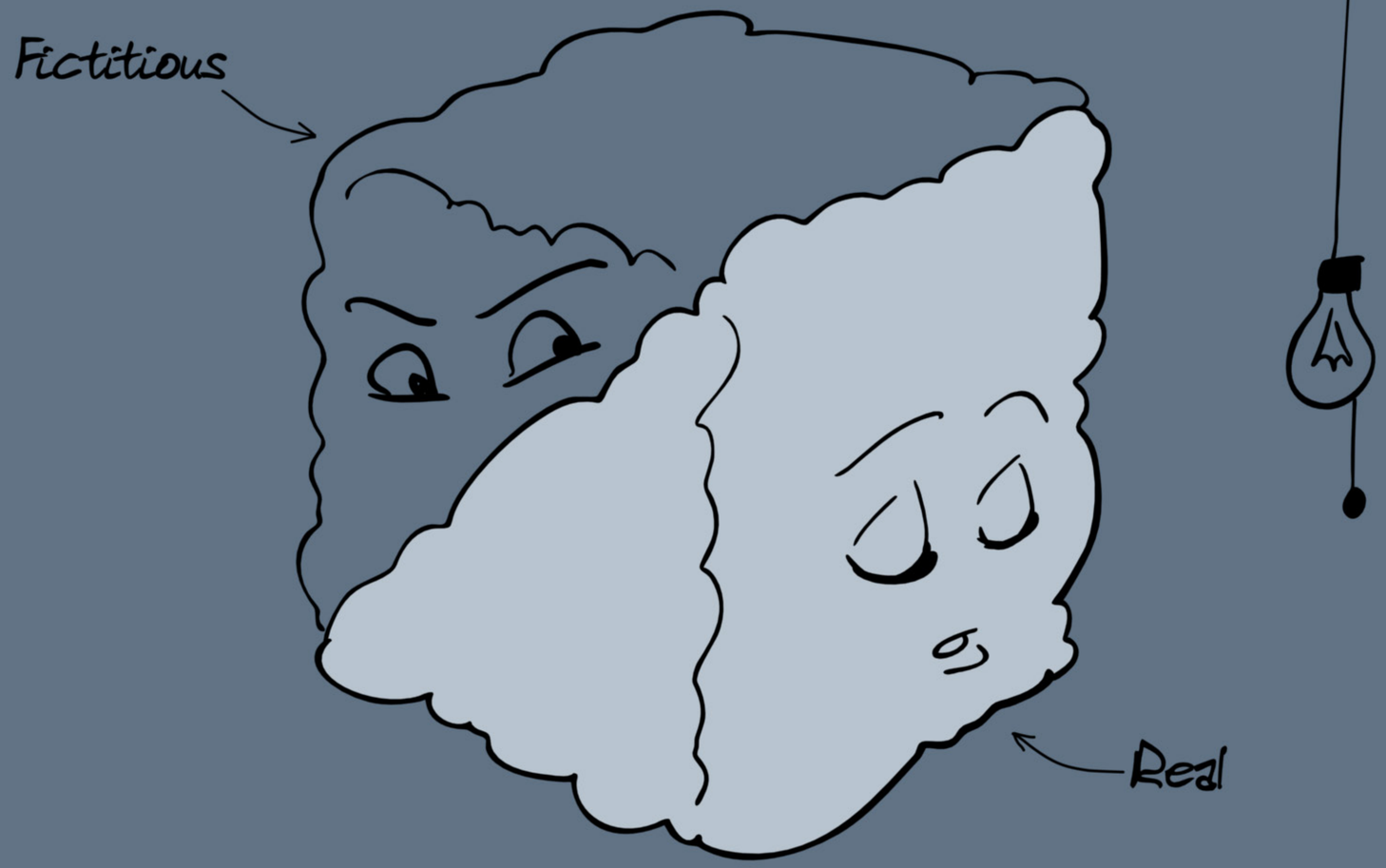
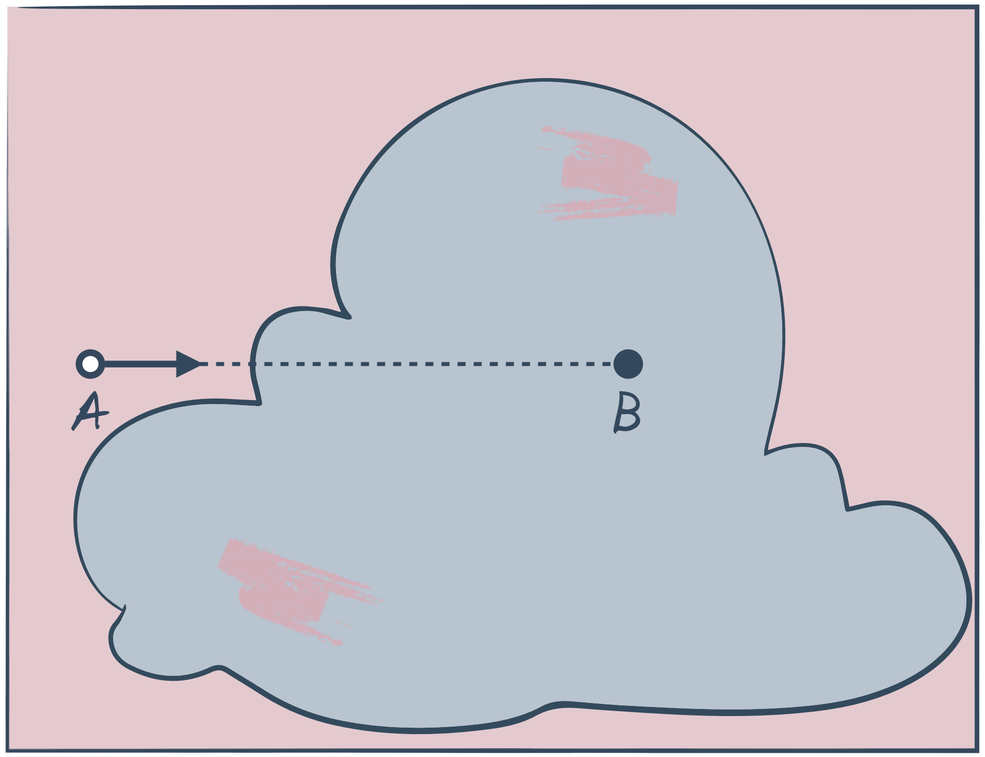
