Spreading Alerts Quietly:

New Insights from Theory and Practice

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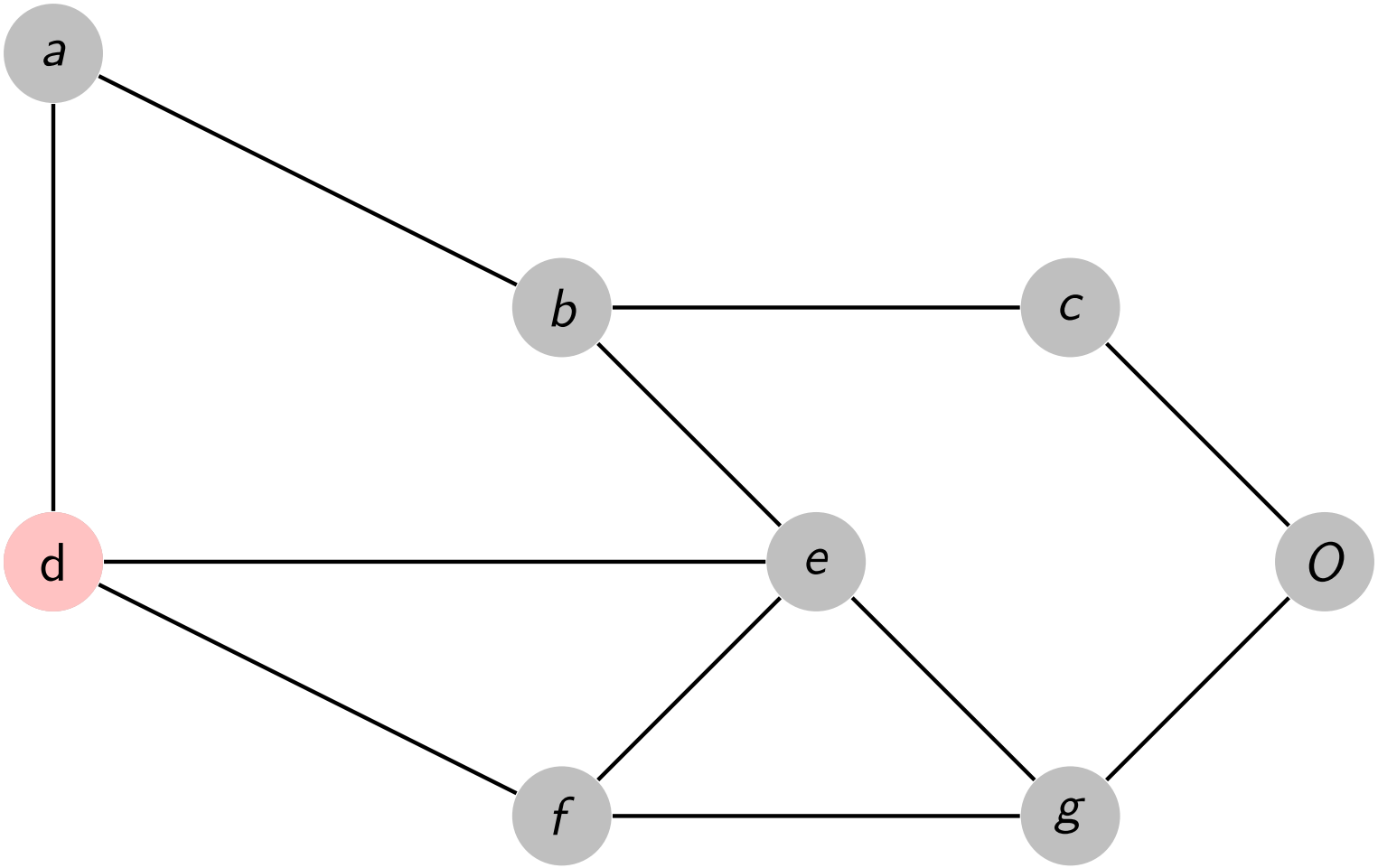
INSTITUT DE RECHERCHE xlim

UNIVERSITÉ PARIS II PANTHÉON-ASSAS

Spreading Alert



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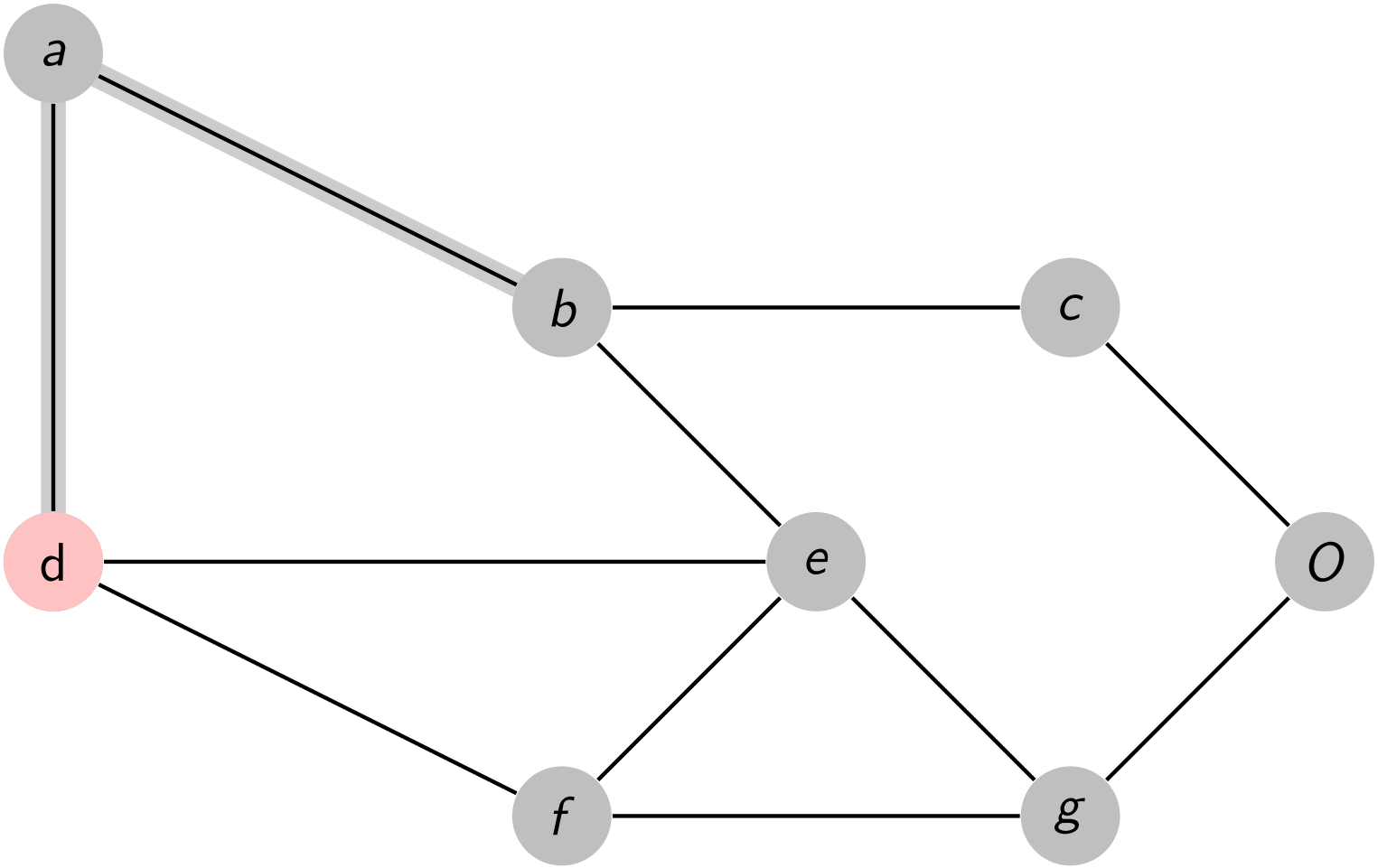

