



Search

# Deep Semantic Matching for Amazon Product Search

Yiwei Song

Amazon Product Search

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Yiwei Song



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Vijai Mohan



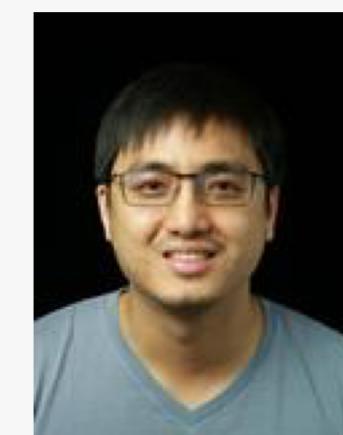
Vihan Lakshman



Weitian Ding



Ankit Shingavi



Choon Hui Teo



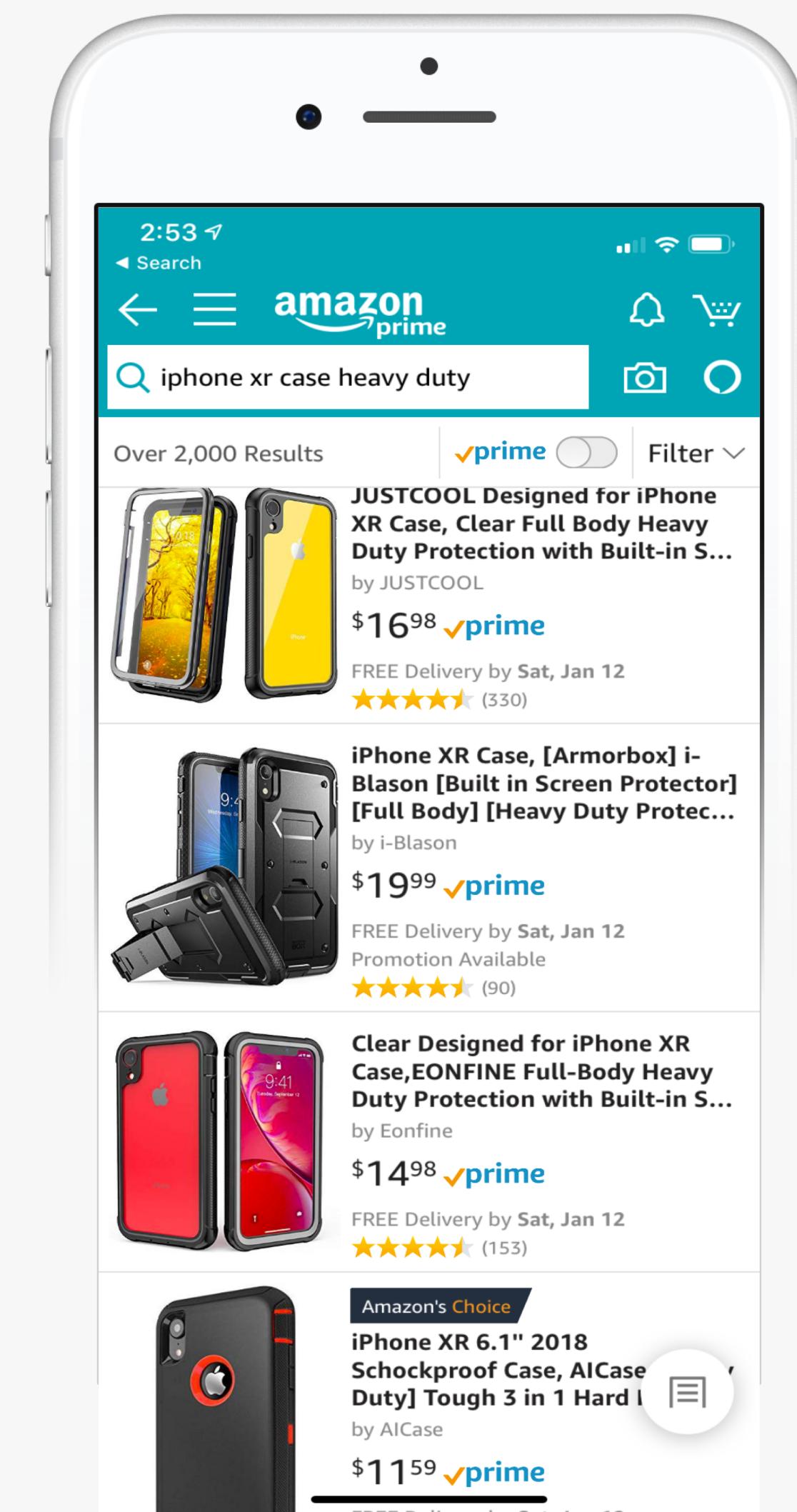
Hao Gu



Bing Yin

# Amazon Product Search

- Amazon is 4th most popular site in US [1]
- Majority of Amazon retail revenue is attributed to search
- Nearly half of US internet users start product search on Amazon [2]



[1] <https://www.alexa.com/topsites/countries/US>

[2] <https://retail.emarketer.com/article/more-product-searches-start-on-amazon/5b92c0e0ebd40005bc4dc7ae>

# Semantic Matching in Product Search

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- Goal of Semantic Matching is to reduce customers' effort to shop
  - Reduced query reformulations
  - Bridge the vocabulary gap between customers' queries and product description

# What is a match for a query?

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Lexical Match

“health shampoo”

Zion Health Adama Clay Minerals  
Shampoo 16 Fluid Ounce  
by Zion Health



# What is a match for a query?

---

“health shampoo”

Lexical Match

Zion Health Adama Clay Minerals  
Shampoo 16 Fluid Ounce  
by Zion Health



Semantic Match

ArtNaturals Organic Moroccan  
Argan Oil Shampoo and  
Conditioner Set - (2 x 16 Fl Oz /  
473ml) - Sulfate Free -  
Volumizing & Moisturizing -  
Gentle on Curly & Color Treated  
Hair - Infused with Keratin  
by ArtNaturals



# What is a match for a query?

---

"countertop wine fridge"

Lexical Match

Antarctic Star 17 Bottle Wine  
Cooler/Cabinet Refrigerator Small  
Wine Cellar Beer Counter Top Fridge  
Quiet Operation Compressor  
Freestanding Black  
by Antarctic Star



# What is a match for a query?

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Lexical Match

Antarctic Star 17 Bottle Wine  
Cooler/Cabinet Refrigerator Small  
Wine Cellar Beer Counter Top Fridge  
Quiet Operation Compressor  
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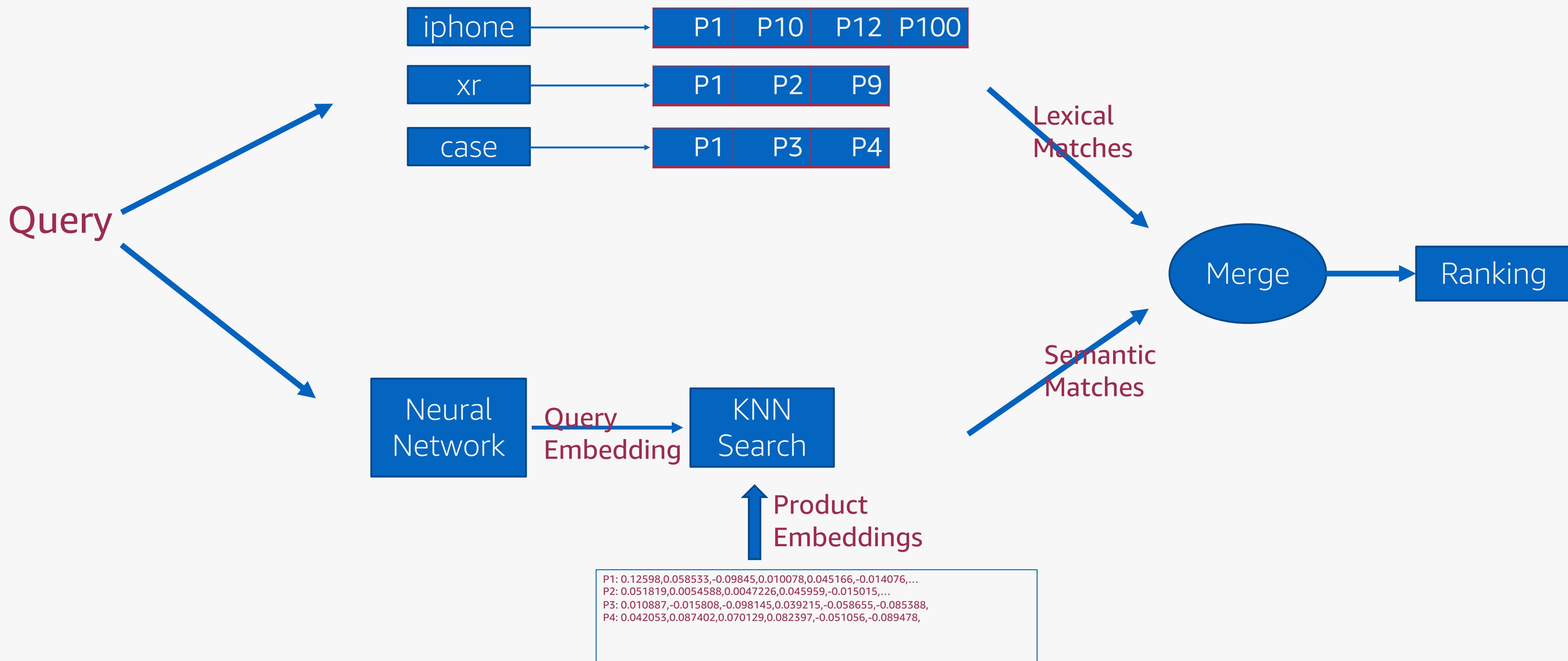


Semantic Match

DELLA 048-GM-48197 Beverage Center  
Cool Built-in Cooler Mini Refrigerator w/  
Lock- Black/Stainless Steel  
by DELLA

