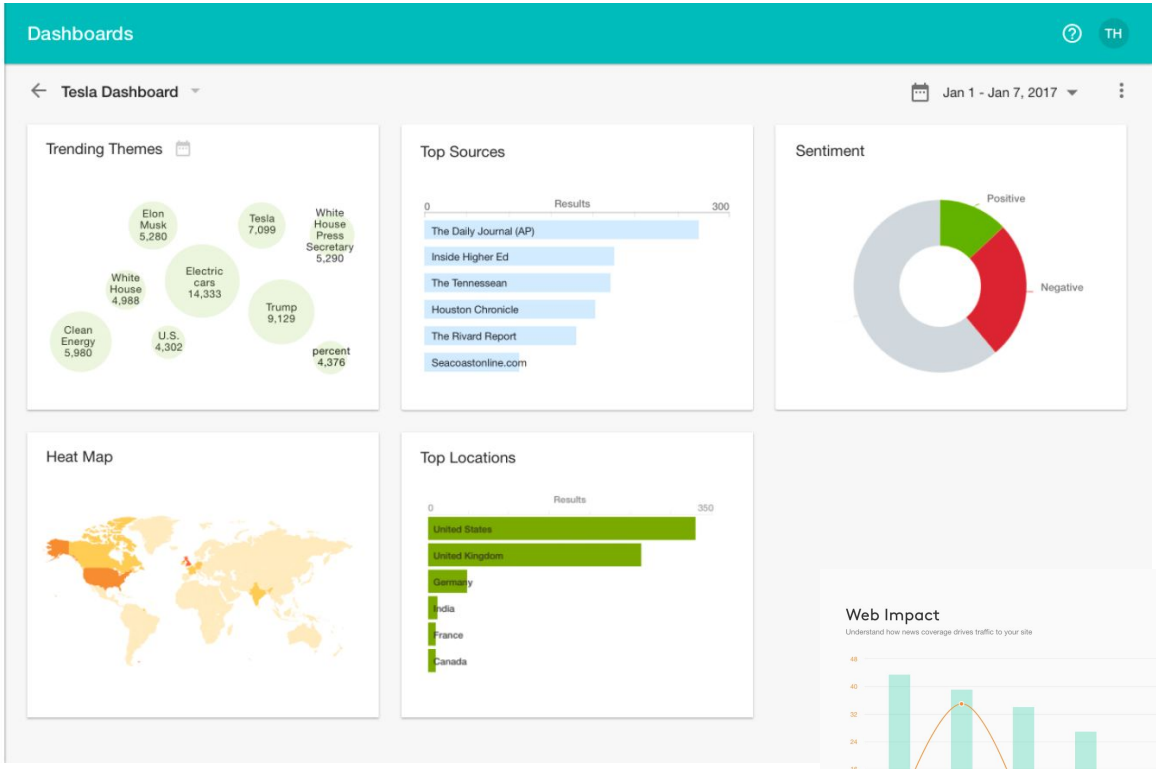
Predicting Resource Consumption in a Large-Scale Information Retrieval System

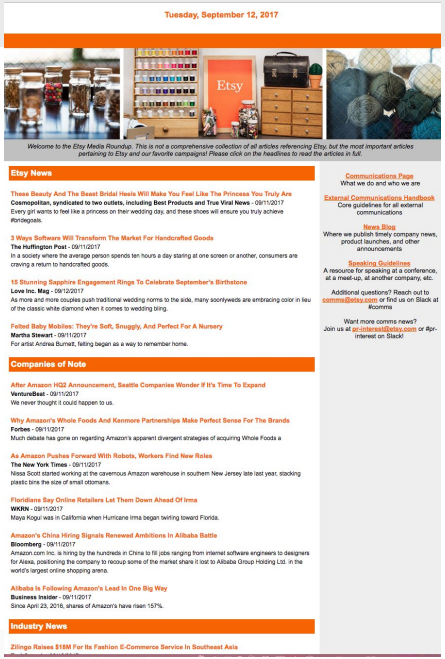
Some ideas on dealing with inherently noisy data in Machine Learning

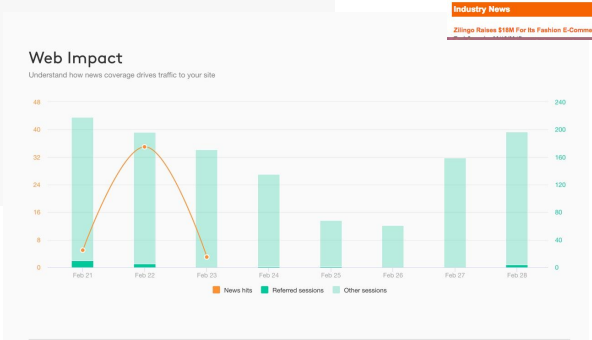
Presented by: David Burke

Meltwater

Who are Meltwater?







