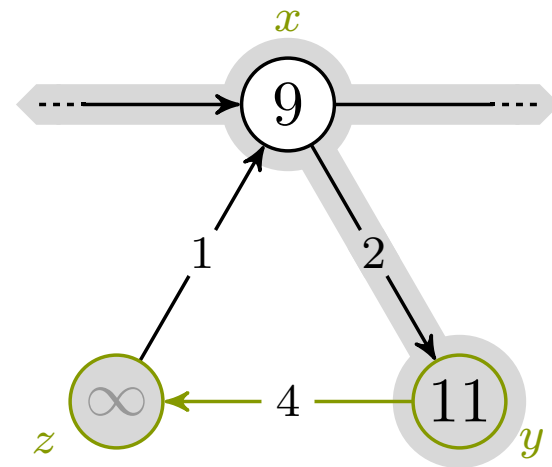
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



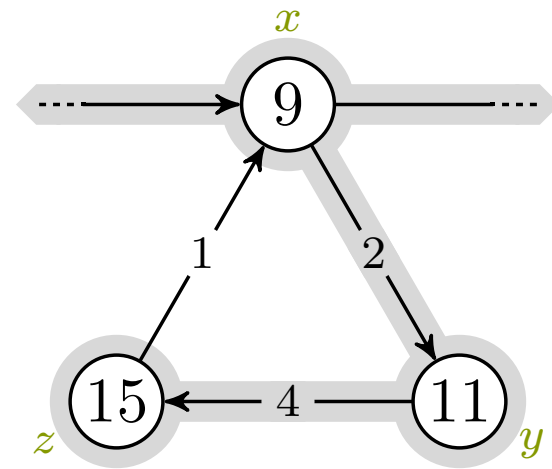
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



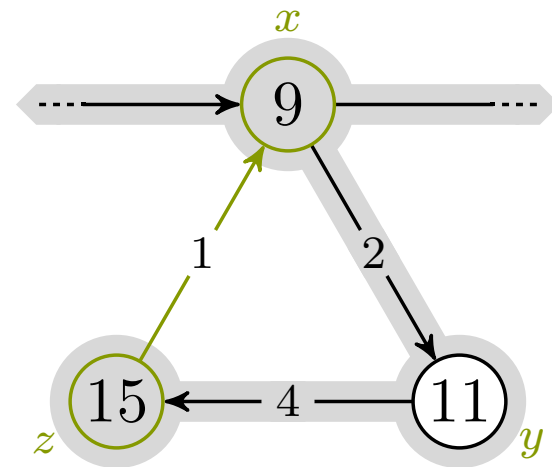
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



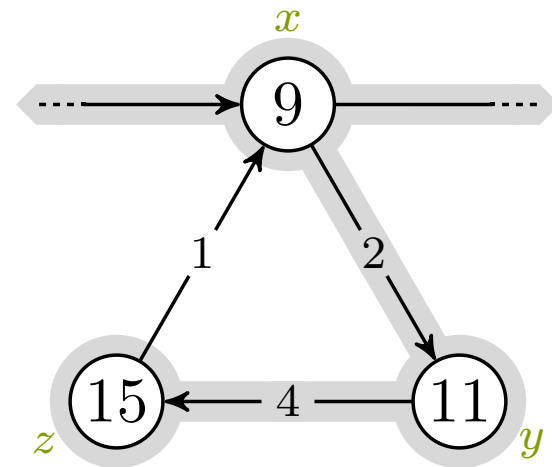
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



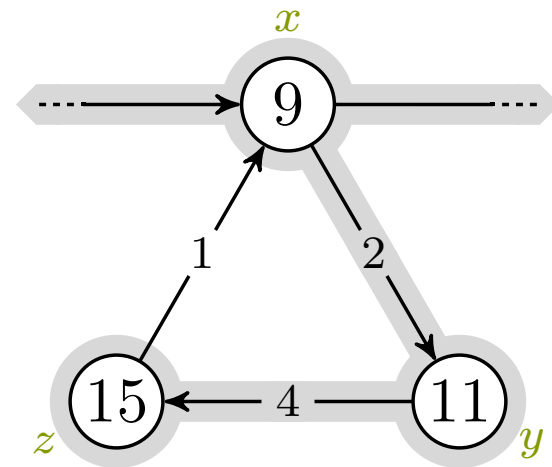
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)

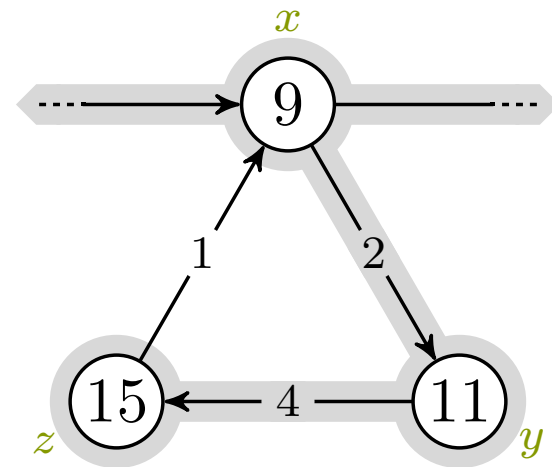


- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



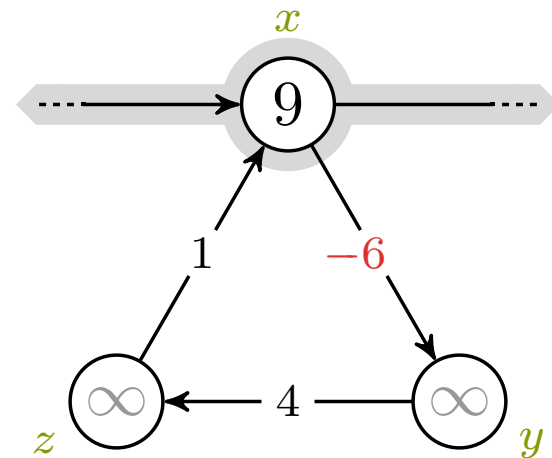
Unødvendig ekstrakostnad

- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)



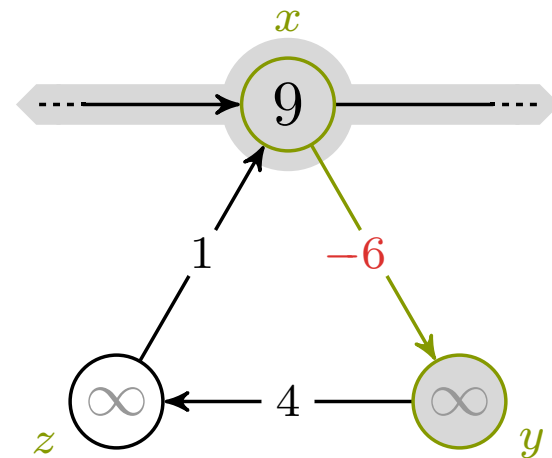
Vil ikke bli del av kortest vei

- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)

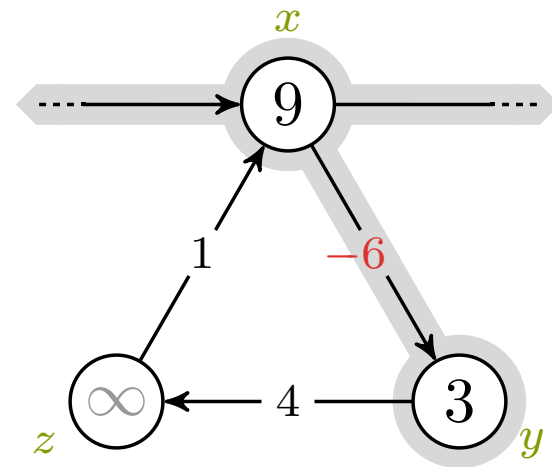


Negativ sykel

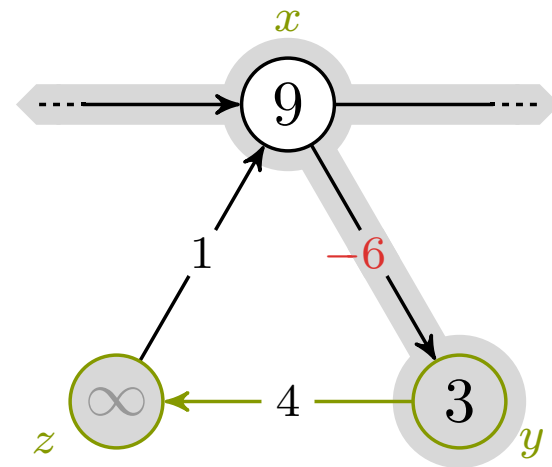
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)