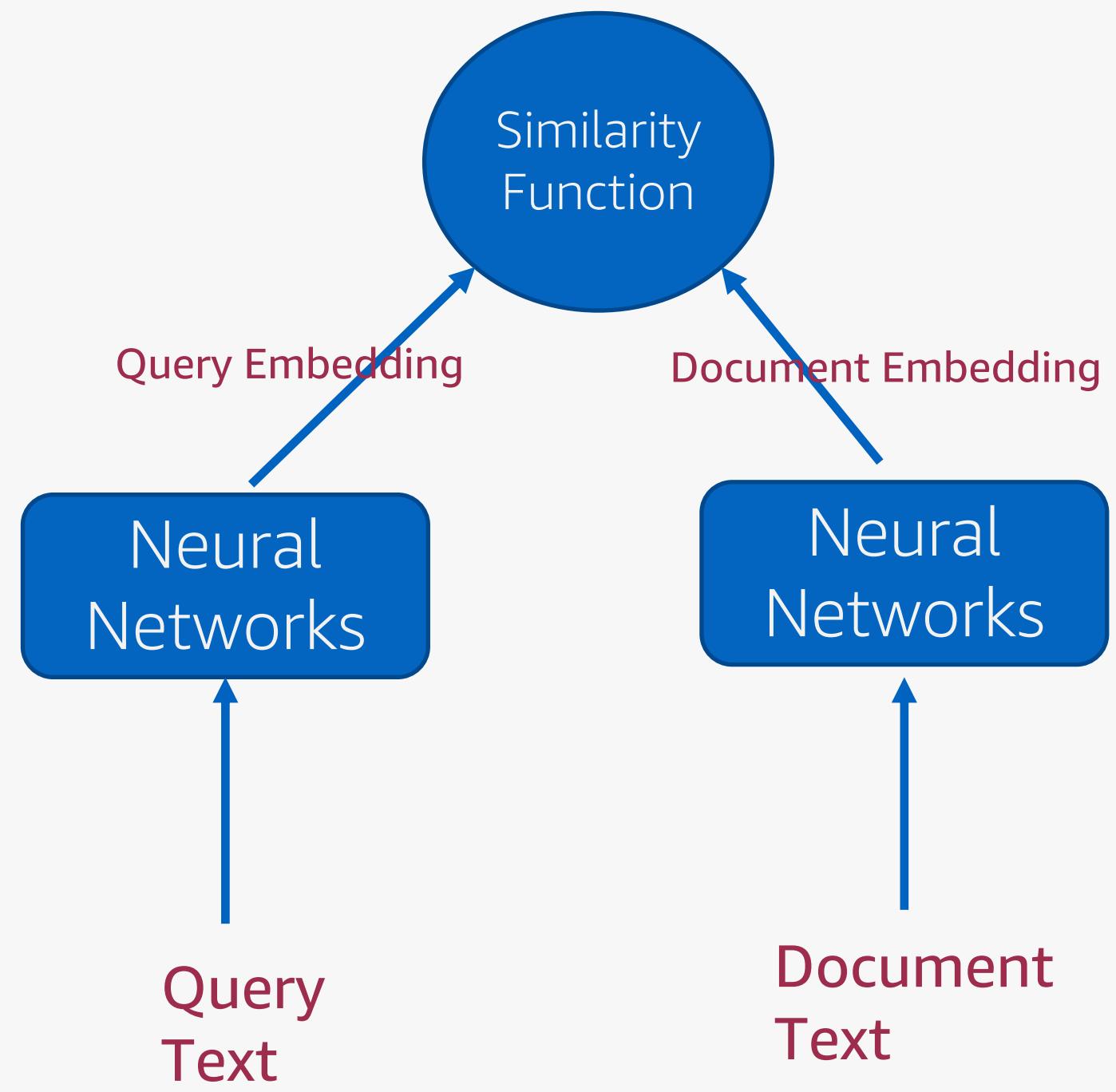


# Semantic Matching augments Lexical Matching



# Neural Network Representation Model

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Widely adopted in web search engines:  
Google's RankBrain, Microsoft Bing, Baidu,  
Yahoo

Product search?

- Shorter queries with patterns
- Structured product attributes
- Smaller search space and non purchased are equally important

# Data

---

“artistic iphone 6s case”

purchased

Showing most relevant results. See all results for [artistic iphone 6s case](#).

**iPhone 6s Case Marble, iPhone 6 Case, ULAKE Colorful Series Slim Hybrid Dual Layer Scratch Resistant Hard Back Cover Shock Absorbent TPU Bumper Case for Apple iPhone 6/6s 4.7 inch(Artistic Marble)**  
by ULAKE  
**\$8.99** ✓prime  
FREE Shipping on eligible orders

**6s Case, iPhone 6S Case, iPhone 6 Case, Freedom Fly iPhone 6/6S Protective Case Soft Flexible TPU Transparent Skin Scratch-Proof Case For Apple iPhone 6/6S 4.7 inch**  
by Freedom Fly  
**\$6.99** ✓prime  
FREE Shipping on eligible orders  
More Buying Choices  
\$2.00 (4 new offers)

**iPhone 6S Case, iPhone 6 Case, ULAKE Slim Fit Dual Layer Soft Silicone & Hard Back Cover Bumper Protective Shock-Absorption & Skid-proof Anti-Scratch Hybrid Case, Artistic/Mint Green Marble**  
by ULAKE  
**\$9.99** Subscribe & Save  
Save more with monthly Subscribe & Save deliveries.  
**\$9.99** ✓prime  
FREE Shipping on eligible orders

**iPhone 6S Case: [SG] Frame BELK 2nd Gen - "FLEX Edge" Soft-Gel Shock-absorbing TPU Sided Hard Wood Case [Easy Snap-On] with Durable Reinforced PC Hybrid Back Case, Cherry**  
by Belk  
**\$12.99** ✓prime  
FREE Shipping on eligible orders  
Only 10 left in stock - order soon.

**iPhone 6s Case, iPhone 6 Case, 6s Wallet Case, ULAKE Marble Wallet iPhone 6S Leather Case with 9 Card Slots Flip for Apple iPhone 6s/6 4.7 Inch, Artistic-marble pattern**  
by ULAKE  
**\$9.99** ✓prime  
FREE Shipping on eligible orders

**iPhone 6 Plus Case, iPhone 6S Plus Case, ULAKE Slim Dual Layer Protection Scratch Resistant Hard Back Cover Shock-Absorbant TPU Bumper Case for Apple iPhone 6/6S Plus 5.5 inch, Artistic Marble**  
by ULAKE  
**\$9.99** ✓prime  
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\$2.00 (4 new offers)

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**\$9.99** Subscribe & Save  
Save more with monthly Subscribe & Save deliveries.  
**\$9.99** prime  
FREE Shipping on eligible orders

**iPhone 6S Case: [SG] Frame BELK 2nd Gen - "FLEX Edge" Soft-Gel Shock-absorbing TPU Sided Hard Wood Case [Easy Snap-On] with Durable Reinforced PC Hybrid Back Case, Cherry**  
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by ULAKE  
**\$9.99** prime  
FREE Shipping on eligible orders

Impressed but not purchased

# Data

“artistic iphone 6s case”

purchased

Showing most relevant results. See all results for artistic iphone 6s case.

**iPhone 6 Case Marble, iPhone 6 Case, ULAKE Colorful Series Slim Hybrid Dual Layer Scratch Resistant Hard Back Cover Shock Absorbent TPU Bumper Case for Apple iPhone 6/6s 4.7 inch(Artistic Marble)** by ULAKE  
\$8.99 prime  
FREE Shipping on eligible orders  
★★★★★ 1,449  
Promotion Available and 1 more promotion •  
Product Features  
... iPhone 6 case, iPhone 6s case designed for Apple iPhone 6 4.7 inch

**6s Case, iPhone 6S Case, iPhone 6 Case, Freedom Fly iPhone 6/6S Protective Case Soft Flexible TPU Transparent Skin Scratch-Proof Case for Apple iPhone 6/6S 4.7 inch** by Freedom Fly  
\$6.99 prime  
FREE Shipping on eligible orders  
More Buying Choices \$2.00 (4 new offers)  
★★★★★ 64  
Product Features  
Package: 1\* iPhone 6S cases

**iPhone 6S Case, iPhone 6 Case, ULAKE Slim Fit Dual Layer Soft Silicone & Hard Back Cover Bumper Protective Shock-Absorption & Skid-proof Anti-Scratch Hybrid Case, Artistic/Mint Green Marble** by ULAKE  
\$9.99 Subscribe & Save  
Save with monthly Subscribe & Save deliveries.  
\$9.99 prime  
FREE Shipping on eligible orders  
★★★★★ 1,386  
Promotion Available and 1 more promotion •  
Product Features  
... iPhone 6S case marble hybrid slim dual layer protective fit for Apple iPhone 6S

**iPhone 6S Case: [SG] Frame BELK 2nd Gen - "FLEX Edge" Soft-Gel Shock-absorbing TPU Sided Hard Wood Case [Easy Snap-On] with Durable Reinforced PC Hybrid Back Case, Cherry** by Belk  
\$12.99 prime  
FREE Shipping on eligible orders  
Only 10 left in stock - order soon.  
★★★★★ 24  
Product Features  
... Artistic Live Edge Wood, Highly ... Friendly Wood Case with Nature ...

**iPhone 6S Case, iPhone 6 Case, 6S Wallet Case, ULAKE Marble Wallet iPhone 6S Leather Case with 9 Card Slots Flip for Apple iPhone 6/6 4.7 Inch, Artistic-marble pattern** by ULAKE  
\$9.99 prime  
FREE Shipping on eligible orders  
★★★★★ 574  
Promotion Available See Details  
Product Features  
... iPhone 6S case for women compatible with iPhone 6S 4.7 inch 2015 ...

