Want to Normalize Scores? Ask Me How!

Unsupervised Linear Score Normalization: Intuition, Assumptions and Performance

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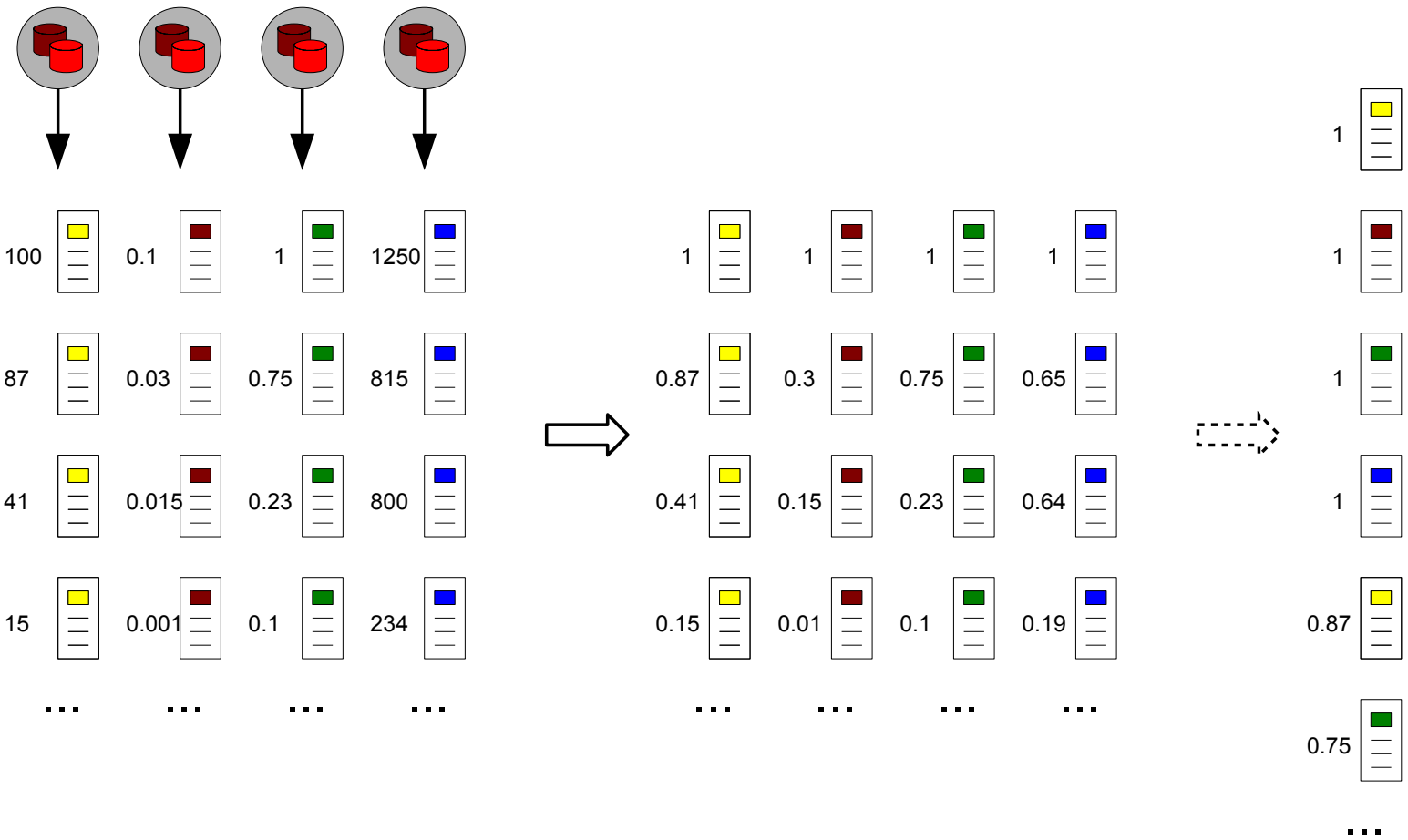
$$s_{norm} = \frac{s}{max}$$

