



Search

Deep Semantic Matching for Amazon Product Search

Yiwei Song

Amazon Product Search

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Priyanka Nigam



Vijai Mohan



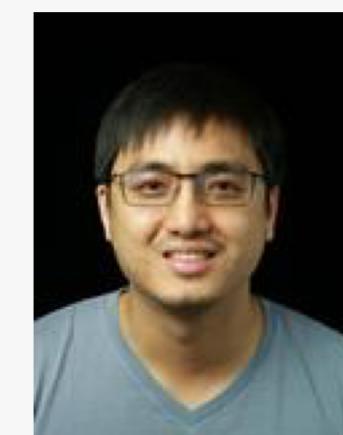
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Weitian Ding



Ankit Shingavi



Choon Hui Teo



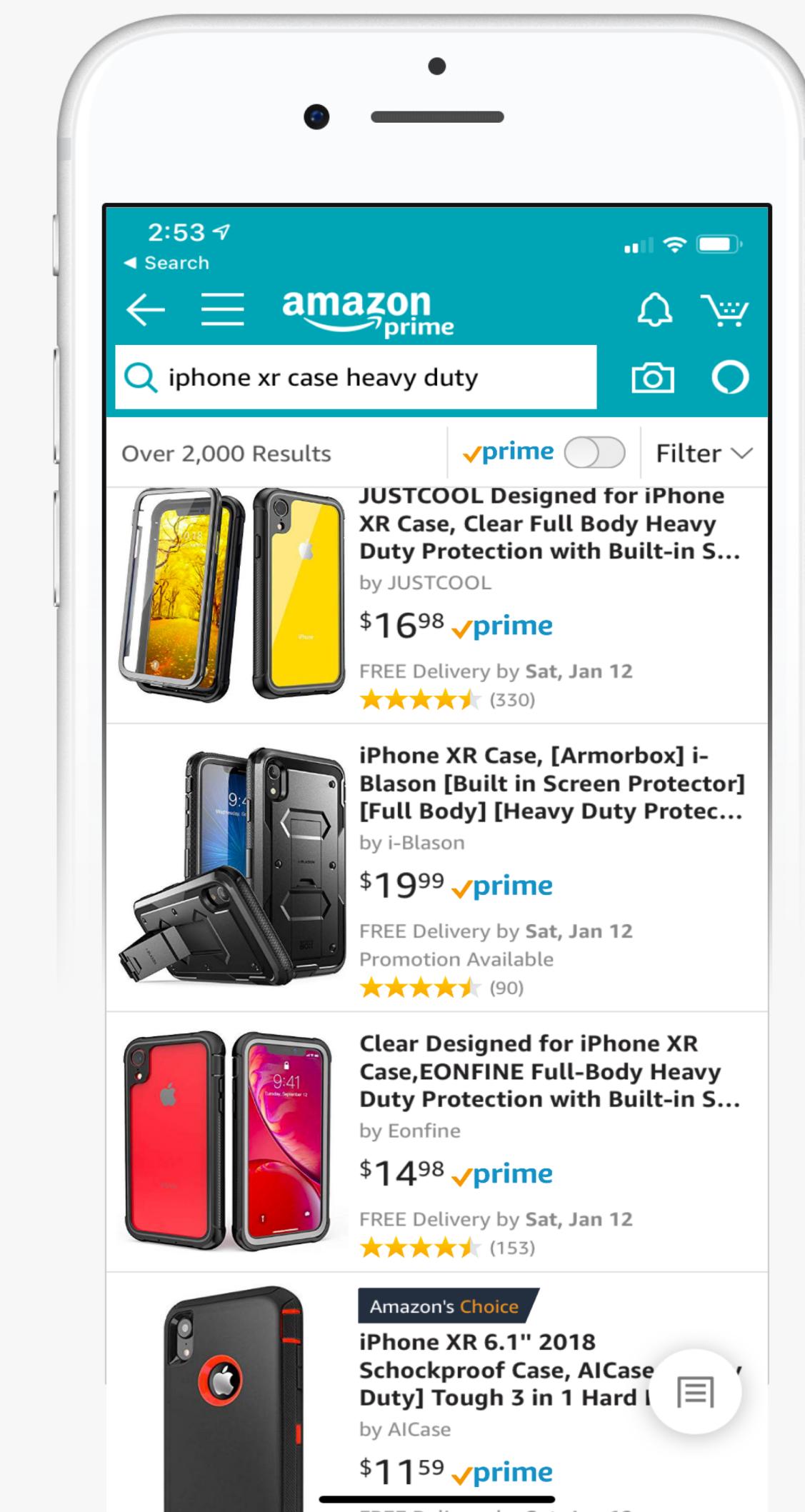
Hao Gu



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

- 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?