**iPhone 6 Plus Case, iPhone 6S Plus Case, ULAKE Slim Dual Layer Protection Scratch Resistant Hard Back Cover Shock-Absorbant TPU Bumper Case for Apple iPhone 6/6S Plus 5.5 inch, Artistic Marble** by ULAKE  
\$9.99 prime  
FREE Shipping on eligible orders  
★★★★★ 975  
Promotion Available and 7 more promotions •  
Product Features  
... hard PC back cover with cute pattern design marble iPhone 6/6S Plus case ...

Impressed but not purchased

Random

**Champ Grip, Strongest Grippers Mop Broom Holders with 5 Ball Slots and 6 Hooks. Items Guaranteed Non Slide. Life-time Guarantee.** by CHAMP GRIP®  
\$12.99 prime  
FREE Shipping on eligible orders  
★★★★★ 887  
Product Features  
... It can also hold heavy items without sliding down. Upon hanging wet ...

**Johnson's Sleepy Time Baby Gift Set, 3 Items** by Johnson's Baby  
\$9.97  
Add-on Item  
FREE Shipping on eligible orders  
★★★★★ 805  
Product Description  
Johnson's Sleepy Time Baby Gift Set, 3 Items

**Blind Item Jun 6, 2017** by Kevin Dickson and Jack Ketsoyan  
Kindle Edition  
\$13.99  
Get it TODAY, Apr 19  
Paperback  
\$18.99 prime  
FREE Shipping on eligible orders  
Available for Pre-order. This item will be released on June 5, 2018.  
Audible Audiobook  
\$0.00  
Free with Audible trial  
Other Formats: Hardcover, Audio CD  
★★★★★ 72

**Amazon.com Gift Card in a Gold Reveal** by Amazon  
\$25.00 - \$40.00  
FREE One-Day Shipping.  
★★★★★ 339  
Product Features  
Gift Card is redeemable towards millions of items storewide at Amazon.com

**Butterfly Notebook** Dec 14, 2000 by Sovak  
Paperback  
\$1.66 prime  
FREE Shipping on eligible orders  
More Buying Choices \$0.50 (46 used & new offers)  
★★★★★ 284

**ProCase Toiletry Bag Travel Case with Hanging Hook, Organizer for Accessories, Shampoo, Cosmetic, Personal Items, Healthcare Bag with Handle, Black** by ProCase  
\$12.99 prime  
FREE Shipping on eligible orders  
More options available:  
\$11.99 Other Sellers  
★★★★★ 266  
Product Features  
... main storage room for large item organize, zippered pockets for ...

# Loss Function

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“artistic iphone 6s case”

Similarity between  
Query\_Emb and  
Product\_Emb

purchased



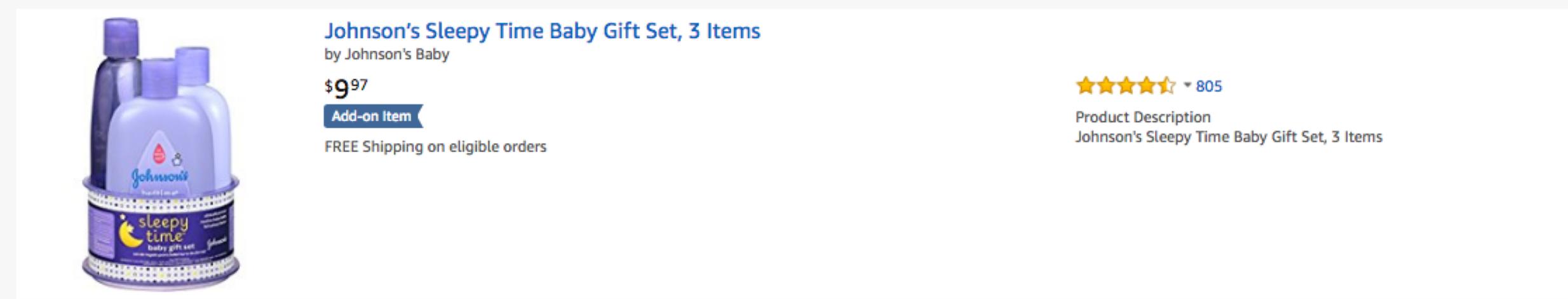
High

Impressed but  
not purchased



Medium

Random



Low

# Loss Function

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- For purchases:

$$\text{loss}(y, \hat{y}) = \begin{cases} 0, & \hat{y} \geq 0.9 \\ (\hat{y} - 0.9)^2, & \hat{y} < 0.9 \end{cases}$$

- For impressed but not purchased:

$$\text{loss}(y, \hat{y}) = \begin{cases} 0, & \hat{y} \leq 0.55 \\ (\hat{y} - 0.55)^2, & \hat{y} > 0.55 \end{cases}$$

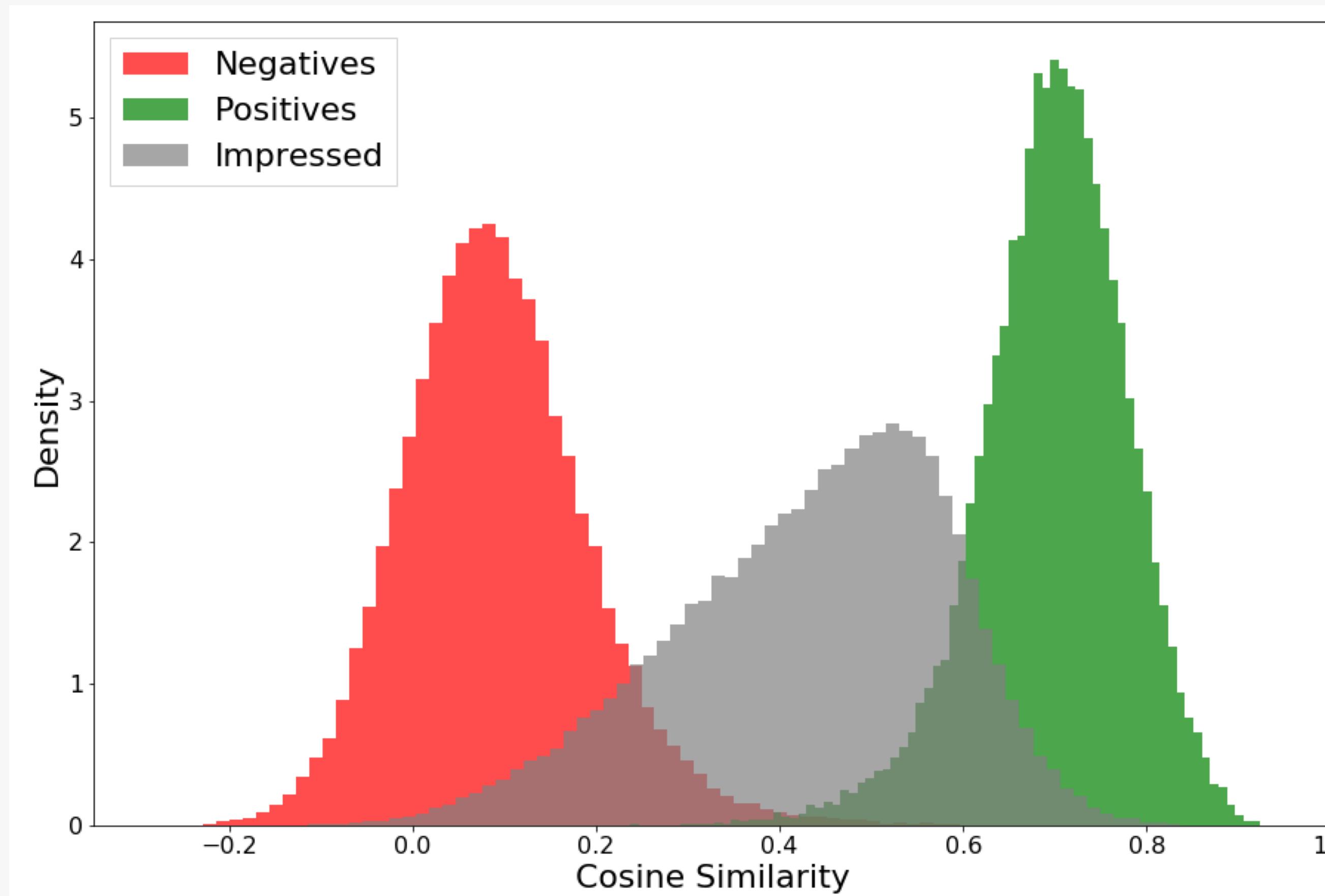
- For randomly-sampled:

$$\text{loss}(y, \hat{y}) = \begin{cases} 0, & \hat{y} \leq 0.2 \\ (\hat{y} - 0.2)^2, & \hat{y} > 0.2 \end{cases}$$

- Point-wise hinge loss for 3 data types
- Margins are hyper-parameters tuned on our dataset
- **Loss of each data point is weighted by purchase and impression count of query-product pair**