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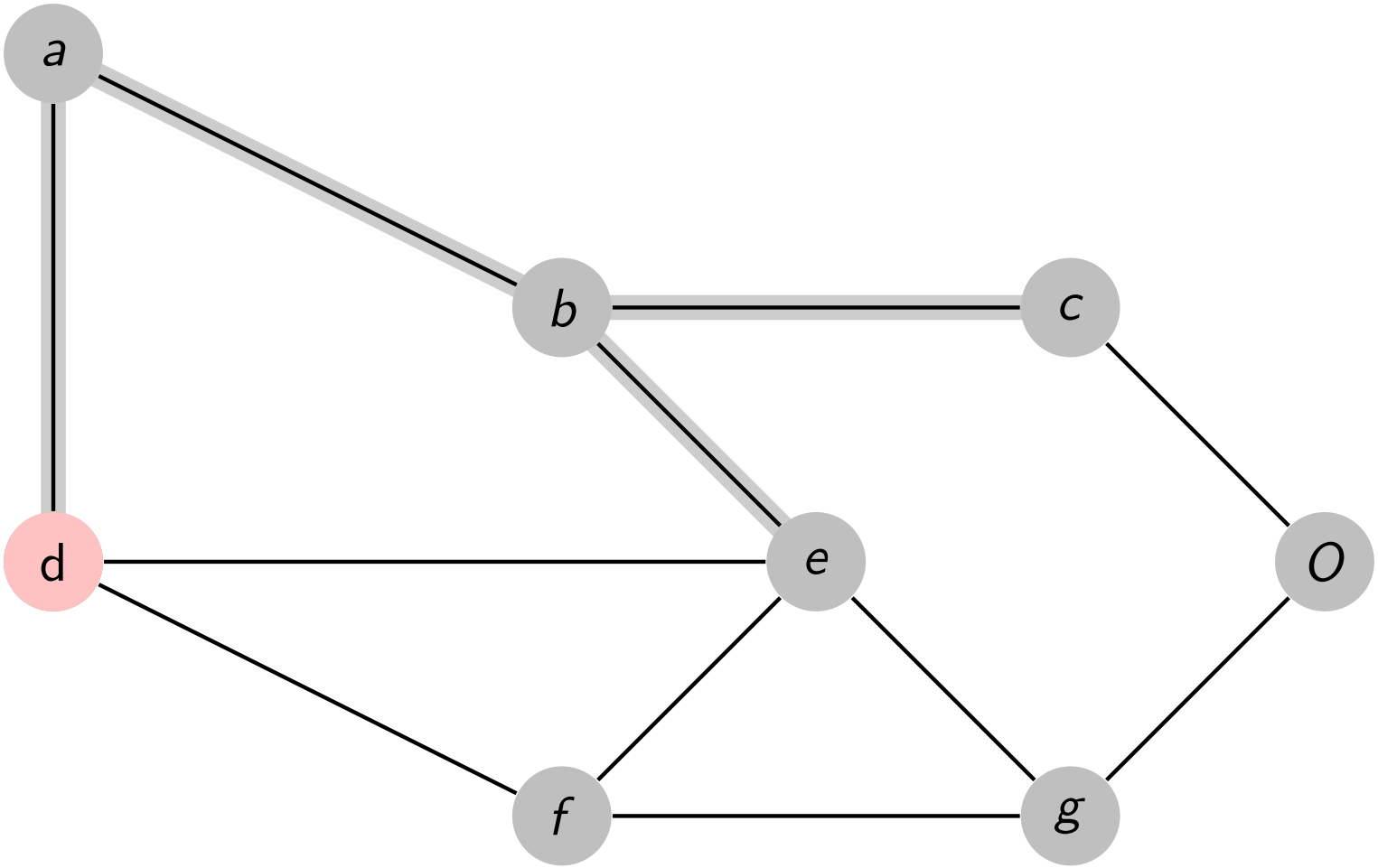

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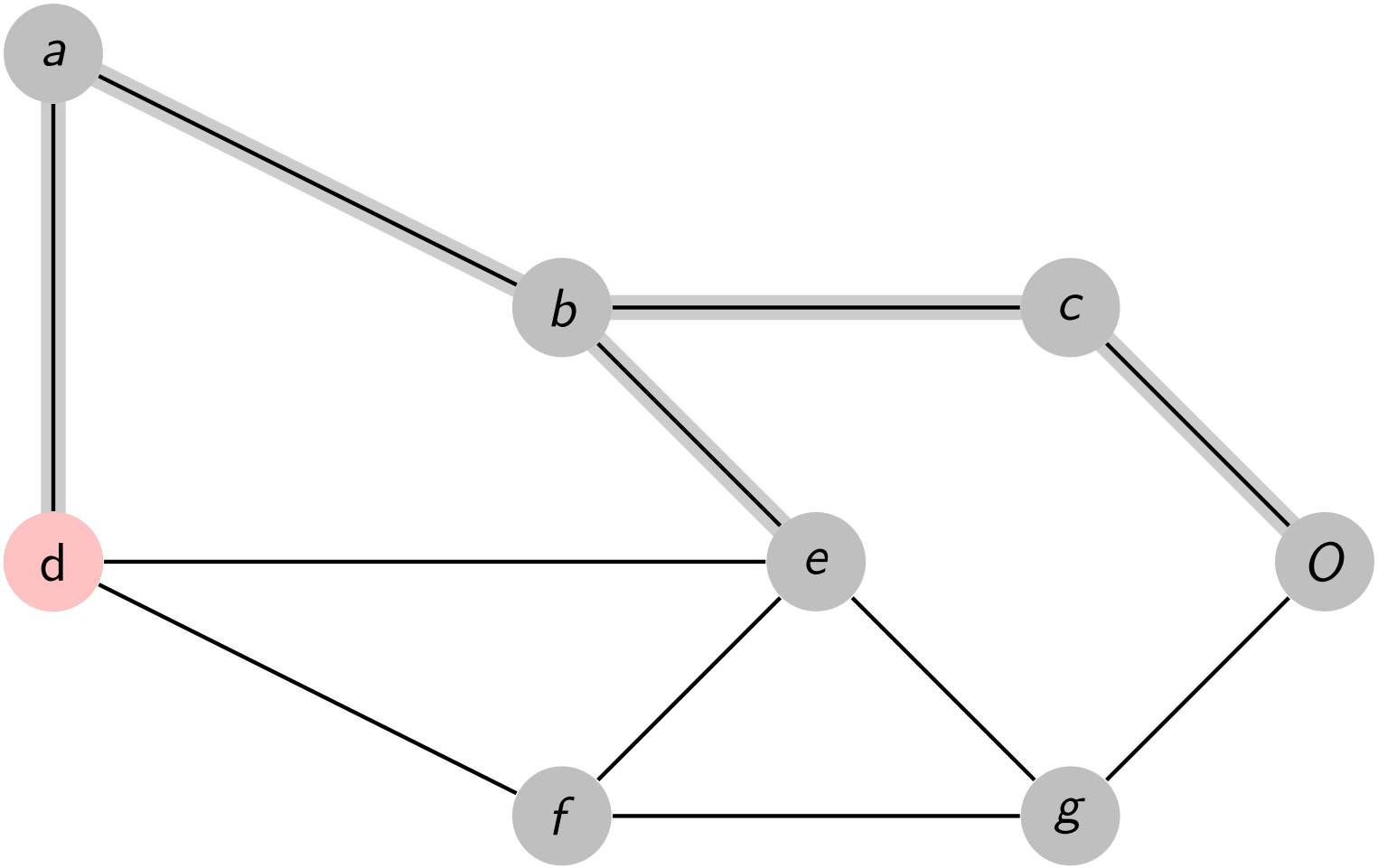

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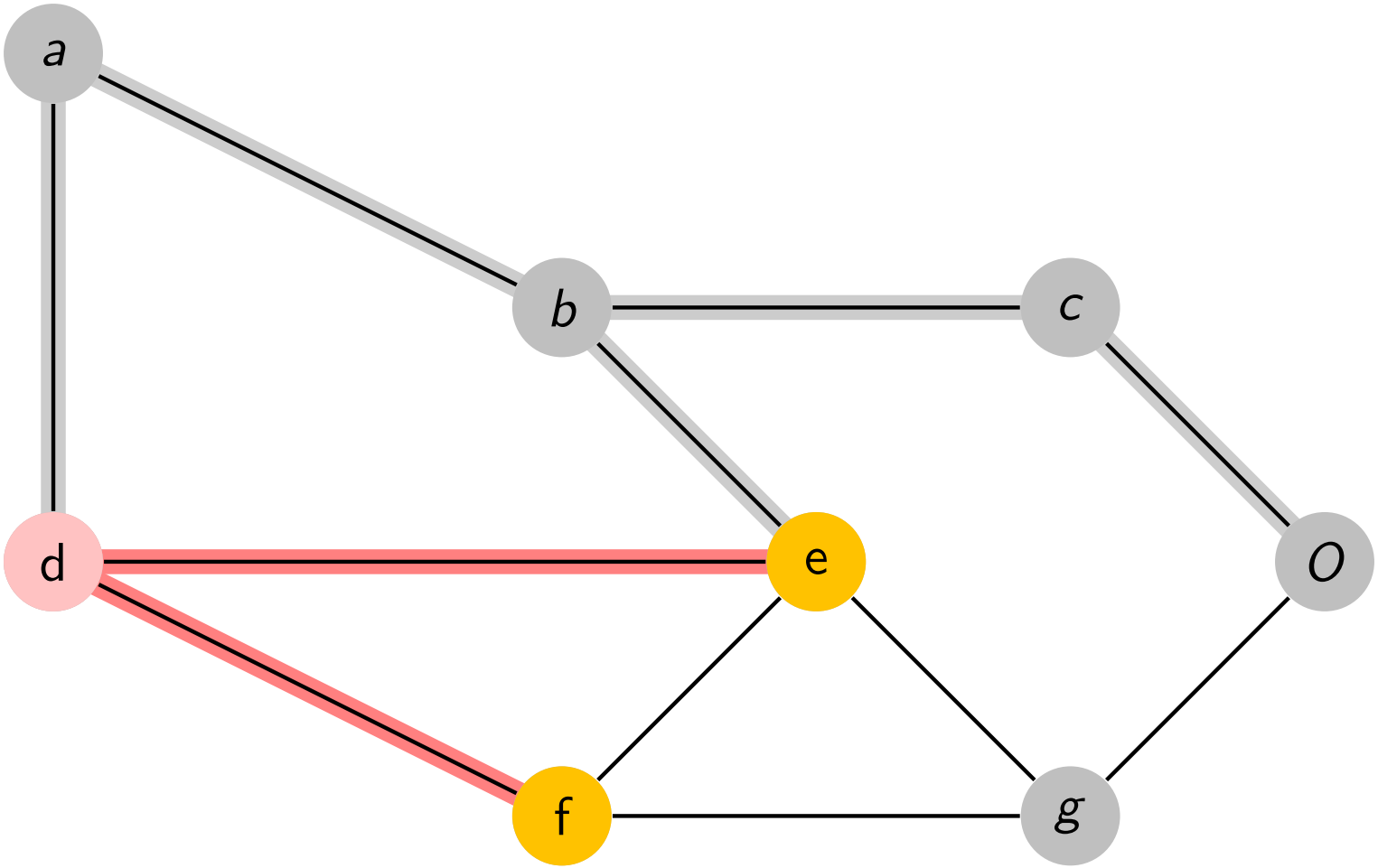