$$s_{norm} = w\frac{s}{max}$$

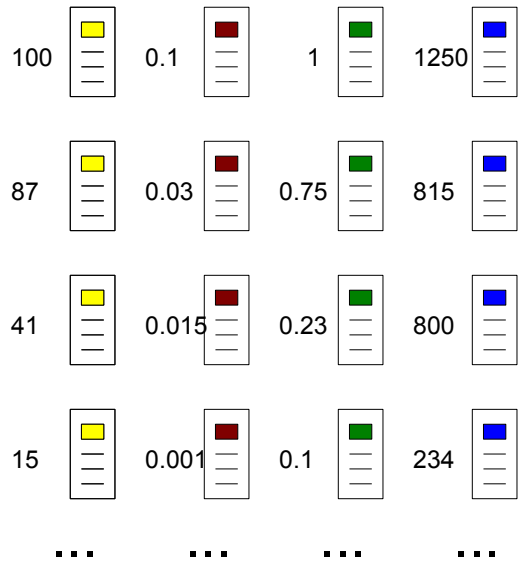
Outline

Score Normalization

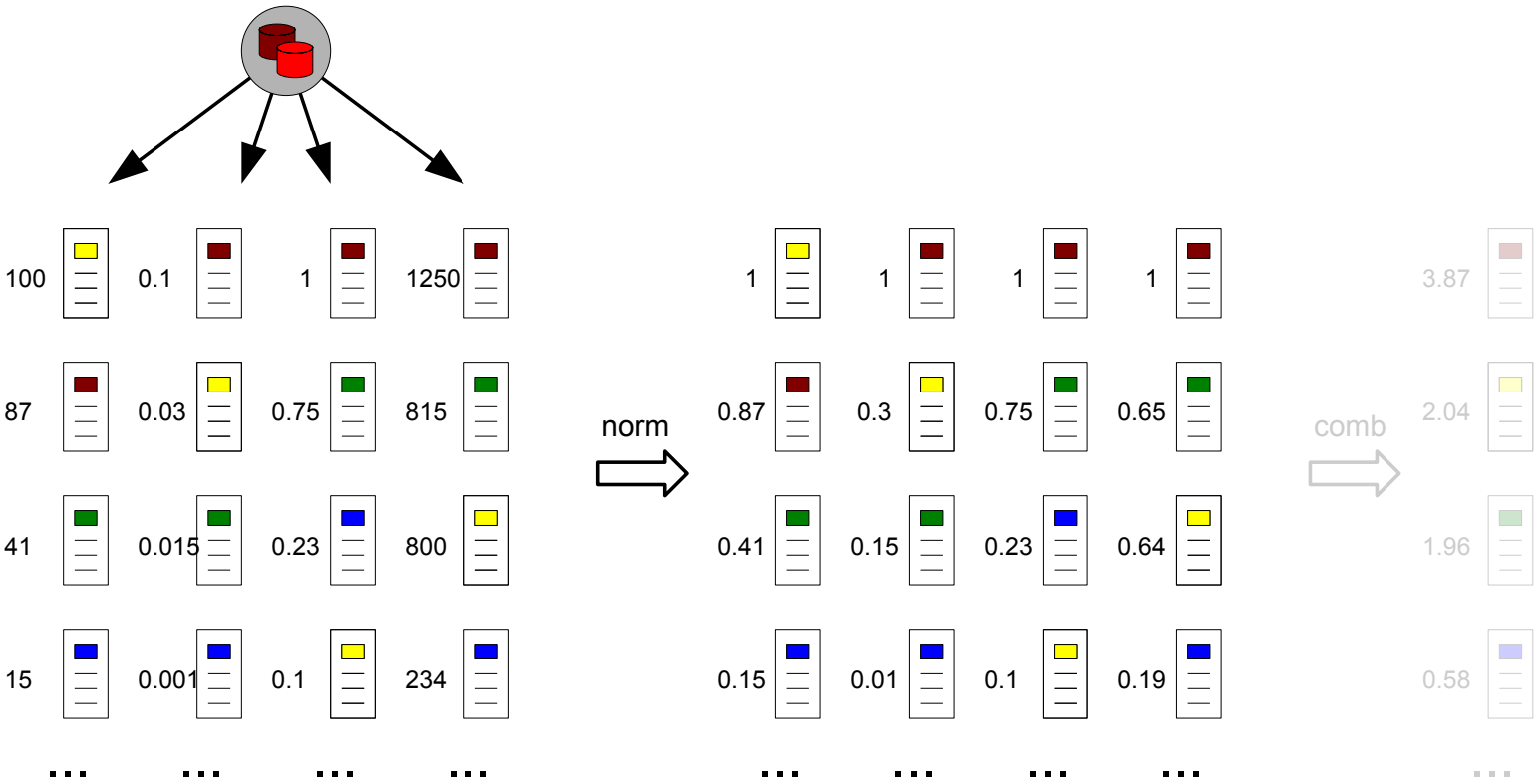


Assumptions

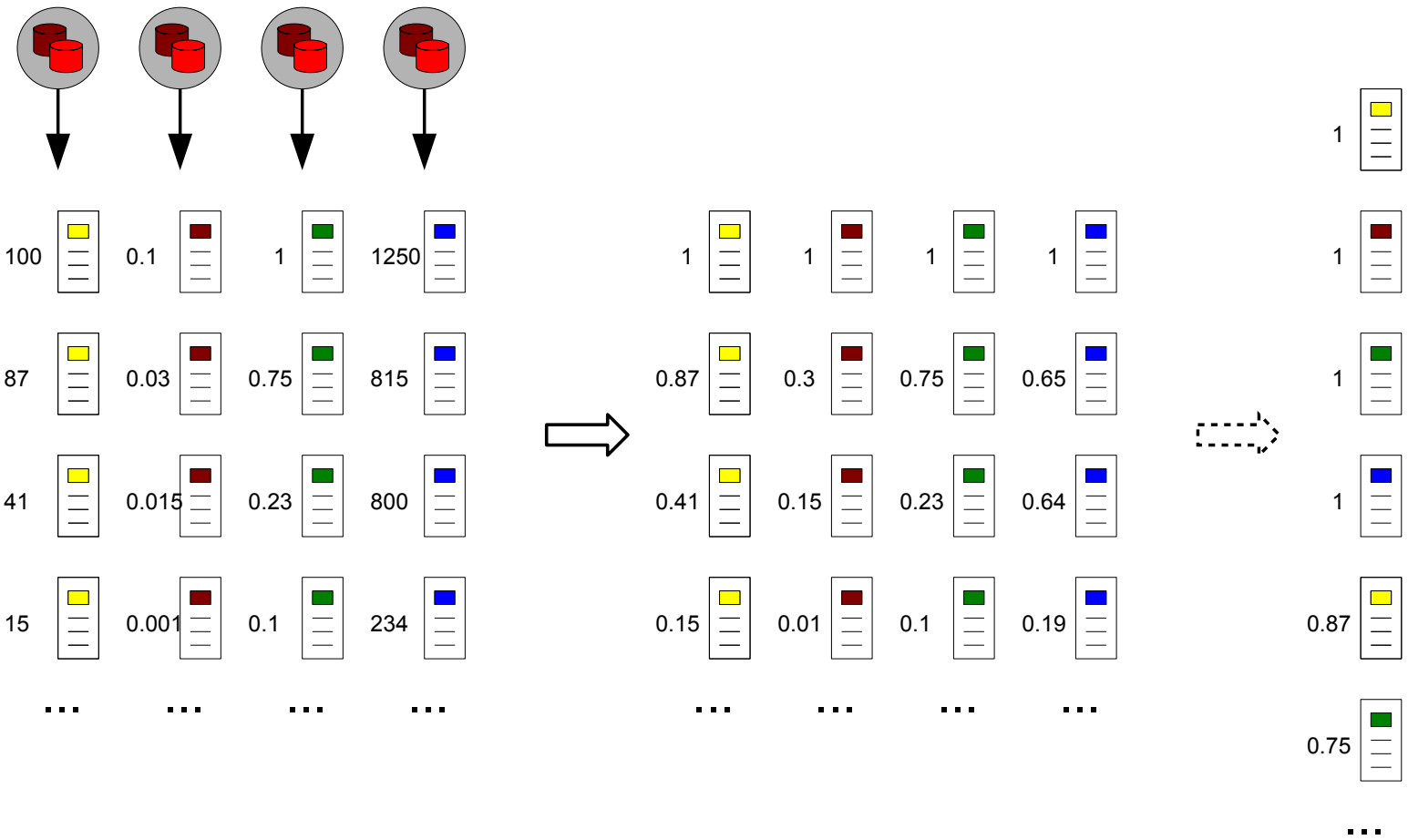
1. Document scores are provided
2. Document lists are disjoint



Data Fusion


100
0.1
1
1250
87
0.03
0.75
815
41
0.015
0.23
800
15
0.001
0.1
234
norm
1
1
1
1
0.87
0.3
0.75
0.65
0.41
0.15
0.23
0.64
0.15
0.01
0.1
0.19
comb
3.87
2.04
1.96
0.58