Lexical Match

“health shampoo”

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



What is a match for a query?

Lexical Match

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



“health shampoo”

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?

“countertop wine fridge”

Lexical Match

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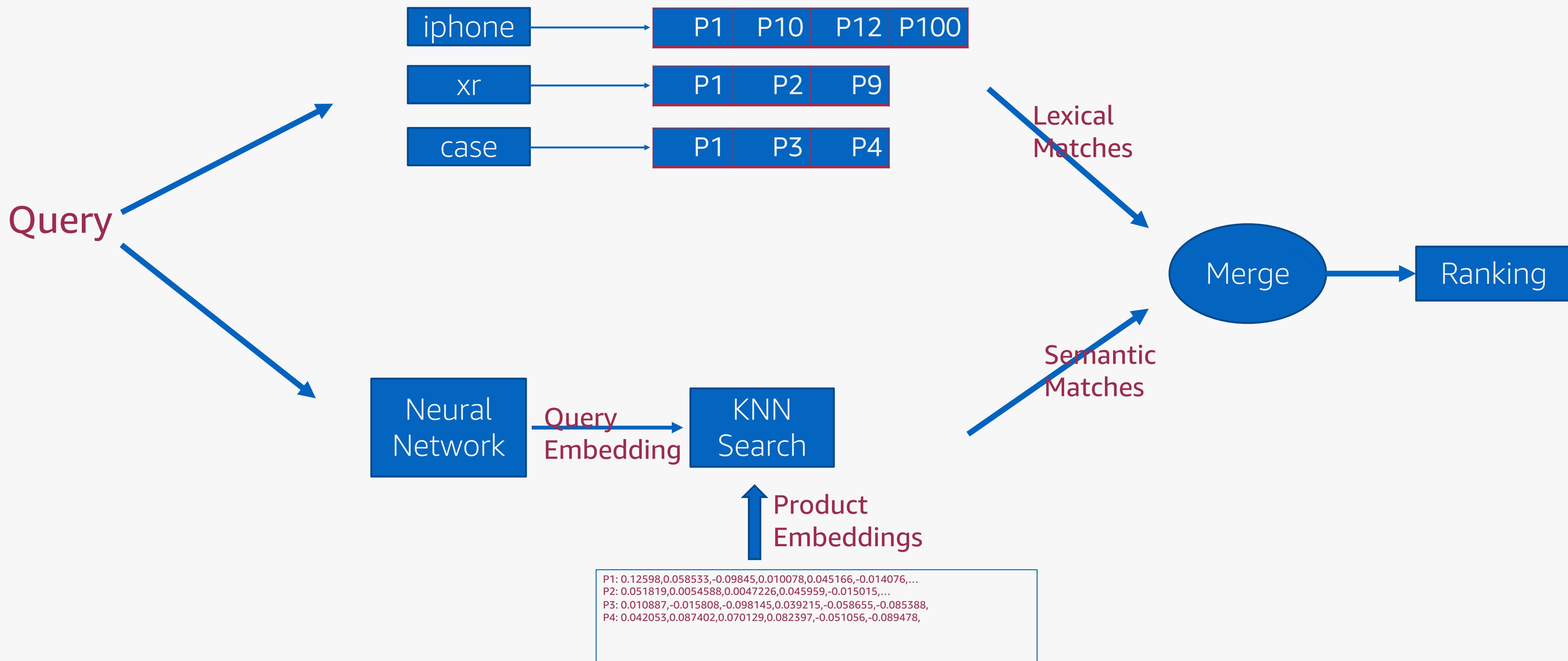