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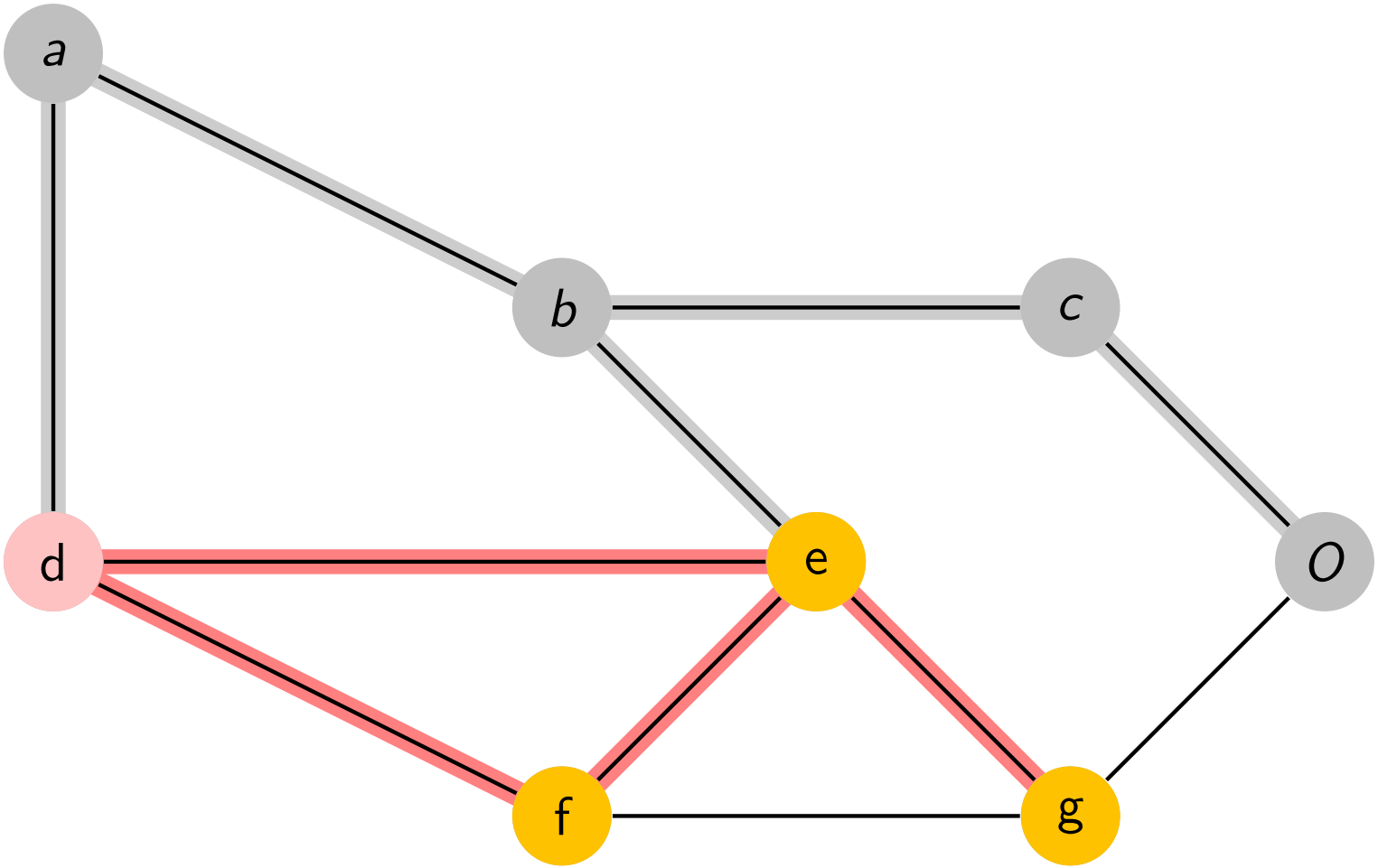

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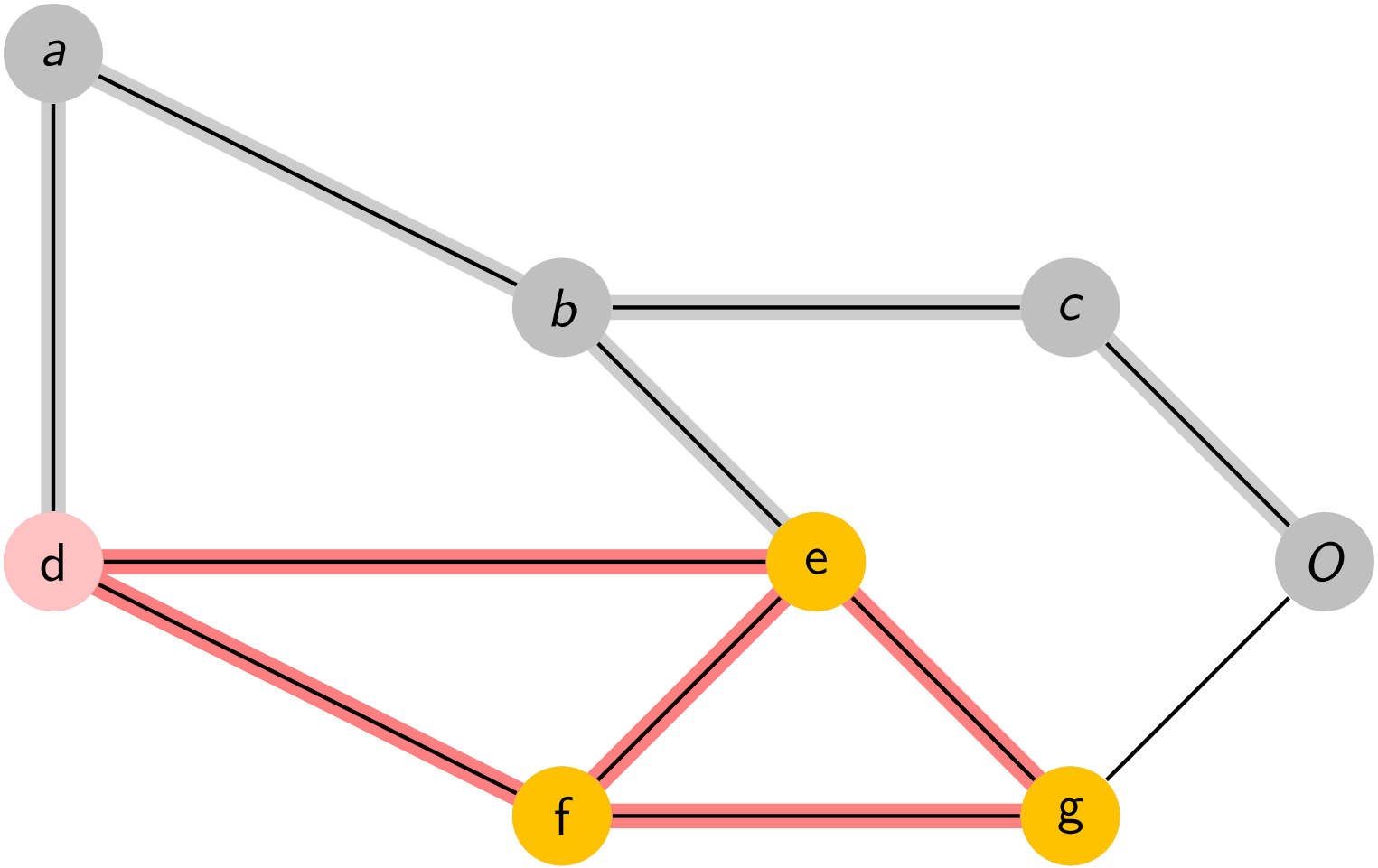