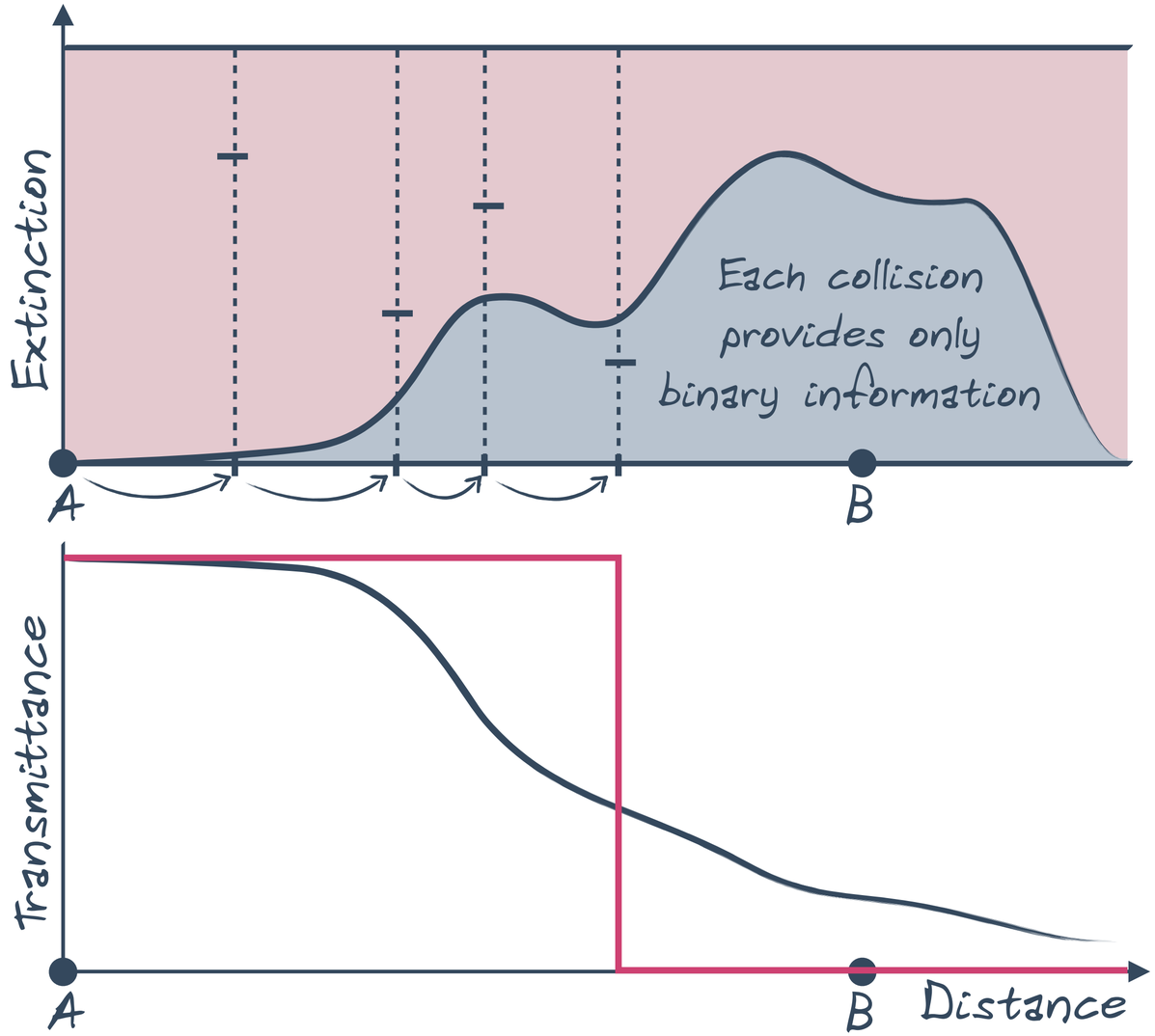
NULL-COLLISION ALGORITHMS—PART 2
TRANSMITTANCE ESTIMATION