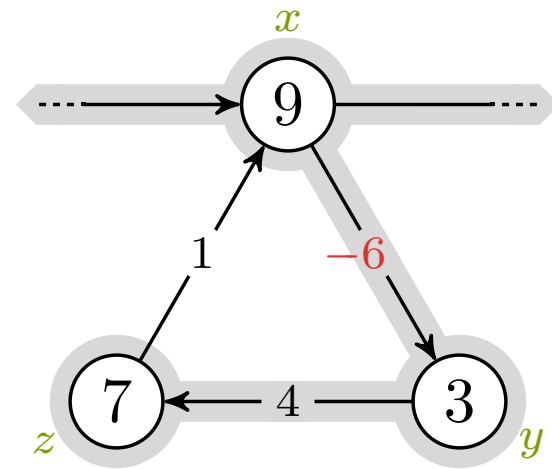
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)



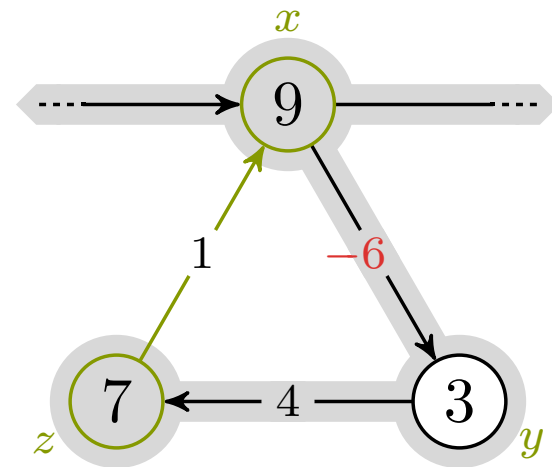
- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)



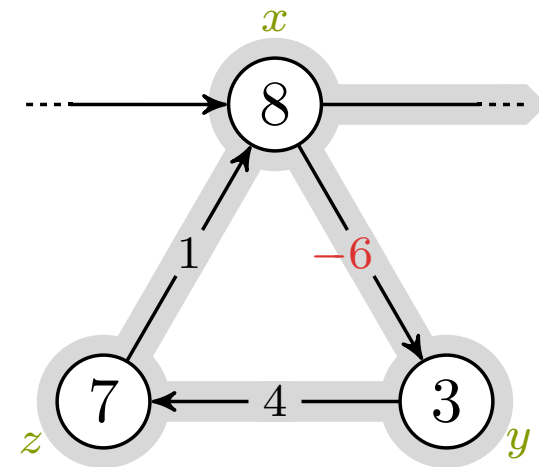
- 1 RELAX(x, y)
- 2 RELAX(y, z)
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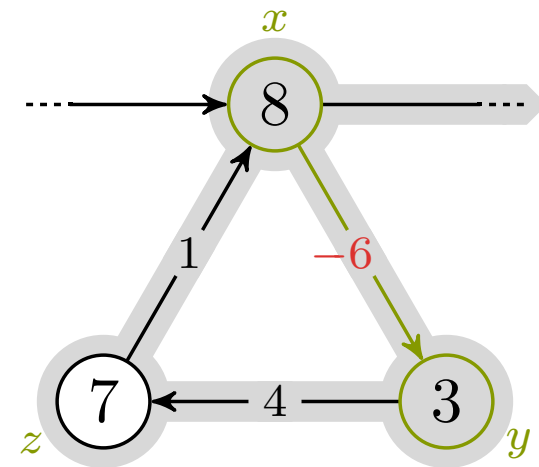


- 1 RELAX(x, y)
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- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
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- 8 RELAX(y, z)
- 9 RELAX(z, x)

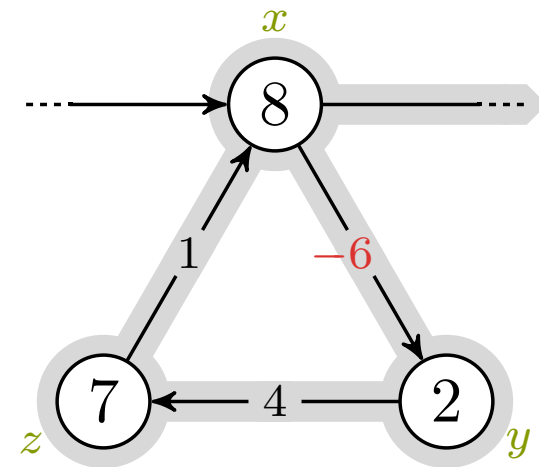


(Impl.: Har kun ett $x.\pi$ -felt)

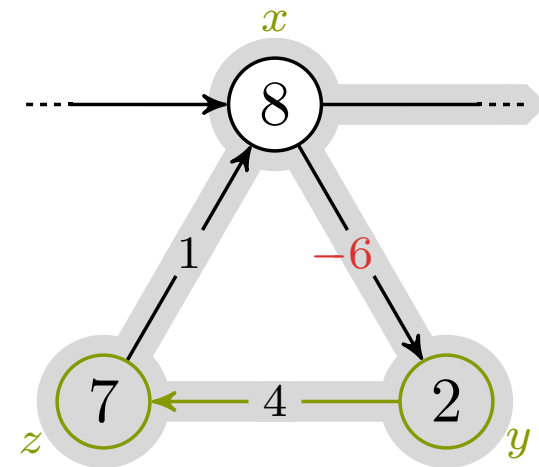
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- 3 RELAX(z, x)
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- 6 RELAX(z, x)
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- 8 RELAX(y, z)
- 9 RELAX(z, x)