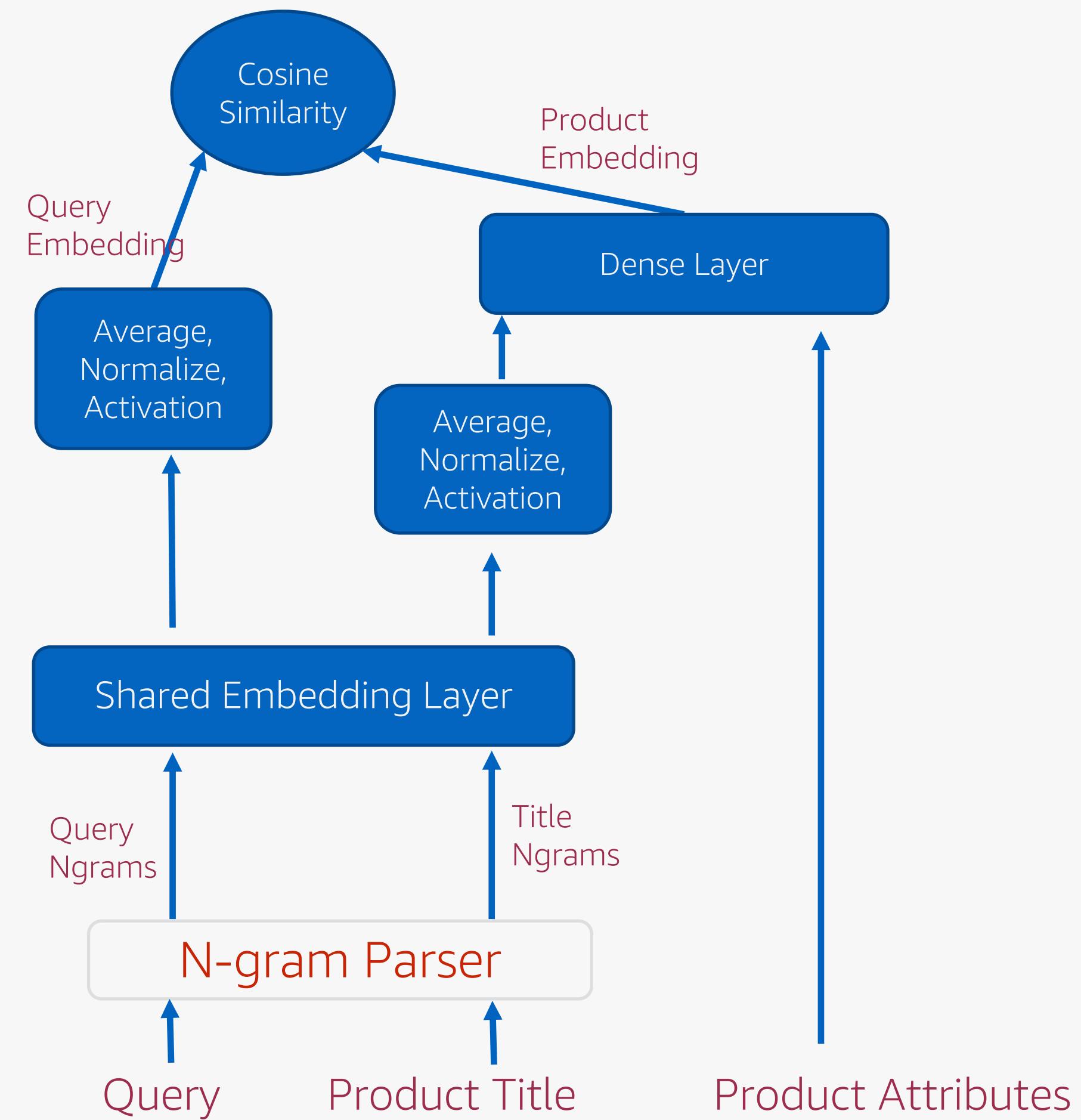
# Loss Function

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# N-gram Average Neural Network

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# N-gram Average Neural Network

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"artistic iphone  
6s case"

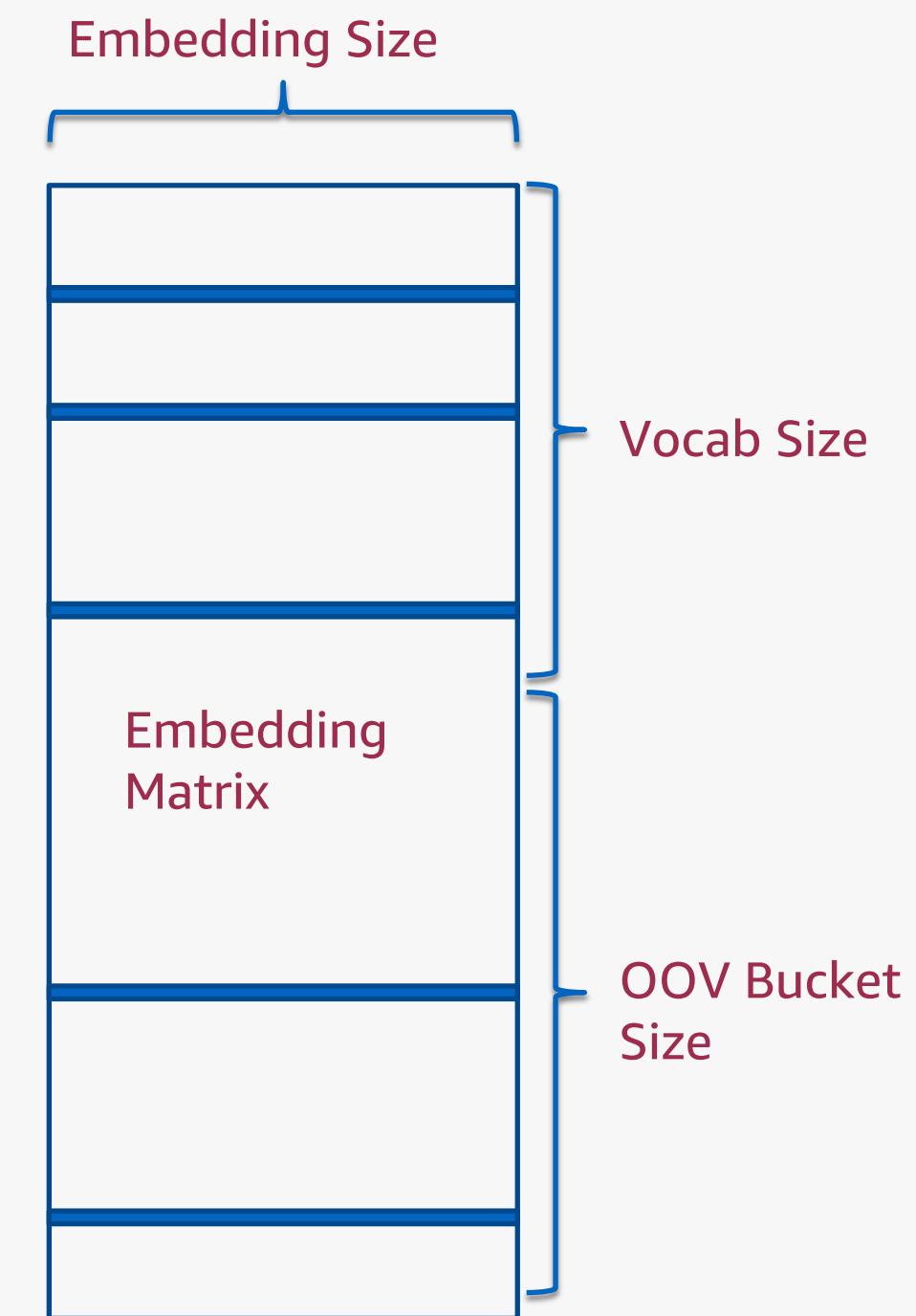


```
"artistic", "iphone", "6s", "case",  
  
"artistic#iphone", "iphone#6s", "6s#case",  
  
"artistic#iphone#6s", "iphone#6s#case",  
  
"#ar", "art", "rti", ..., "#ca", "cas", "ase", "se#"
```

- **Word-ngrams capture phrase level information.**  
"chocolate milk" vs "milk chocolate"  
"for iphone" indicates iphone accessories
- **Character-ngrams capture subword information**  
Morphism: "chocolates" vs "chocolate"  
Compound words: "amazontv", "firetvstick"  
Parts number: "36x14" vs "36 x 14"  
Typos: "iphione"
- **OOV ngrams?**  
Vocab size grows exponentially with n!

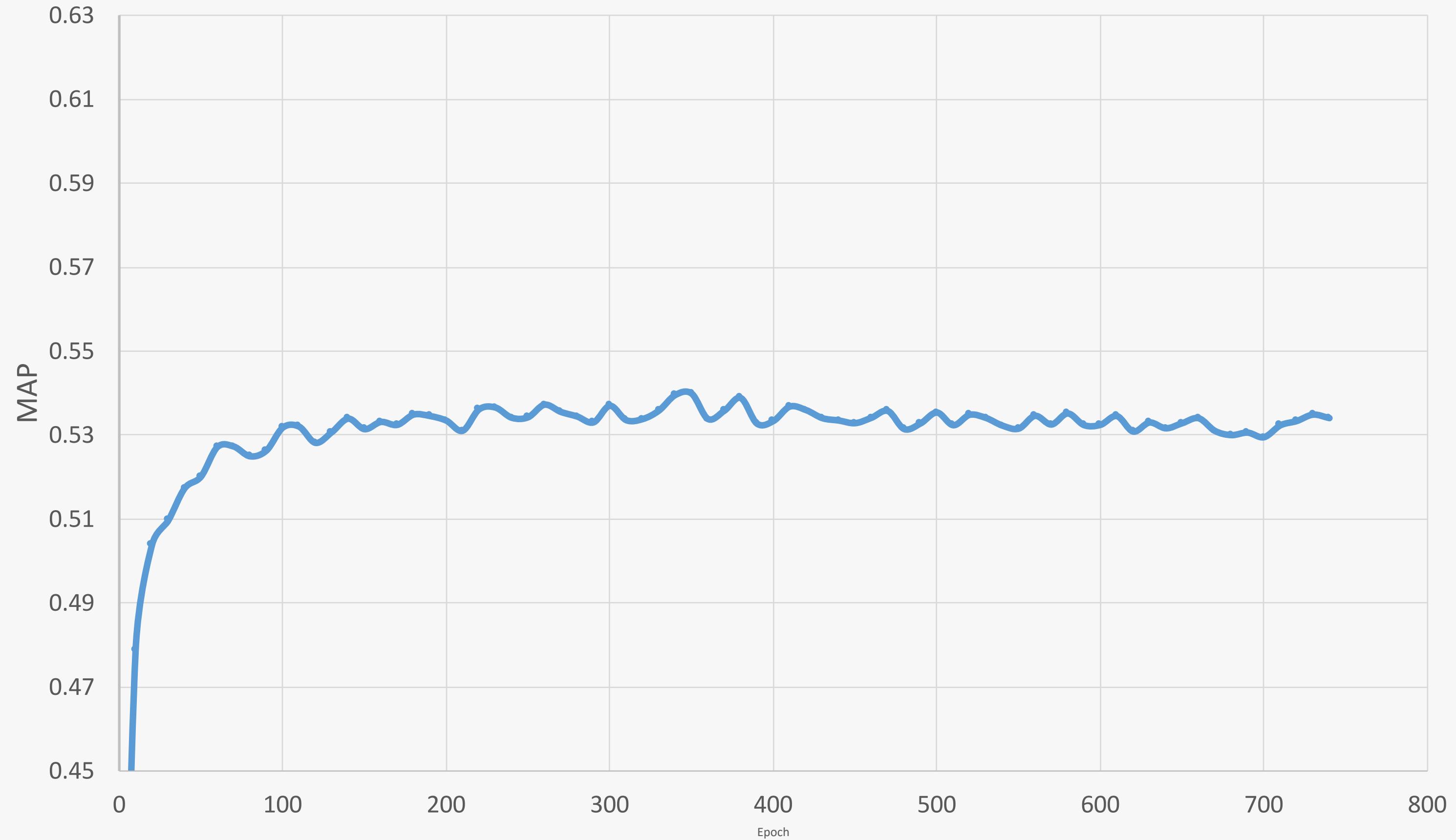
# N-gram Average Neural Network

Build N-gram vocab by frequency  
Hash OOV token to a bin to group low count tokens