Score Normalization



Outline

Linear Score Normalization

- MinMax

$$s_{norm} = \frac{s - min}{max - min}$$

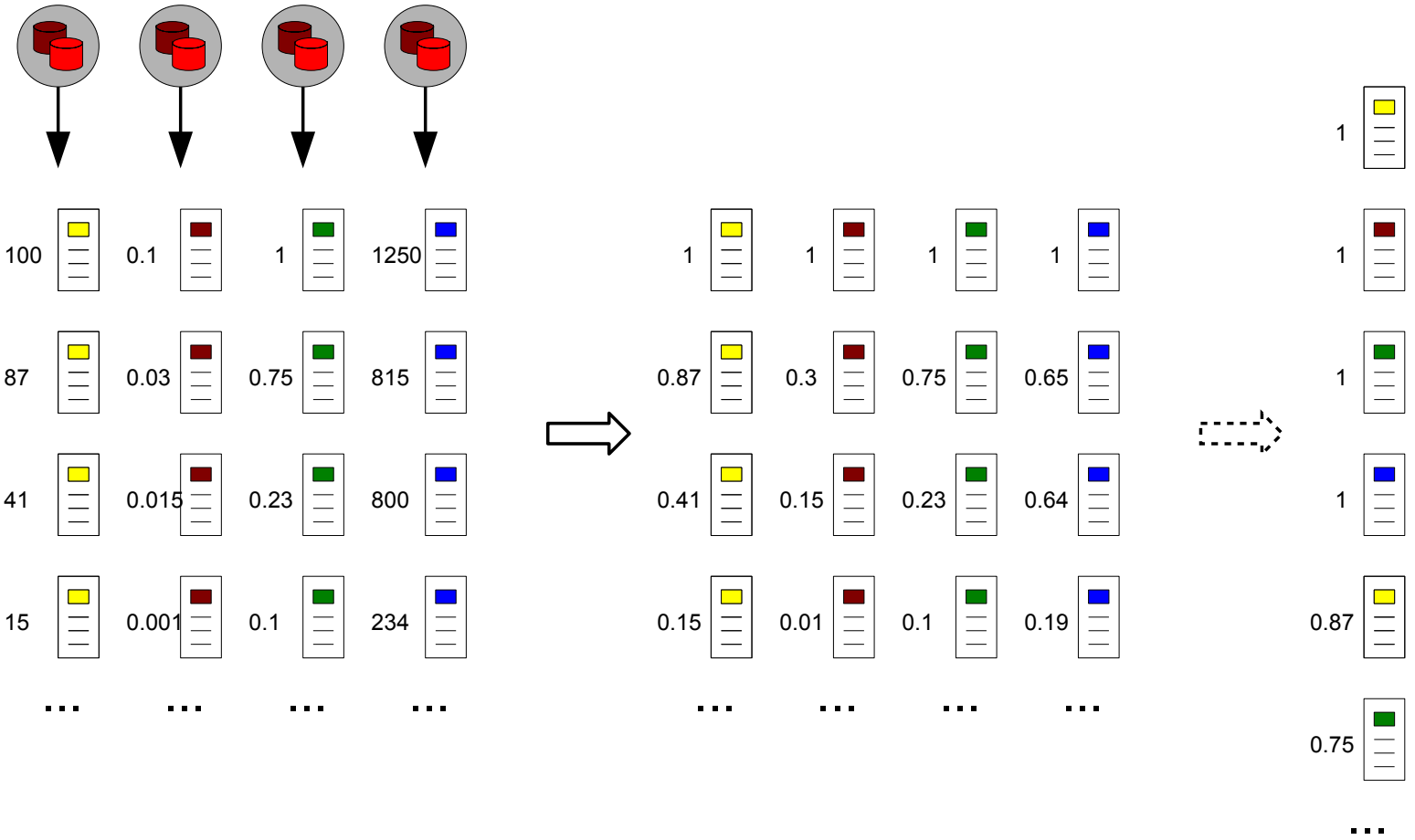
- Z-Score

$$s_{norm} = \frac{s - \mu}{\sigma}$$

- Sum

$$s' = s - min, \; s_{norm} = \frac{s'}{\sum_i s'_i}$$

MinMax



$$s_{norm} = \frac{s - min}{max - min}$$

MinMax

- Formula

$$s_{norm} = \frac{s - min}{max - min}$$

- Assumptions
  - Each collection contains at least 1 relevant document.
  - This document is most likely to be ranked 1st.
- Discussion
  - 1st documents are ranked before any other in the merged list.
  - High early precision is achieved when assumptions are hold.
- Results

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
top-10	0.1966	0.1936	0.0161	0.0148
top-1000	0.1953	0.1919	0.0161	0.0148

Max

- Observations
  - The lowest theoretical score of many scoring functions is 0.
- Formula

$$s_{norm} = \frac{s}{max}$$

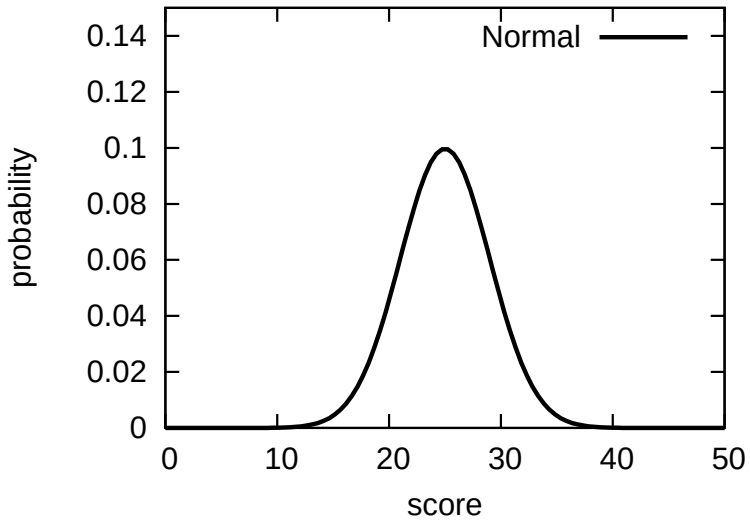
- Results

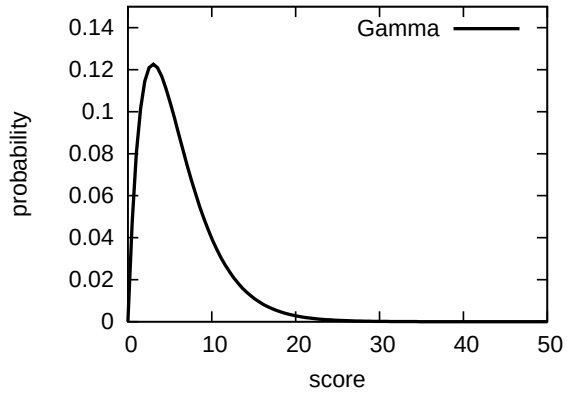
		gov2.30		gov2.1000	
		p@10	p@20	p@10	p@20
top-10	MinMax	0.1966	0.1936	0.0161	0.0148
	Max	0.1953	0.1926	0.0161	0.0148
top-1000	MinMax	0.1953	0.1919	0.0161	0.0148
	Max	0.1953	0.1919	0.0161	0.0148

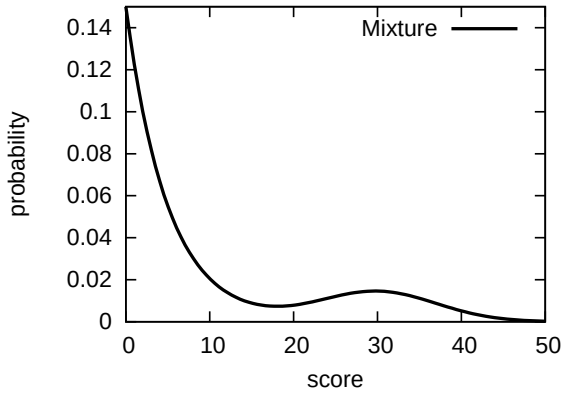
- Discussion
  - Performance similar to MinMax.
  - Not affected by minimum score.

