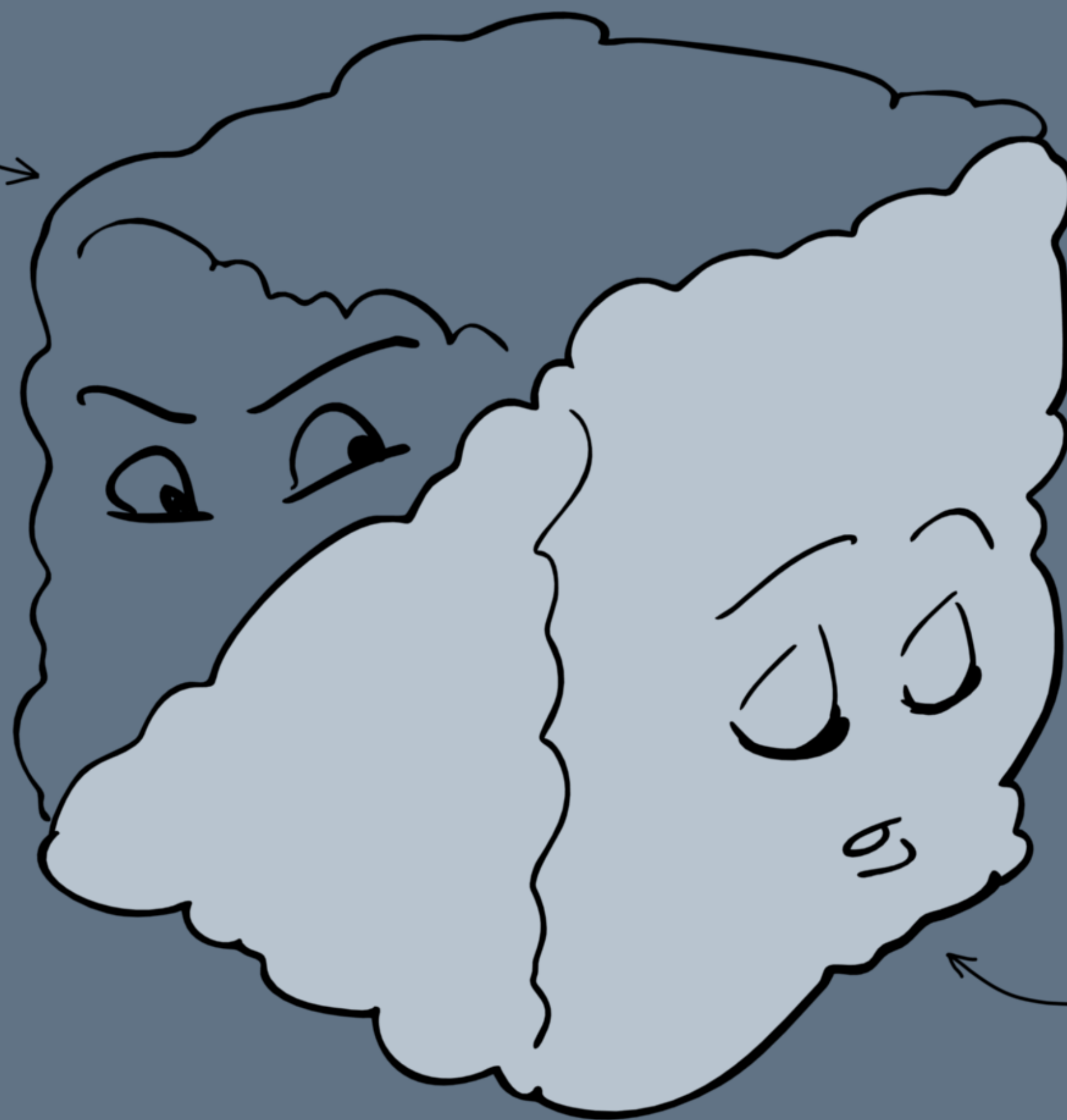


# NULL-COLLISION ALGORITHMS—PART 2

## TRANSMITTANCE ESTIMATION

Jan Novák  
Disney Research

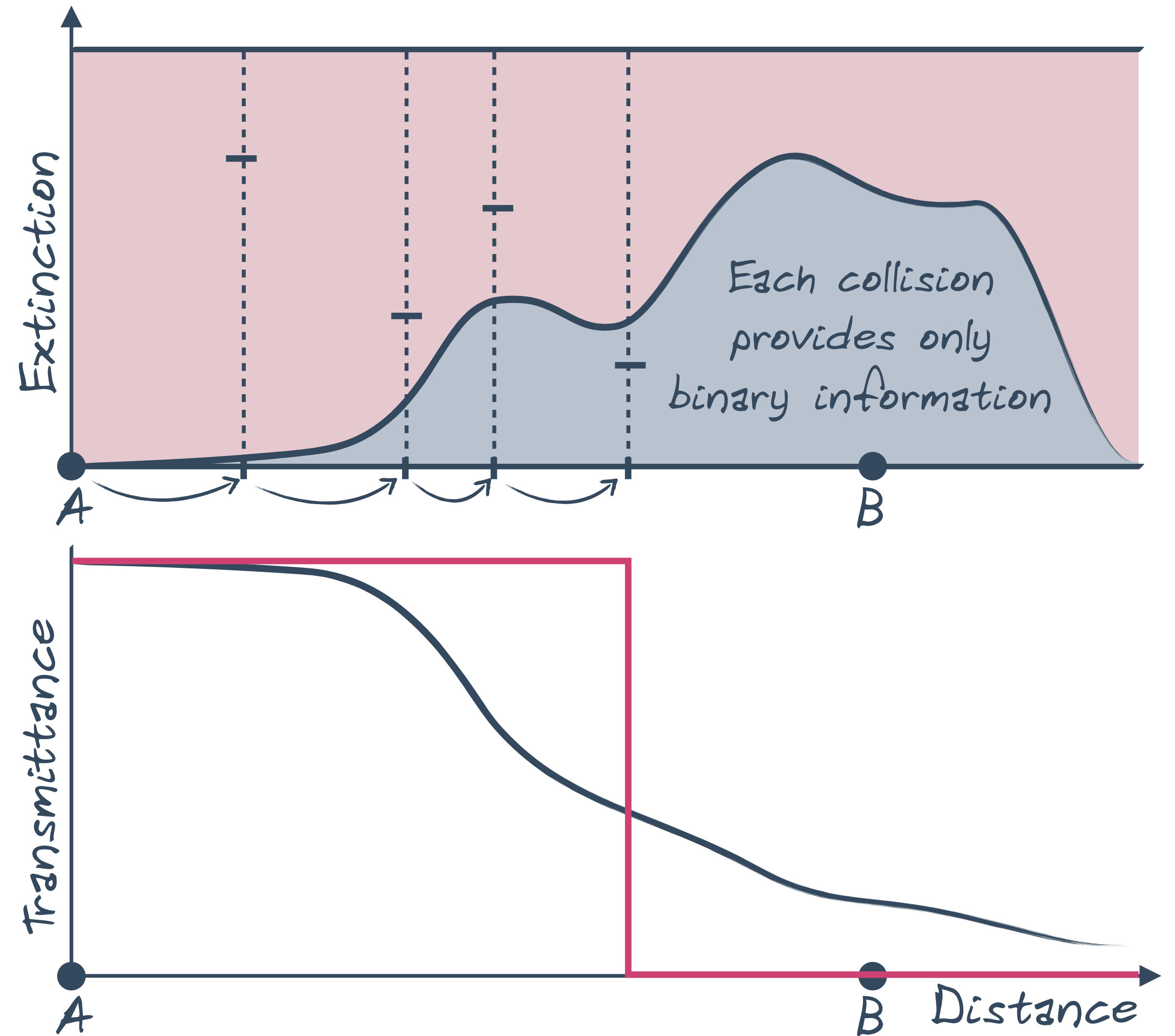
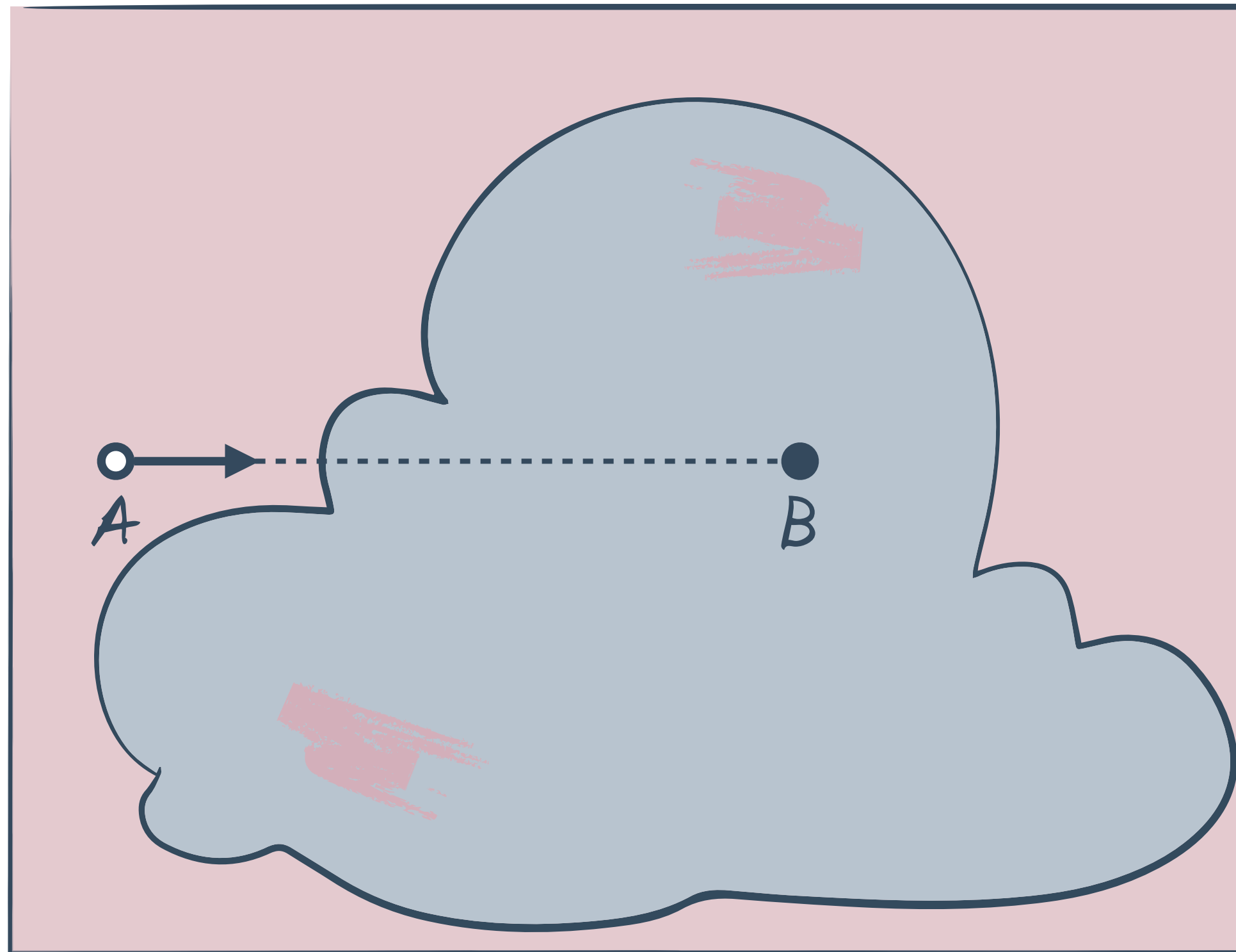
*Fictitious*