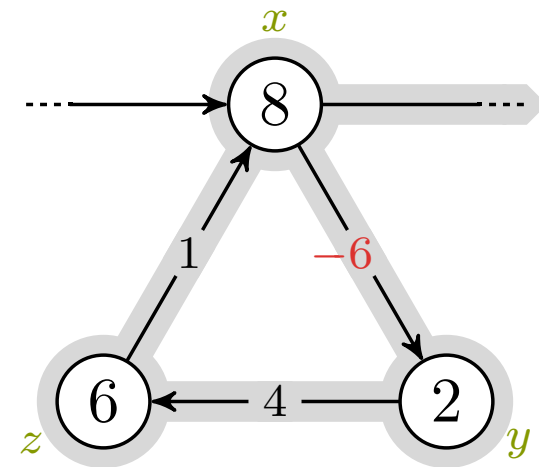
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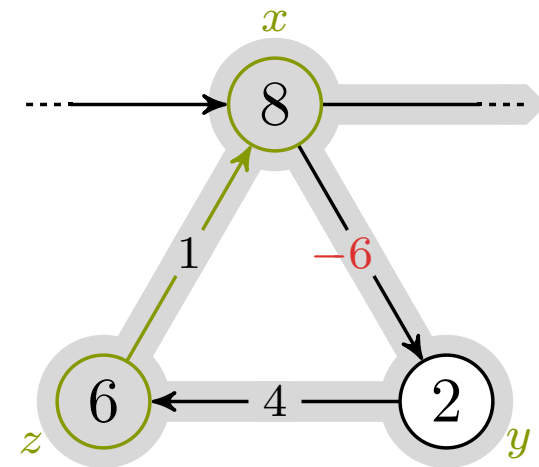
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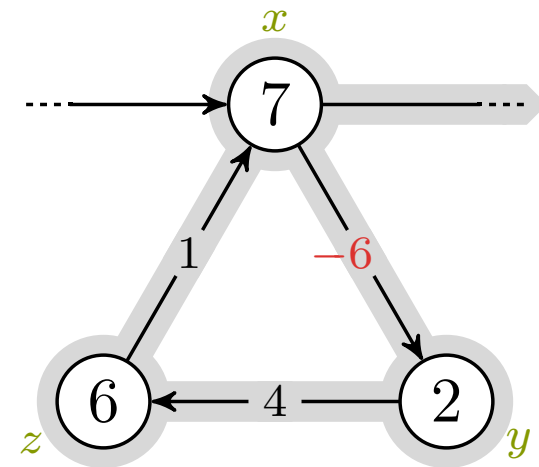
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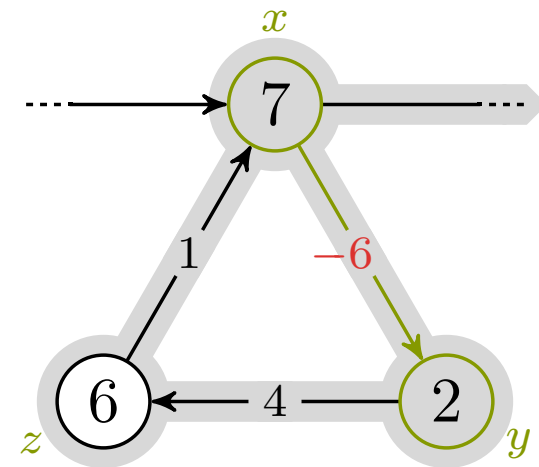
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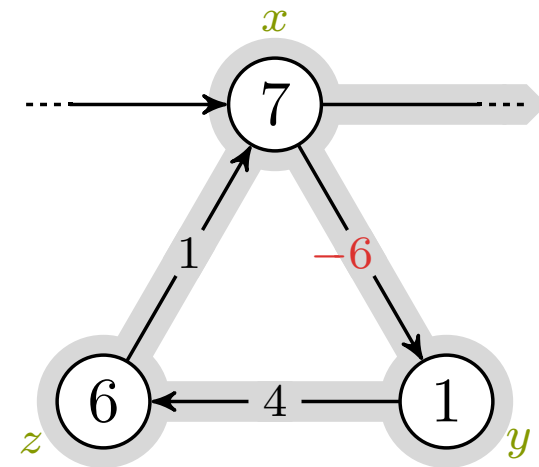
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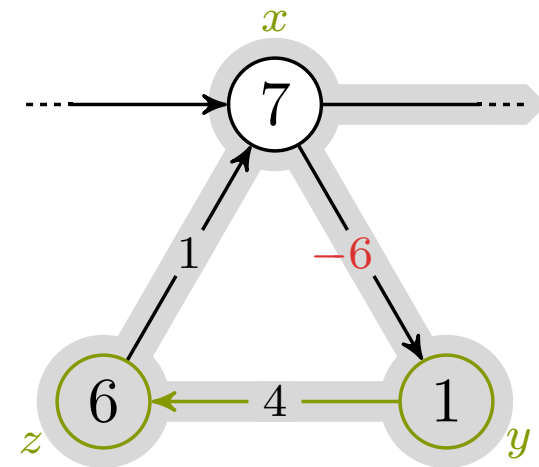
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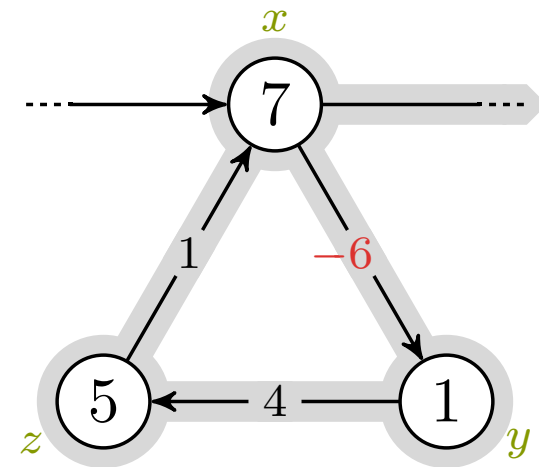
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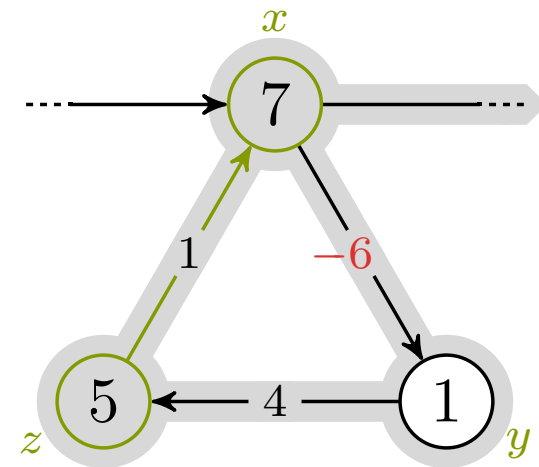
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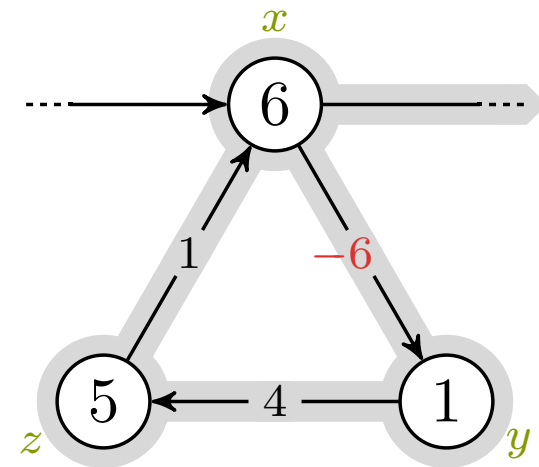
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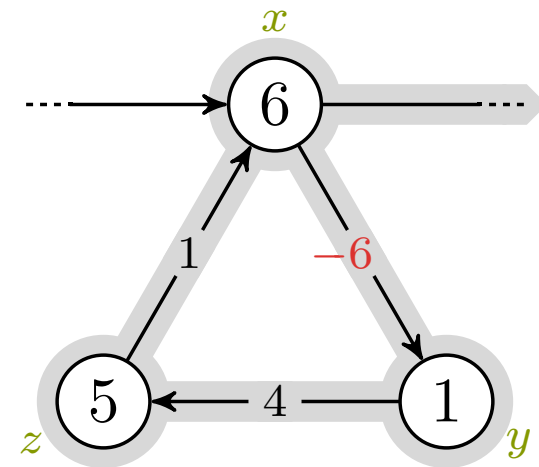
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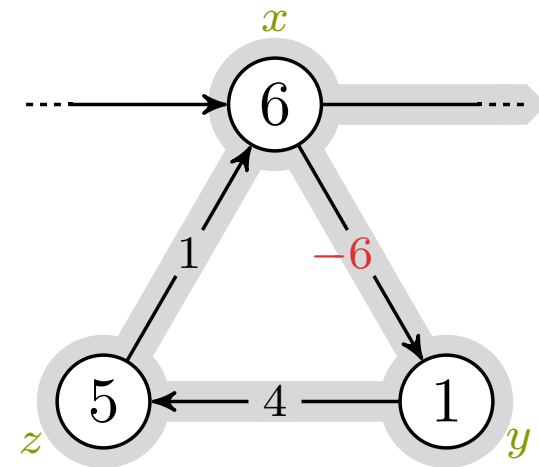


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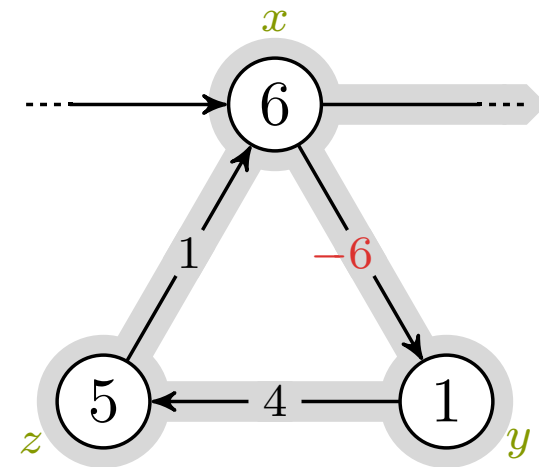
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- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)

Etc.



- 1 RELAX(x, y)
- 2 RELAX(y, z)
- 3 RELAX(z, x)
- 4 RELAX(x, y)
- 5 RELAX(y, z)
- 6 RELAX(z, x)
- 7 RELAX(x, y)
- 8 RELAX(y, z)
- 9 RELAX(z, x)

Etc.



Ingen sti er kortest!