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Large-Scale Information Retrieval

35B
AVAILABLE DOCUMENTS

2.2M
SEARCHES/DAY

75M
INCOMING DOCUMENTS/DAY

elastic

500
DATA NODES

99.96%
UPTIME/SERVICE LEVEL

168ms
MEDIAN RESPONSE TIME

Horace

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```
{
  "query": {
    "notMatchQuery": {
      "field": "body.content.text",
      "type": "term",
      "value": "Greek"
    },
    "matchQuery": {
      "allQueries": [
        {
          "field": "body.content.text",
          "type": "term",
          "value": "GAIA"
        },
        {
          "field": "body.content.text",
          "type": "term",
          "value": "Conference"
        },
        {
          "anyQueries": [
            {
              "field": "body.content.text",
              "type": "term",
              "value": "Gothenburg"
            },
            {
              "field": "body.content.text",
              "type": "term",
              "value": "Göteborg"
            }
```

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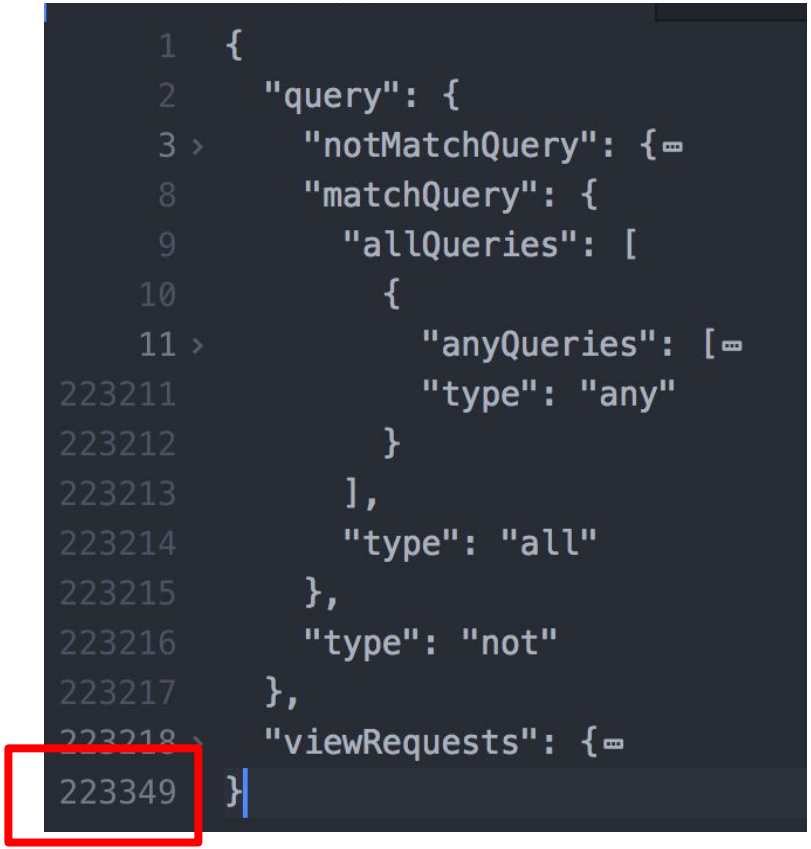
Some fun queries