Z-Score

$$s_{norm} = \frac{s - \mu}{\sigma}$$







Z-Score

- Formula

$$s_{norm} = \frac{s - \mu}{\sigma}$$

- Assumptions
  - Score distribution is a bell-shape curve.
- Discussion
  - May be true for top documents.
  - Low ranked documents affect normalized scores of top ranked documents.
- Results

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
top-10	0.1839	0.1852	0.0007	0.0037
top-1000	0.0819	0.0953	0.0013	0.0023

Unit Variance (UV)

- Formula

$$s_{norm} = \frac{s}{\sigma}$$

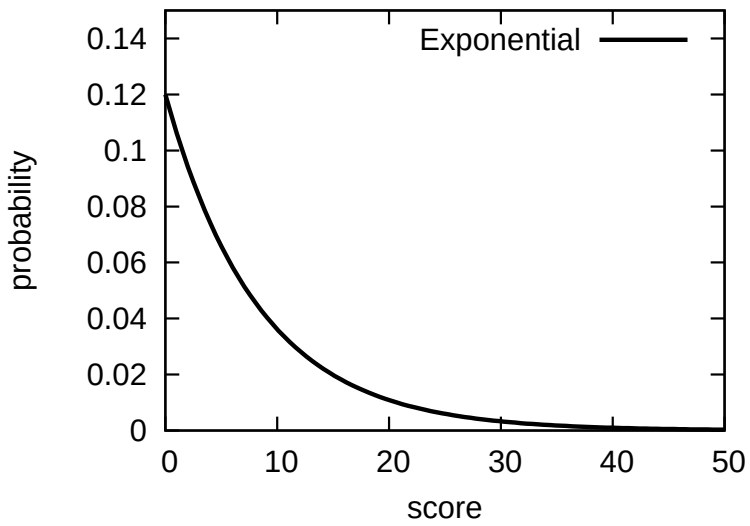
- Results

		gov2.30		gov2.1000	
		p@10	p@20	p@10	p@20
top-10	Z-Score	0.1839	0.1852	0.0007	0.0037
	UV	*0.1980*	*0.1936*	*0.0228*	*0.0188*
top-1000	Z-Score	0.0819	0.0953	0.0013	0.0023
	UV	*0.1248*	*0.1144*	0.0013	0.0007

- Discussion
  - More robust and less affected by low scores.

Sum

$$s' = s - min,\ s_{norm} = \frac{s'}{\sum_i s'_i}$$



$$p(s) \sim \mathcal{E}(s;\lambda),\ \lambda = \frac{n}{\sum_i s_i}$$

$$p(s_{norm}) = p\left(\frac{s'}{\sum_i s'_i}\right) \sim \mathcal{E}(s;n)$$

Sum

- Formula

$$s' = s - min, \; s_{norm} = \frac{s'}{\sum_i s'_i}$$

- Assumptions
  - Document scores are distributed exponentially.
  - The mean of different exponentials is made the same.
- Discussion
  - Should not hold especially for top documents.
- Results

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
top-10	0.1785	0.1758	0.0013	0.0023
top-1000	0.0134	0.0114	0.0013	0.0017

Overall Results

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
MinMax	0.1966	0.1936	0.0161	0.0148
Max	0.1953	0.1926	0.0161	0.0148
Z-Score	0.1839	0.1852	0.0007	0.0037
UV	0.1980	0.1936	*0.0228*	*0.0188*
Sum	0.1785	0.1758	0.0013	0.0023

Table: Top 10 documents are retrieved.

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
MinMax	*0.1953*	*0.1919*	*0.0161*	*0.0148*
Max	*0.1953*	*0.1919*	*0.0161*	*0.0148*
Z-Score	0.0819	0.0953	0.0013	0.0023
UV	0.1248	0.1144	0.0013	0.0007
Sum	0.0134	0.0114	0.0013	0.0017

Table: Top 1000 documents are retrieved.

Outline

$$s_{norm} = \frac{s}{max}$$

$$s_{norm} = w\frac{s}{max}$$

Possible Weights for MinMax

... calculated directly from a list of document scores.

- Min and max
- Mean and standard deviation
- Median and median absolute deviation
- Sum and mean