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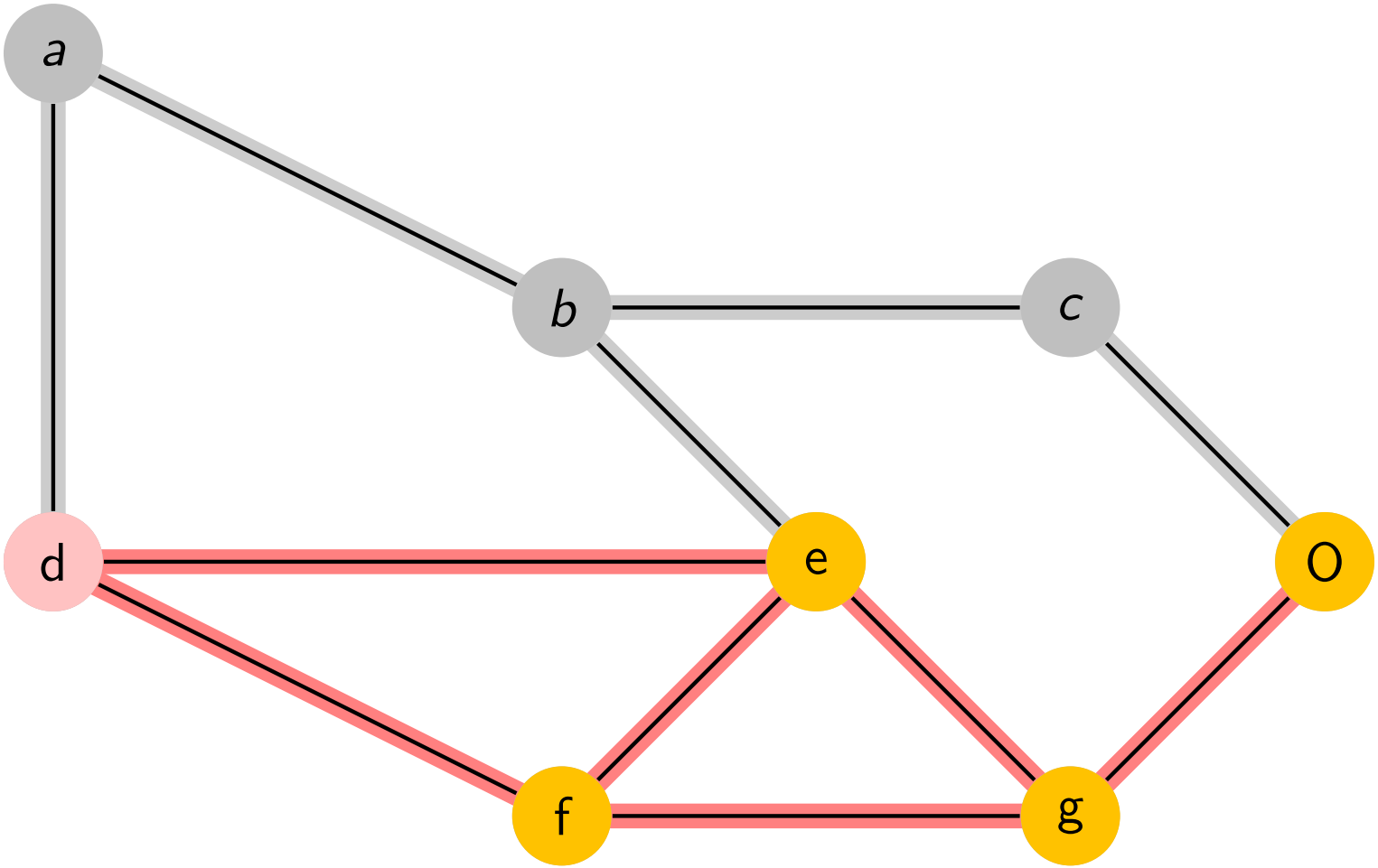

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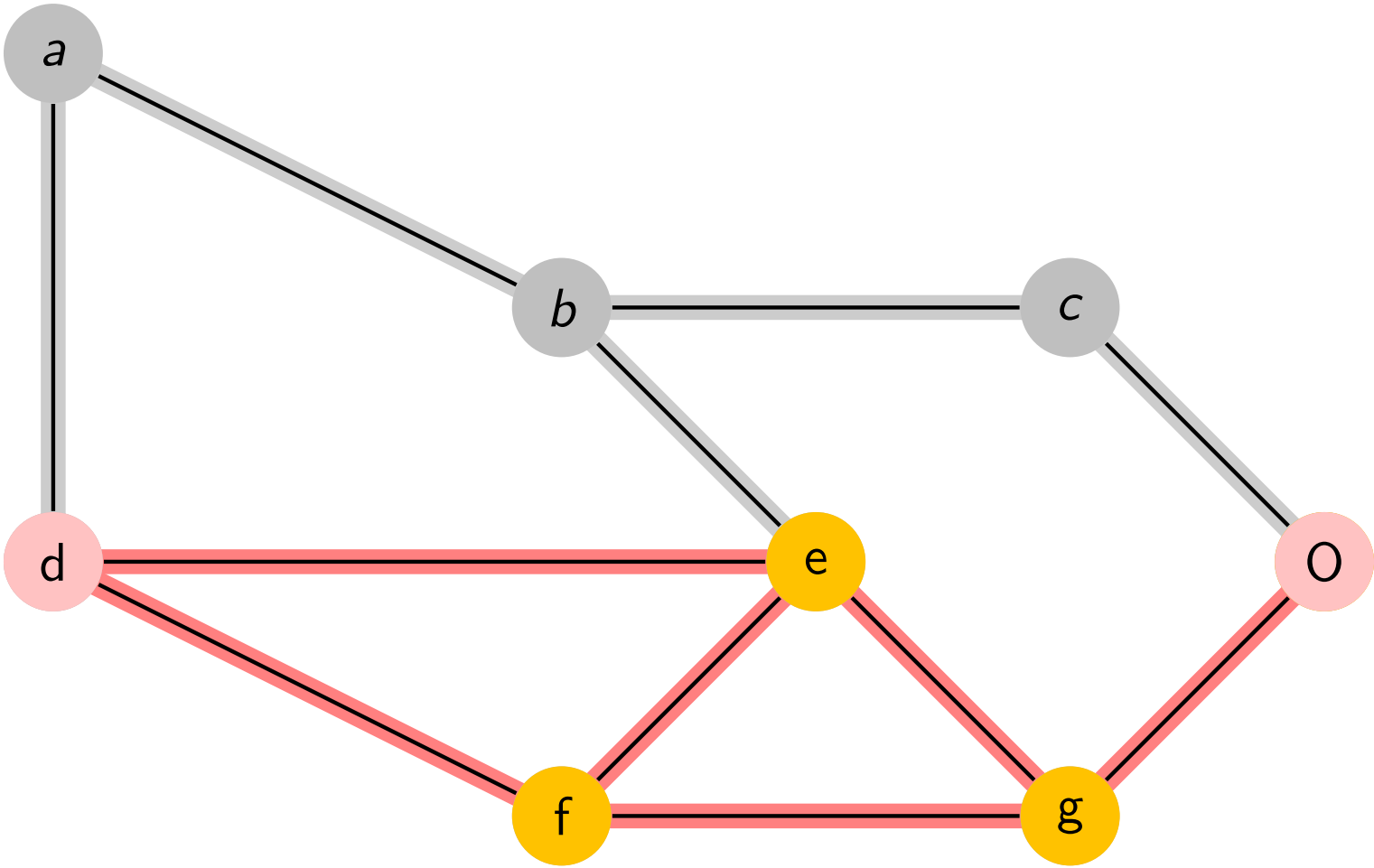

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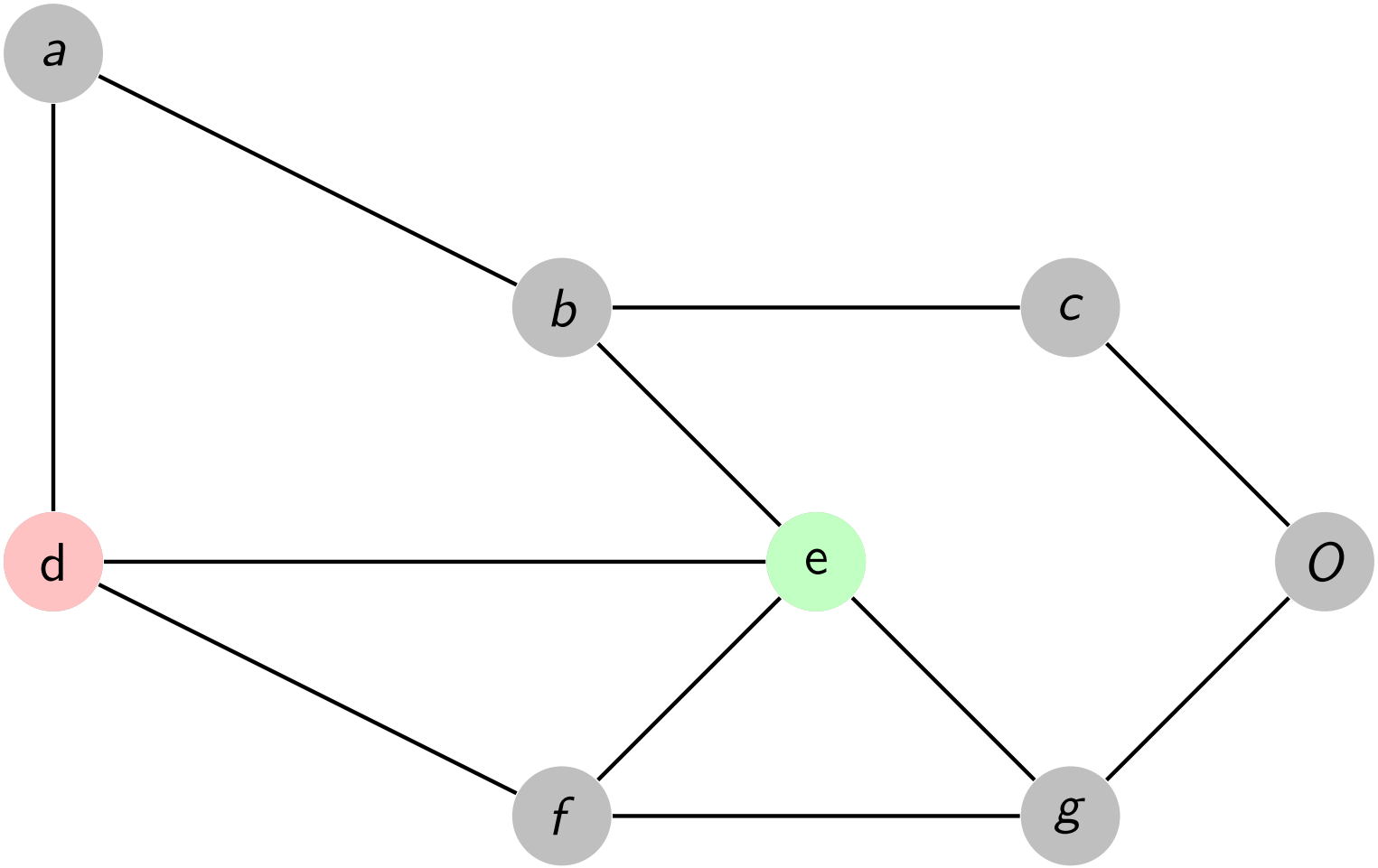