```
{
  "query": {
    "anyQueries": [
      {
        "field": "body.content.text",
        "type": "wildcard",
        "value": "a*"
      },
      {
        "field": "body.content.text",
        "type": "wildcard",
        "value": "b*"
      },
      {
        "field": "body.content.text",
        "type": "wildcard",
        "value": "c*"
      },
      {
        "field": "body.content.text",
        "type": "wildcard",
        "value": "d*"
      },
      ...
```



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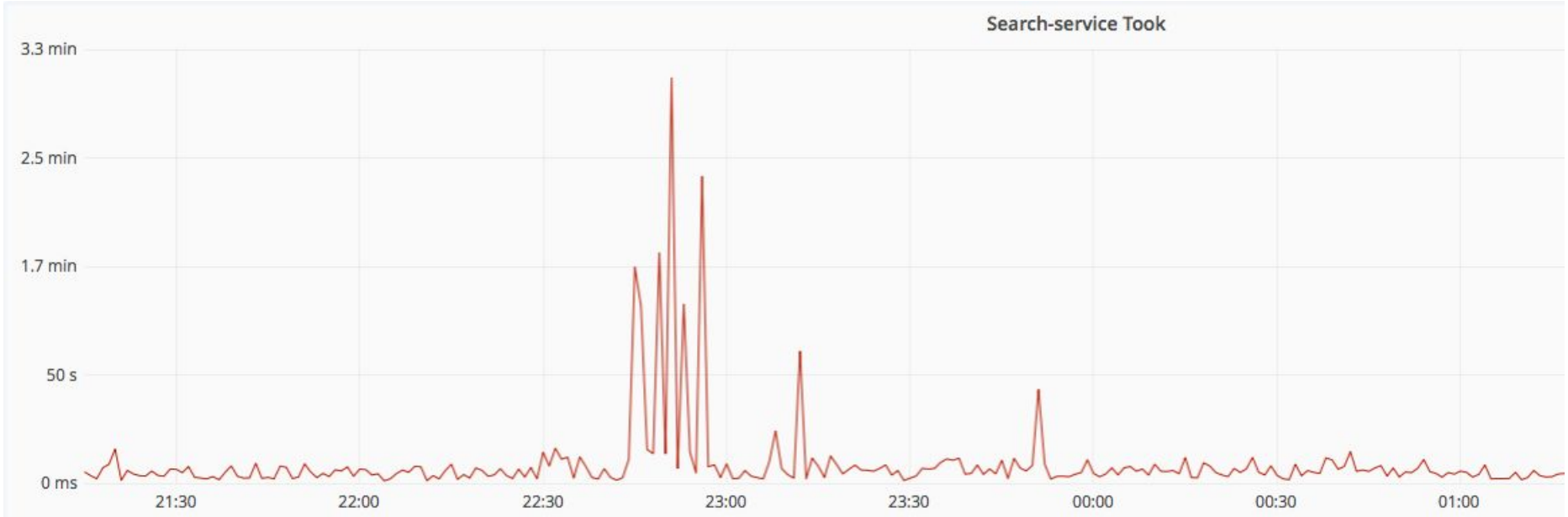