Jan Novák
Disney Research



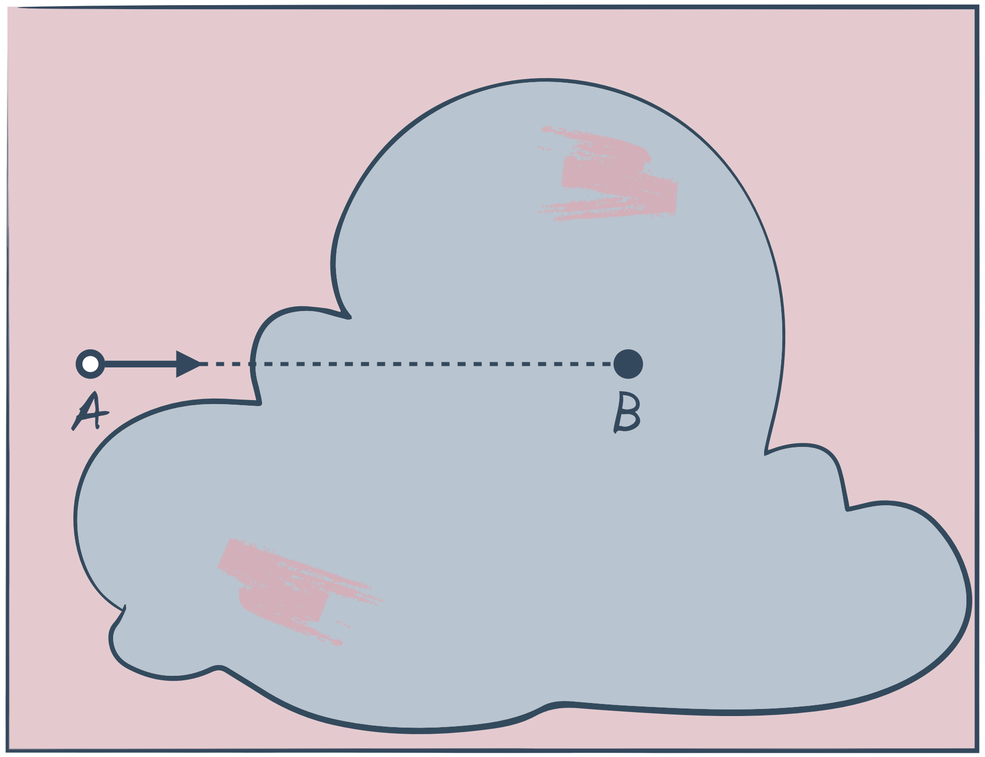
DELTA TRACKING

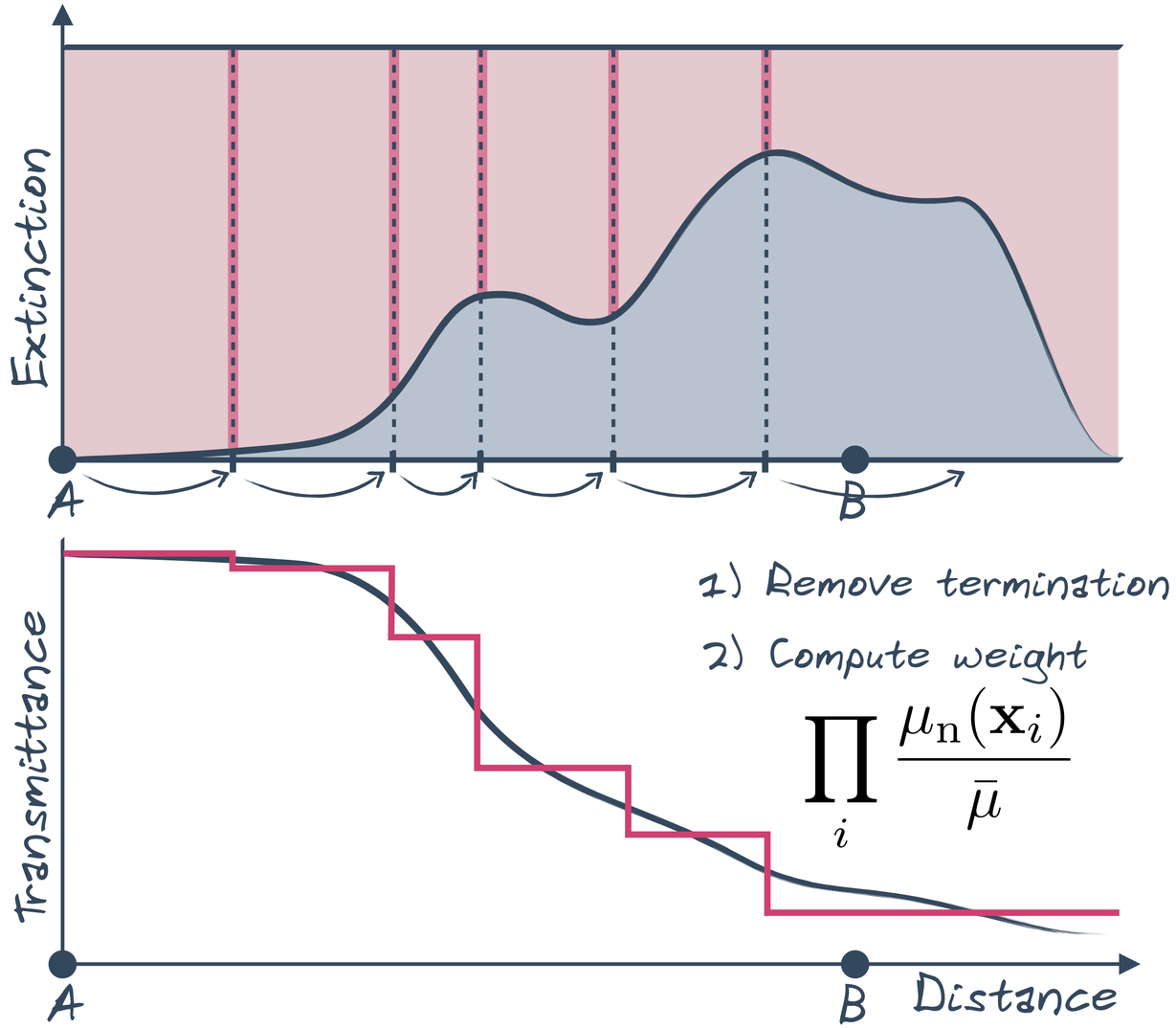




RATIO TRACKING

[Cramer 1978, Novák et al. 2014]