*Real*

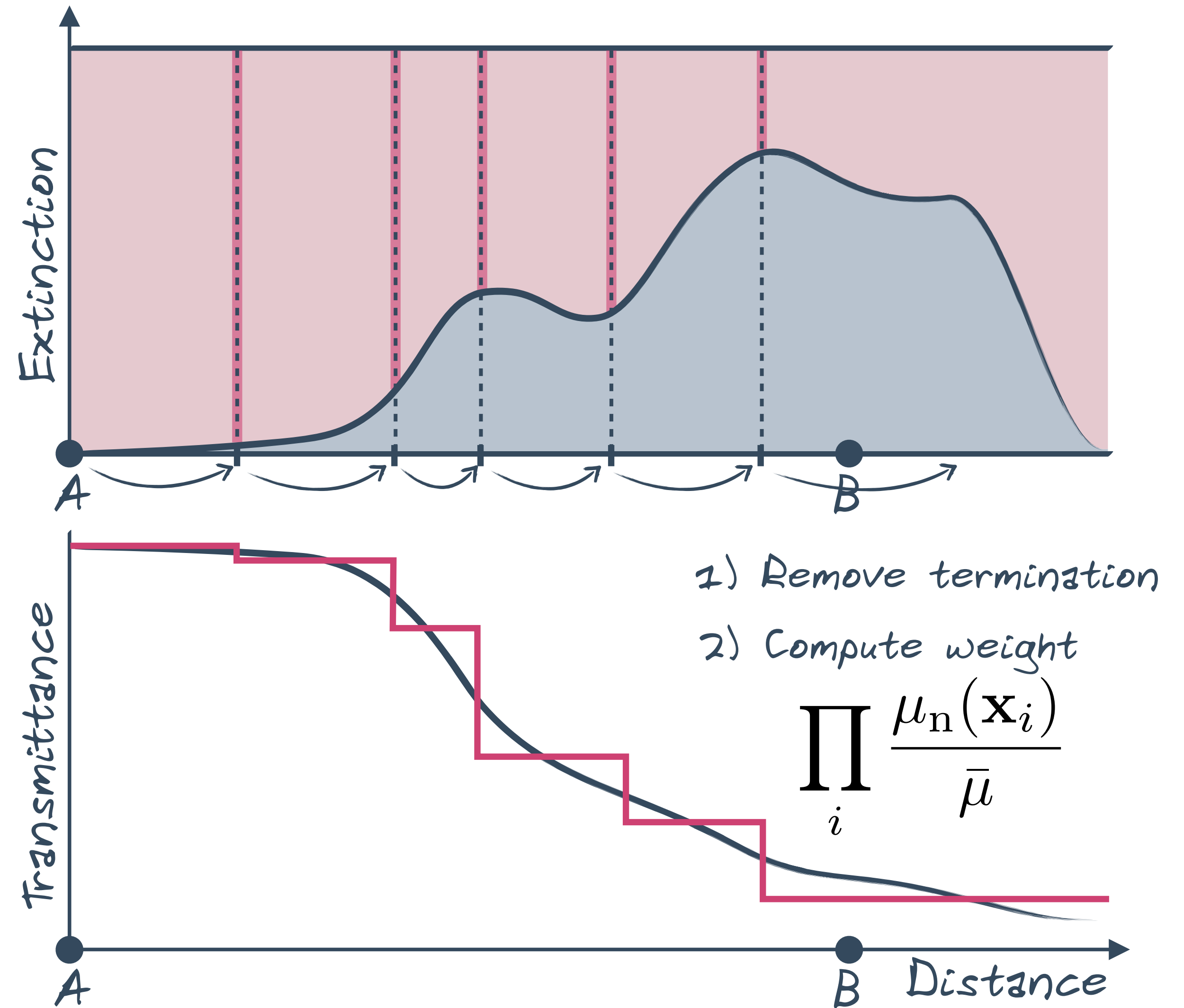
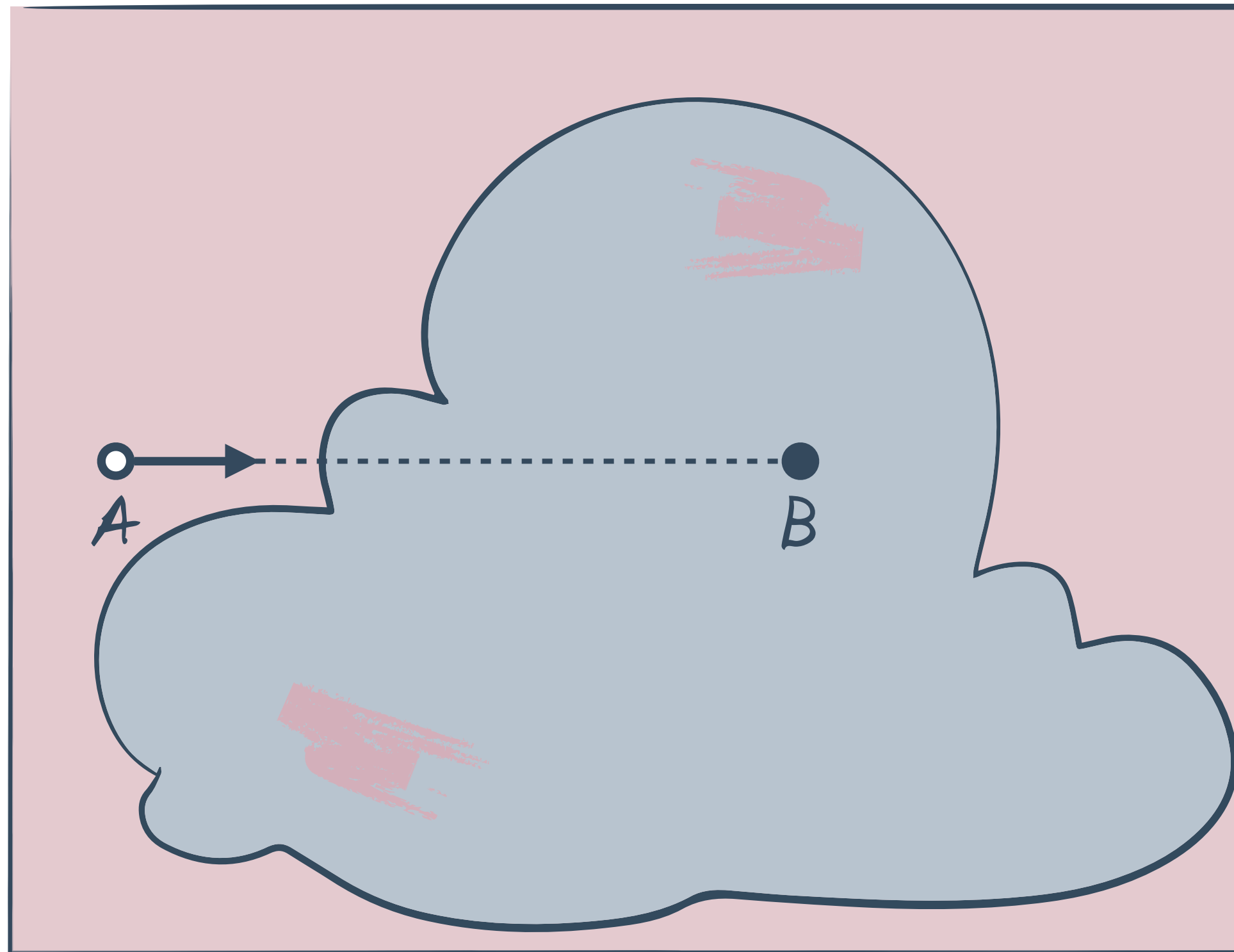