Search spikes

Search Times (average)



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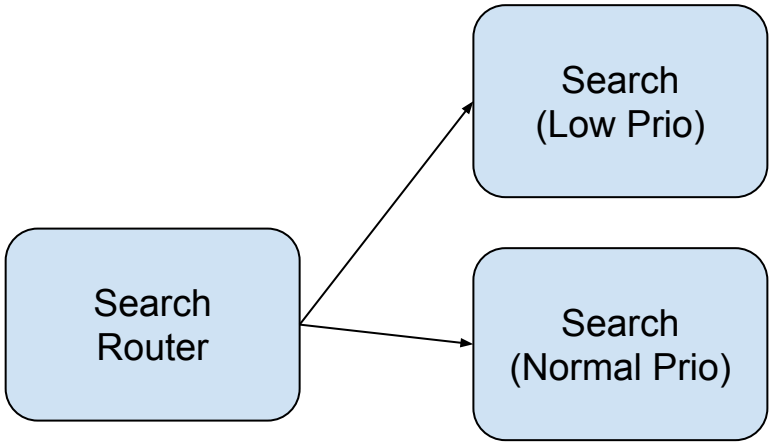
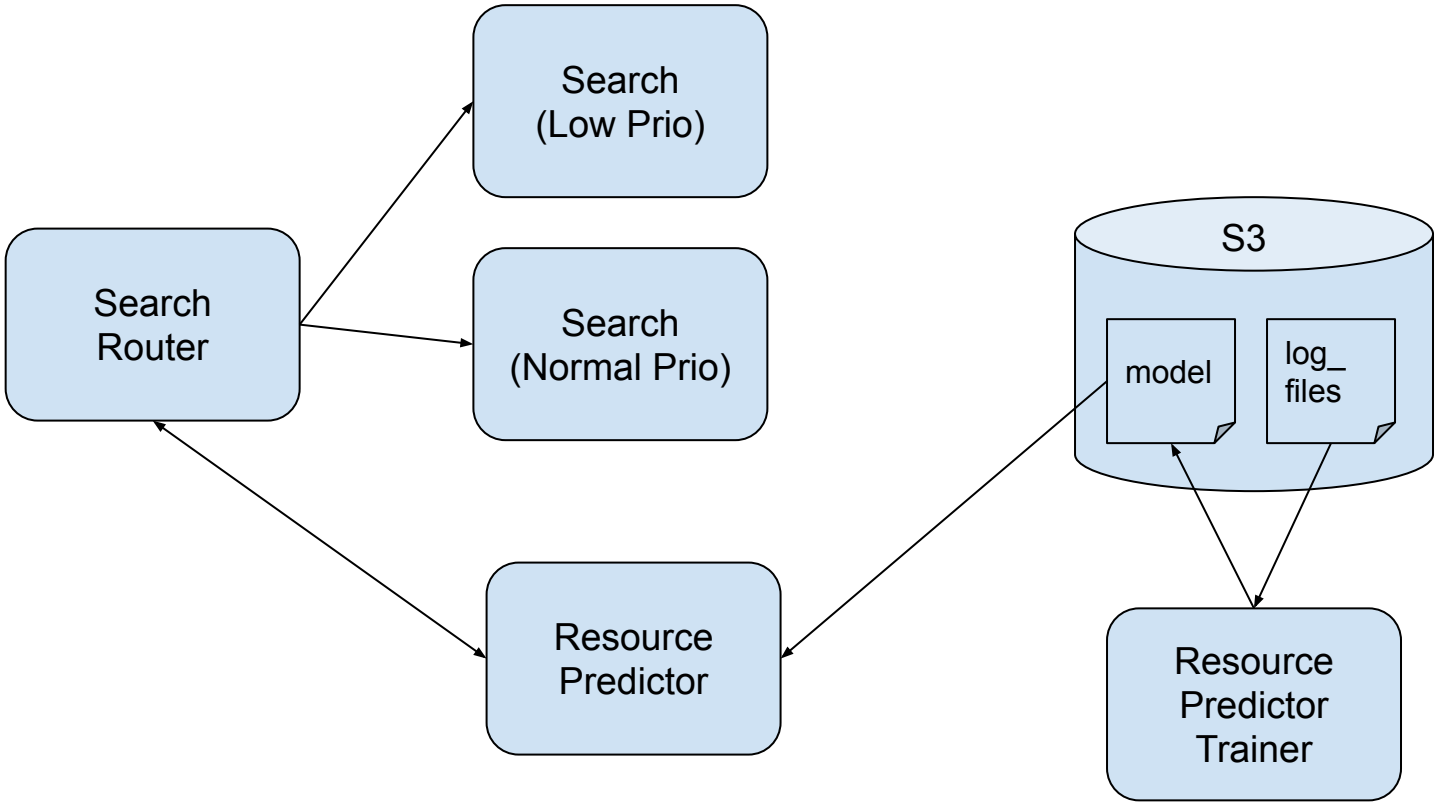
Query Resource Prediction for Routing

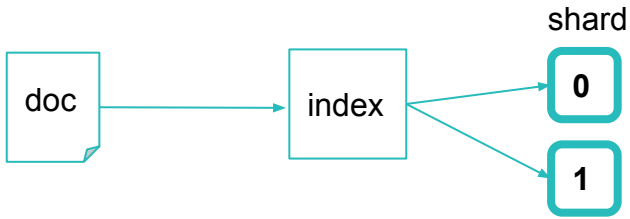


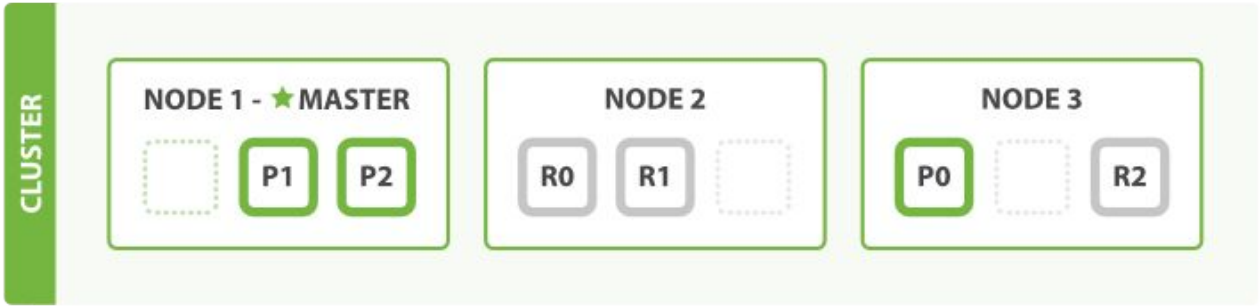
Query Resource Prediction for Routing



Elasticsearch

elasticsearch - scalable, distributed search





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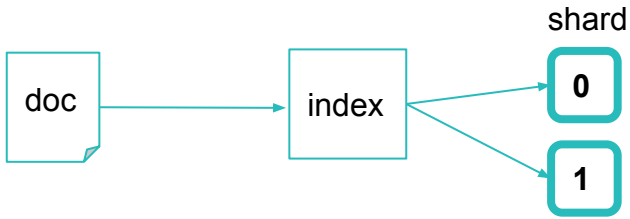
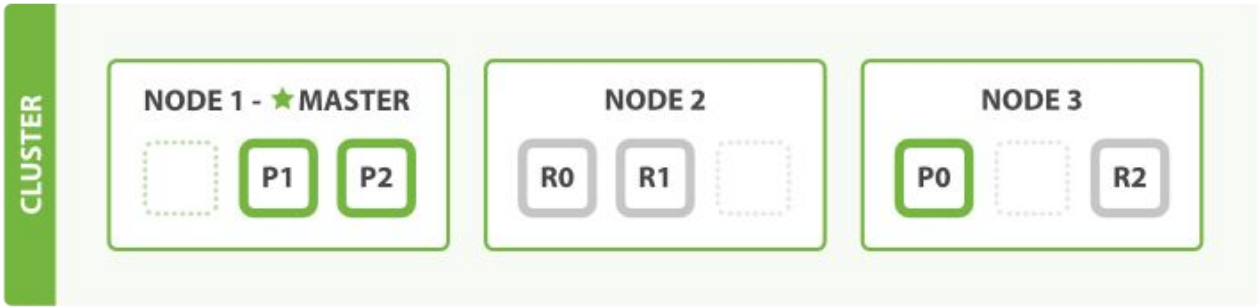