MinMax * Stdv

- Formula

$$s_{norm} = \sigma \frac{s - min}{max - min}$$

- Results

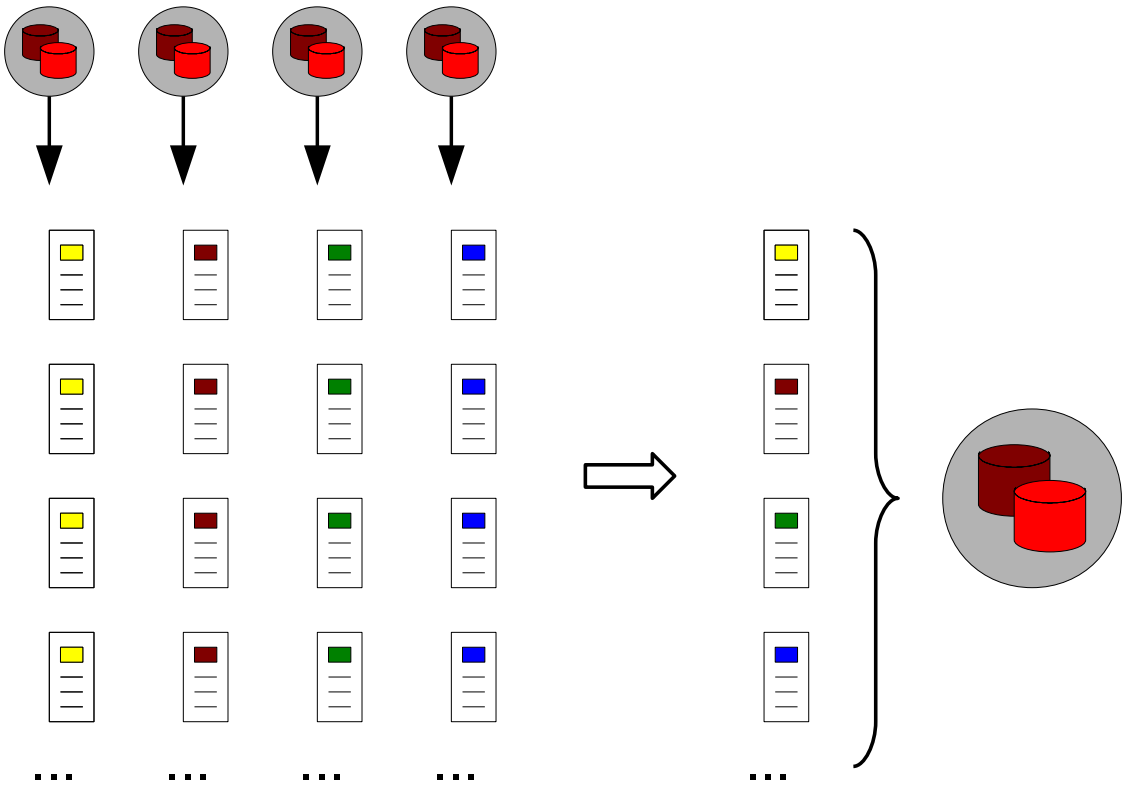
		gov2.30		gov2.1000	
		p@10	p@20	p@10	p@20
top-10	MinMax	*0.1966*	*0.1936*	*0.0161*	*0.0148*
	MM-Stdv	0.1604	0.1728	0.0054	0.0081
top-1000	MinMax	*0.1953*	*0.1919*	*0.0161*	0.0148
	MM-Stdv	0.1738	0.1617	0.0114	0.0148

- Discussion
  - The σ weight does not help (neither do other weights).

Resource Selection for MinMax

+ Removes non-relevant collections.
+ Provides collection relevant scores.
– Complex and requires centralized sample index.

Centralized Sample Index



Centralized sample index can be used for

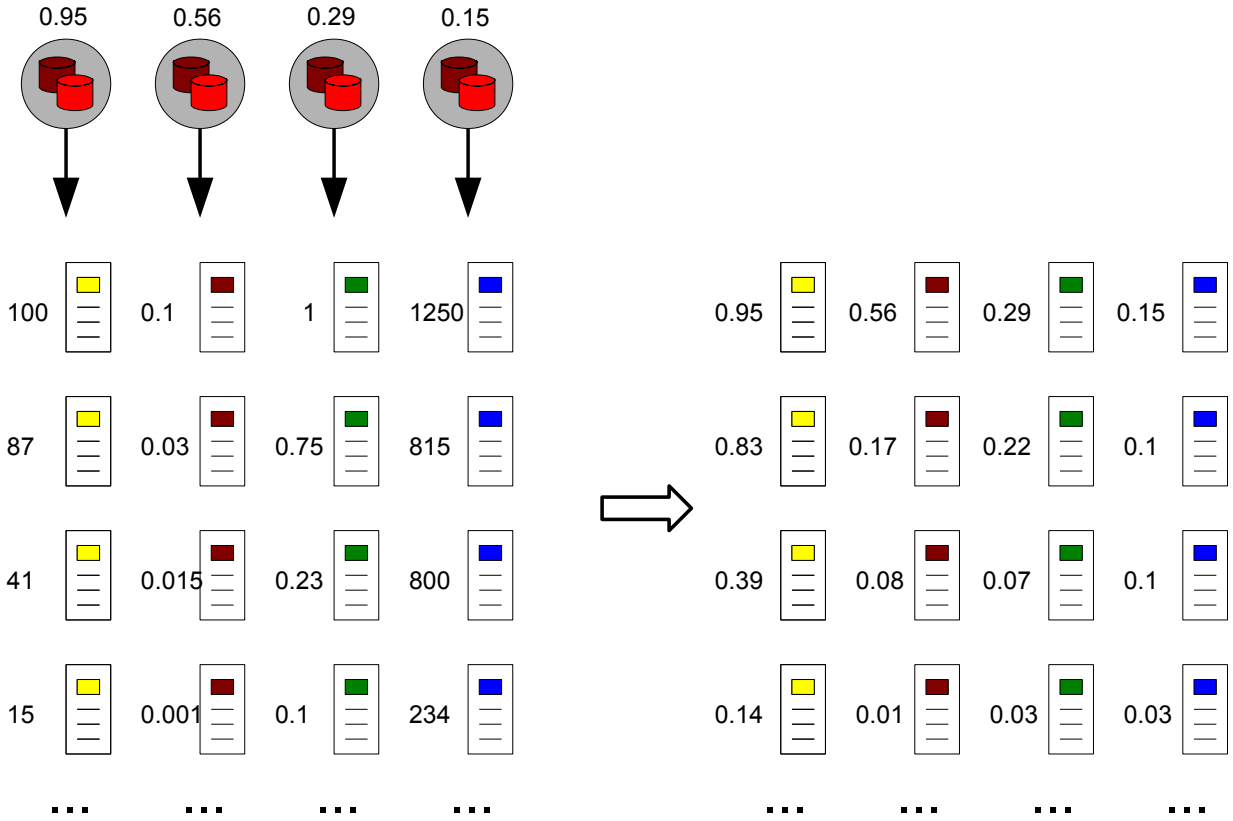
- resource selection
- score normalization

Sometimes cannot be built.