# N-gram Average Neural Network

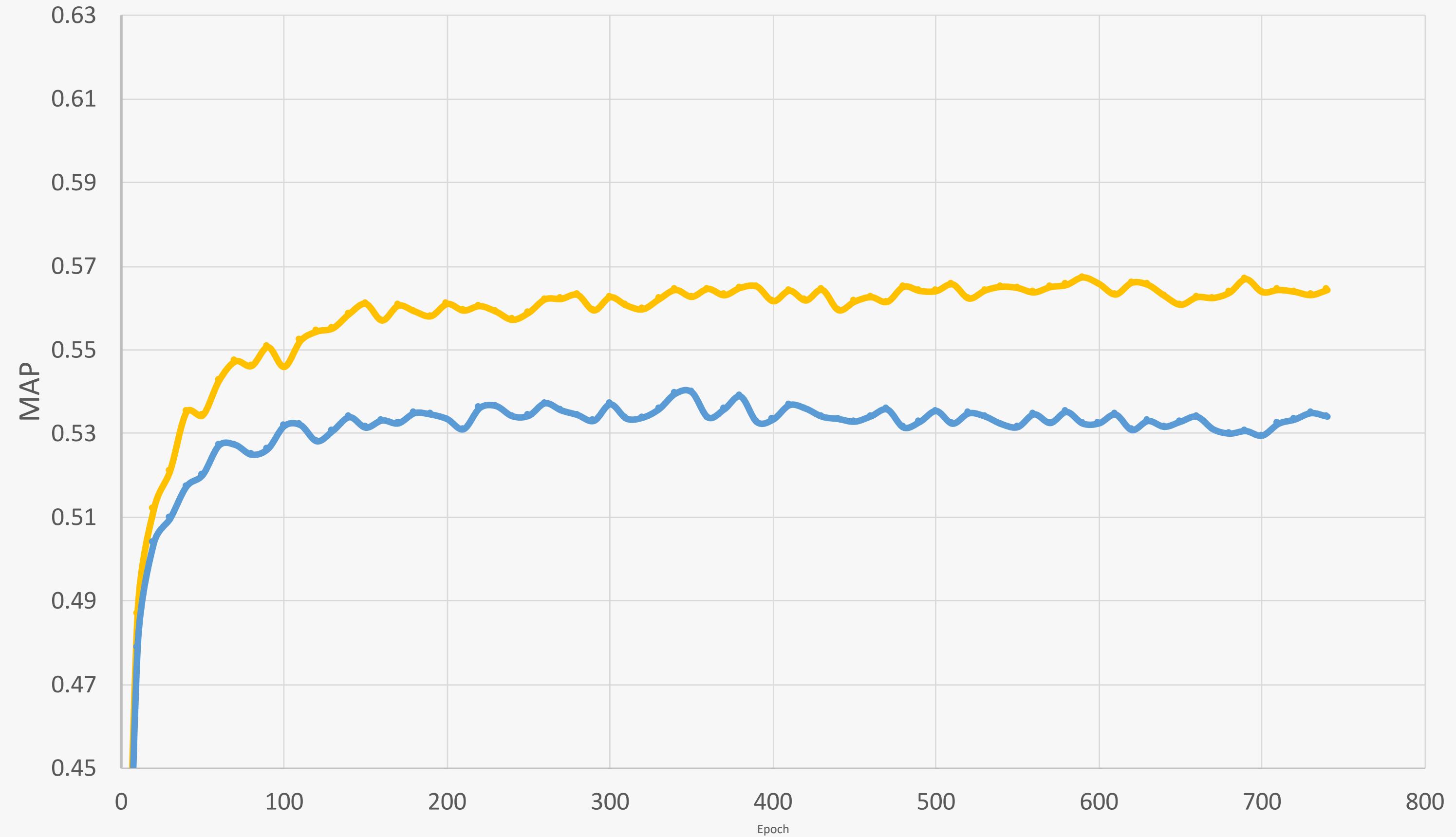
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- Word Unigram baseline on small dataset

# N-gram Average Neural Network

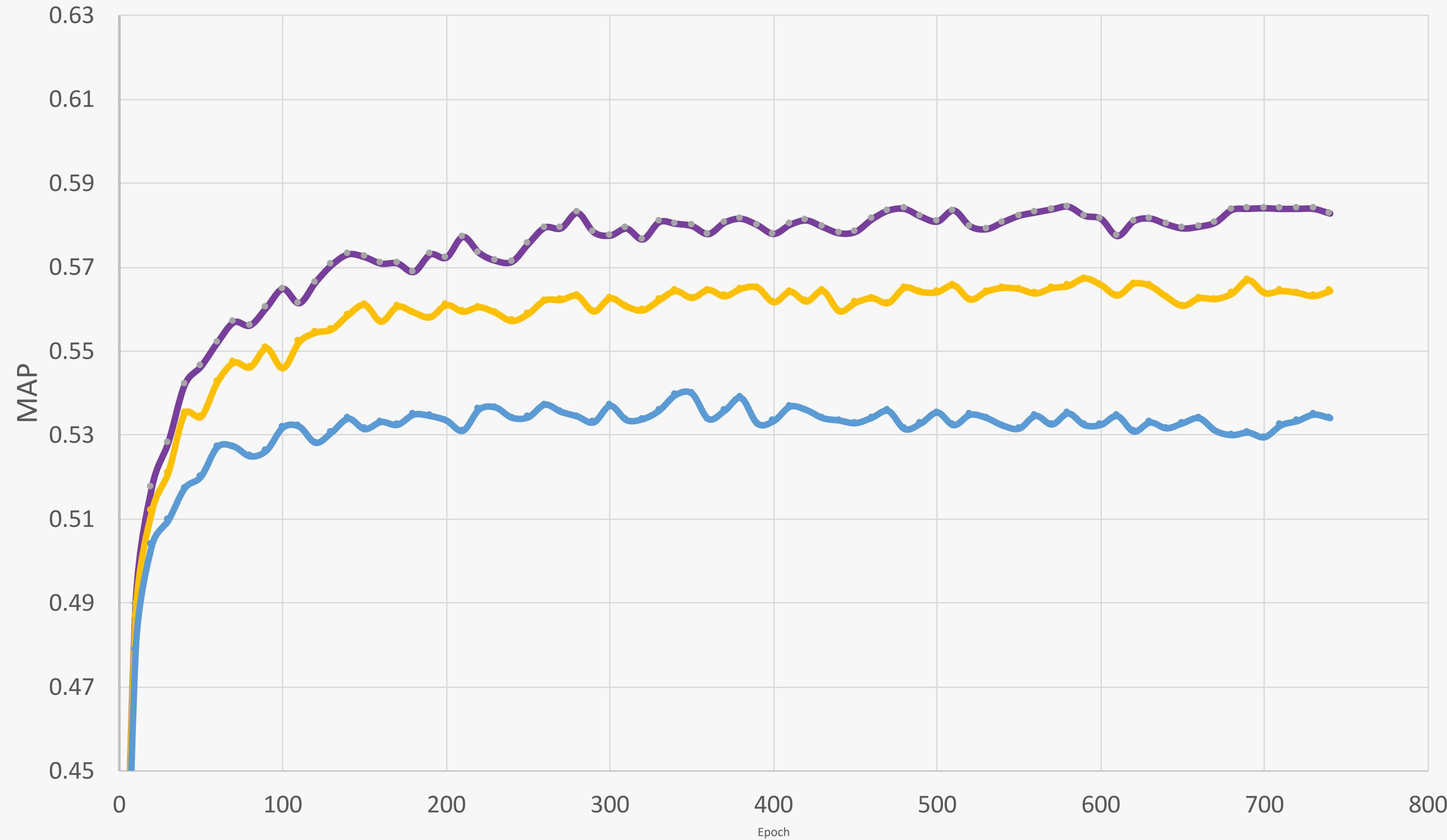
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- Word Unigram baseline on small dataset
- Use more data