# DELTA TRACKING

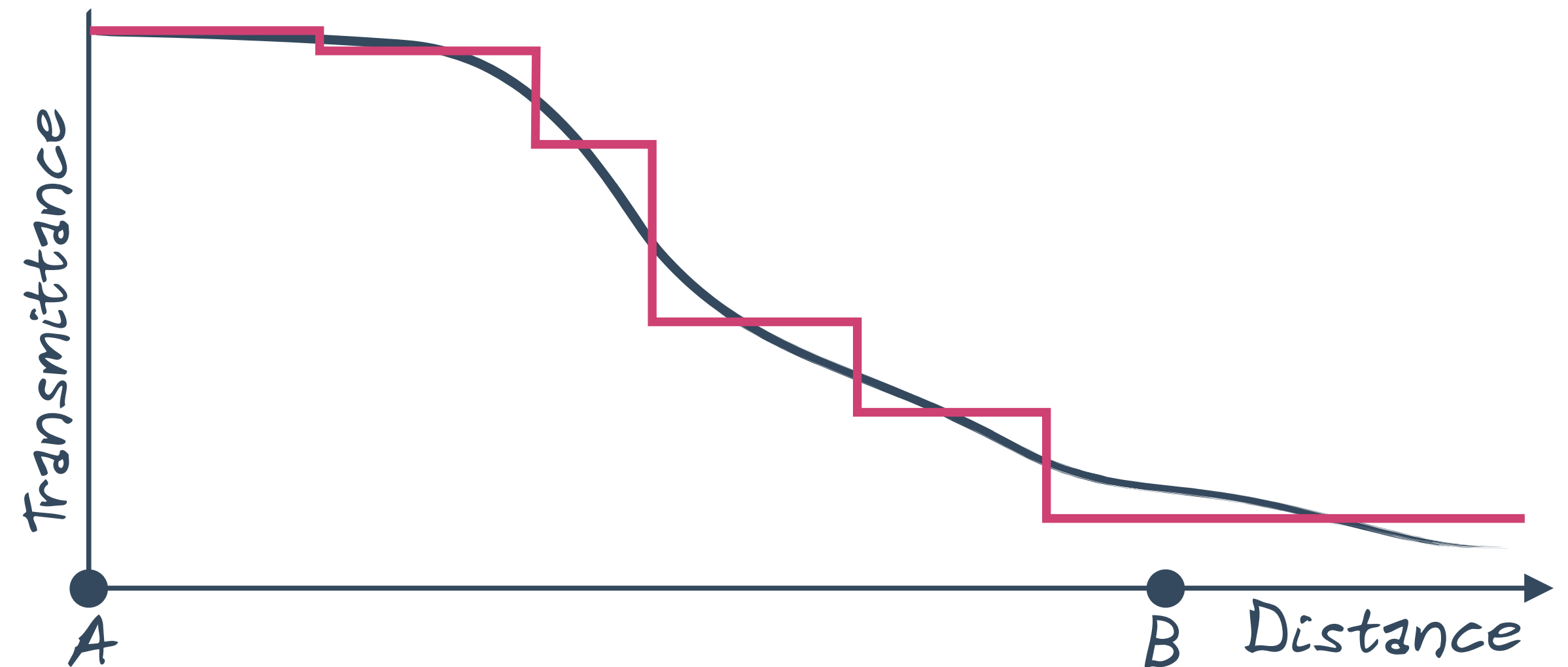
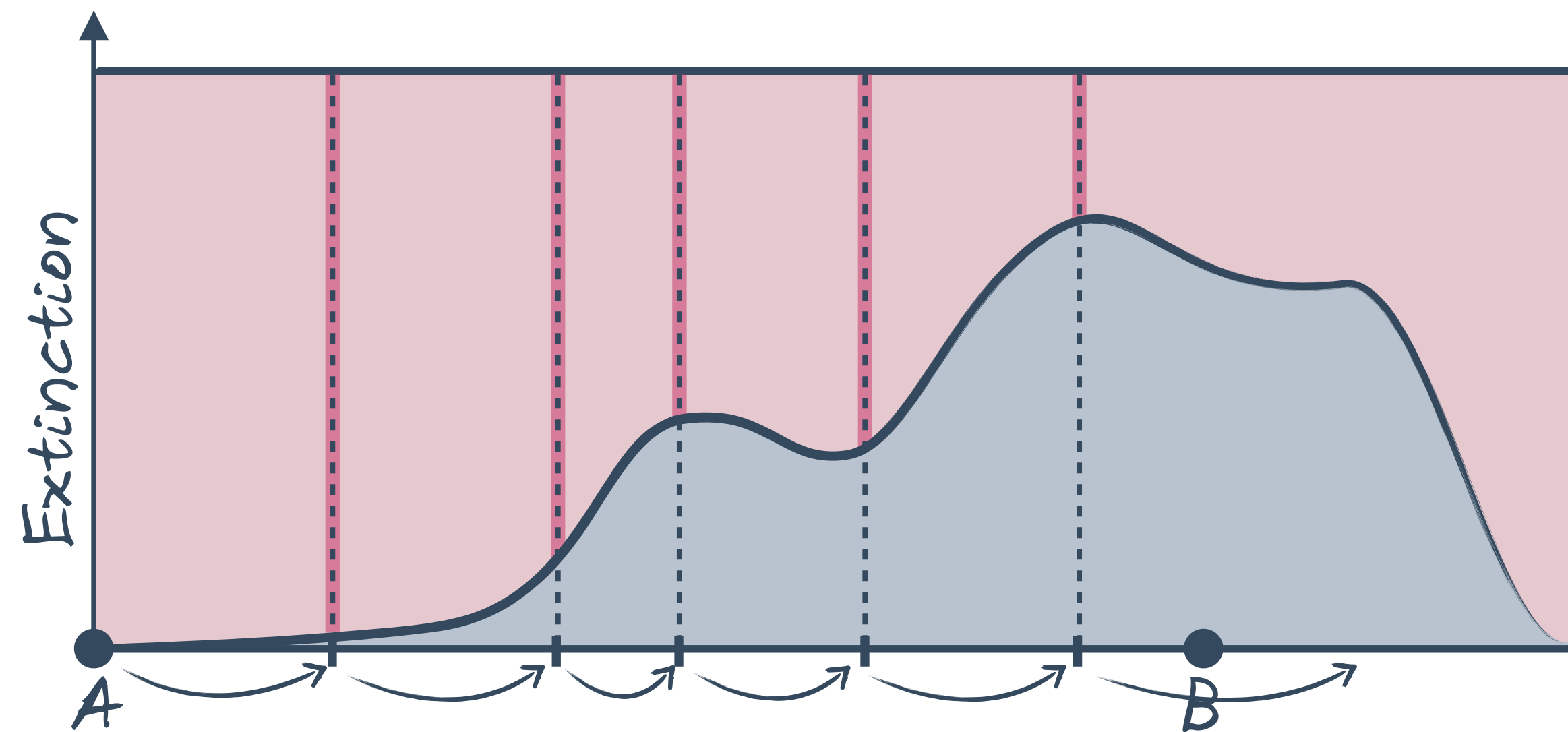


# RATIO TRACKING

[Cramer 1978, Novák et al. 2014]