elasticsearch - scalable, distributed search



Resource consumption
≅query_time x # shards



Building a model

Query	$feature_1$	$feature_2$	...	$feature_n$	rc
q_1	f_{11}	f_{12}	...	f_{1n}	$\mathbf{r_1}$
q_2	f_{21}	f_{22}	...	f_{2n}	$\mathbf{r_2}$
...					
q_n	f_{n1}	f_{n2}	...	f_{nn}	$\mathbf{r_n}$

Building a model

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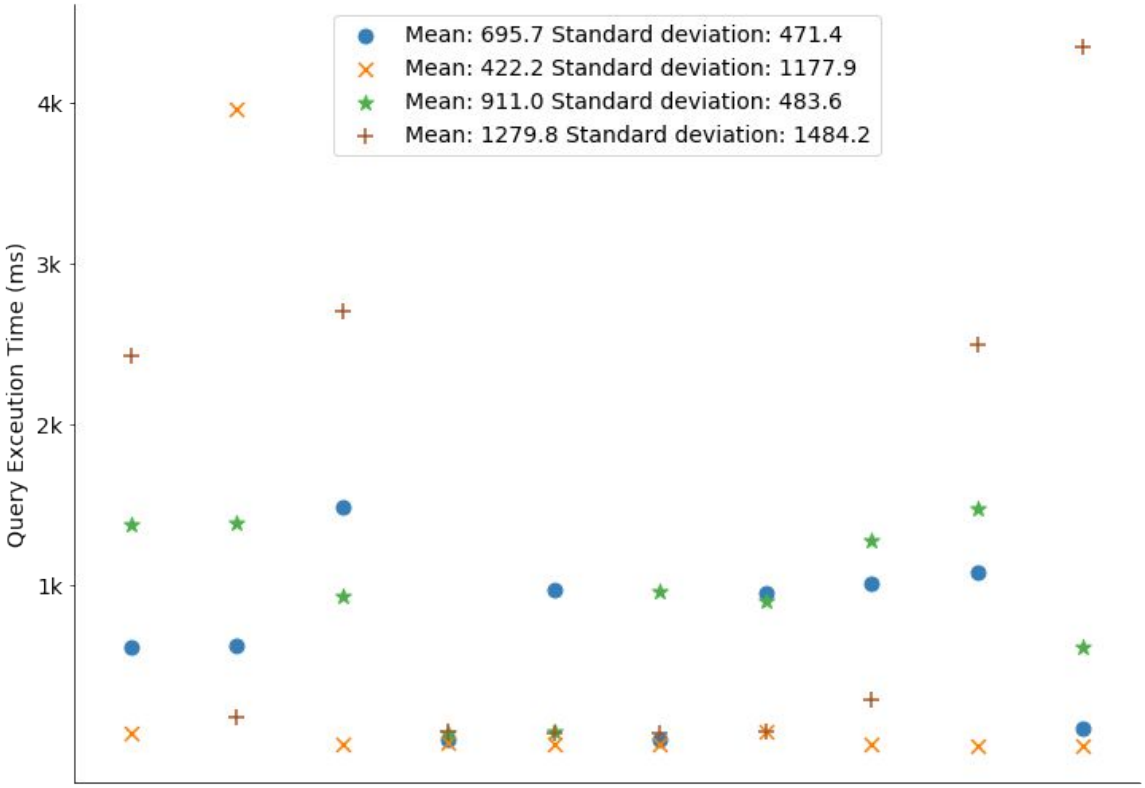

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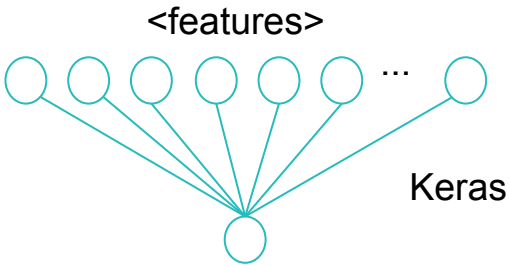
Building a model