# N-gram Average Neural Network

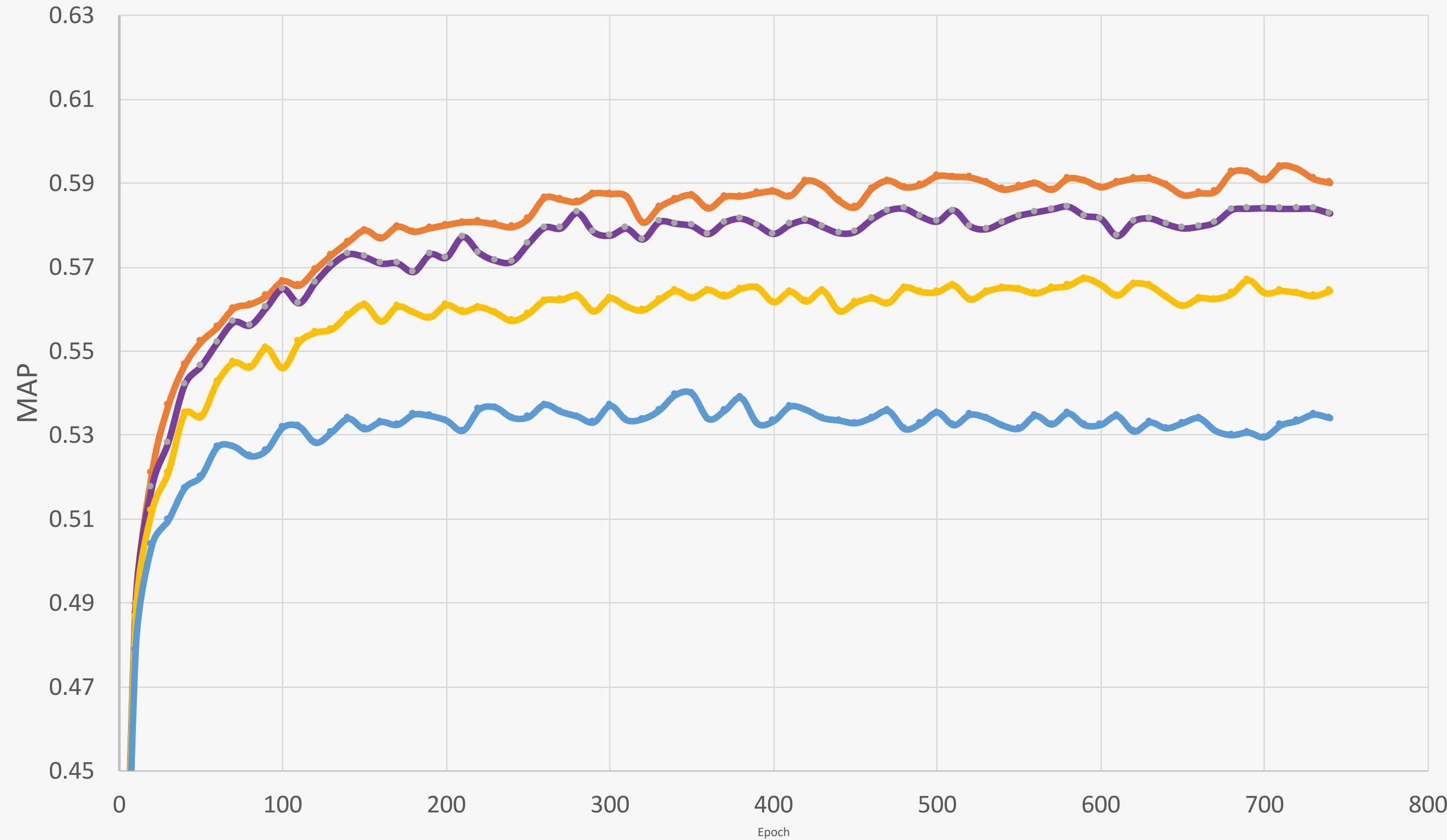
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- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram

# N-gram Average Neural Network

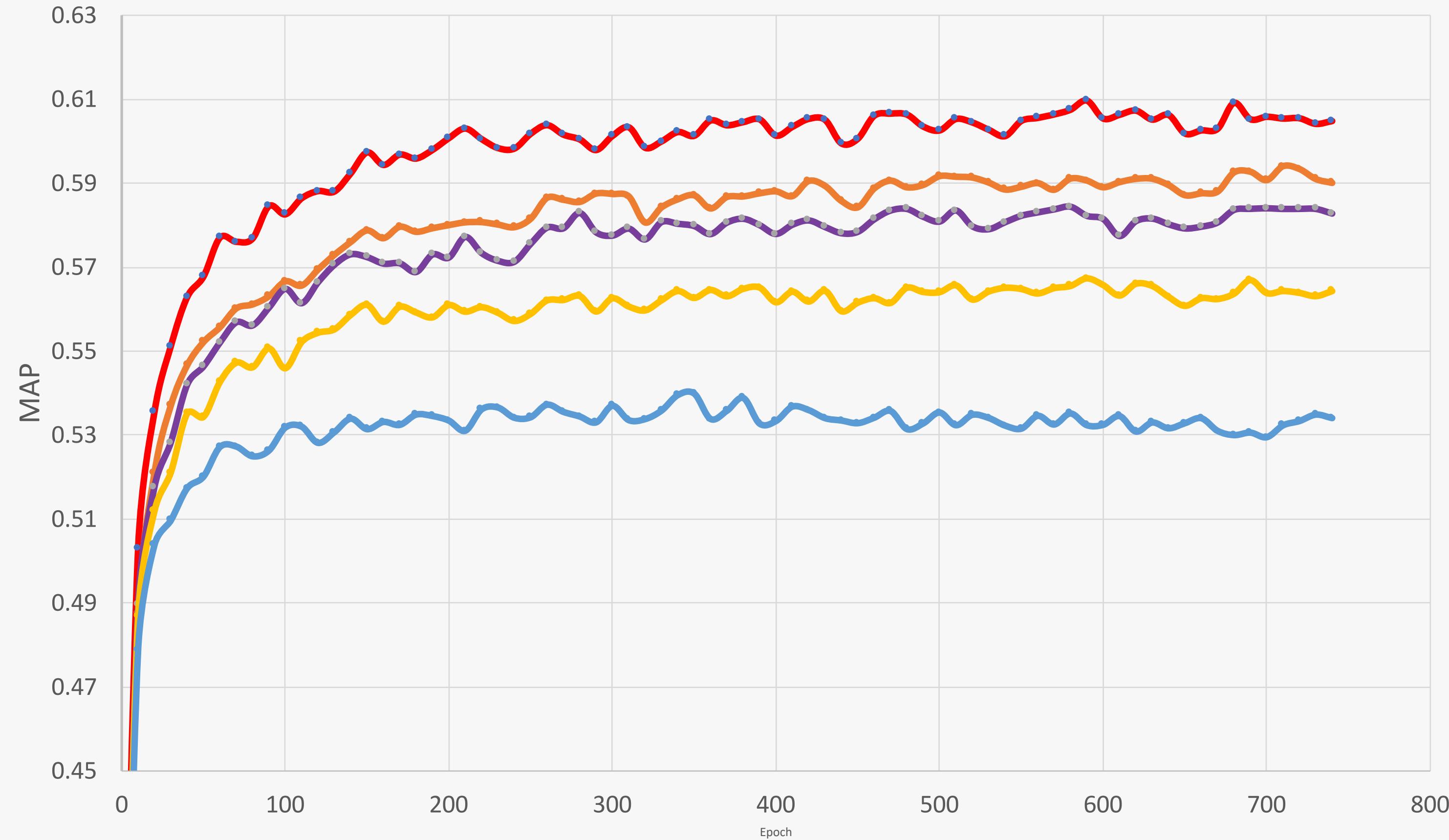
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- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram

# N-gram Average Neural Network

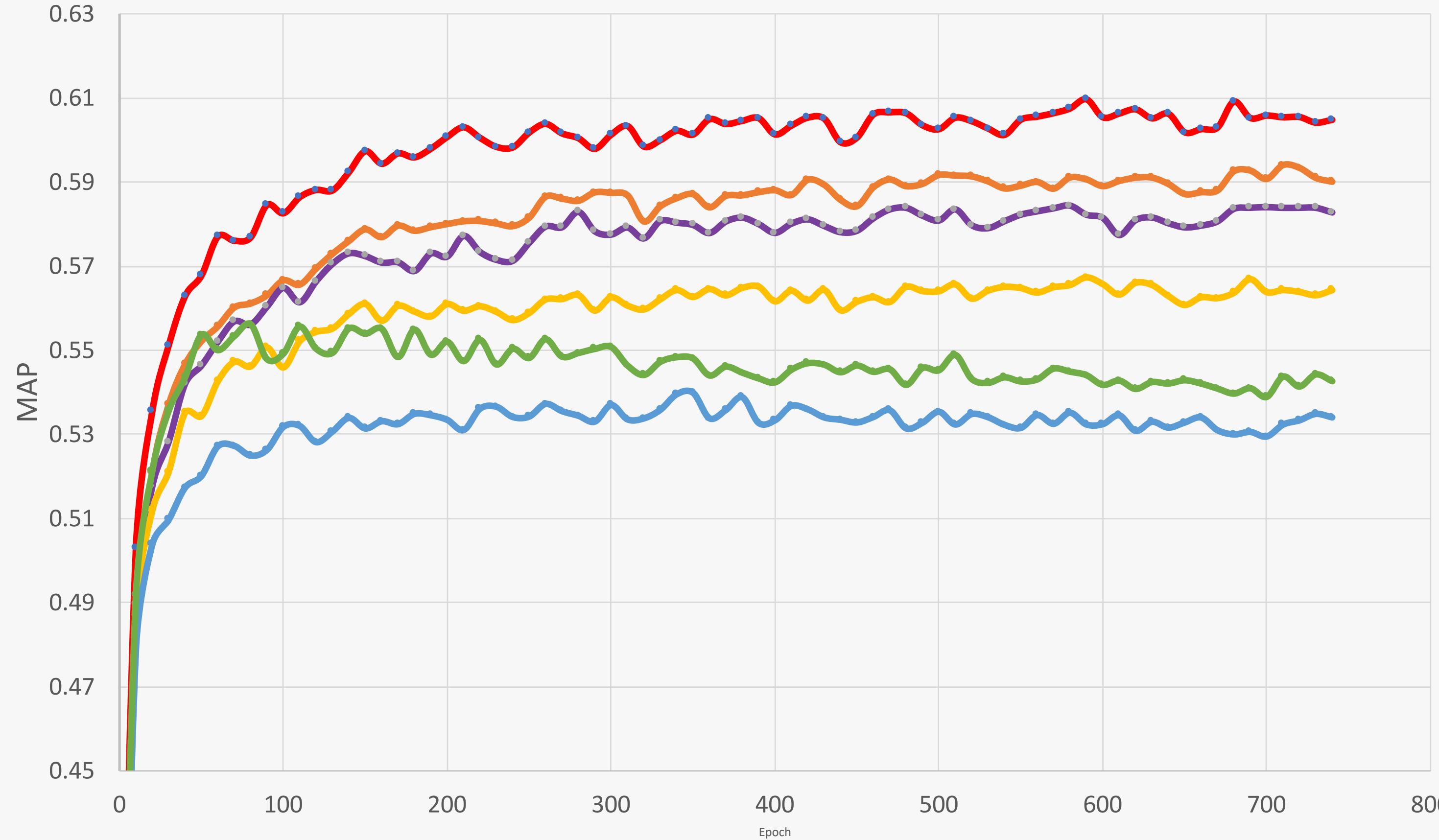
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- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram
- Add OOV hashing for ngrams