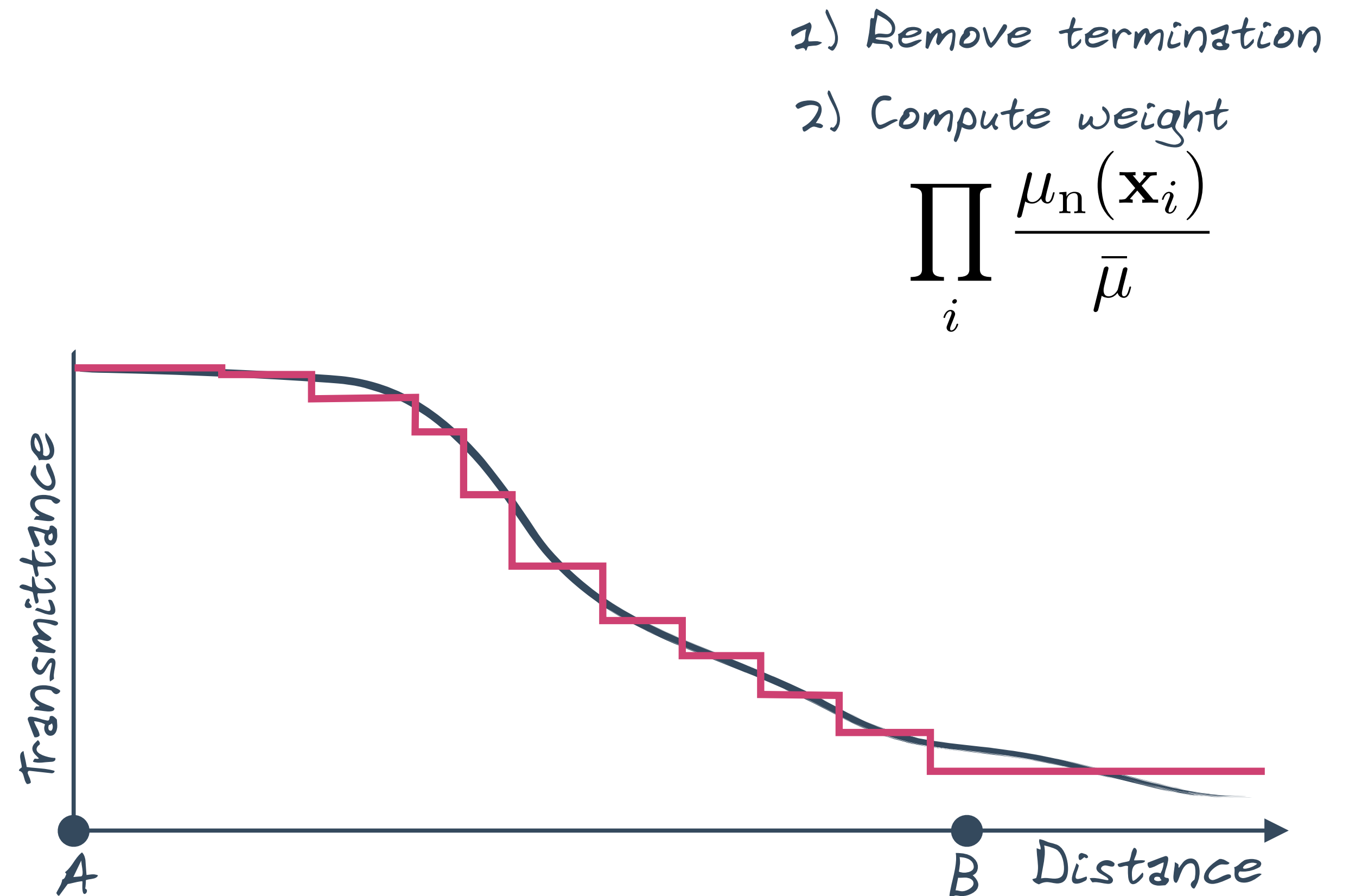
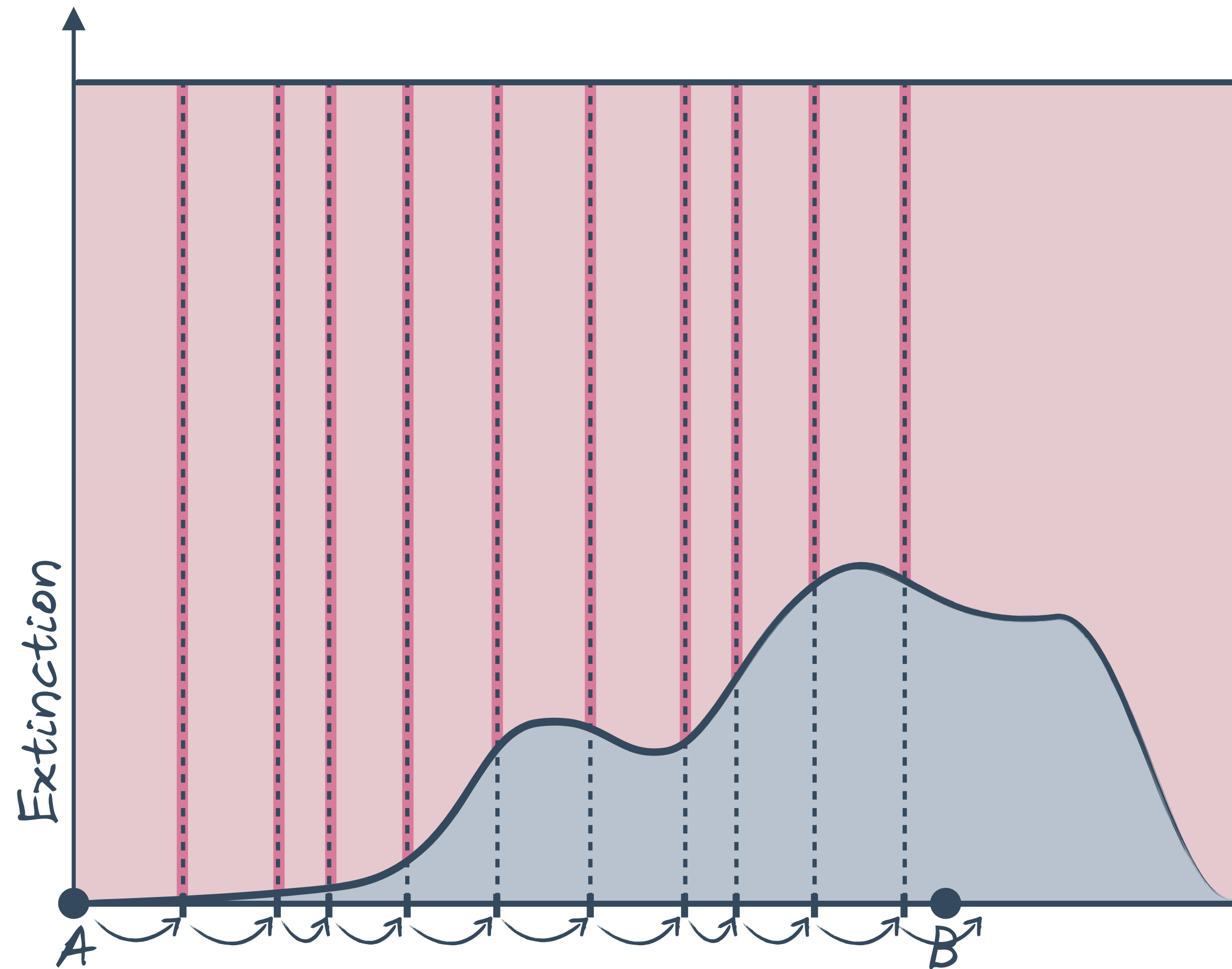
# RATIO TRACKING



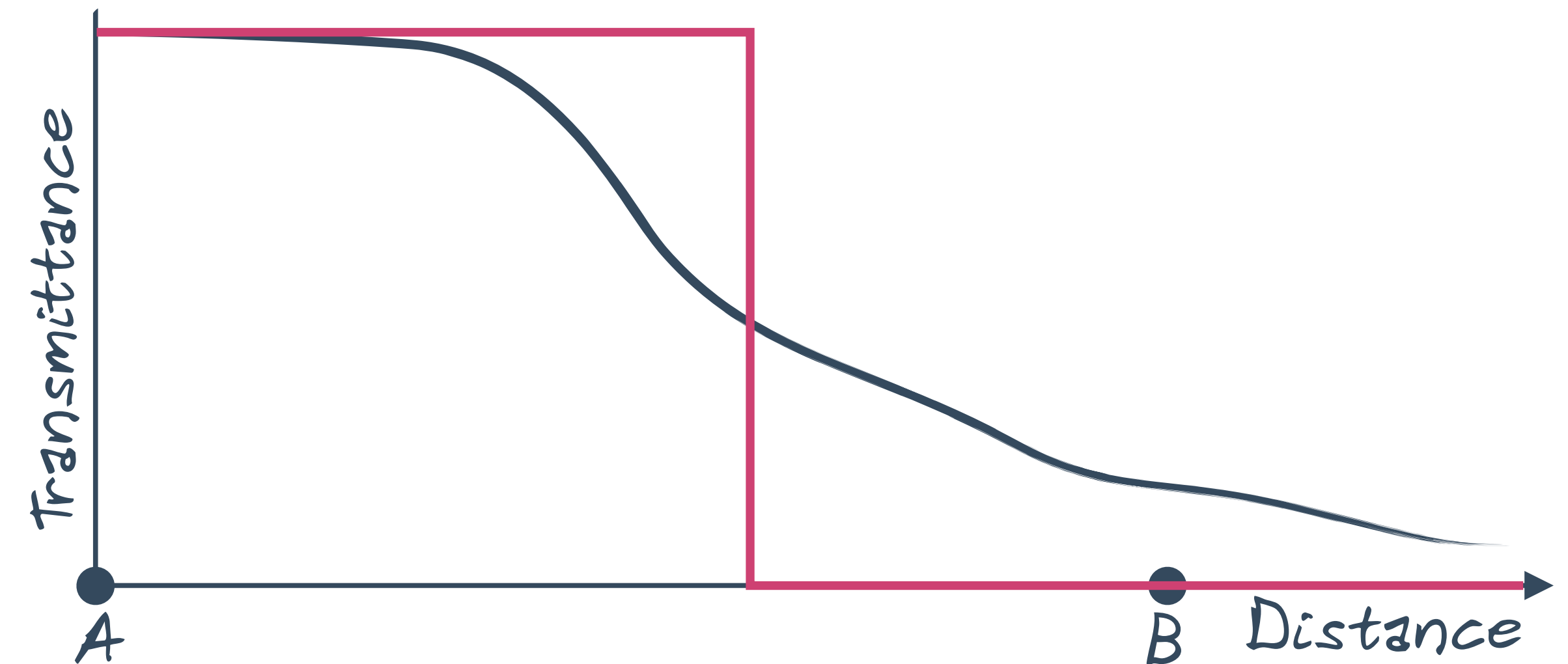
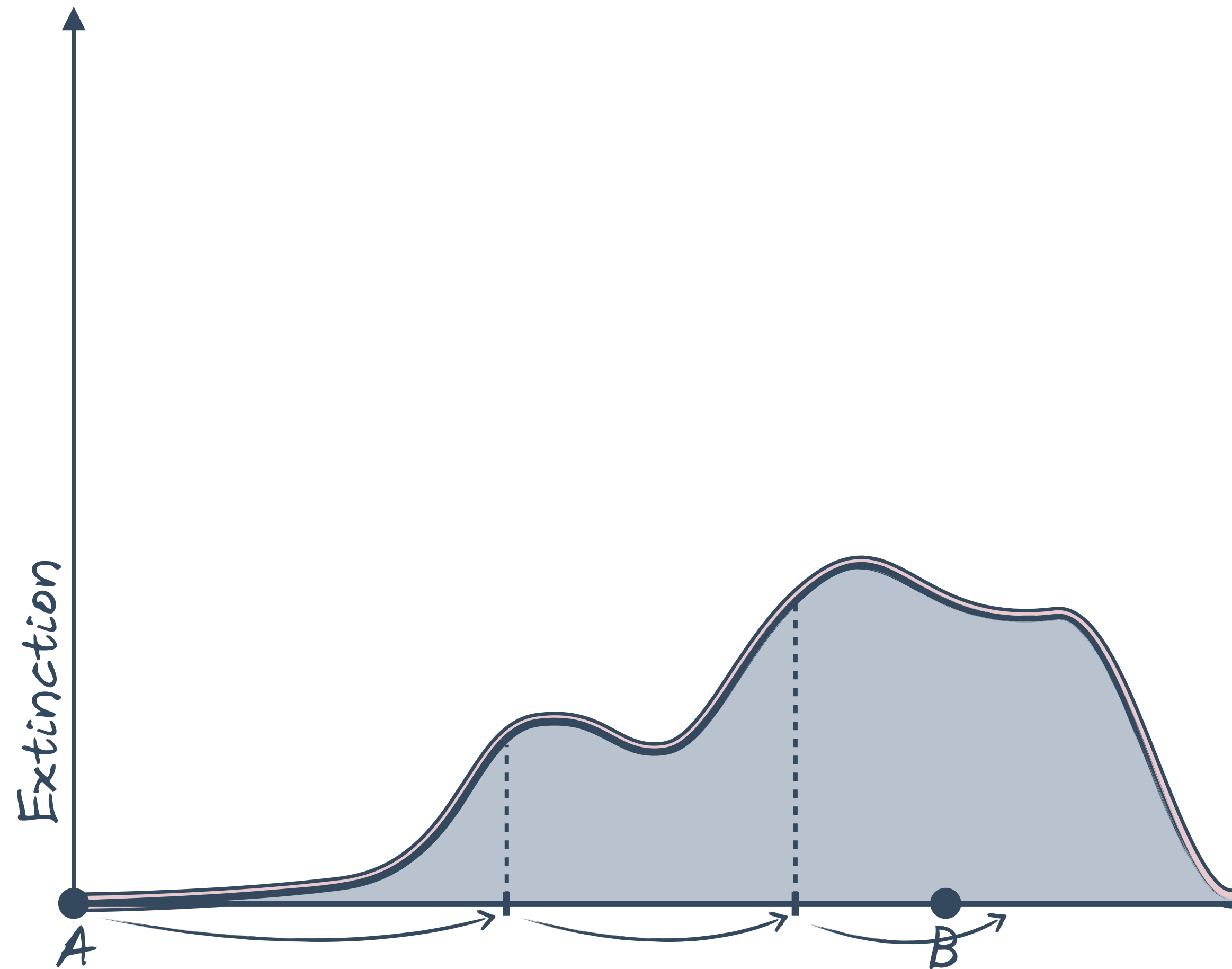
- 1) Remove termination
- 2) Compute weight