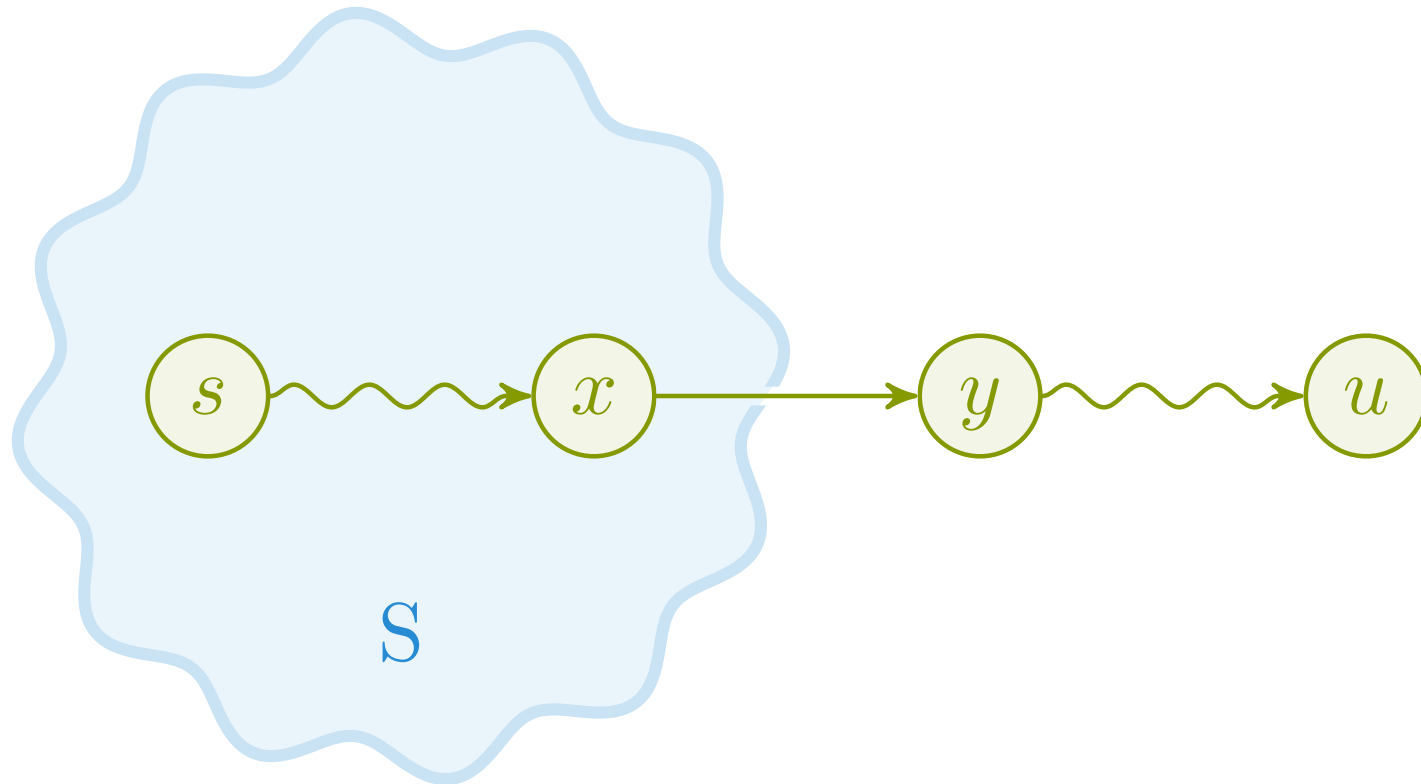
Dijkstra › **Korrekthet**



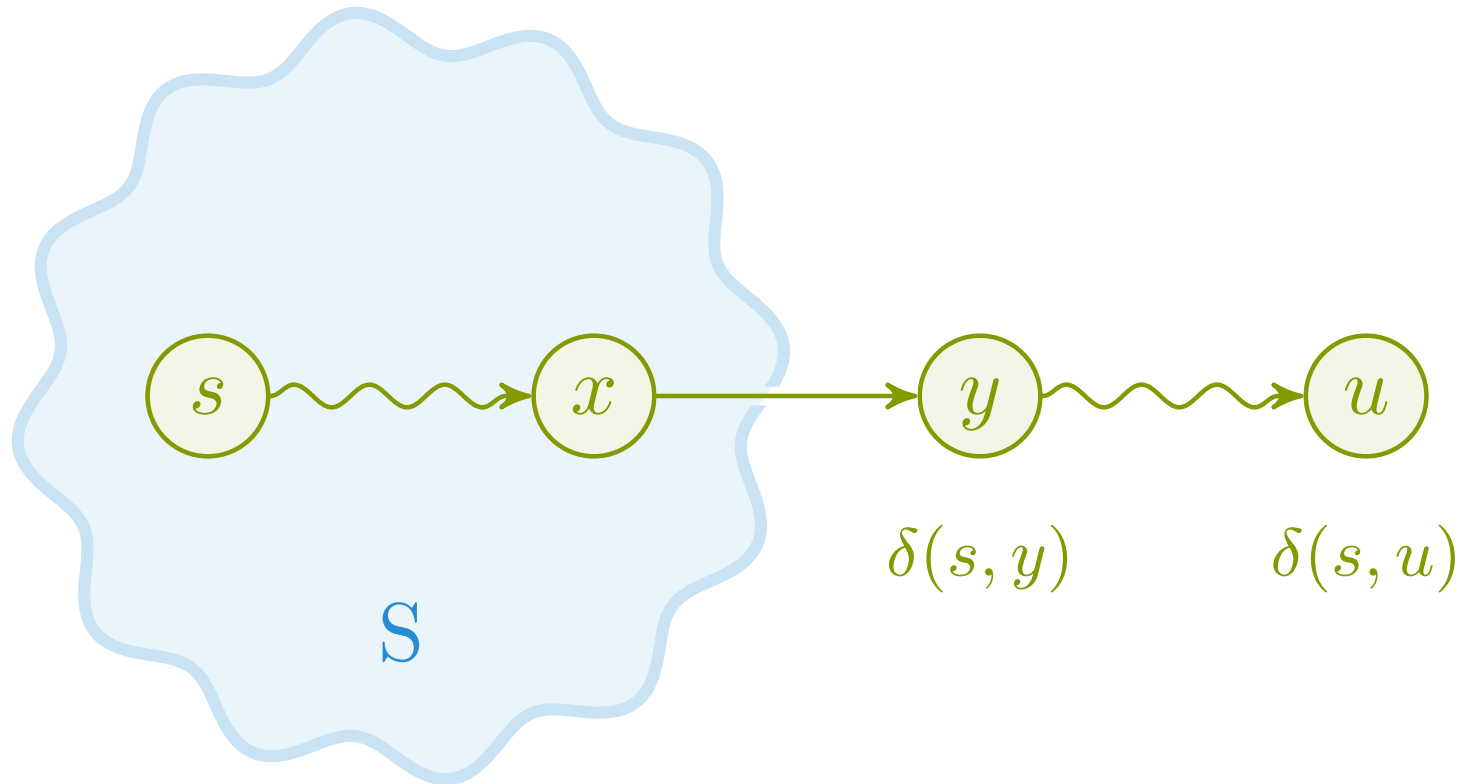
La u være den neste som skal besøkes; kan $u.d$ være feil?