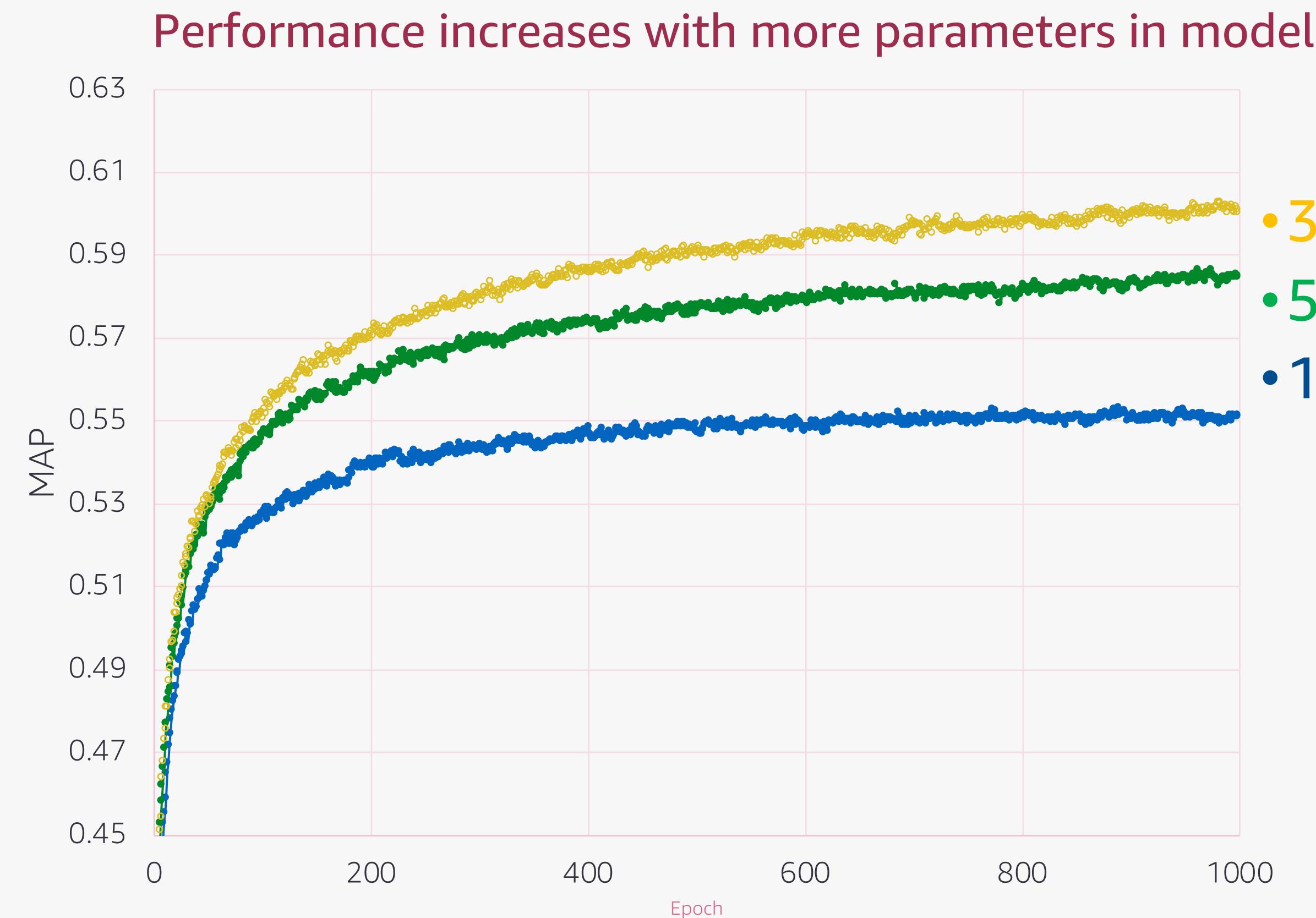
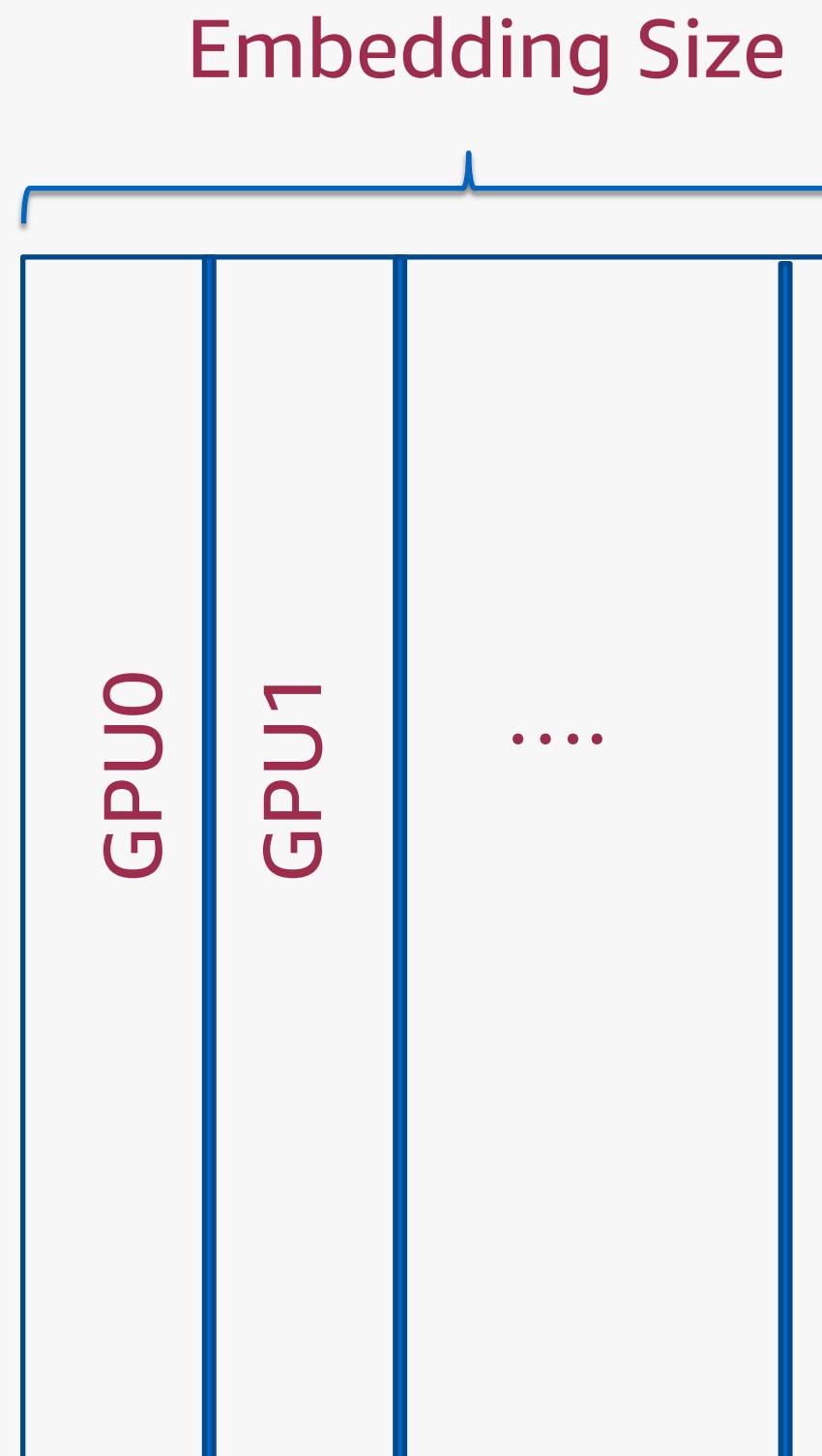
# N-gram Average Neural Network

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- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram
- Add OOV hashing for ngrams
- More tokens/parameters overfits on small dataset