$$\prod_i \frac{\mu_n(\mathbf{x}_i)}{\bar{\mu}}$$

# RATIO TRACKING



# RATIO TRACKING



- 1) Remove termination
- 2) Compute weight

$$\prod_i \frac{\mu_n(\mathbf{x}_i)}{\bar{\mu}}$$

Extra steps  $\Rightarrow$  higher cost than delta tracking

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

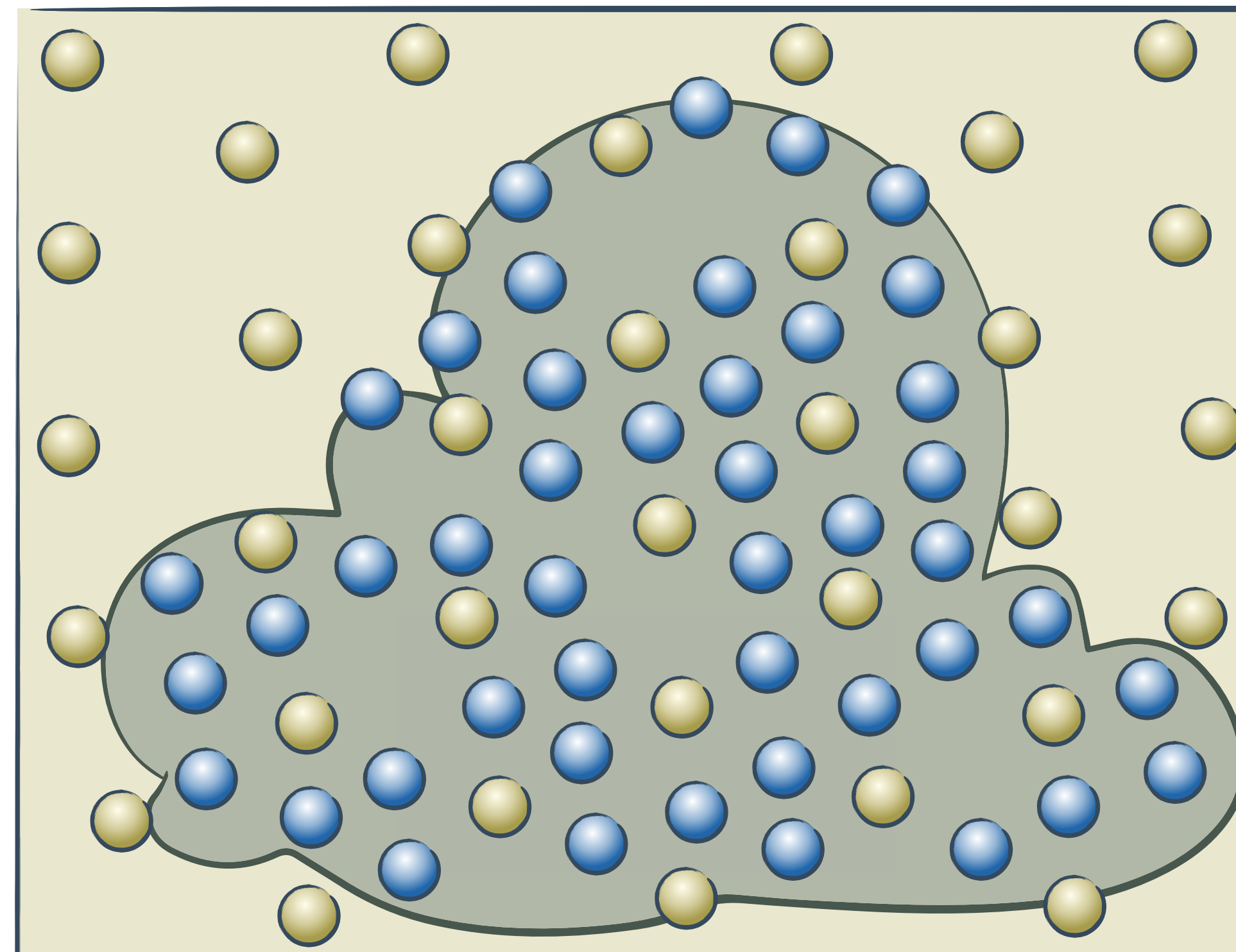
- ▶ Rational score instead of binary
- ▶ Requires more steps than a delta-tracking estimator (must reach  $B$ )
- ▶ Reduces the need for tight majorants
  - ▶ Loose majorants produce (more null collisions and therefore) finer estimates



# RESIDUAL RATIO TRACKING

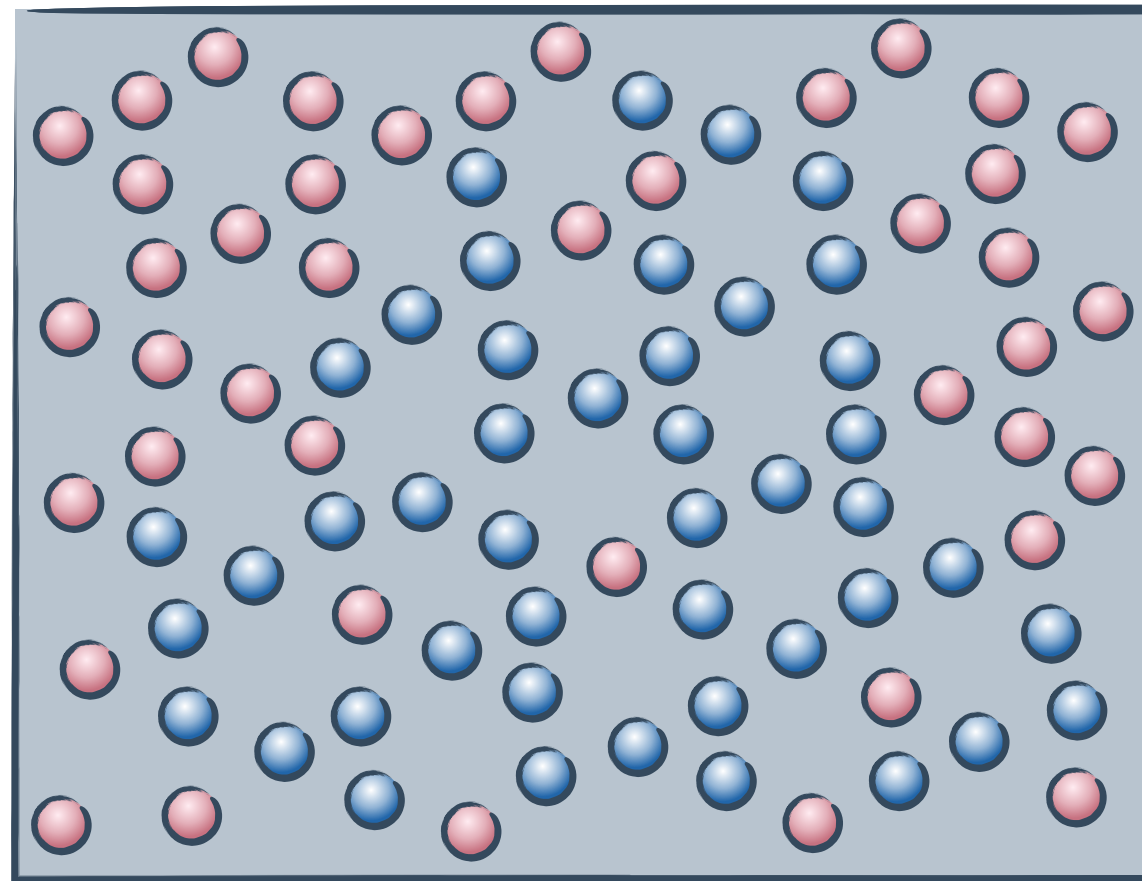
Compute part of the transmittance analytically

- ▶ [Novák et al. 2014]