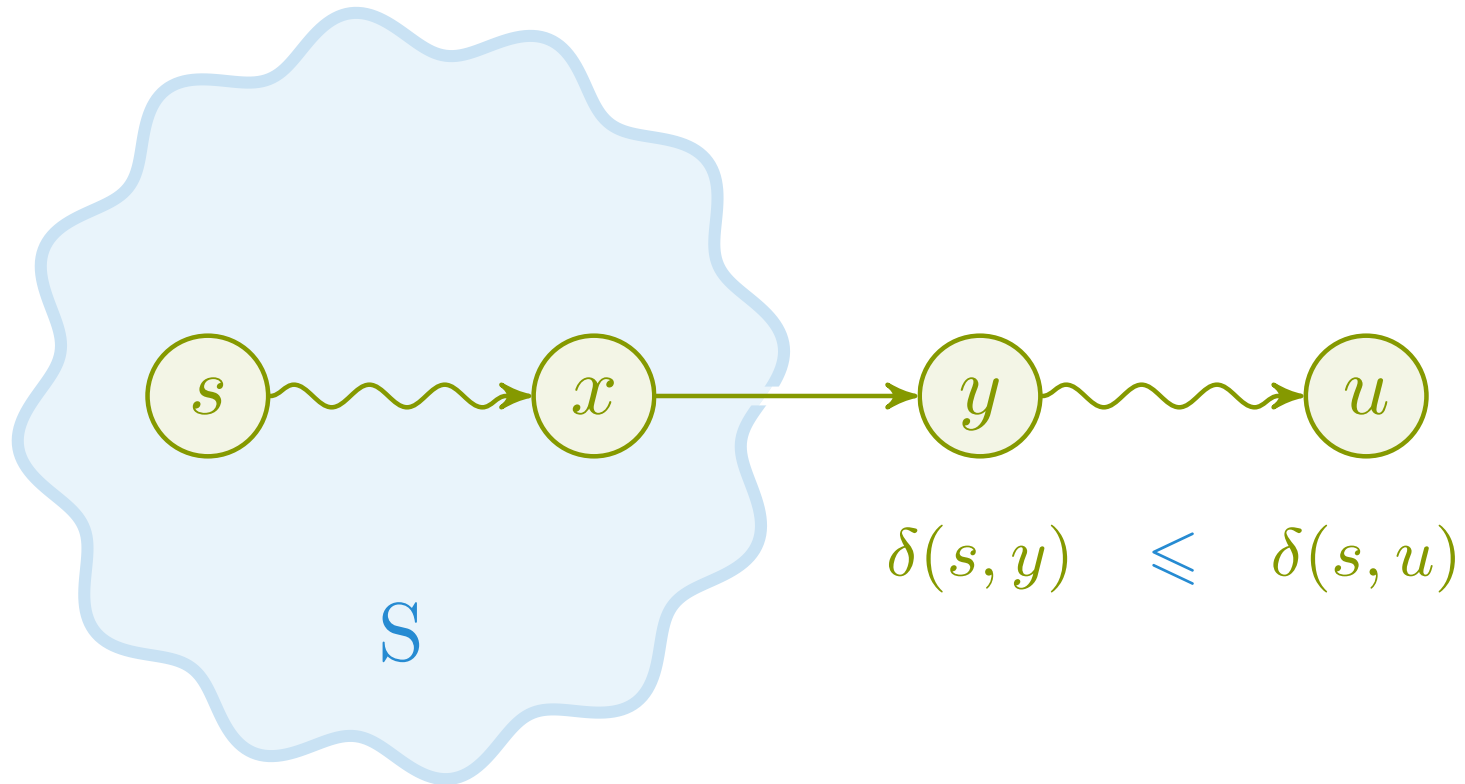


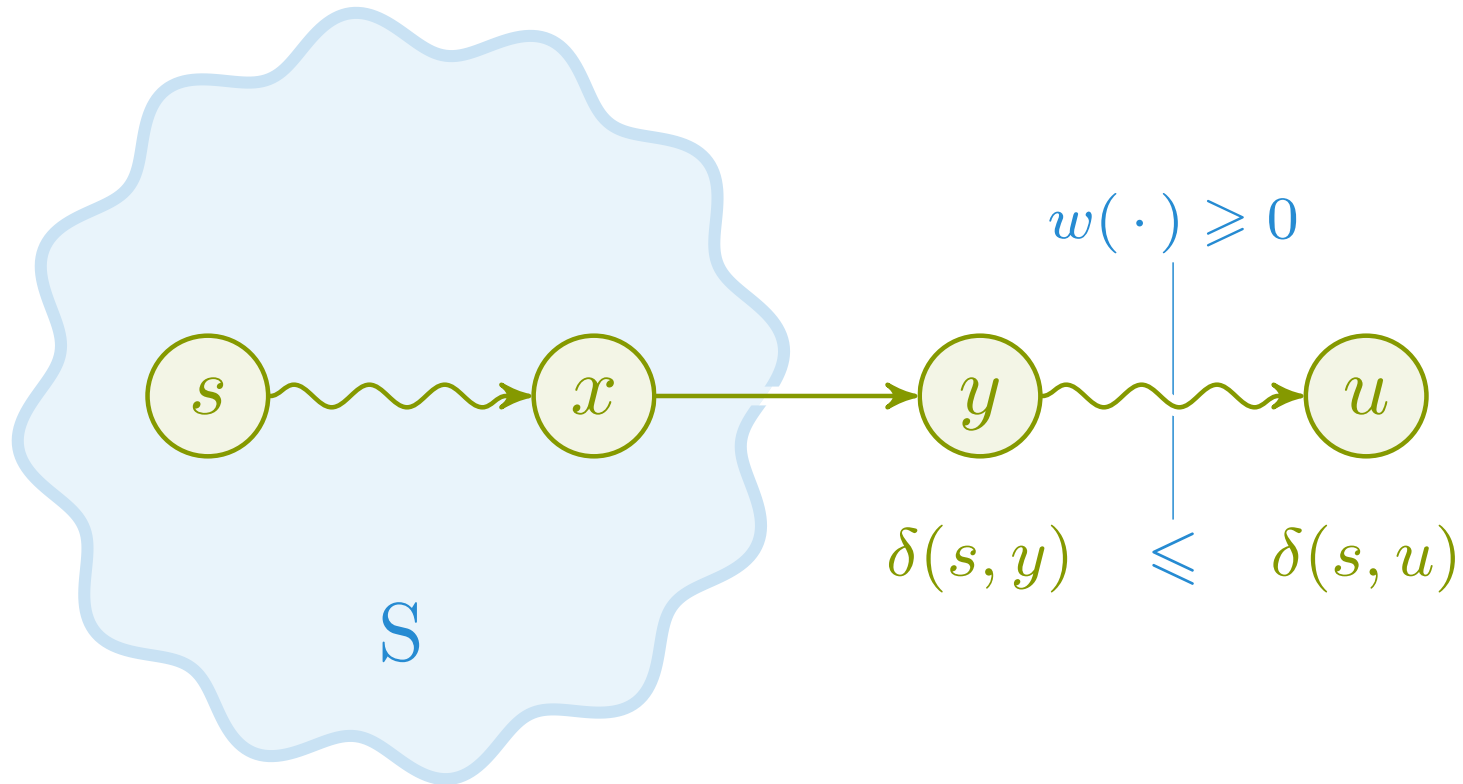
(x, y) ligger på en av de korteste stiene fra s til u



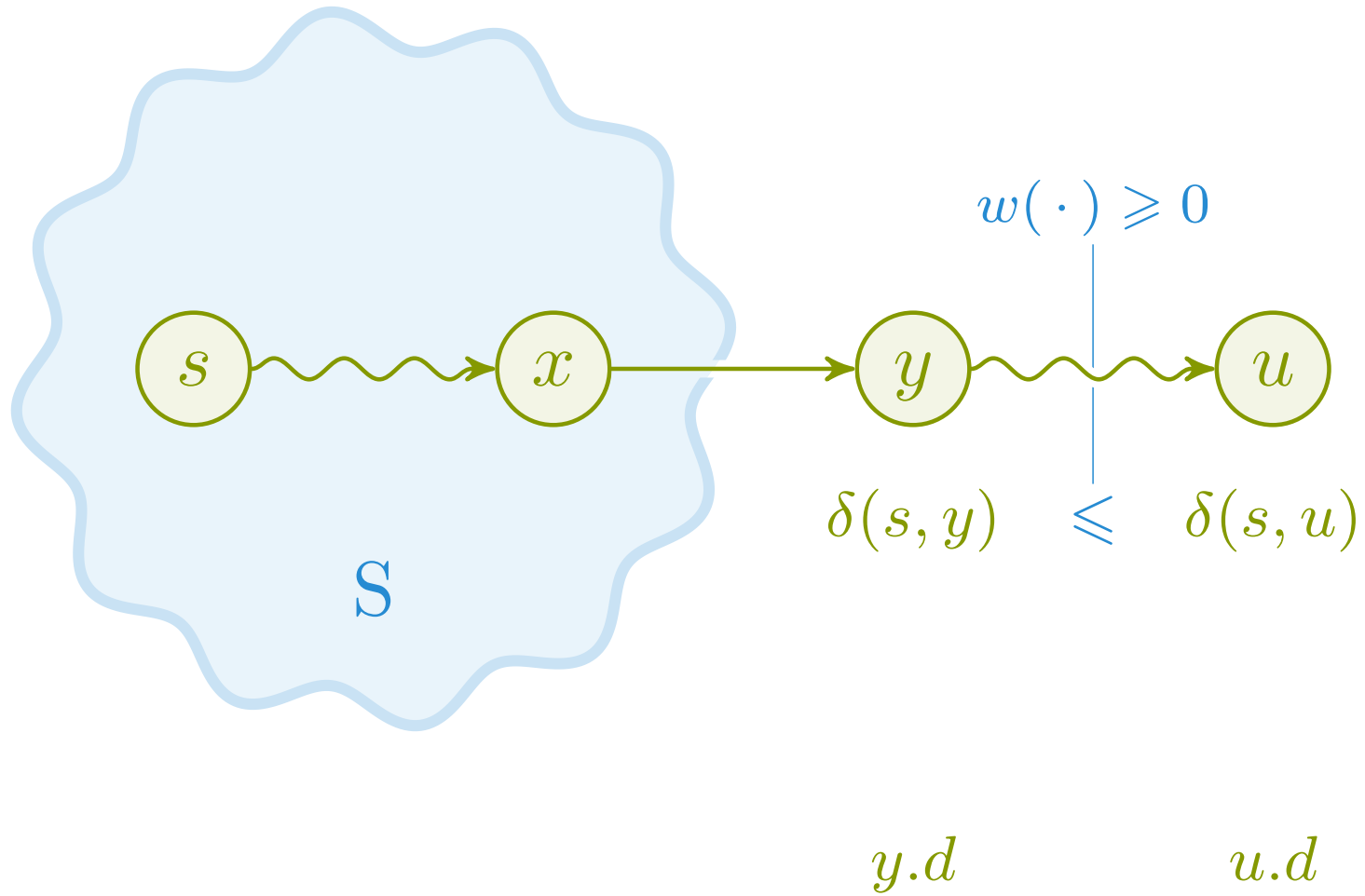
x ligger i S ; vi kan ha $s = x$ eller $y = u$; $y \rightsquigarrow u$ kan gå innom S