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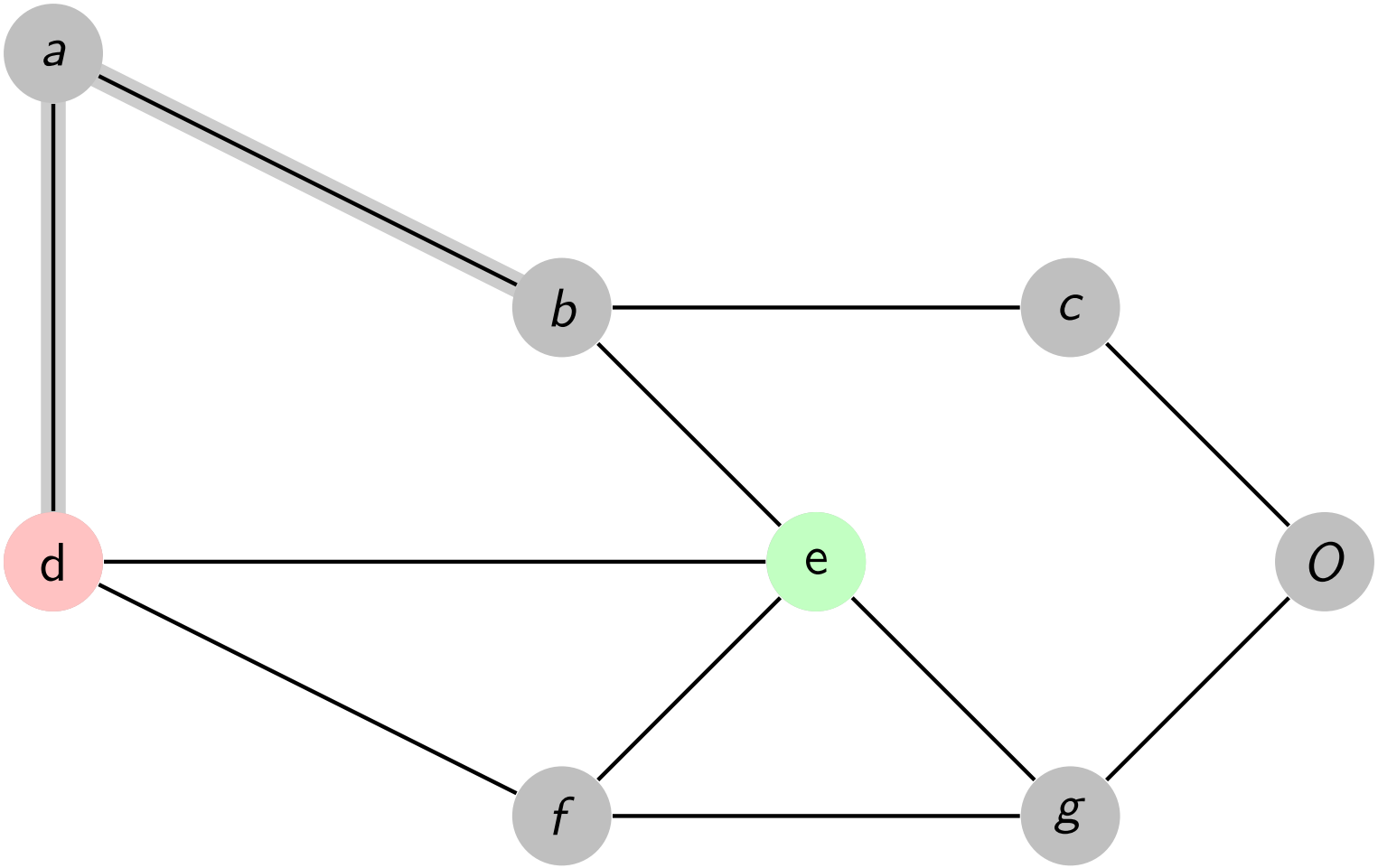

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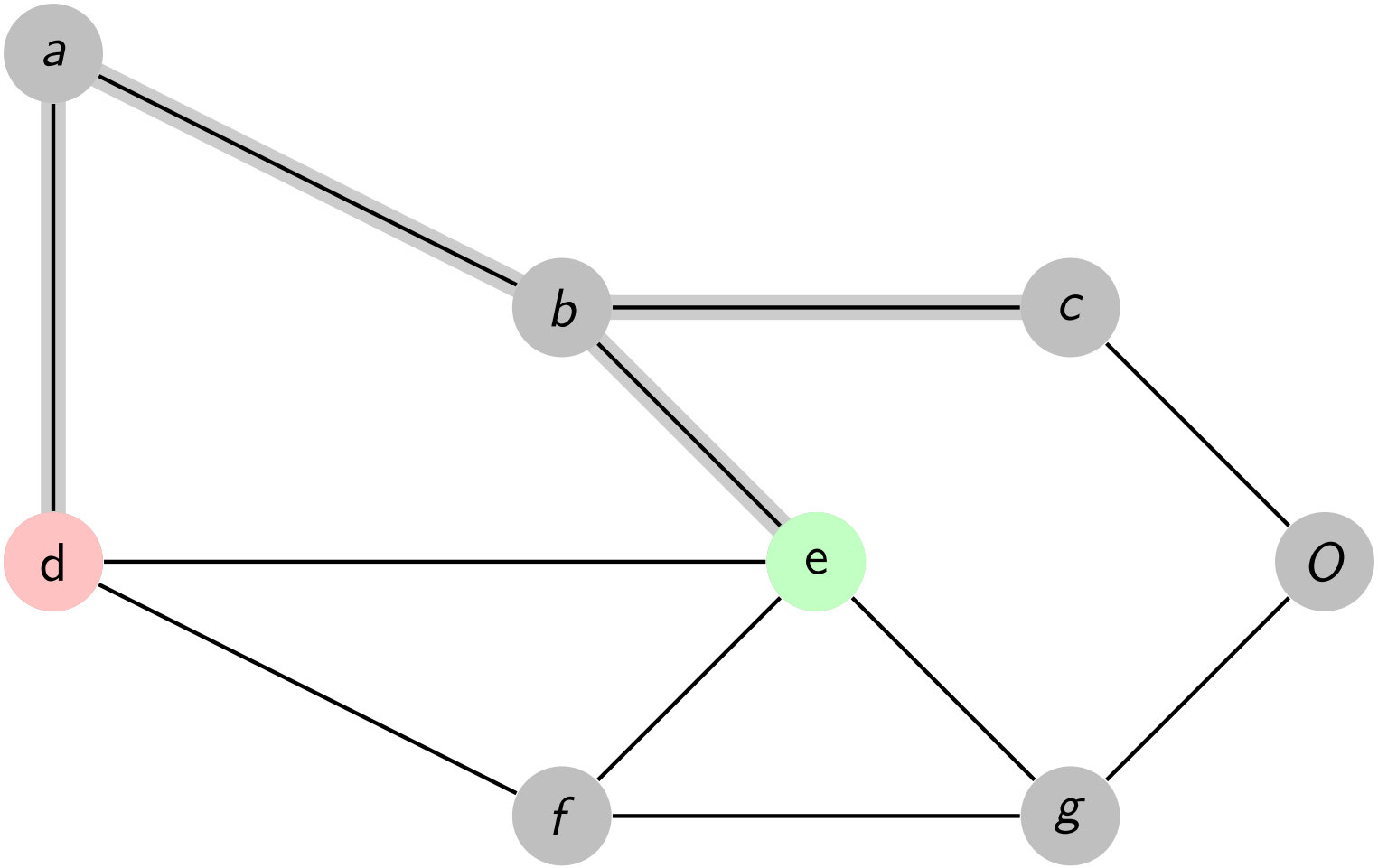