```
Features =
{
        number_of_words,
        number_of_wildcards,
        number_of_ors,
        number_of_ands,
        number_of_nots,
        …
        etc.
}
```

Model Strategies

1. Dynamic/online noisy model

Building a model

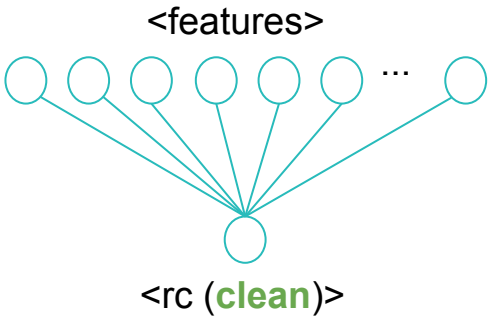
Query	$feature_1$	$feature_2$	...	$feature_n$	rc	rc_c
q_1	f_{11}	f_{12}	...	f_{1n}	$\mathbf{r_1}$	$\mathbf{r_{1c}}$
q_2	f_{21}	f_{22}	...	f_{2n}	$\mathbf{r_2}$	$\mathbf{r_{2c}}$
...						
q_n	f_{n1}	f_{n2}	...	f_{nn}	$\mathbf{r_n}$	$\mathbf{r_{nc}}$

Clean measurements

Model Strategies

1. Dynamic/online noisy model

Building a model



Model Strategies

1. Dynamic/online noisy model
2. Static/offline clean model

Building a model

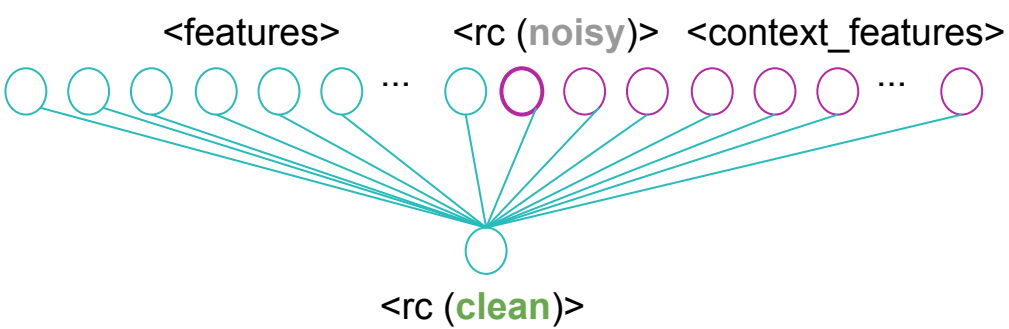
Query	$feature_1$	$feature_2$	...	$feature_n$	rc	rc_c	rc_d
q_1	f_{11}	f_{12}	...	f_{1n}	$\mathbf{r_1}$	$\mathbf{r_{1c}}$	$\mathbf{r_{1d}}$
q_2	f_{21}	f_{22}	...	f_{2n}	$\mathbf{r_2}$	$\mathbf{r_{2c}}$	$\mathbf{r_{1d}}$
...							
q_n	f_{n1}	f_{n2}	...	f_{nn}	$\mathbf{r_n}$	$\mathbf{r_{nc}}$	$\mathbf{r_{1d}}$

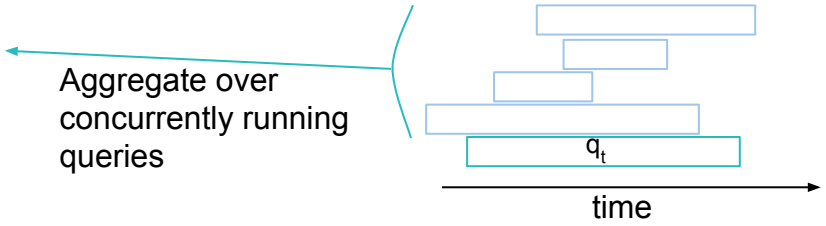