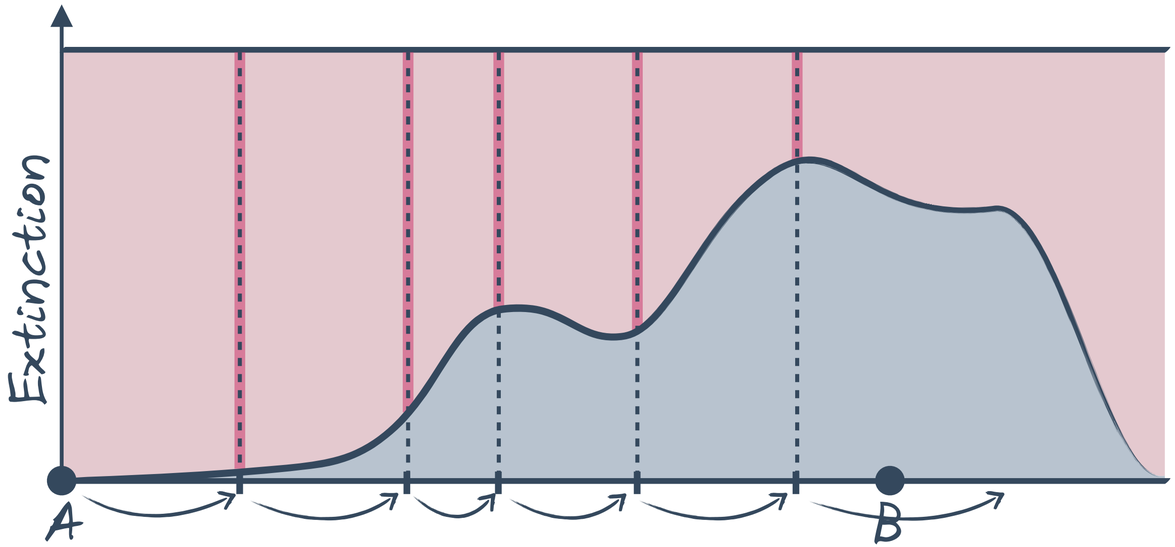


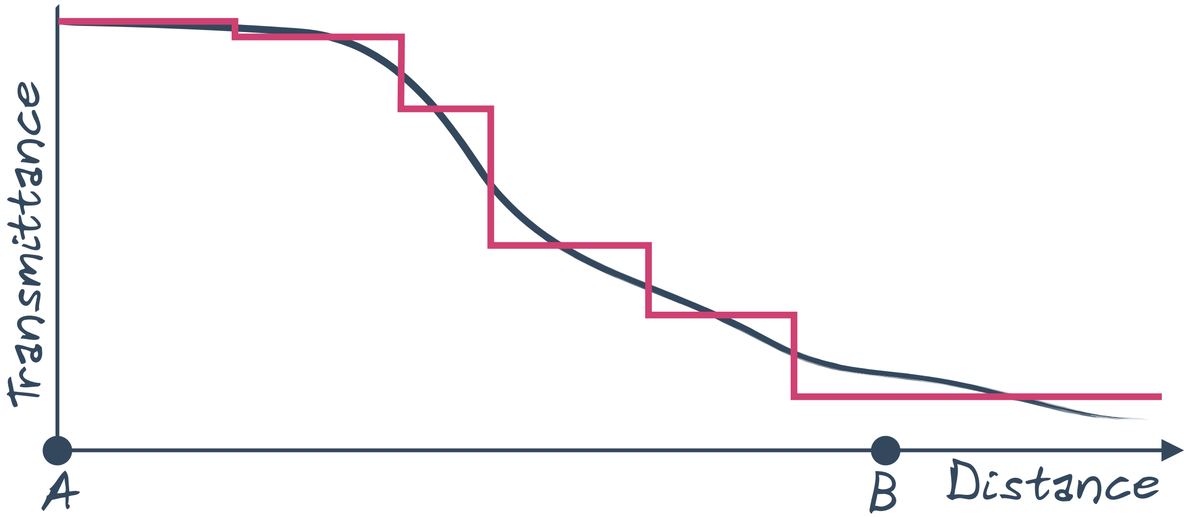
RATIO TRACKING

1) Remove termination

2) Compute weight

$$\prod_i \frac{\mu_{\mathrm{n}}(\mathbf{x}_i)}{\bar{\mu}}$$





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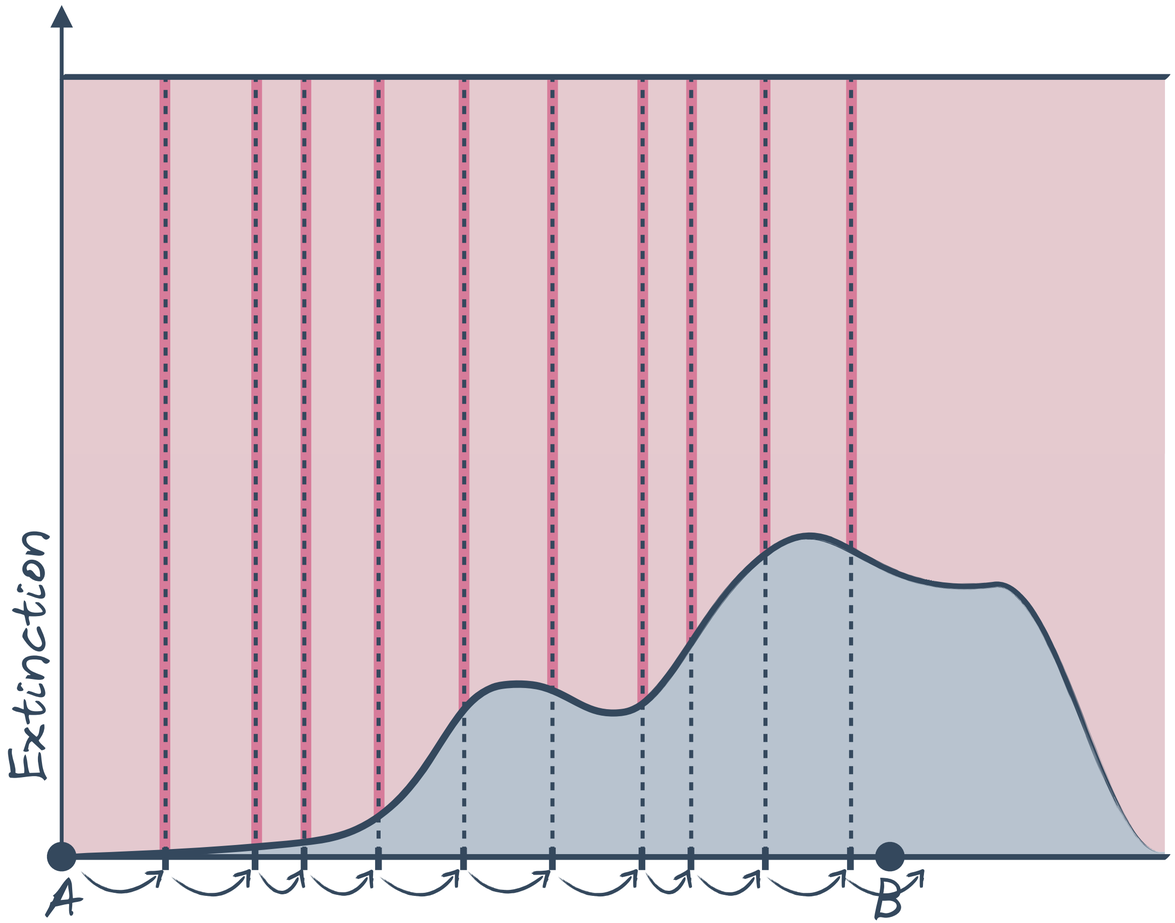