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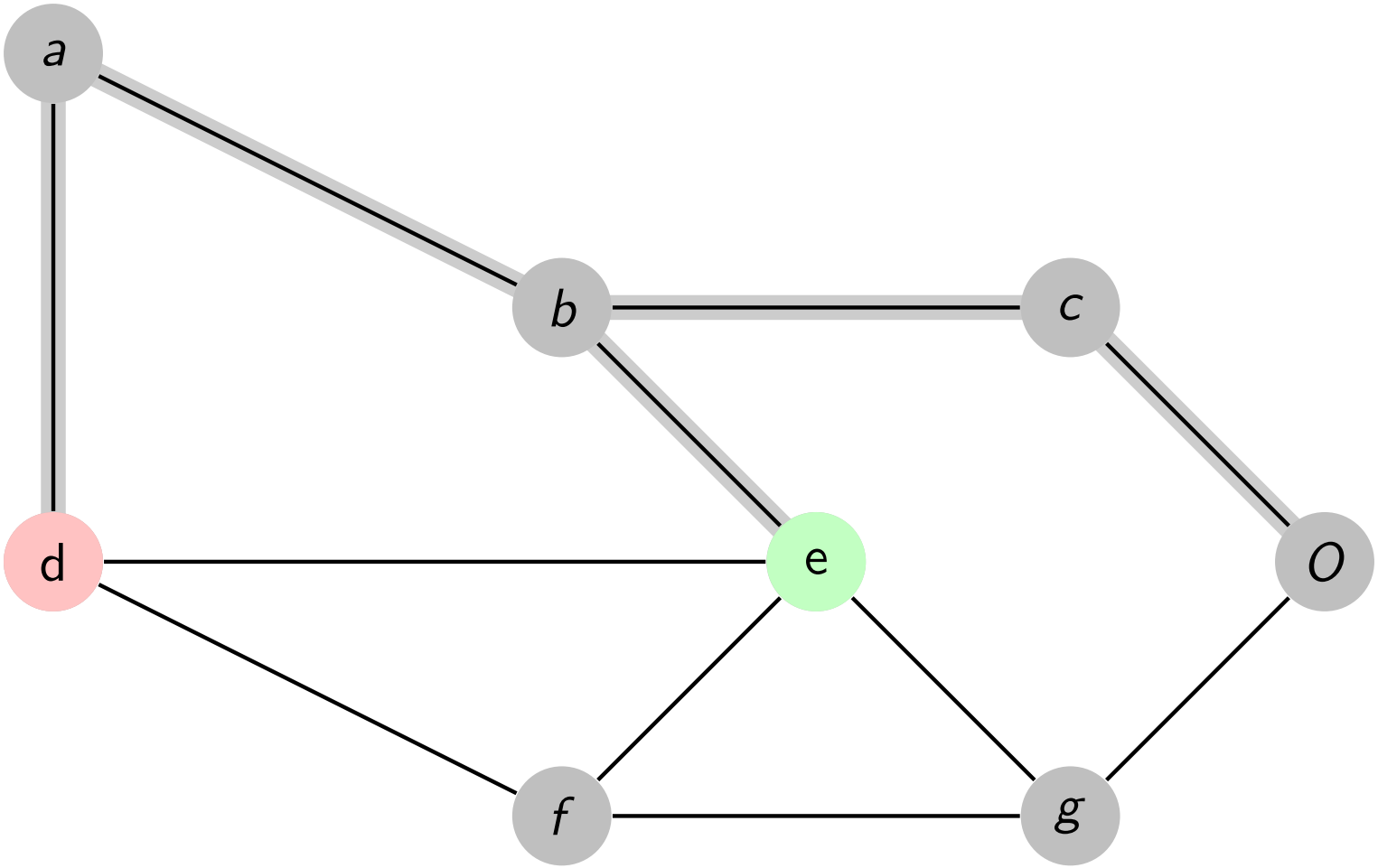

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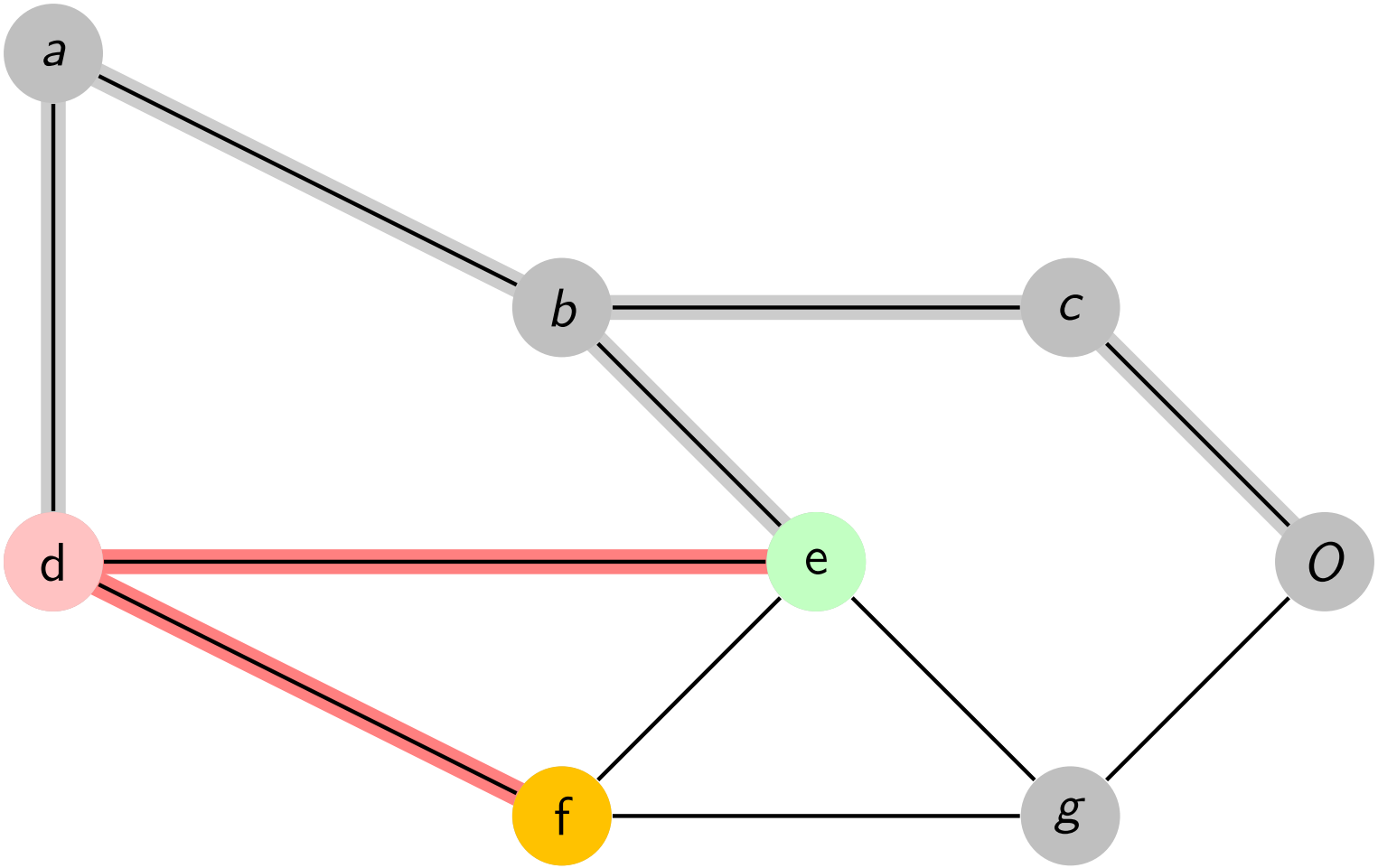

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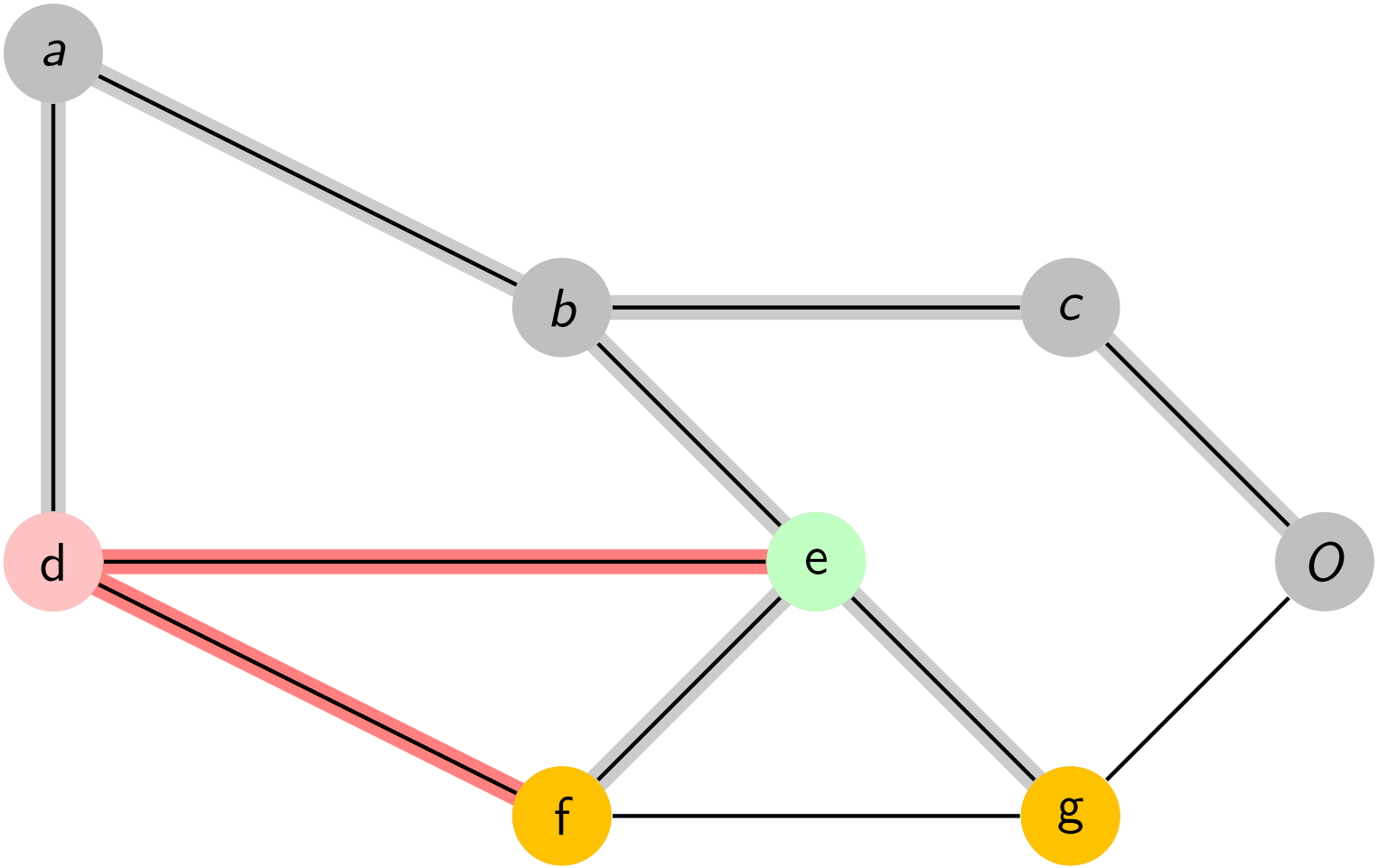