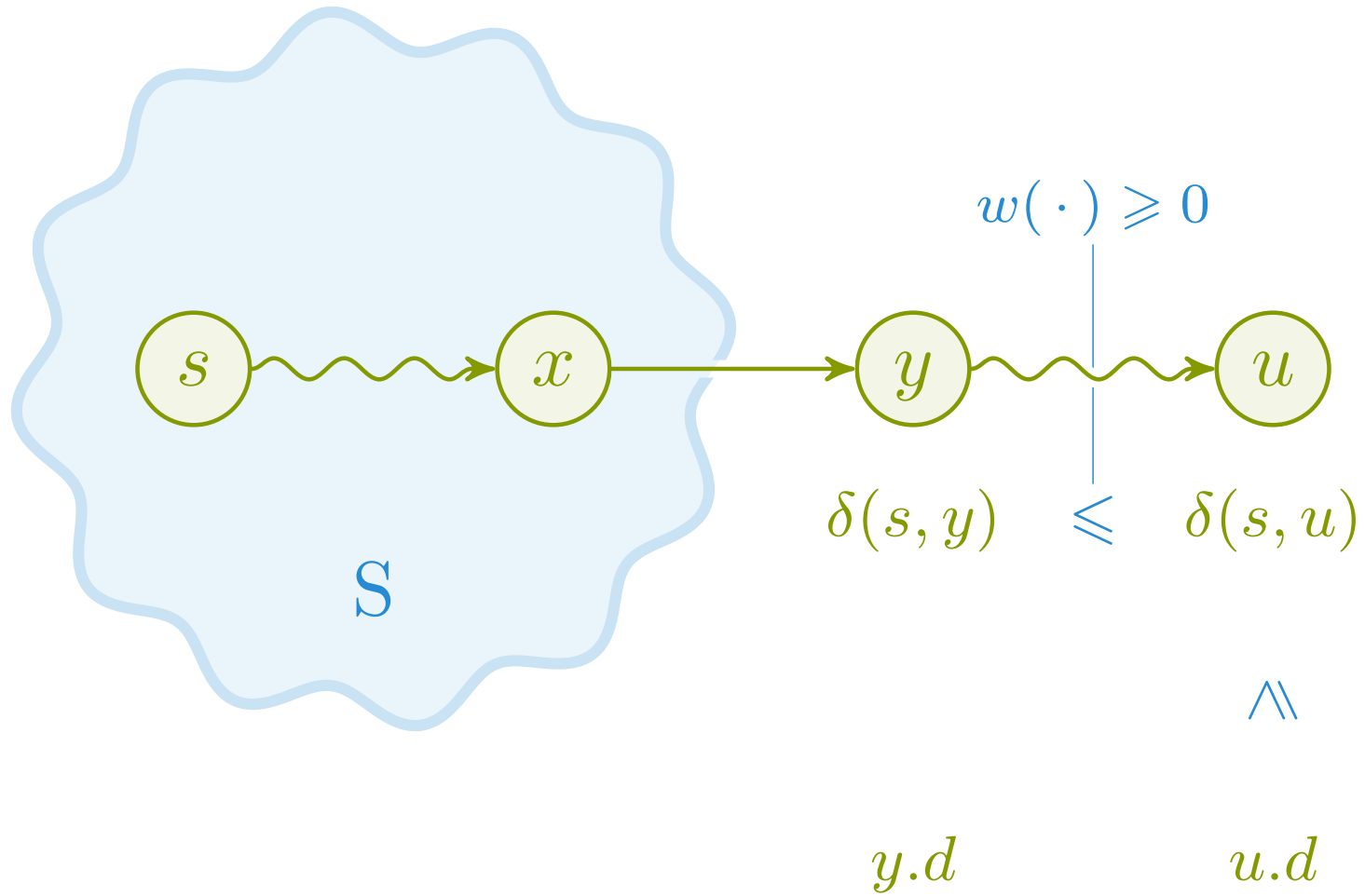


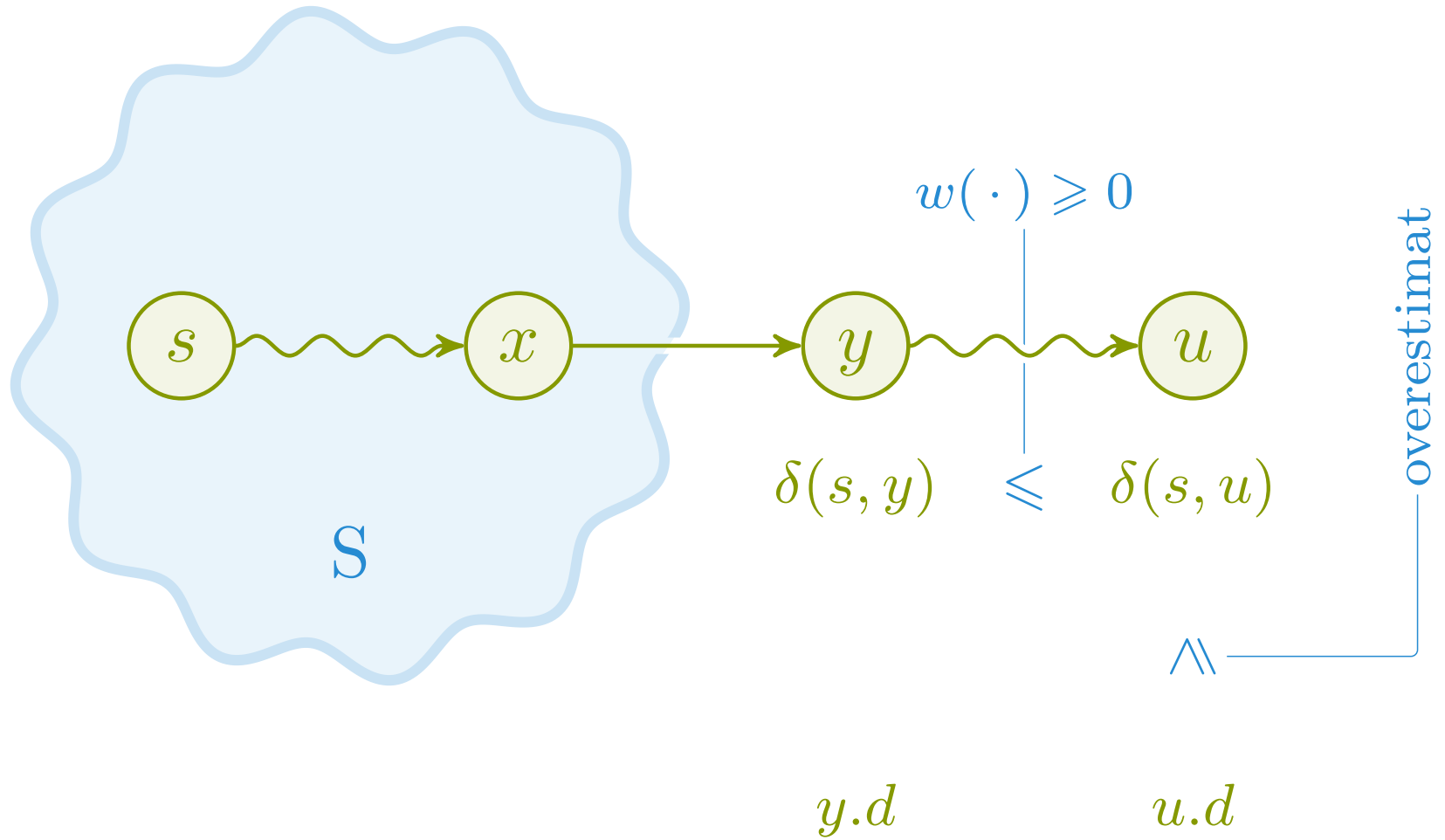


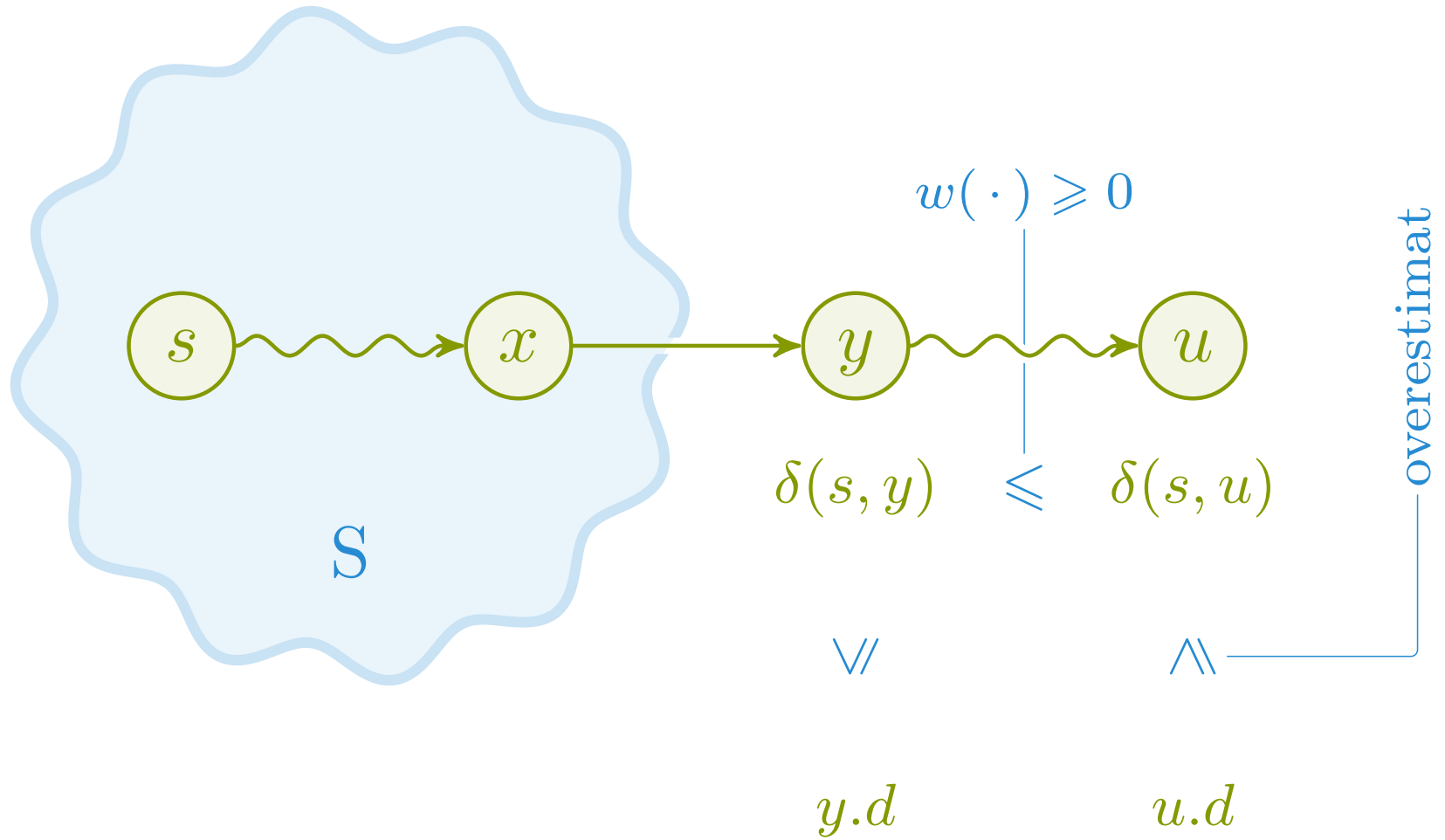