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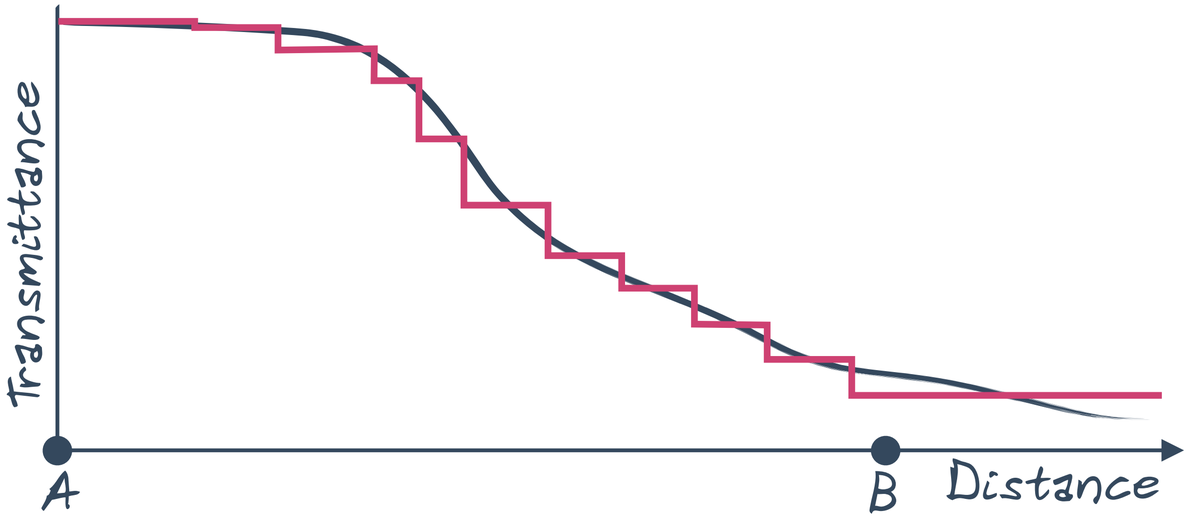

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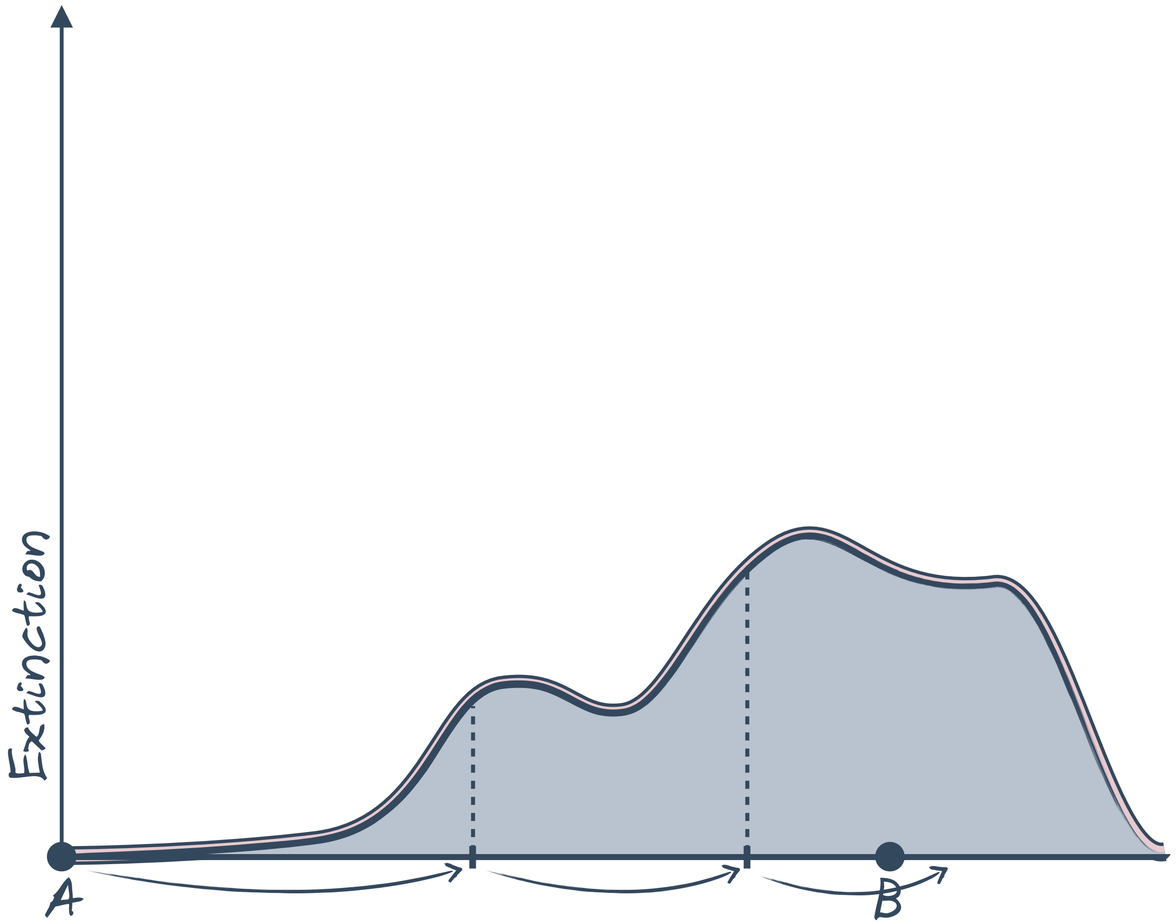
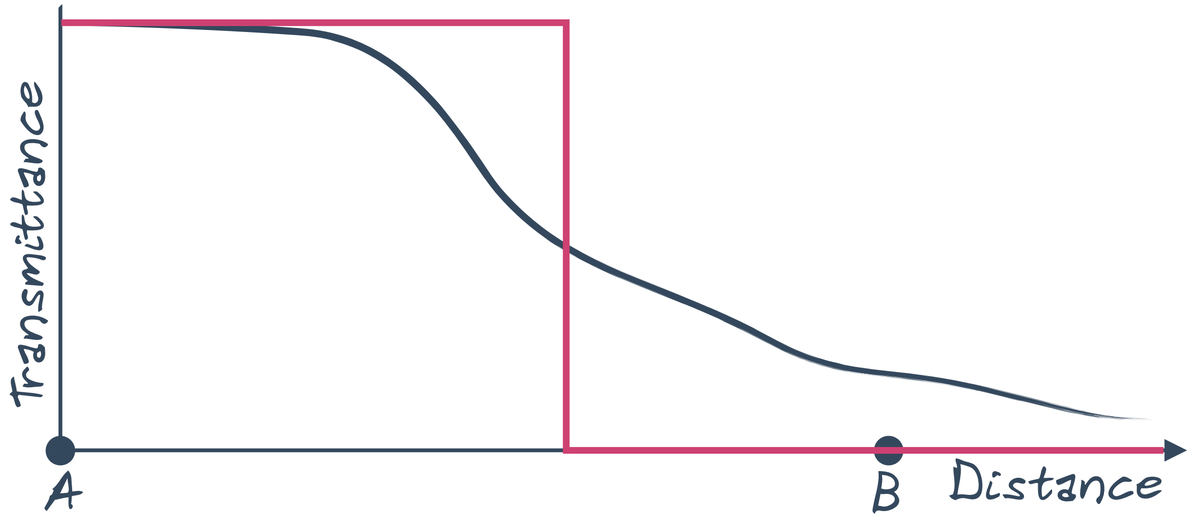