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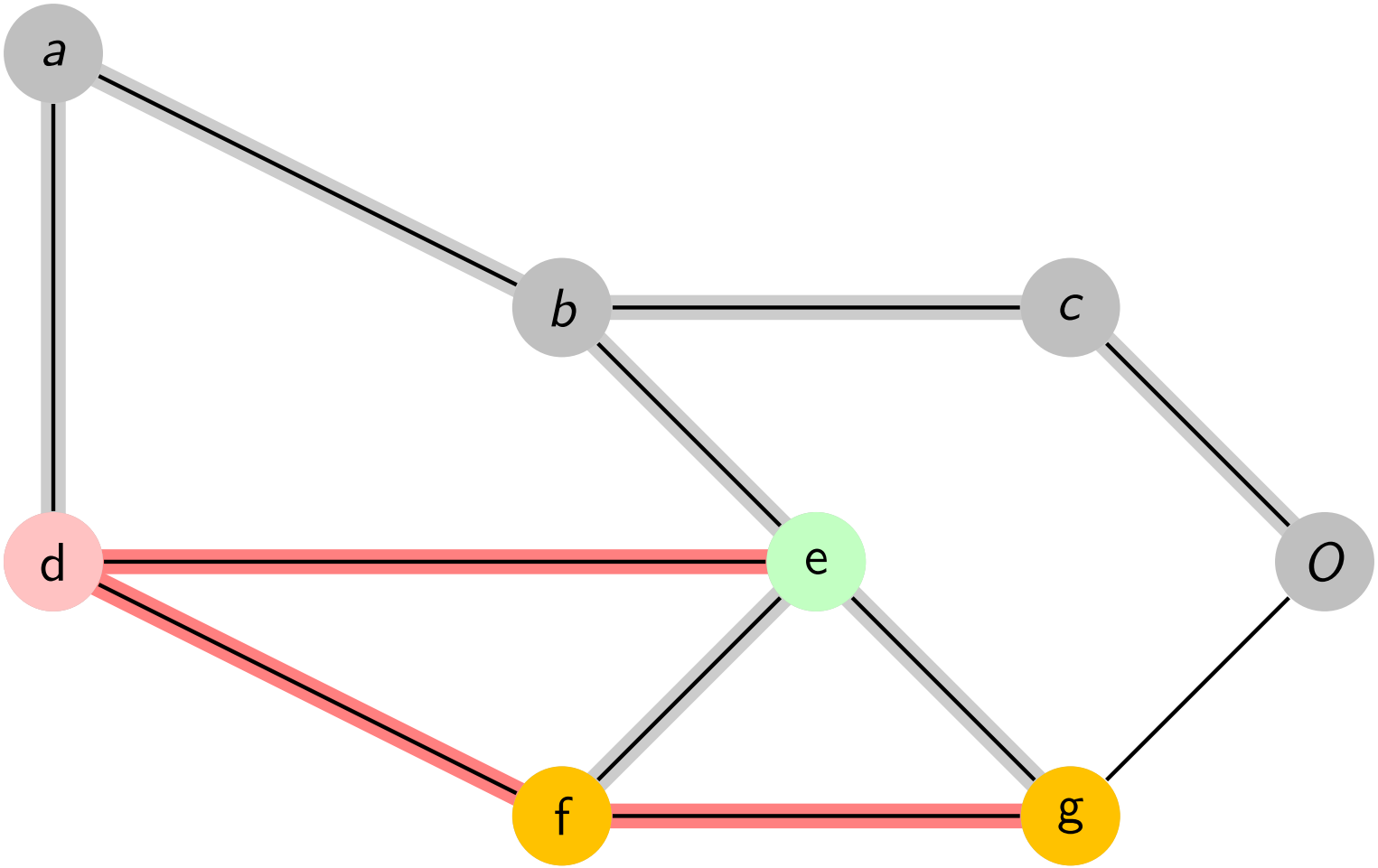

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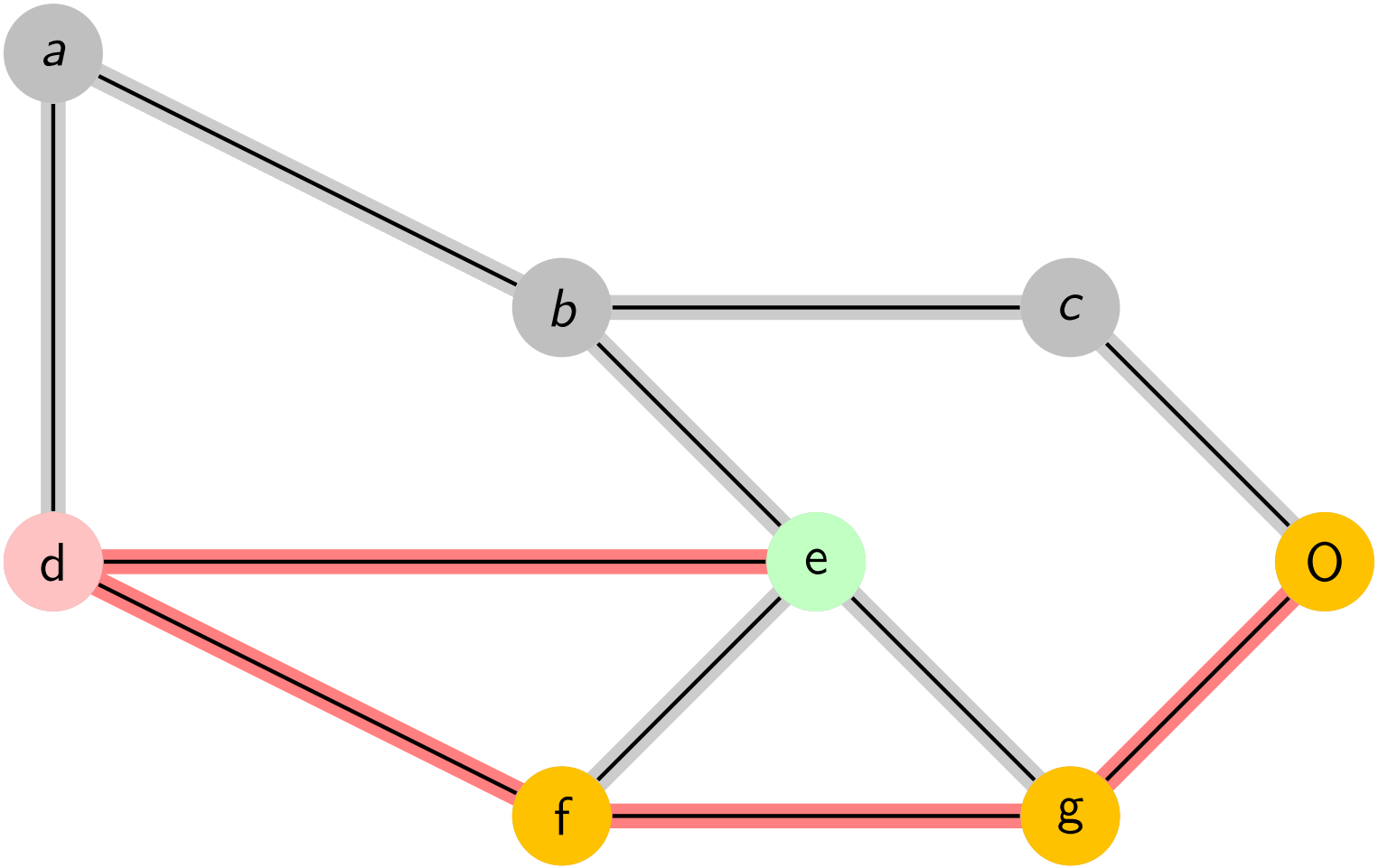