MinMax and Resource Selection

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
no selection	0.1966	0.1936	0.0161	0.0148
10 collections	0.2148	0.2060	0.1369	0.1275
3 collections	*0.3342*	*0.2752*	*0.2389*	*0.1973*

Weighted MinMax



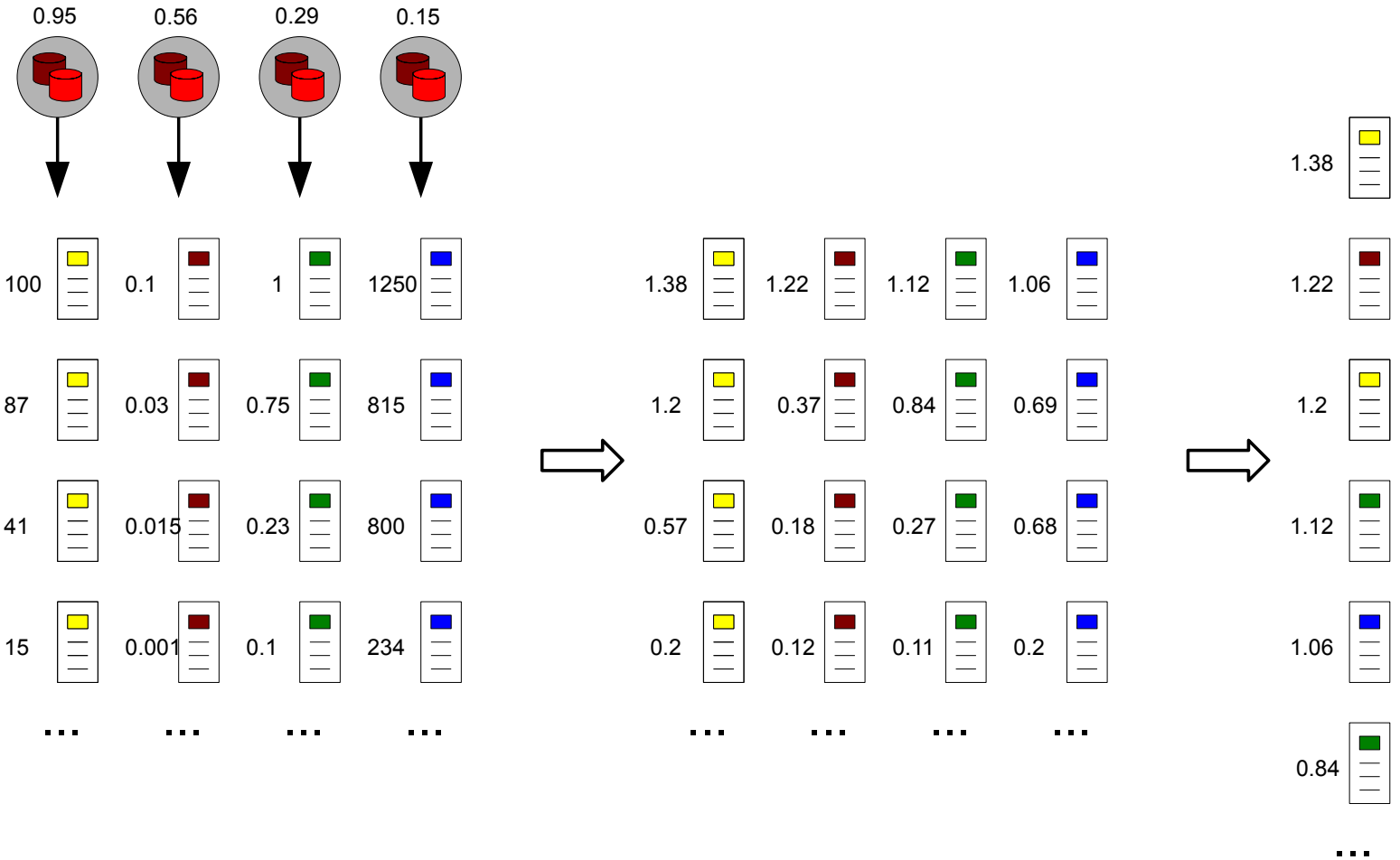
$$s_{norm} = w_{coll} \frac{s - min}{max - min}$$

Weighted MinMax

		gov2.30		gov2.1000	
		p@10	p@20	p@10	p@20
no selection	MinMax	0.1966	0.1936	0.0161	0.0148
	WeightedMM	*0.3658*	*0.2802*	*0.2705*	*0.2205*
10 collections	MinMax	0.2148	0.2060	0.1369	0.1275
	WeightedMM	*0.3664*	*0.2782*	*0.2705*	*0.2228*
3 collections	MinMax	0.3342	0.2752	0.2389	0.1973
	WeightedMM	*0.3638*	0.2812	*0.2678*	0.2027