Extra steps => higher cost than delta tracking

RATIO TRACKING

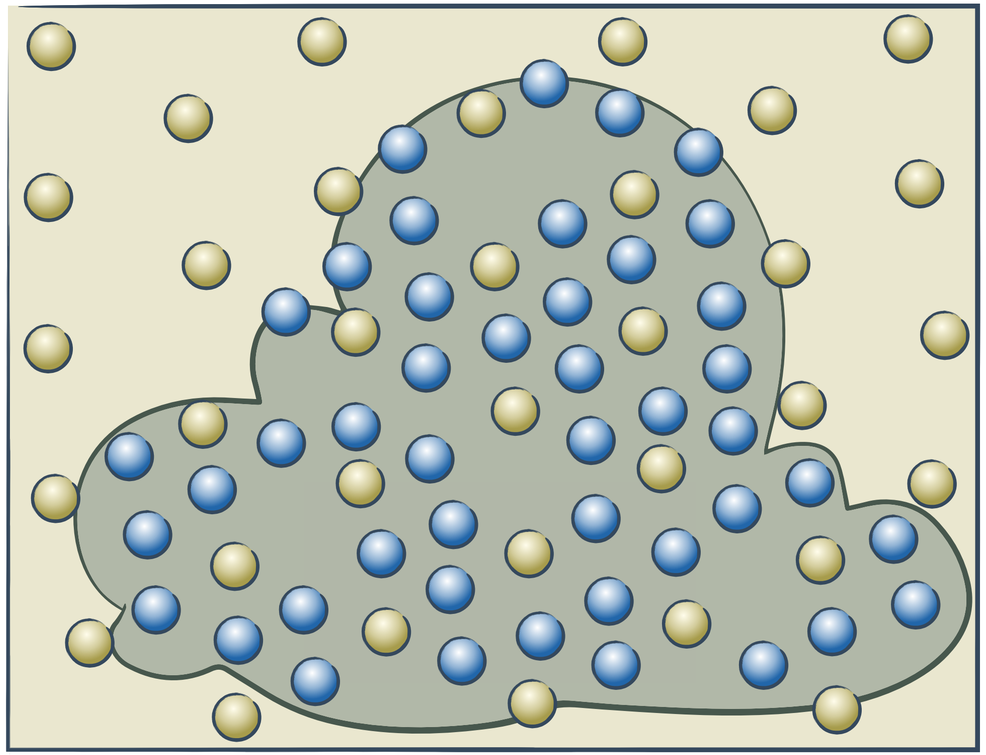
Probabilistic **TERMINATION** replaced by **WEIGHTING**

- Rational score instead of binary
- Requires more steps than a delta-tracking estimator (must reach B)
- Reduces the need for tight majorants
  - Loose majorants produce (more null collisions and therefore) finer estimates