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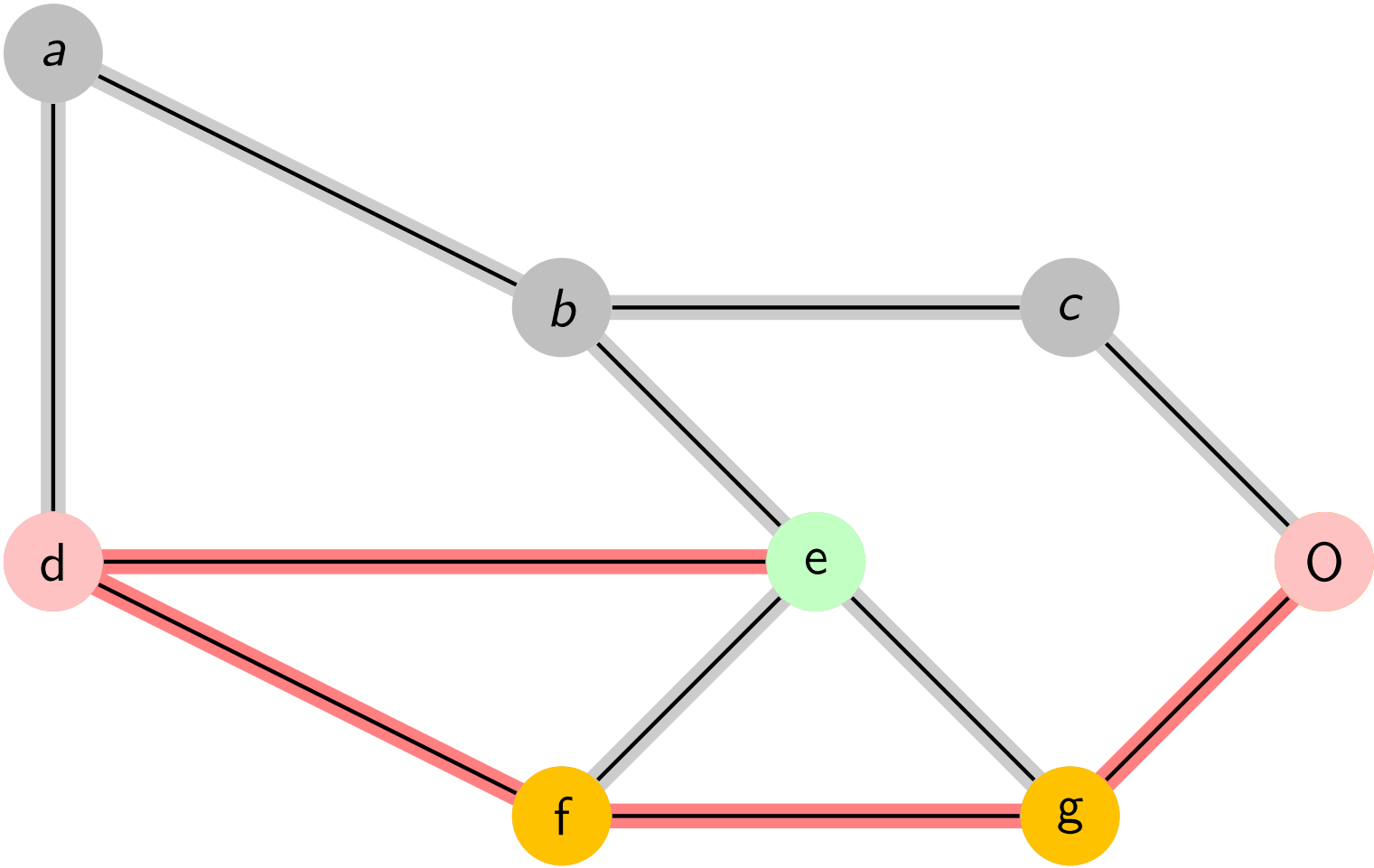

Concerns

Spreading Alert

- No other attack than denial of service
- O should be active if there is at least one alert

Quietly

Intermediate block should not learn if there is an alert

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- (Strongly) Connected Graph of non faulty nodes

Blind Coupon Mechanism

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- $\mathsf{BCMDecode}_{\mathsf{sk}}(c)$ returns 1 if c is a signal coupon (belonging to S_{sk}) and 0 if it is a dummy coupon (belonging to D_{sk});

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Unforgeability

Given access to many valid dummy coupons the adversary should not be able to create a valid signal coupon.

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- $\mathsf{BCMDecode}_{\mathsf{sk}}$. Given a valid $c = (c_1, c_2)$, outputs 1 iff $c_2 = c_1^x$.

Combination (Absorbing)

Dummy-Dummy $\equiv$ Dummy

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Signal-Signal $\equiv$ Signal

$$(g^r, h^r) \cdot (g^s, h^s) \equiv (g^t, h^t) \xleftarrow{\$} \mathbb{G}^2$$

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Under the DDH assumption

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Unforgeability

Impossible to generate a Diffie Hellman tuple in an unknown basis.

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- Verify(vk, τ, M, σ): Outputs 1 iff the signature is valid.

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  $\mathsf{sk} = (\xi_i, \delta_i)$, $h_2 \in \mathbb{Z}_p^{2\times 2} \times \mathbb{G}_2$, and $\mathsf{vk} = (h_2, \mathsf{hp}_i) \in \mathbb{G}_2 \times \mathbb{G}_2^2$

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- Sign(sk, ϵ, M): $\sigma = (z,u) = (M_0, M_1) \odot (-\xi_i, -\delta_i)$:

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- Verify($\mathsf{vk}, \epsilon, M, \sigma$): checks whether

$$1_{\mathbb{G}_T} = e(z, g_2) e(u, h_2) e(M_0, \mathsf{hp}_0) e(M_1, \mathsf{hp}_1)$$

Combining

- BCMGen(1^λ): $(\mathsf{vk}, \mathsf{sk}) \leftarrow \mathsf{Sign.KeyGen}()$, $\beta_h \xleftarrow{\$} \mathbb{Z}_p$, $g \xleftarrow{\$} \mathbb{G}_1$, $h = g^{\beta_h}$, sets $\mathsf{pk} = \mathsf{vk}, \mathsf{sk} = (\mathsf{sk}, g, h, \beta_h)$

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- $\mathsf{BCMVerify}_{\mathsf{pk}}(c)$: Outputs $\mathsf{Sign.Verify}(\mathsf{vk}, \epsilon, c_1, c_2)$.
- $\mathsf{BCMCombine}_{\mathsf{pk}}(c_u, c_R)$: Picks $\lambda, \mu \xleftarrow{\$} \mathbb{Z}_p$ and outputs $\mathsf{SignDerive}(\mathsf{vk}, (\lambda, c_u, \mu c_R))$.

Combining

- BCMGen(1^λ): $(\mathsf{vk}, \mathsf{sk}) \leftarrow$ Sign.KeyGen(), $\beta_h \xleftarrow{\$} \mathbb{Z}_p$, $g \xleftarrow{\$} \mathbb{G}_1$, $h = g^{\beta_h}$, sets $\mathsf{pk} = \mathsf{vk}, \mathsf{sk} = (\mathsf{sk}, g, h, \beta_h)$
- $\mathsf{BCMCouponGen}_{\mathsf{pk},\mathsf{sk}}(1^\lambda)$: Picks $\rho_i, \rho_i' \xleftarrow{\$} \mathbb{Z}_p^*$, outputs a dummy $((g^{\rho_i}, h^{\rho_i}), \mathsf{Sign}(\mathsf{sk}, (g^{\rho_i}, h^{\rho_i})))$, and a signal $((g^{\rho_i}, h^{\rho_i'}), \mathsf{Sign}(\mathsf{sk}, (g^{\rho_i}, h^{\rho_i'})))$.
- $\mathsf{BCMVerify}_{\mathsf{pk}}(c)$: Outputs $\mathsf{Sign.Verify}(\mathsf{vk}, \epsilon, c_1, c_2)$.
- $\mathsf{BCMCombine}_{\mathsf{pk}}(c_u, c_R)$: Picks $\lambda, \mu \xleftarrow{\$} \mathbb{Z}_p$ and outputs $\mathsf{SignDerive}(\mathsf{vk}, (\lambda, c_u, \mu c_R))$.
- $\mathsf{BCMDecode}_{\mathsf{sk}}(\mathsf{sk}, c)$: Using β_h, checks whether $c_2 / c_1^{\beta_h} \neq 1_{\mathbb{G}_1}$.

Conclusion

	Base Order	Memory Used	Signal Size	Combine Cost	Verification
[ADGPY05]	$n = pqz$	2 $\mathbb{G}_n$	1 $\mathbb{G}_n$	1 M	1 P
Us (Trivial)	Prime	4 $\mathbb{G}$	2 $\mathbb{G}$	2 M	1 E
Us (Full)	Prime	6 $\mathbb{G}_1$ + 4 $\mathbb{G}_2$	3 $\mathbb{G}_2$ + 2 $\mathbb{G}_1$	6 P + 8 E + 4 M	6 P

✓ Better security (Unconditional and/or Stronger Model)

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- ⇛ A post-quantum solution?