Denoised measurements

Model Strategies

1. Dynamic/online noisy model
2. Static/offline clean model

Building a model

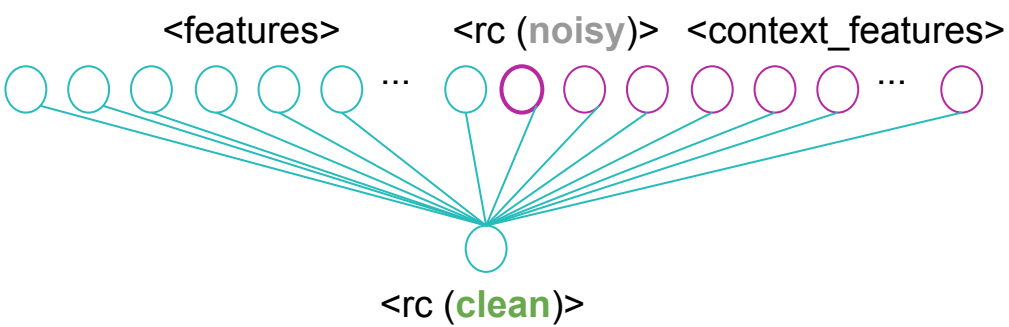


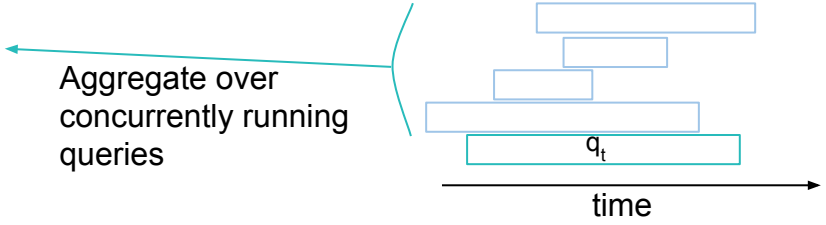


Model Strategies

1. Dynamic/online noisy model
2. Static/offline clean model
3. Dynamic/online denoised model
    - Denoise noisy measurements
    - Train on denoised measurements

Building a model





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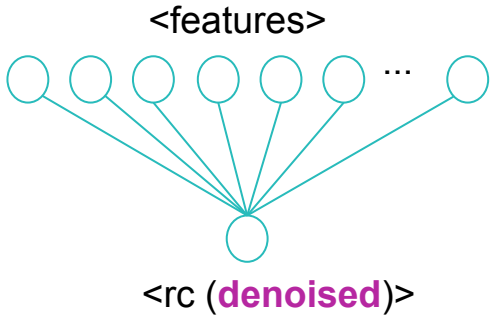
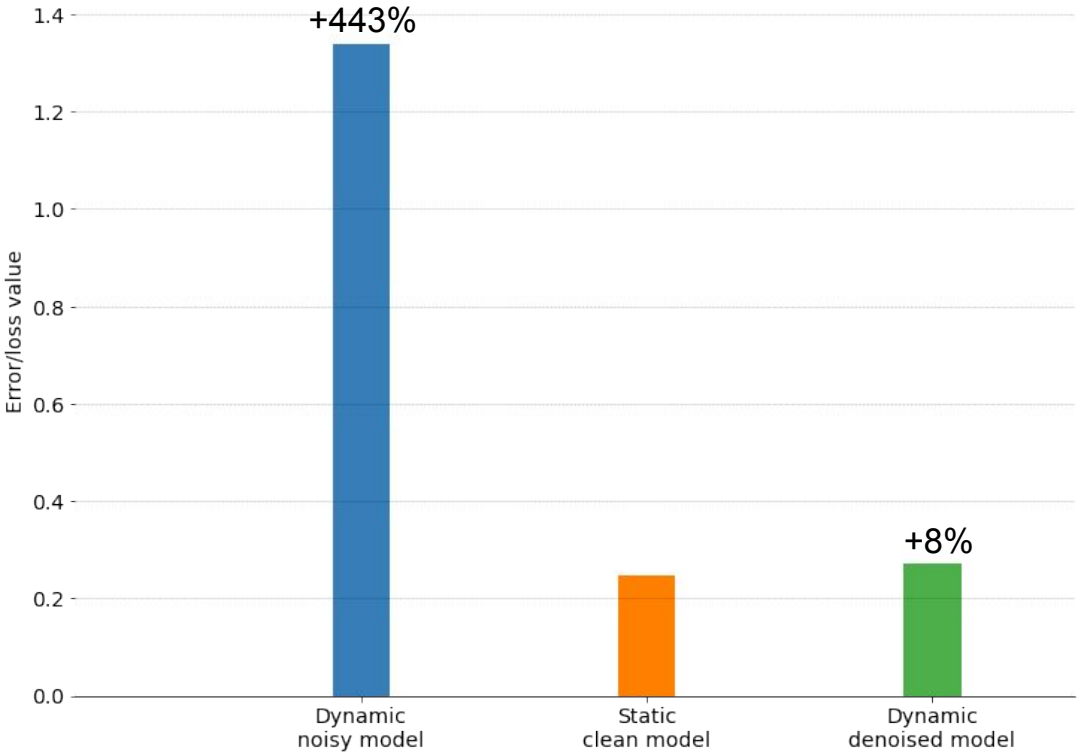


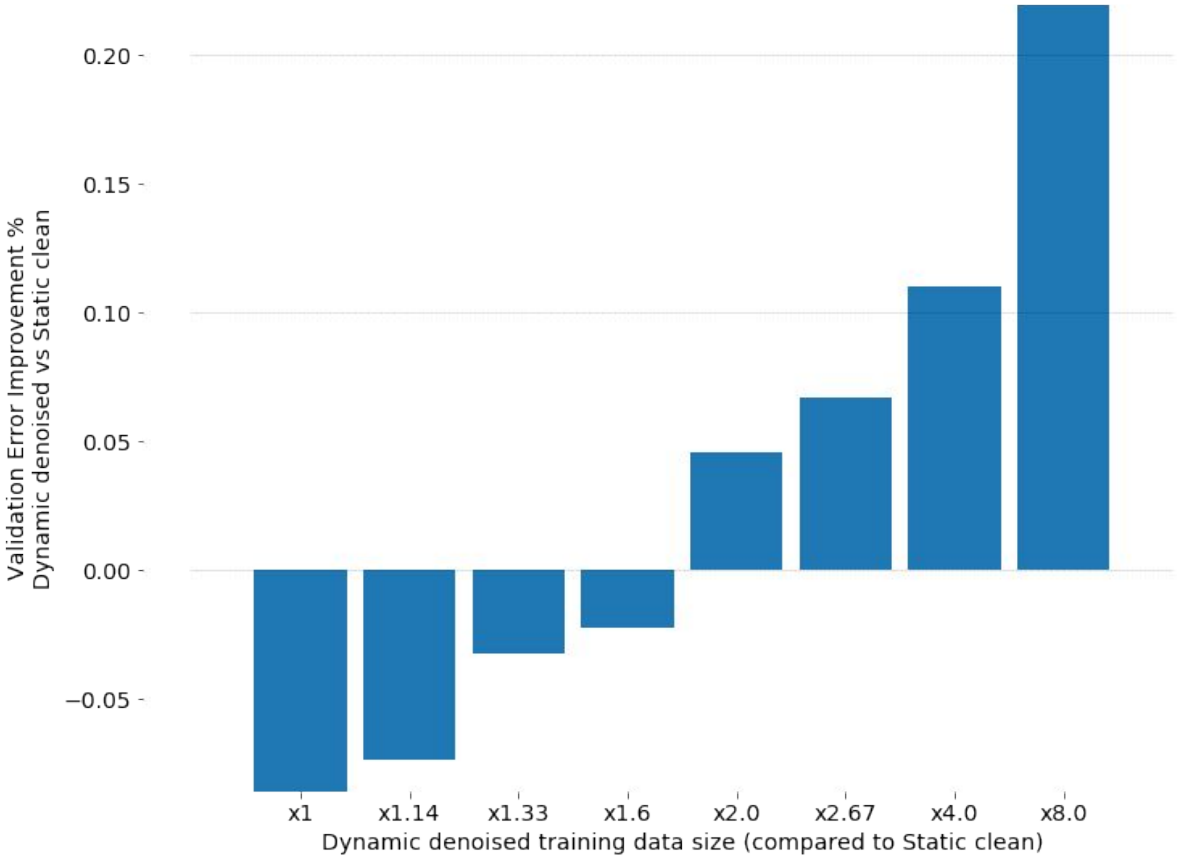
Comparing strategies



Validation Error Comparison

- Fixed training data size
- Fixed number of training cycles/epochs

Comparing strategies



- Static model extremely limited in how much training data can be obtained.
- Dynamic denoised can easily be trained on much larger data sets, to give better results.

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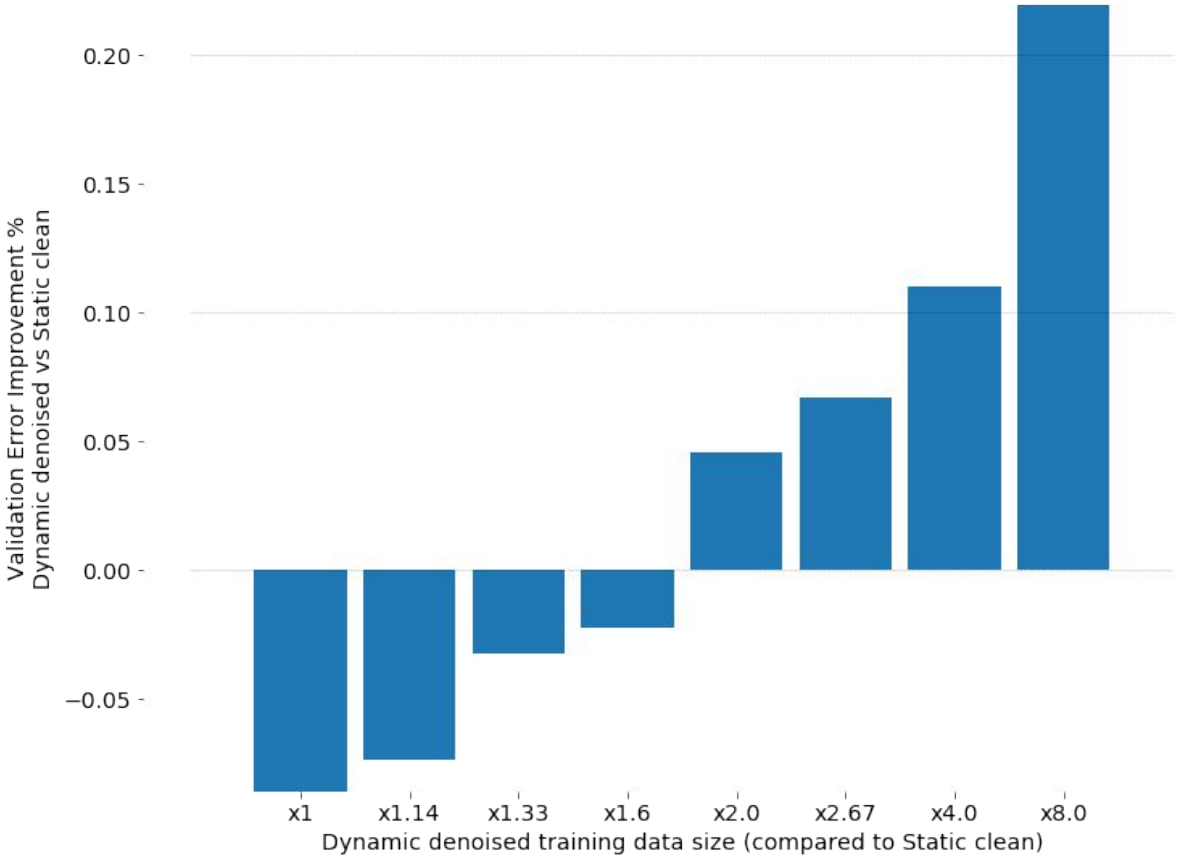
Comparing strategies



Model Strategies

1. Dynamic noisy model
2. Static clean model