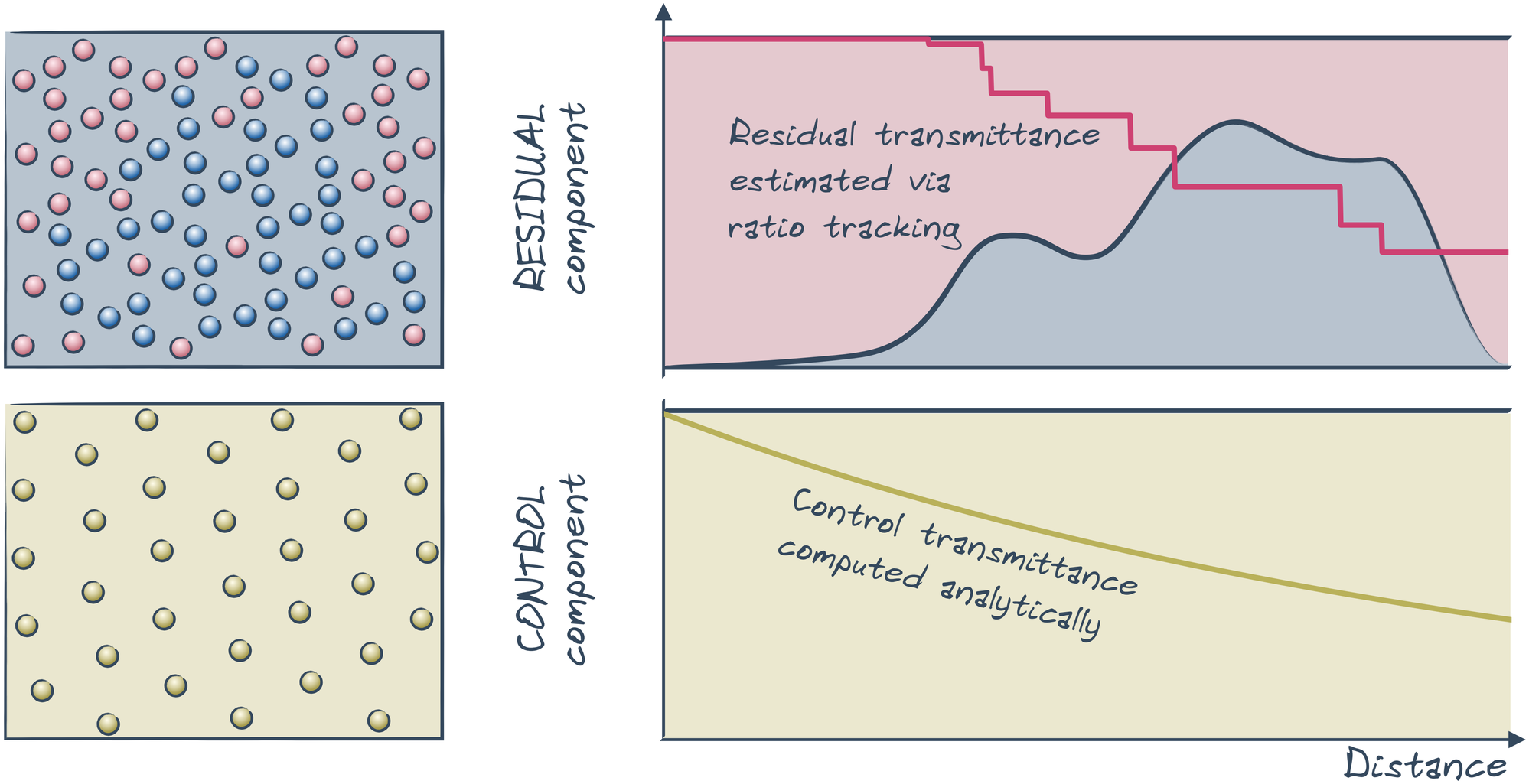
RESIDUAL RATIO TRACKING

Compute part of the transmittance analytically

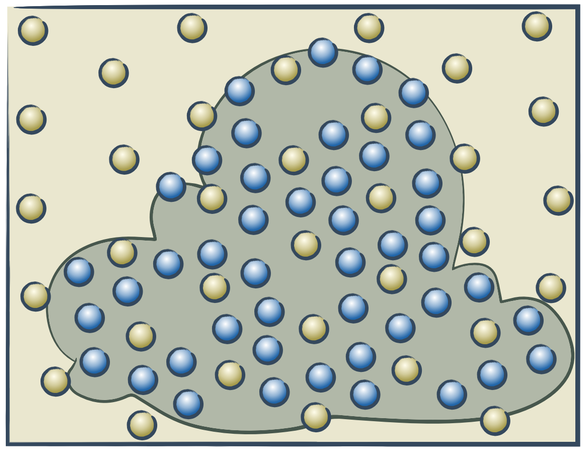
- [Novák et al. 2014]

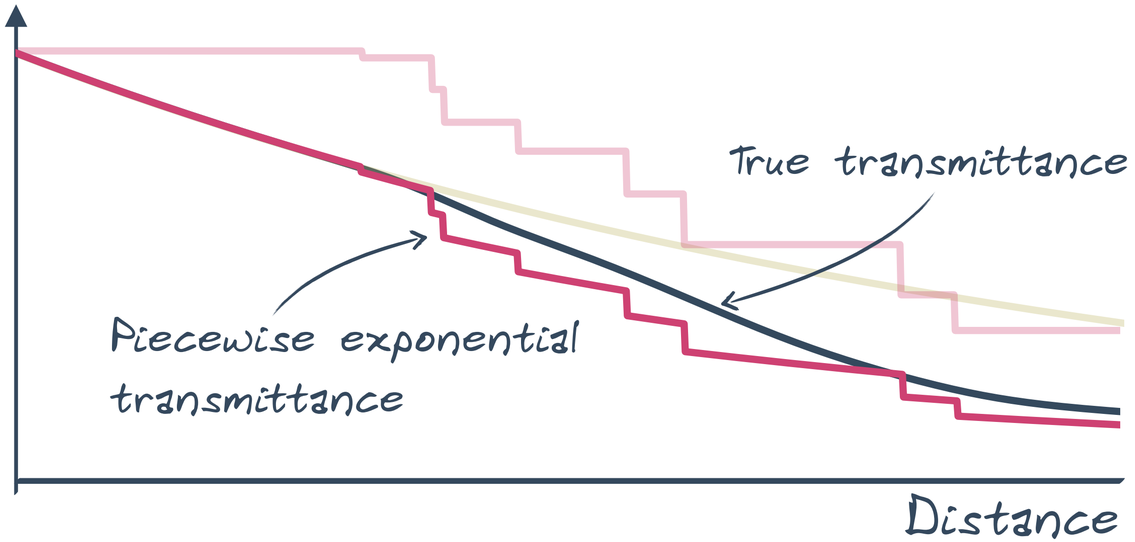


RESIDUAL RATIO TRACKING



RESIDUAL RATIO TRACKING





$$\langle T(t) \rangle = T_{\text{control}}(t) \; \langle T_{\text{residual}}(t) \rangle$$

RESIDUAL RATIO TRACKING

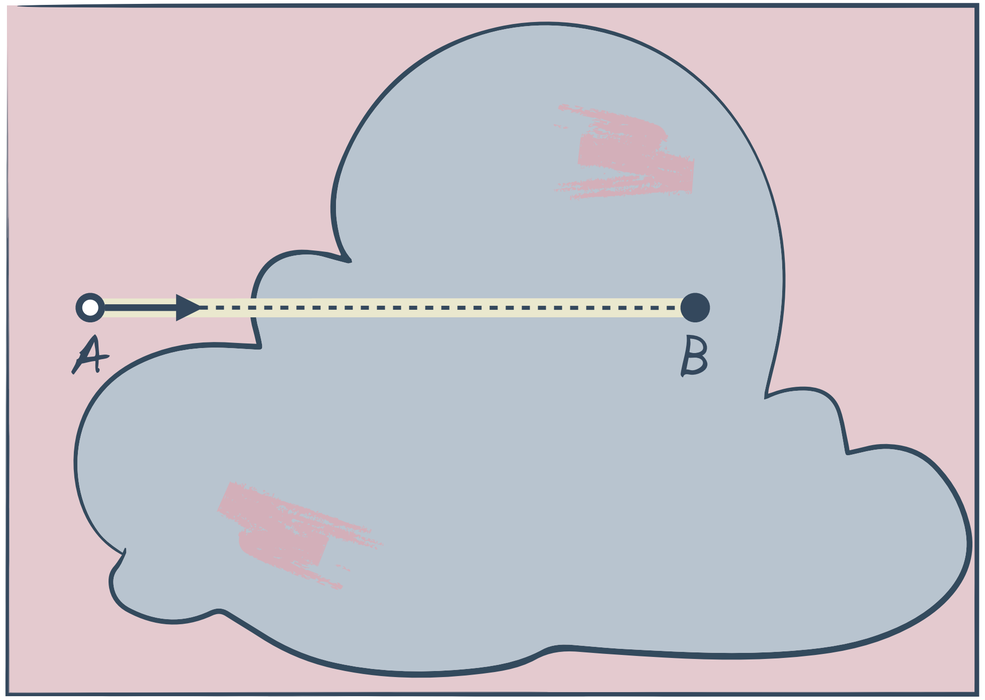
HOMOGENEOUS and **RESIDUAL HETEROGENEOUS** components

- Reduces noise by handling part of the transmittance analytically
- Requires a space-partitioning data structure (e.g. octree) to be practical
- Can handle negative residual extinctions