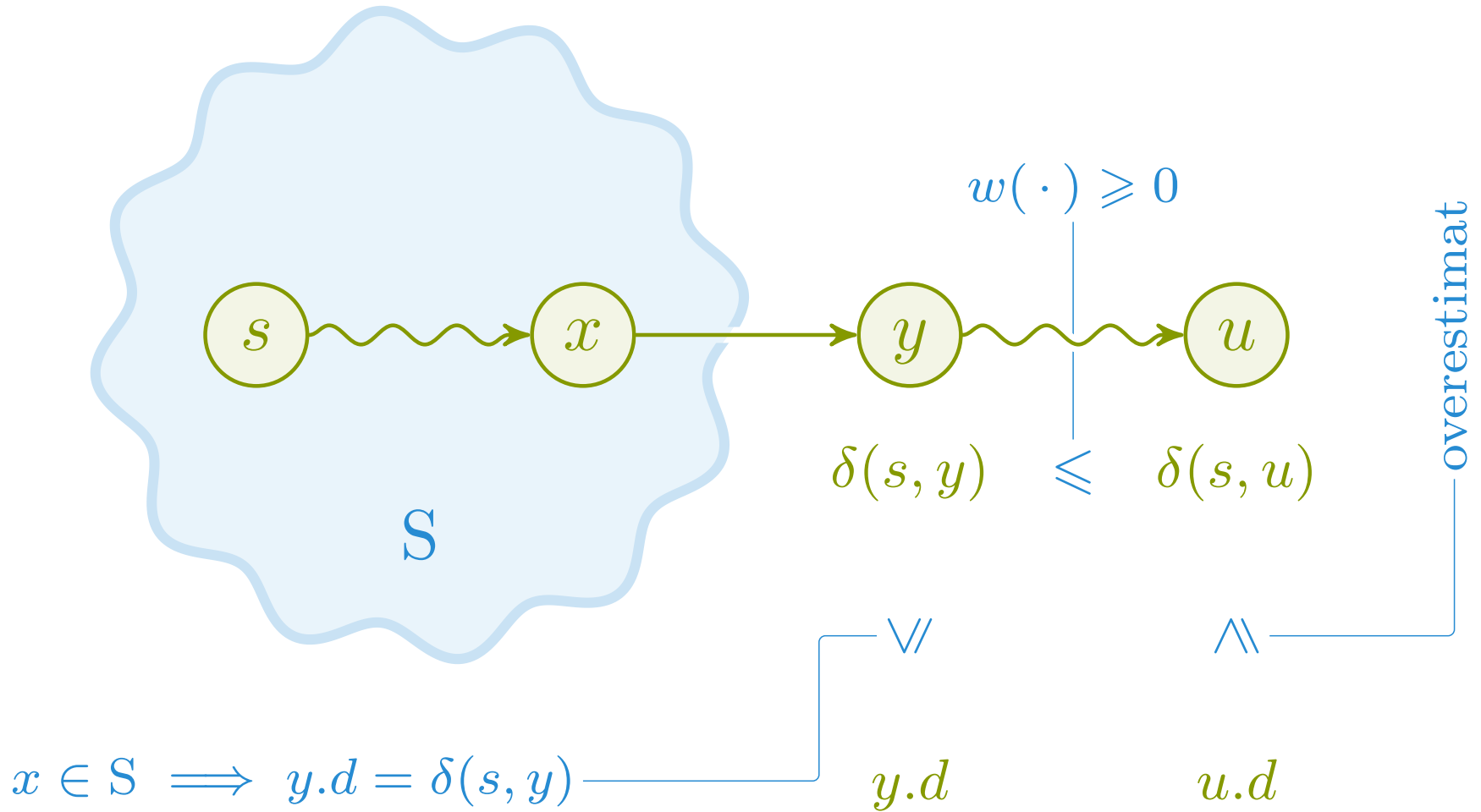
Ikke-negative vektor \implies avstandene synker ikke