3. Dynamic denoised model

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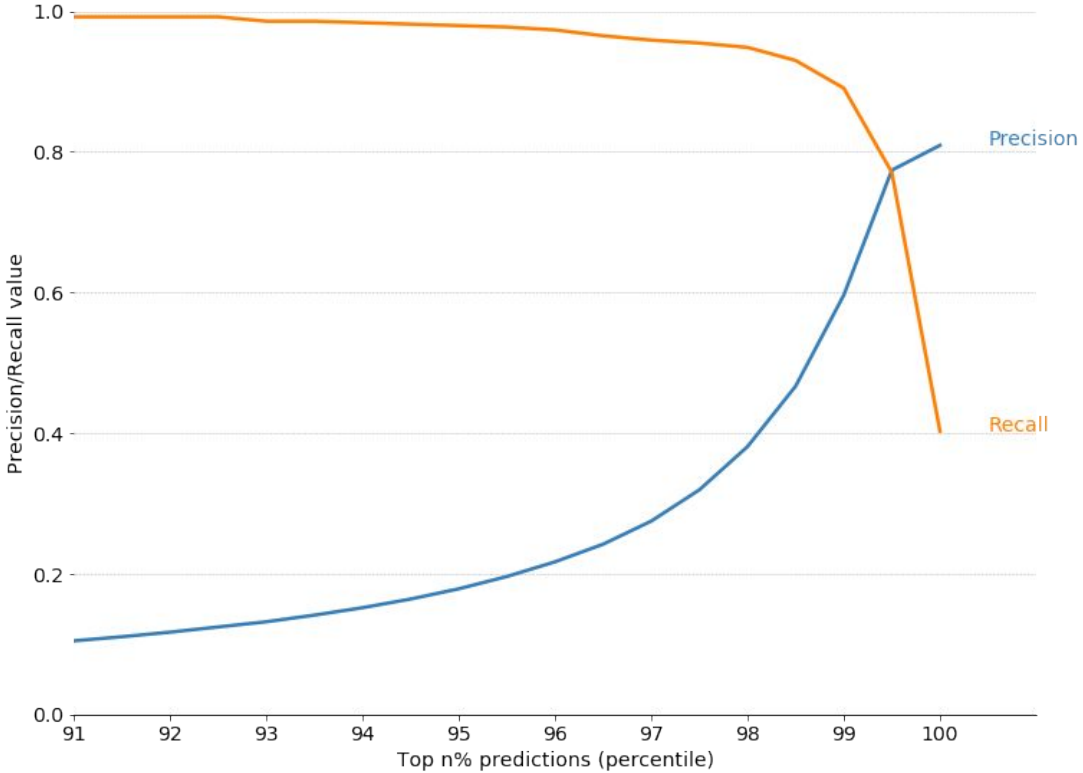
Routing decisions



Can we successfully predict the top 1% (heaviest resource consumption) of queries?

Taking the 99th percentile of predictions, gives:

precision = recall = 0.77

- We detect 77% of the heaviest queries

Future work, Less noise, Better results

- New model features
- Network topology
- Robust regression
  - RANdom Sample Consensus (RANSAC)
  - Ensemble methods

Machine Learning in Information Retrieval

- Improved search result relevance based on user-interactions
- Deep ingressor: generation of ingress/summary for documents
- Deep narration: learn what makes a set of documents different from a background set, and generate a narrative that describes these significant differences
- Provide recommendations on top of search results
- Query augmentation and expansion

Acknowledgements

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- Meltwater Gothenburg
- Team Horace
- Johan Nilsson Hansen
- Mikael Johansson

Q and A

Meltwater