NEXT-FLIGHT ESTIMATORS

Score a weight at every tentative collision

- Cramer [1978] combines next-flight estimation with delta and ratio tracking



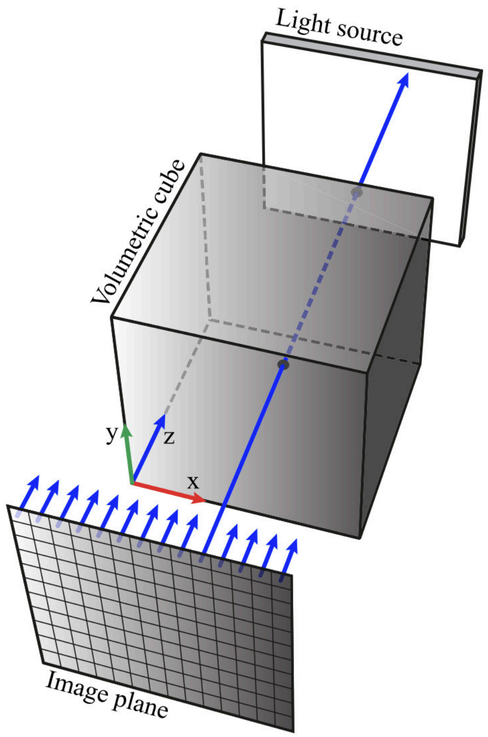
NEXT-FLIGHT DELTA TRACKING

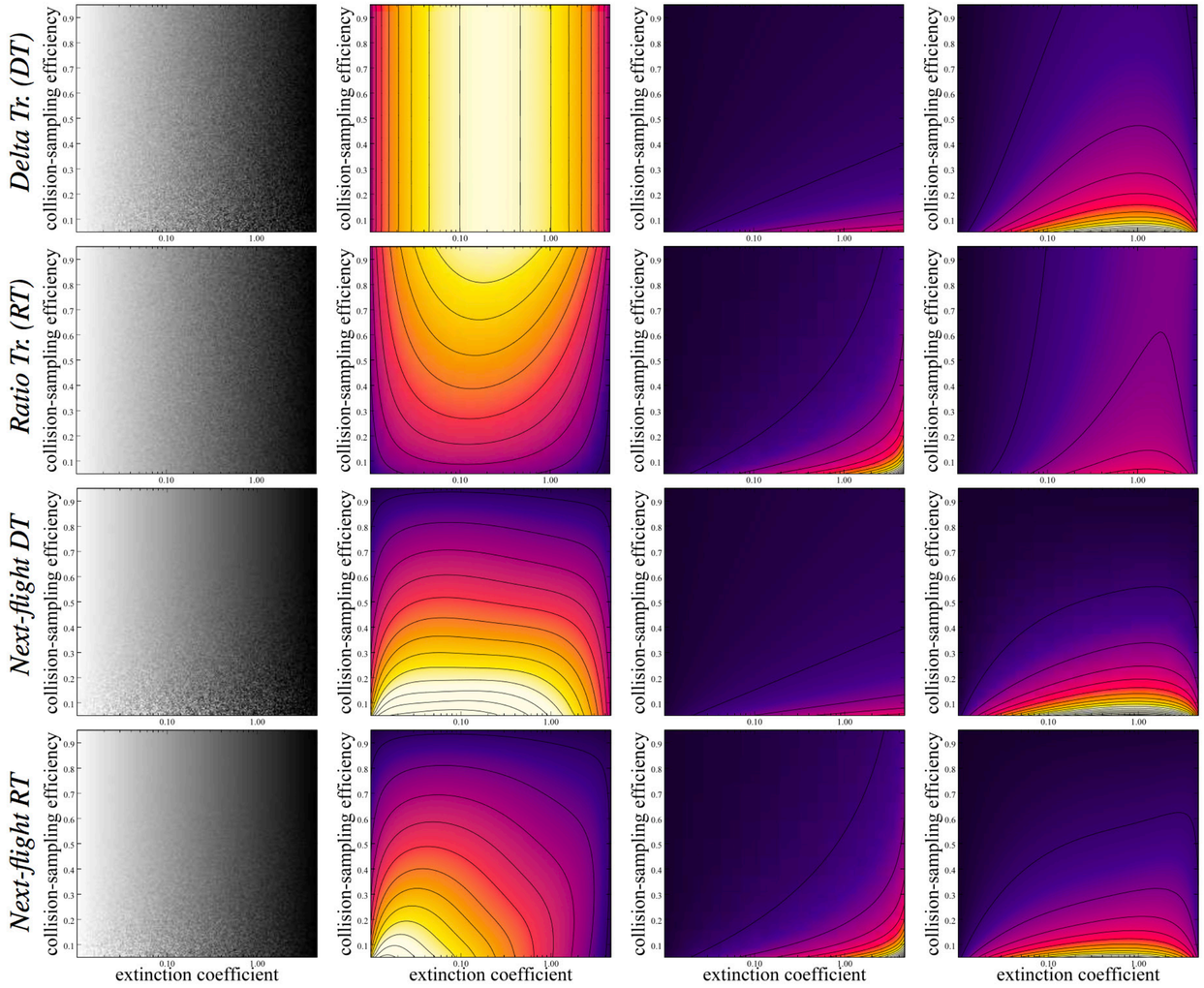
$$\langle T(t) \rangle = T_{\bar{\mu}}(0,t) + \sum_{j=1}^{n} \frac{\mu_{\mathrm{n}}(t_j)}{\bar{\mu}(t_j)} T_{\bar{\mu}}(t_j,t)$$

Transmittance along the remaining segment through real + fictitious matter

Fraction of fictitious matter

COMPARISON





(a) *Canonical scene* **(b)** *Equal-cost renders* **(c)** *Variance of* $\langle T \rangle$ **(d)** *Cost* $\langle T \rangle$ **(e)** *Variance* $\times$ *cost*

SUMMARY

DELTA TRACKING estimator

- Relatively cheap but binary, inefficient w/ loose majorants

RATIO TRACKING estimator

- More expensive, but also more accurate especially w/ loose majorants

RESIDUAL TRACKING estimators

- Reduces variance by employing analytic computation for part of the transmittance function

NEXT-FLIGHT estimators

- Further improve performance by scoring a weight at each step
- Not fully explored yet in the context of rendering…