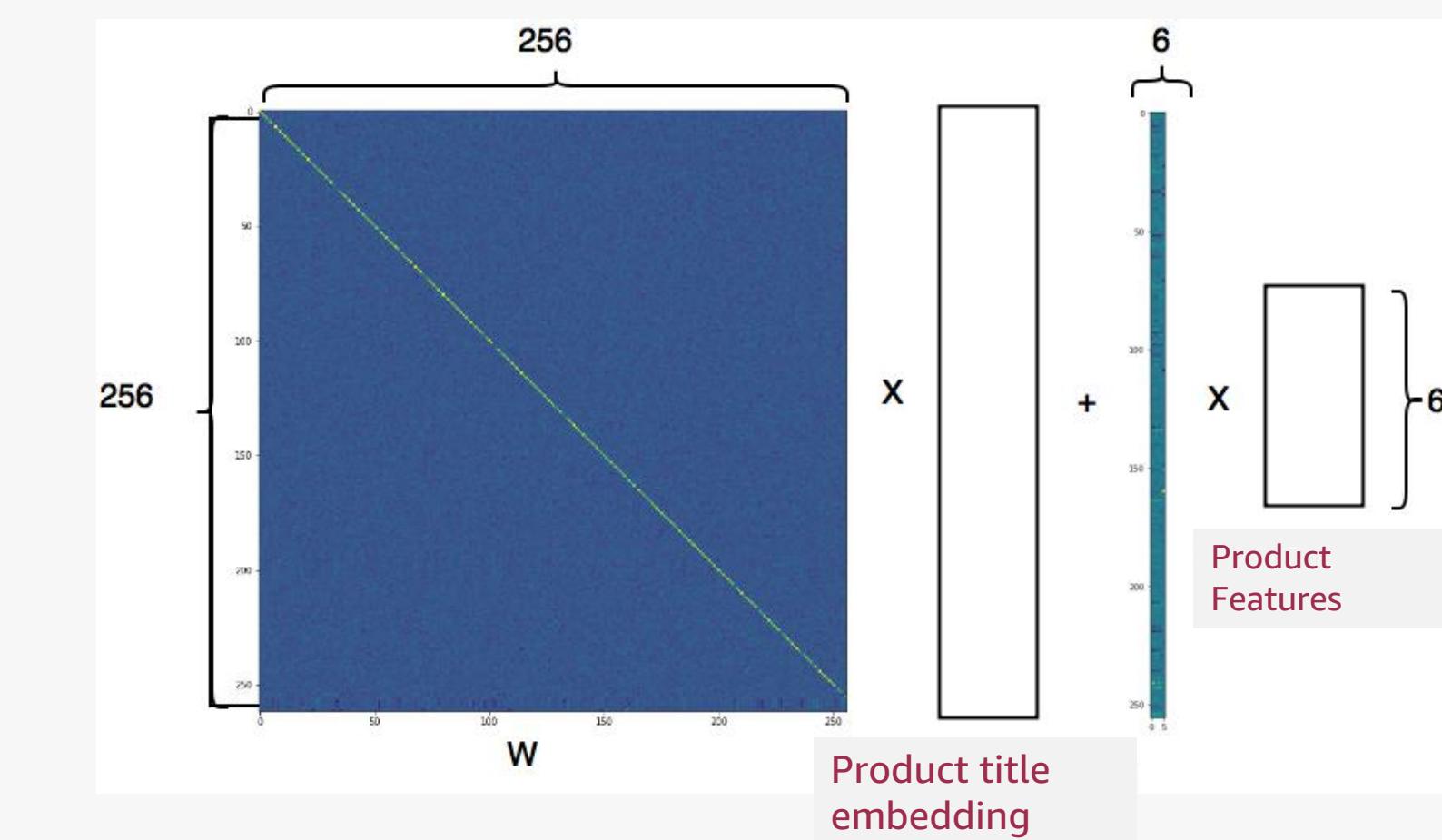
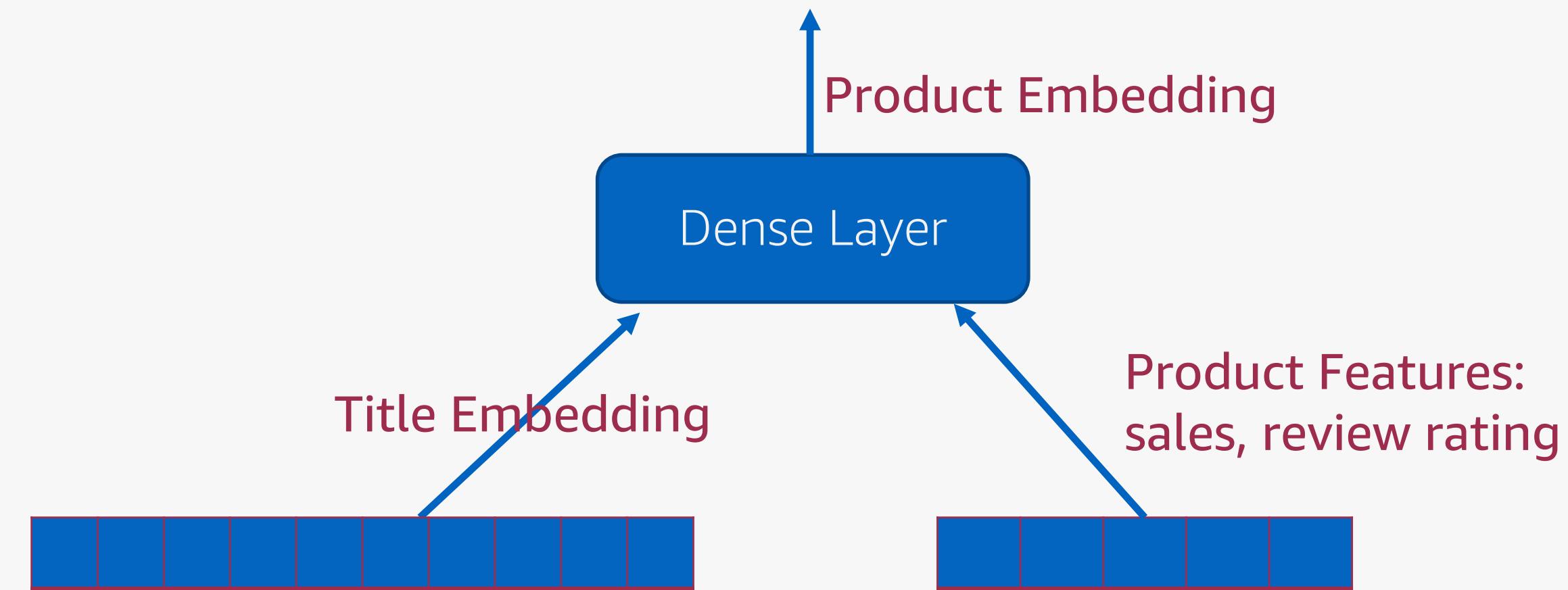
# Increase Vocab Size by Model Parallelism



# Structured Product Features

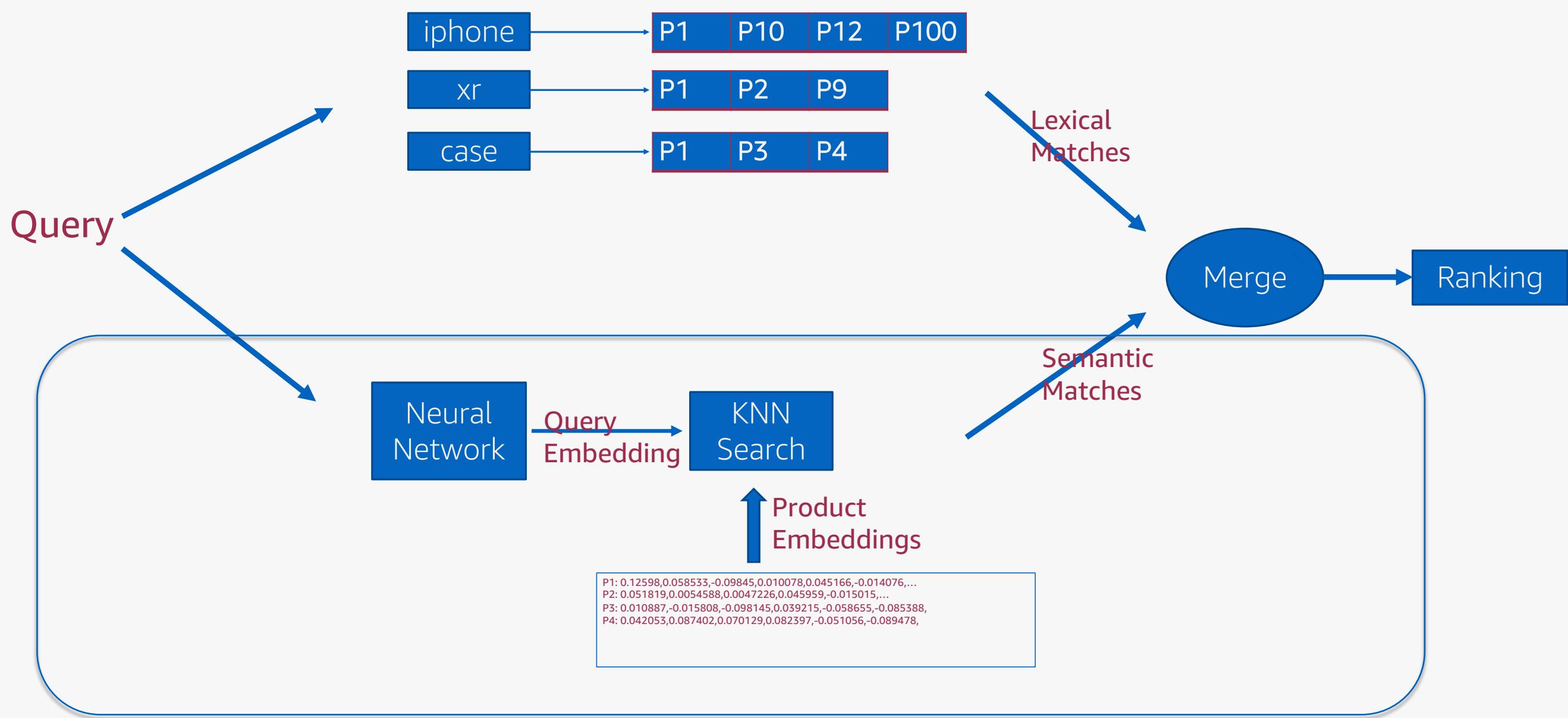
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- Merge Structured Product Features with a dense layer after batch\_norm and dropout
- Model learns to put weights on product attribute features



# Still Day 1

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We are building an engineering component to bring semantic matching from offline to online

- KNN search over one hundred millions documents within milli-seconds latency

# Still Day 1

---

- Better Matching Models
  - Richer text features: customer reviews and product description
  - Better negative sampling
  - Query reformulate
- Ranking Improvements
  - Sparse features such as product id

# Thank you

Questions? Want to join us?

ywsong@amazon.com

<https://www.amazon.jobs/en/teams/search.html>