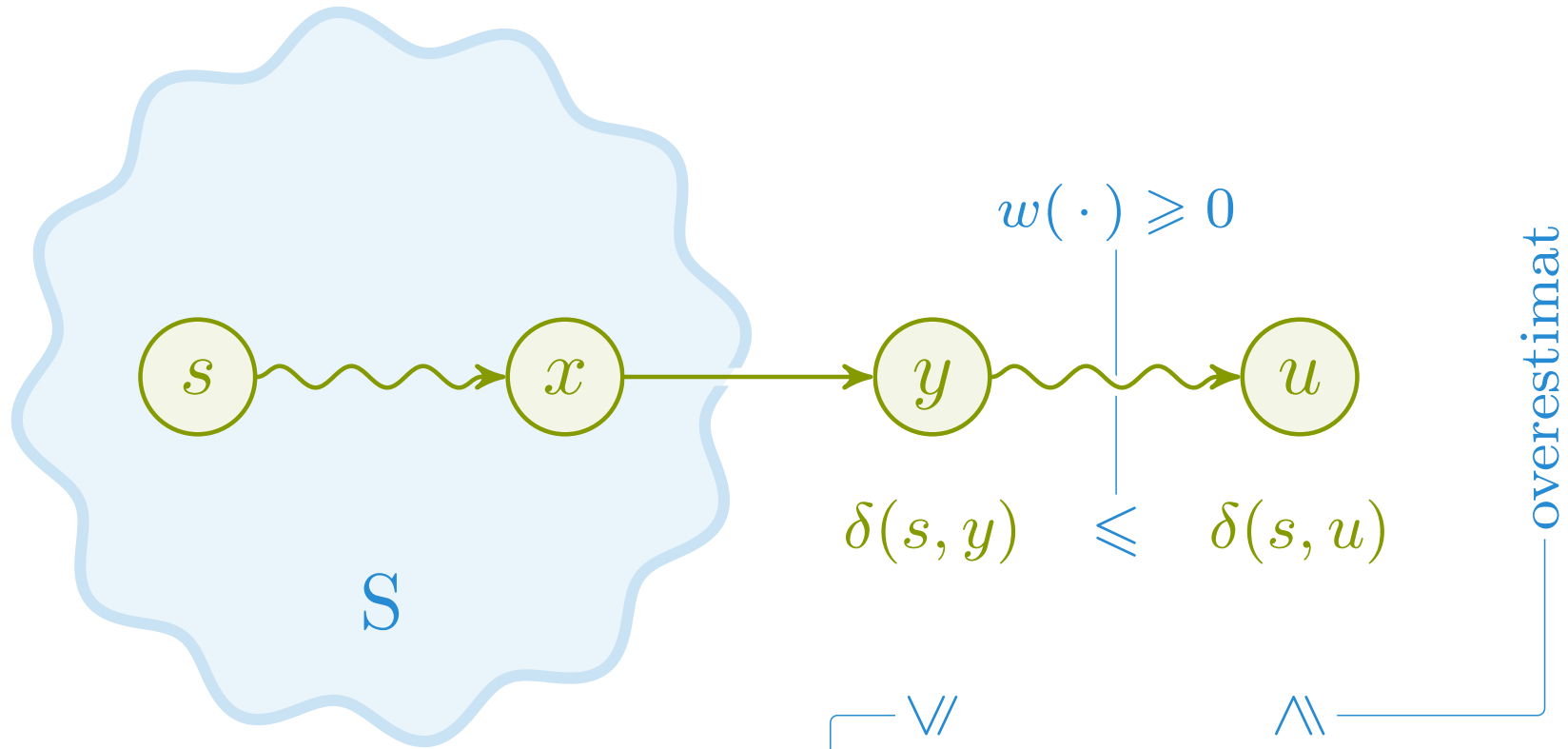




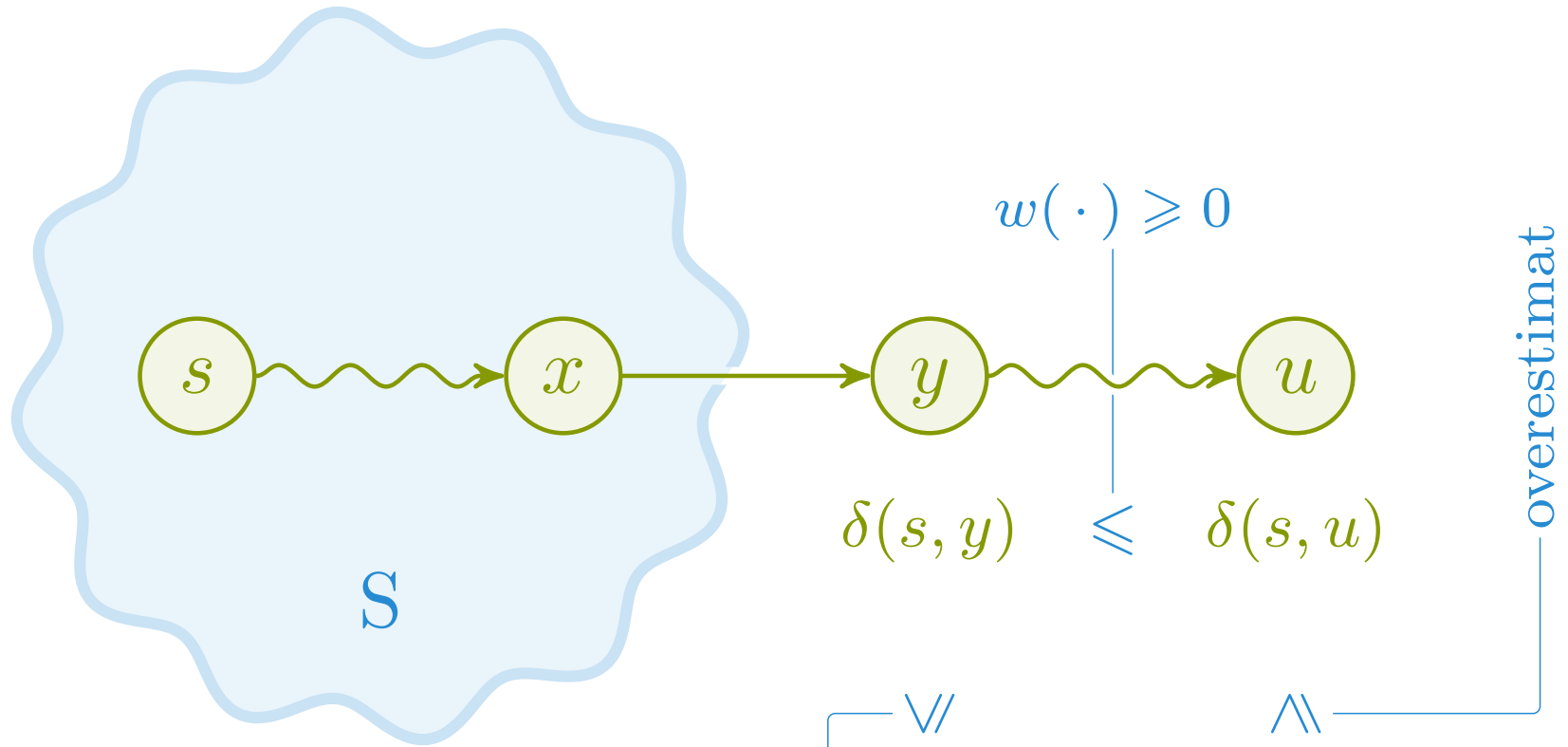




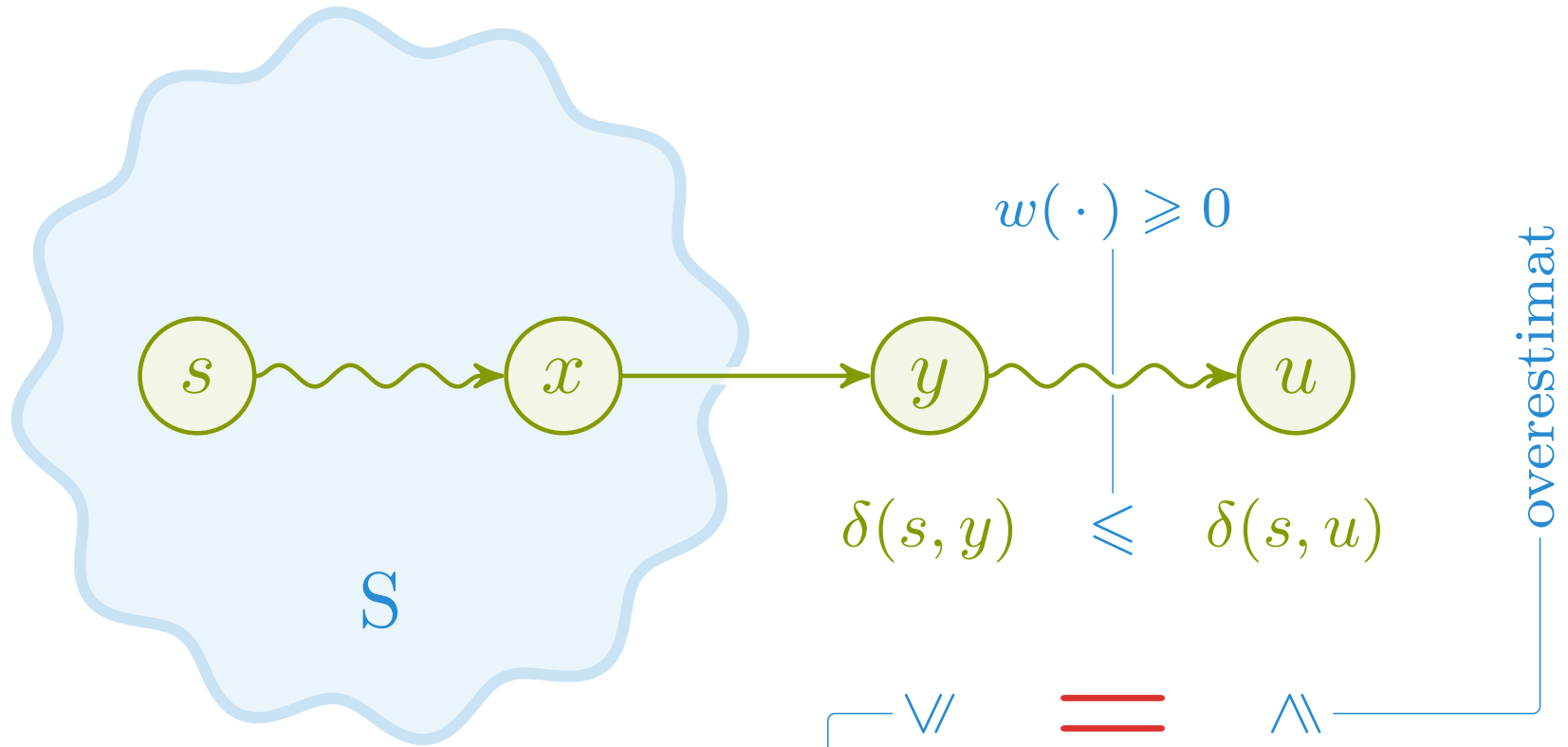




$$x \in S \implies y.d = \delta(s, y) \quad \forall \quad y.d \geq u.d \quad \wedge \quad \text{overestimat}$$



$x \in S \implies y.d = \delta(s, y)$ \forall $y.d \geq u.d$
 grådighet: u velges før y \wedge overestimat



$x \in S \implies y.d = \delta(s, y)$ \forall $=$ \wedge $u.d$
 grådighet: u velges før y $y.d \geq u.d$

$$\delta(s, y) \leq \delta(s, u)$$

$$\forall \quad = \quad \wedge$$

$$y.d \geq u.d$$

Når u velges, så er $u.d$ lik $\delta(s, u)$, altså korrekt