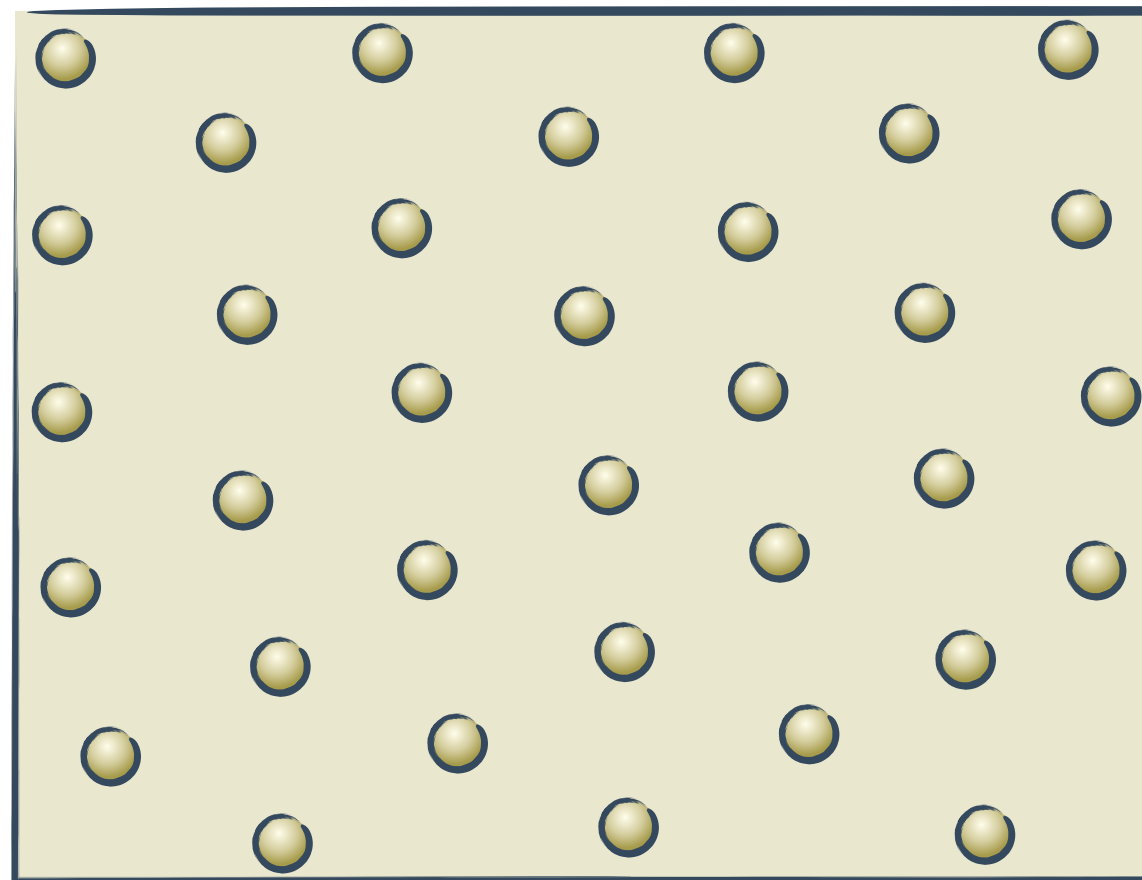
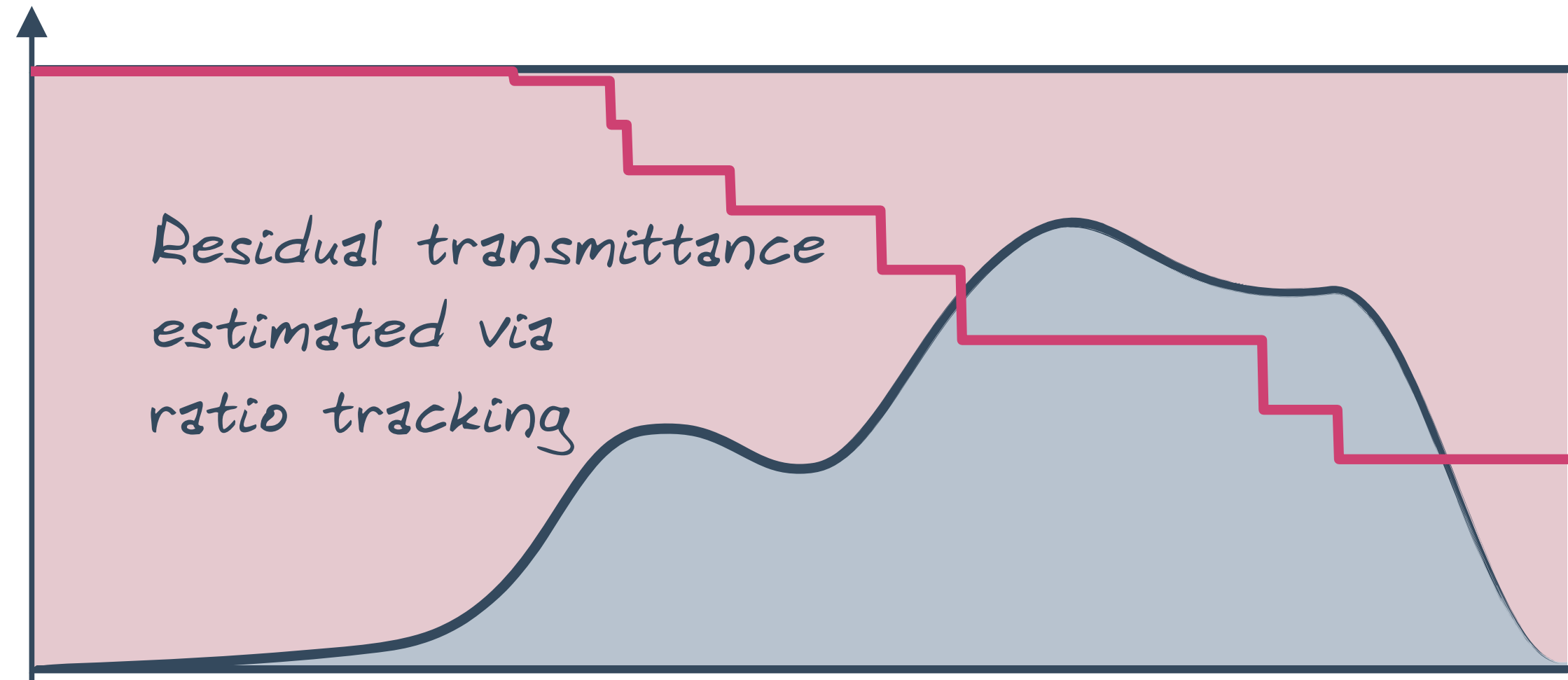