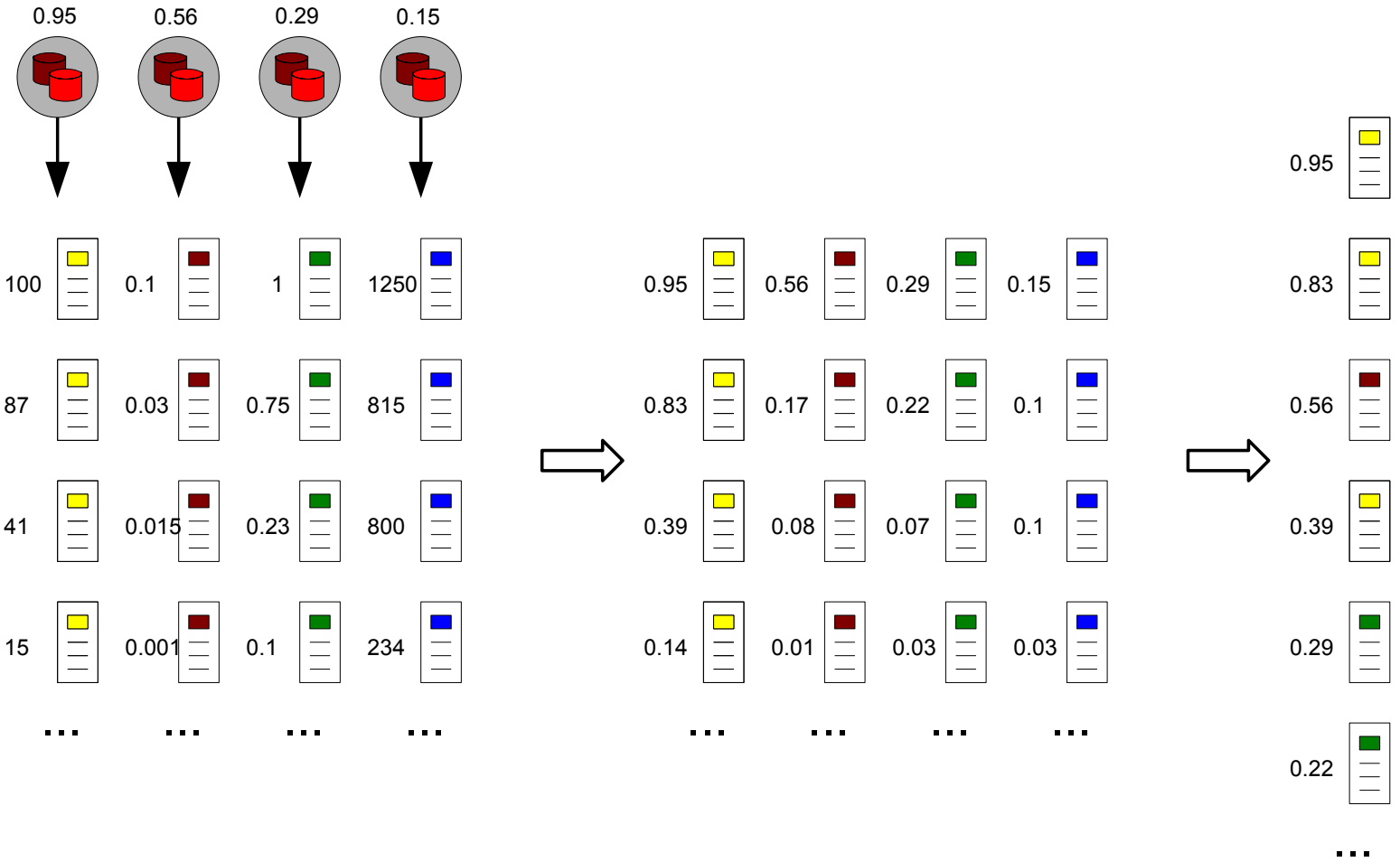
- No need in resource selection.
- Removing some collections hurts weighted MinMax.

Collection Retrieval Inference Network (CORI)



$$s_{norm} = (1 + 0.4 \cdot w_{coll}) \frac{s - min}{max - min}$$

Weighted MinMax



$$s_{norm} = w_{coll} \frac{s - min}{max - min}$$

Collection Retrieval Inference Network (CORI)

		gov2.30		gov2.1000	
		p@10	p@20	p@10	p@20
no selection	WeightedMM	*0.3658*	*0.2802*	*0.2705*	*0.2205*
	CORI	0.2906	0.2295	0.1879	0.1131
10 collections	WeightedMM	*0.3664*	*0.2782*	*0.2705*	*0.2228*
	CORI	0.2718	0.2181	0.1966	0.1544
3 collections	WeightedMM	*0.3638*	0.2812	*0.2678*	0.2027
	CORI	0.3396	0.2768	0.2409	0.1987

- CORI depends on how many collections are selected.
- No clear intuition behind the formula.

Other Score Normalization

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
MinMax	0.1966	0.1936	0.0161	0.0148
WeightedMM	*0.3658*	*0.2802*	*0.2705*	*0.2205*
CORI	0.2906	0.2295	0.1879	0.1131
SAFE	0.1879	0.1698	0.0698	0.0718
HIS	0.1728	0.1845	0.0819	0.0822

Table: No resource selection.

	gov2.30		gov2.1000	
	p@10	p@20	p@10	p@20
MinMax	0.3342	0.2752	0.2389	0.1973
WeightedMM	*0.3638*	0.2812	*0.2678*	0.2027
CORI	0.3396	0.2768	0.2409	0.1987
SAFE	0.2691	0.2490	0.2477	0.1983
HIS	0.3054	0.2816	0.2070	0.1883

Table: 3 collections are selected.

Open Question

Is it possible to calculate collection weights simpler,
with minimum additional information
and without centralized sample index?

$$s_{norm} = \frac{s}{max}$$

$$s_{norm} = w\frac{s}{max}$$

Alternative ways to calculate collection weights?