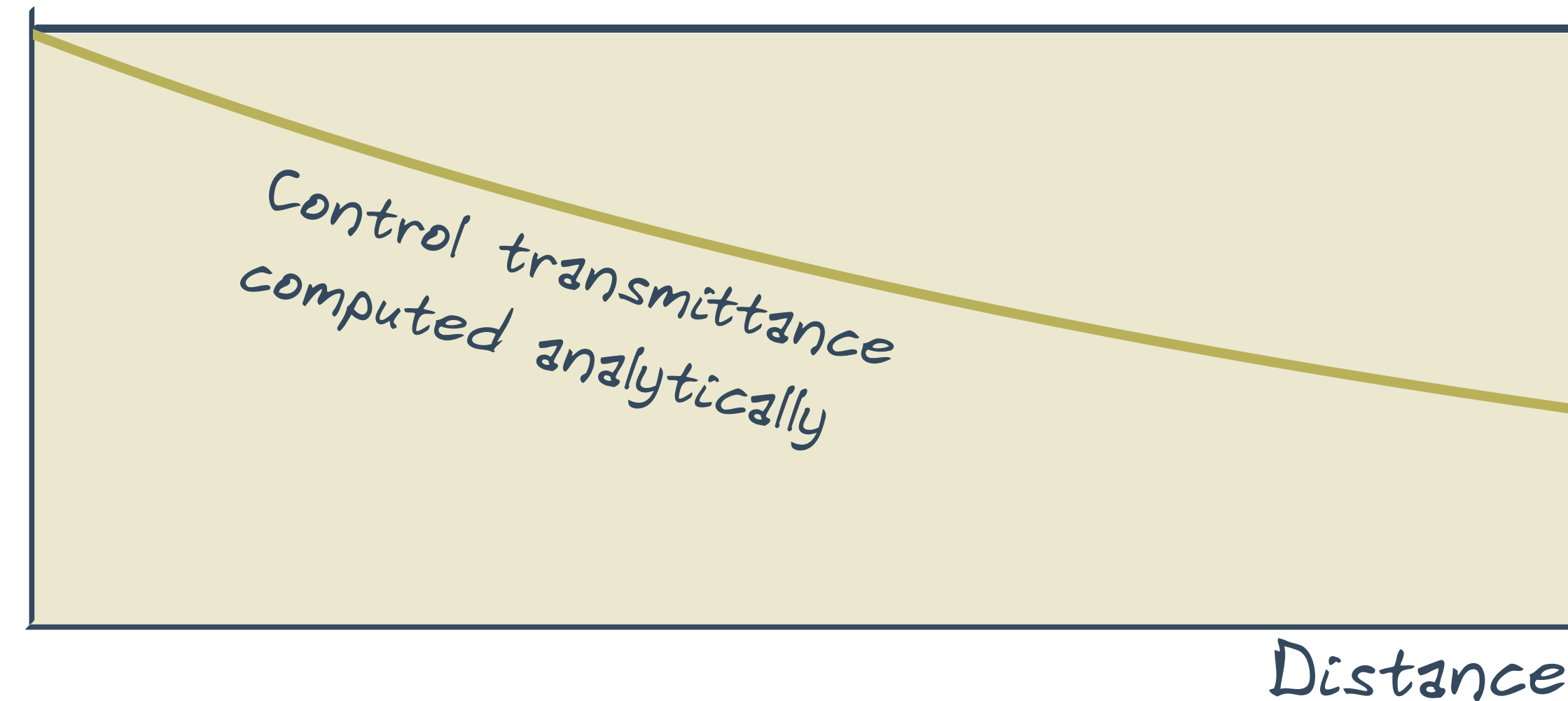
# RESIDUAL RATIO TRACKING



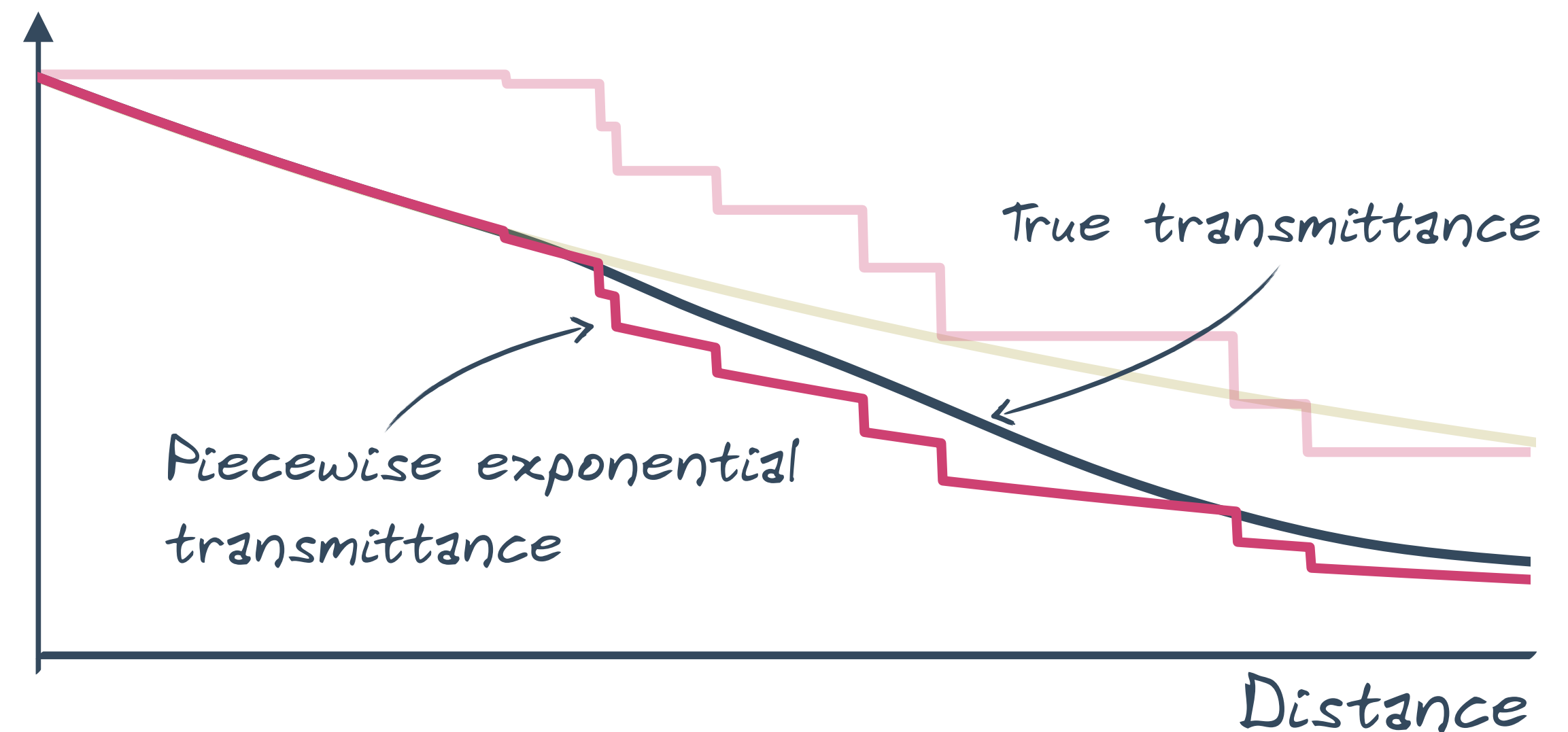
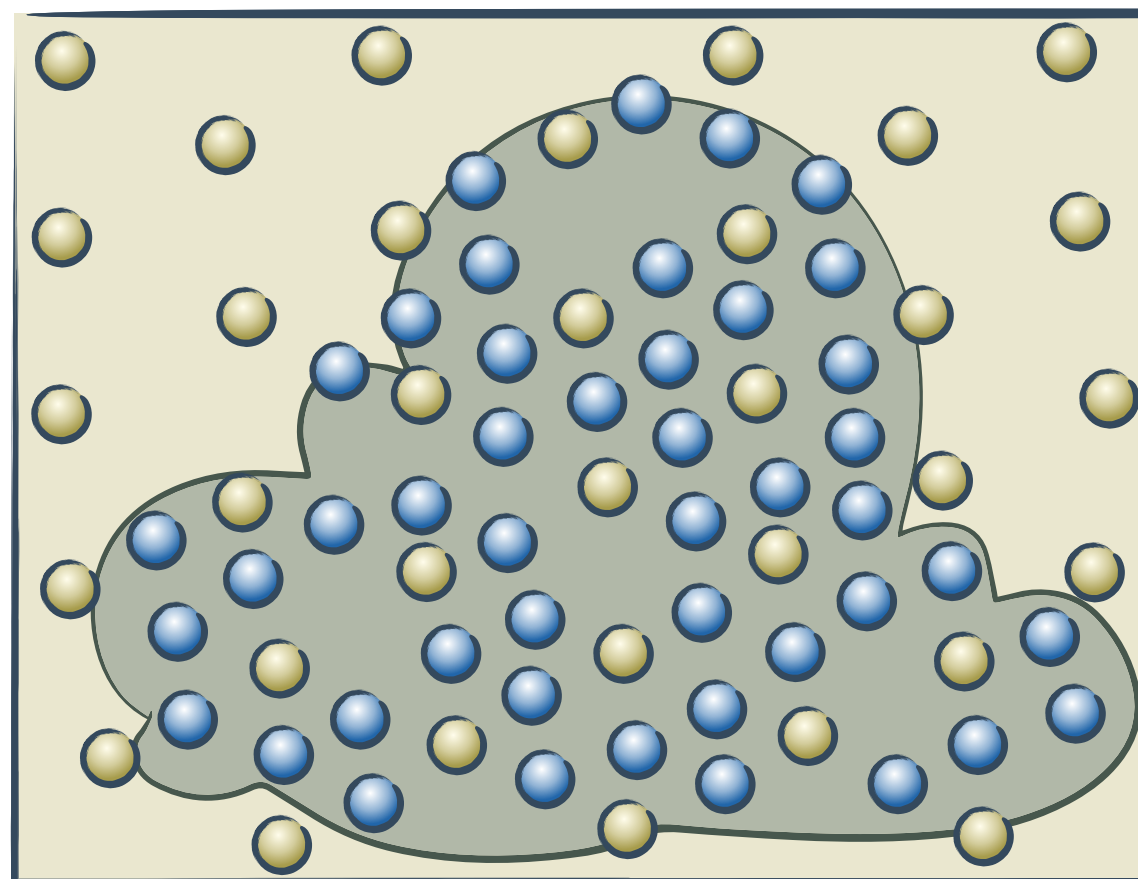
RESIDUAL  
component



CONTROL  
component



# RESIDUAL RATIO TRACKING



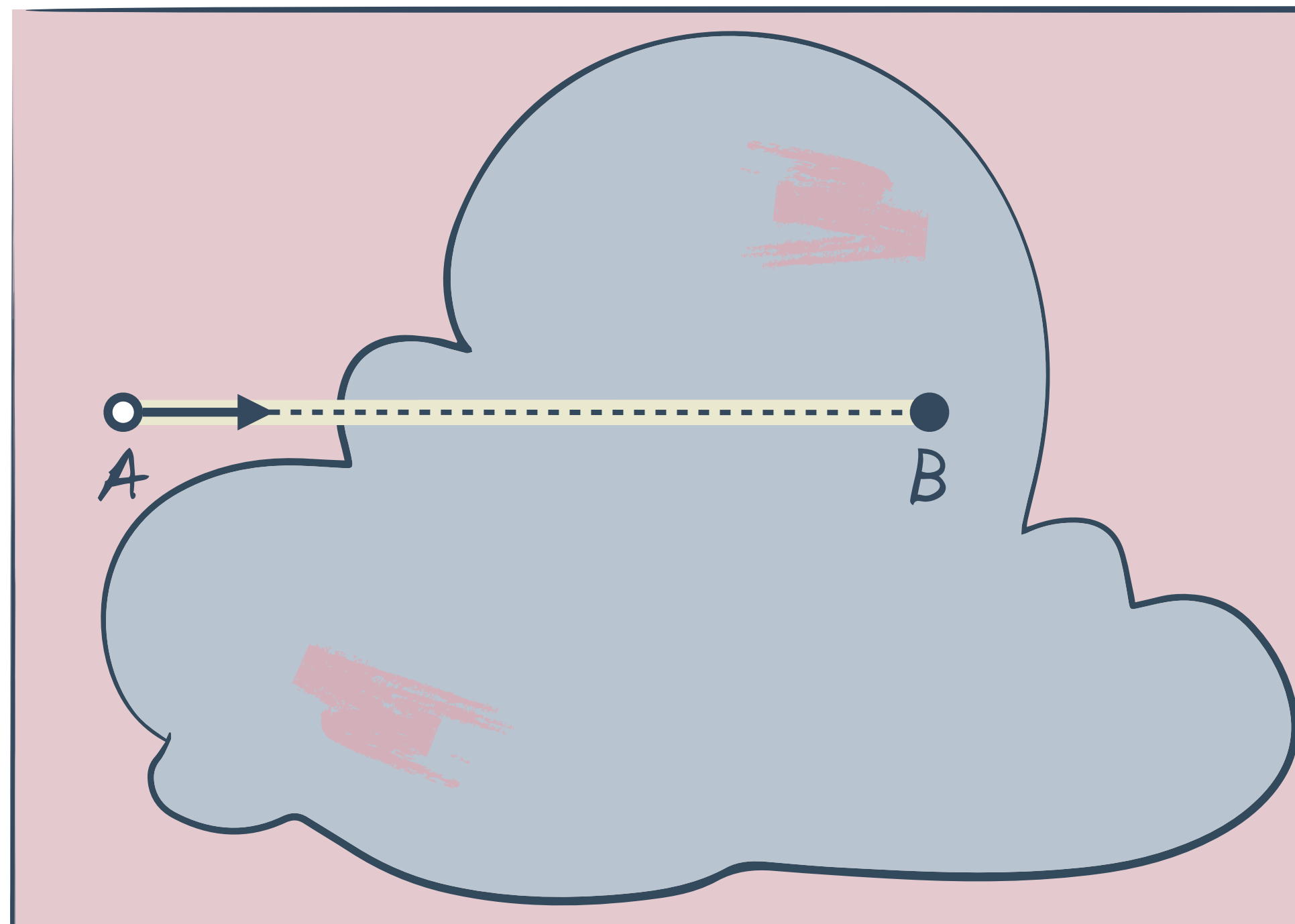
$$\langle T(t) \rangle = T_{\text{control}}(t) \langle T_{\text{residual}}(t) \rangle$$

## 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

Score a weight at every tentative collision

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



## NEXT-FLIGHT DELTA TRACKING

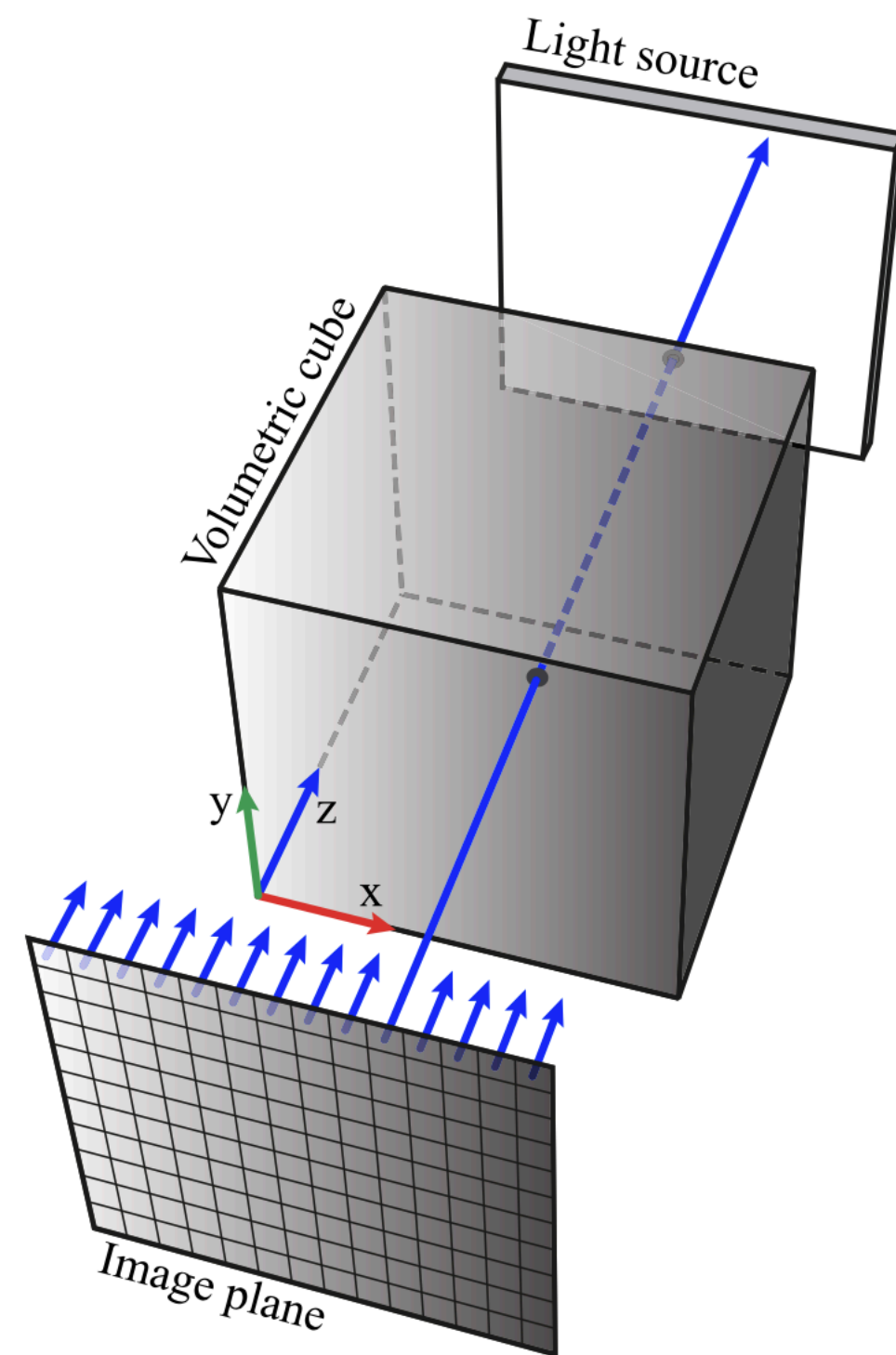
$$\langle T(t) \rangle = T_{\bar{\mu}}(0, t) + \sum_{j=1}^n \frac{\mu_n(t_j)}{\bar{\mu}(t_j)} T_{\bar{\mu}}(t_j, t)$$

Transmittance along the  
remaining segment through  
real + fictitious matter

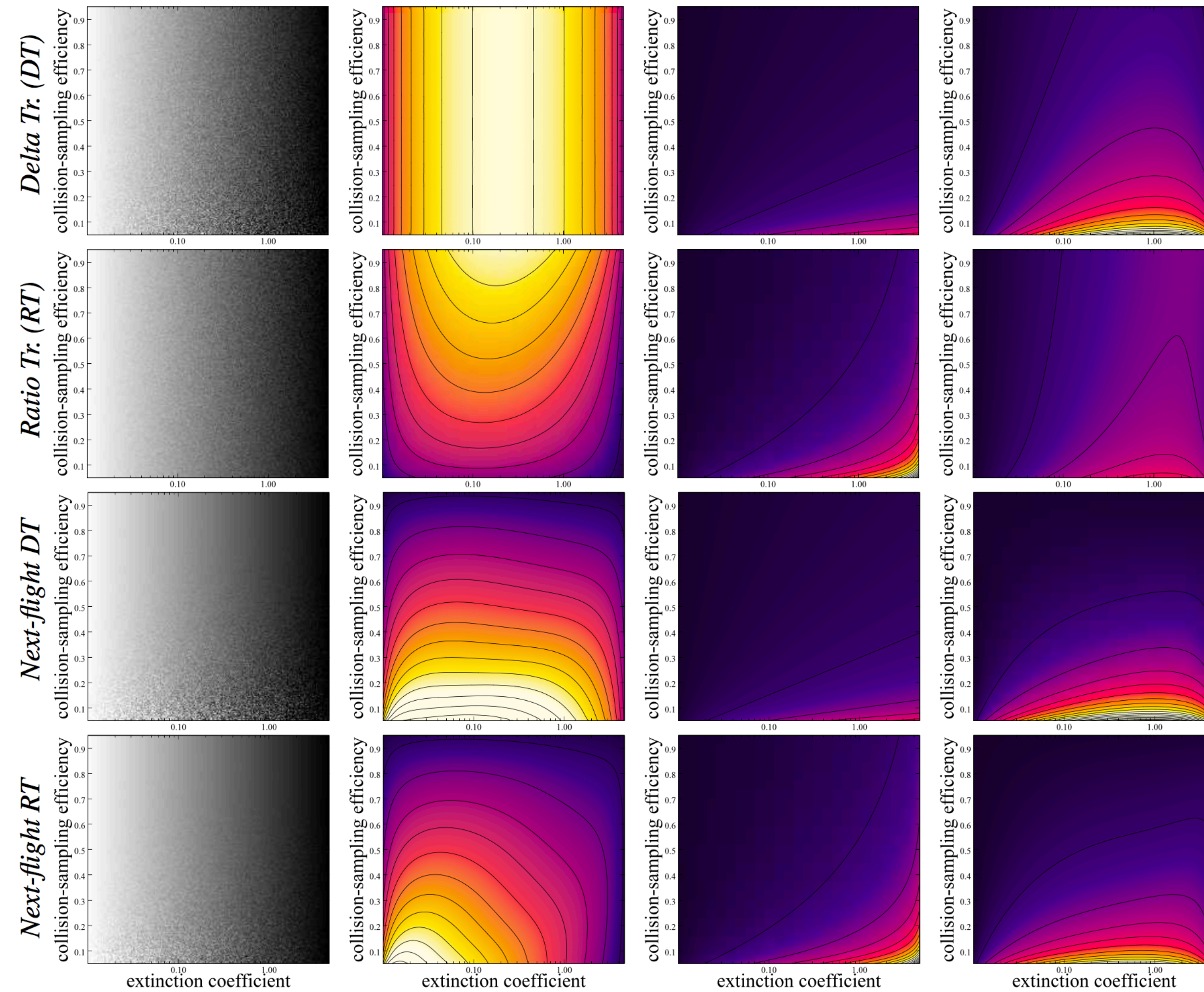
Fraction of  
fictitious matter



# COMPARISON



(a) *Canonical scene*



(b) *Equal-cost renders*

(c) *Variance of  $\langle T \rangle$*

(d) *Cost  $\langle T \rangle$*

(e) *Variance  $\times$  cost*

## **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...