Semantic Match

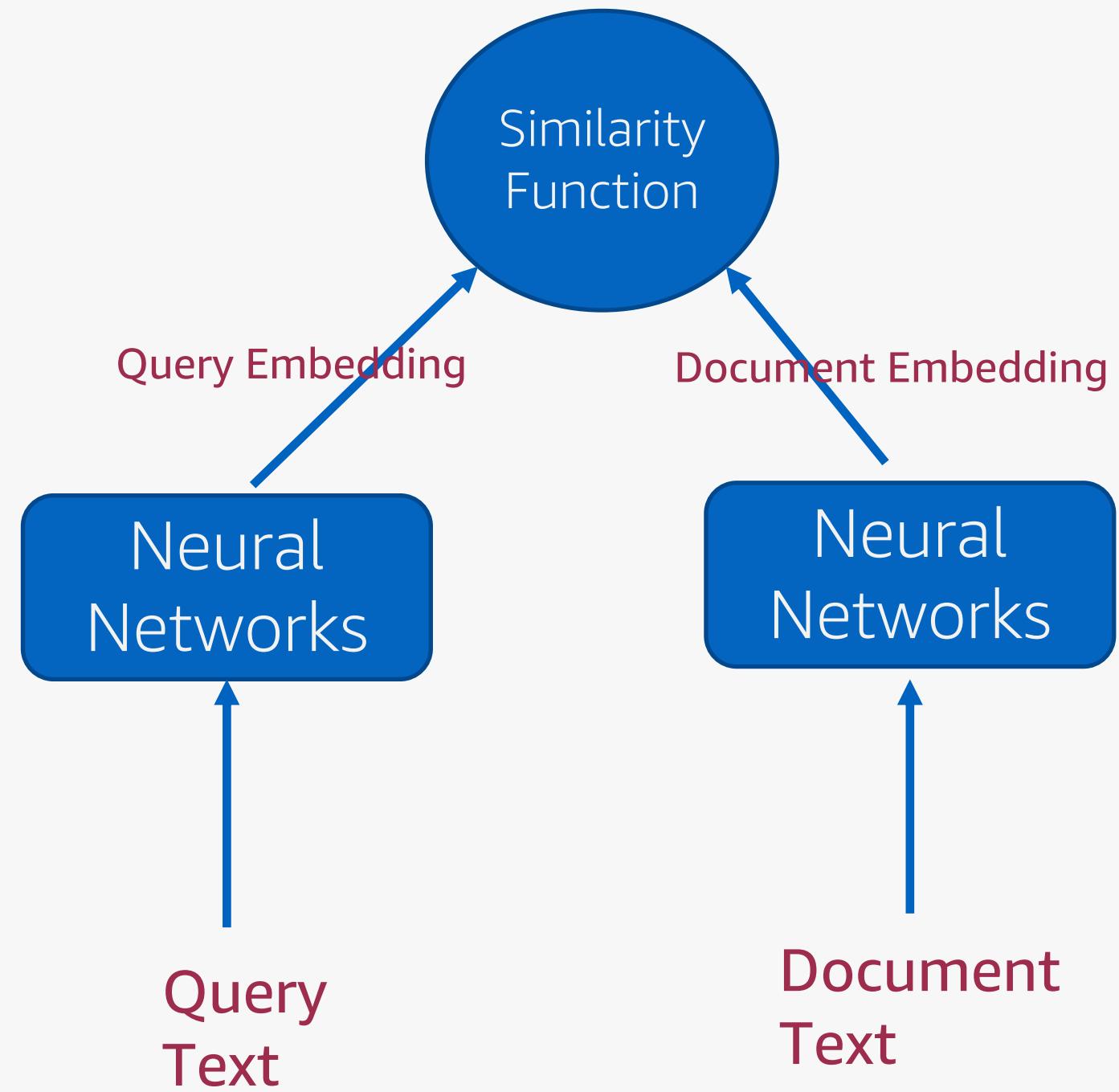
DELLA 048-GM-48197 Beverage Center
Cool Built-in Cooler Mini Refrigerator w/
Lock- Black/Stainless Steel
by DELLA



Semantic Matching augments Lexical Matching



Neural Network Representation Model



Widely adopted in web search engines:
Google, 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
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. ...
★ ★ ★ ★ ☆ * 64
Product Features
Package: 1* iPhone 6S cases
★ ★ ★ ★ ☆ * 1,386
Promotion Available and 1 more promotion *
Product Features
... iPhone 6s case marble hybrid slim dual layer protective fit for Apple ...
★ ★ ★ ★ ☆ * 24
Product Features
... Artistic Live Edge Wood, Highly ... Friendly Wood Case with Nature ...
★ ★ ★ ★ ☆ * 574
Promotion Available See Details
Product Features
... iPhone 6s case for women compatible with iPhone 6s 4.7 inch 2015 ...
★ ★ ★ ★ ☆ * 975
Promotion Available and 7 more promotions *
Product Features
... hard PC back cover with cute pattern design marble iPhone 6/6S Plus case ...

Data

“artistic iphone 6s case”

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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)
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\$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
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★★★★★ 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.
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FREE Shipping on eligible orders
★★★★★ 1,386
Promotion Available and 1 more promotion •
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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 ...

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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

“artistic iphone 6s case”

Similarity between
Query_Emb and
Product_Emb

purchased



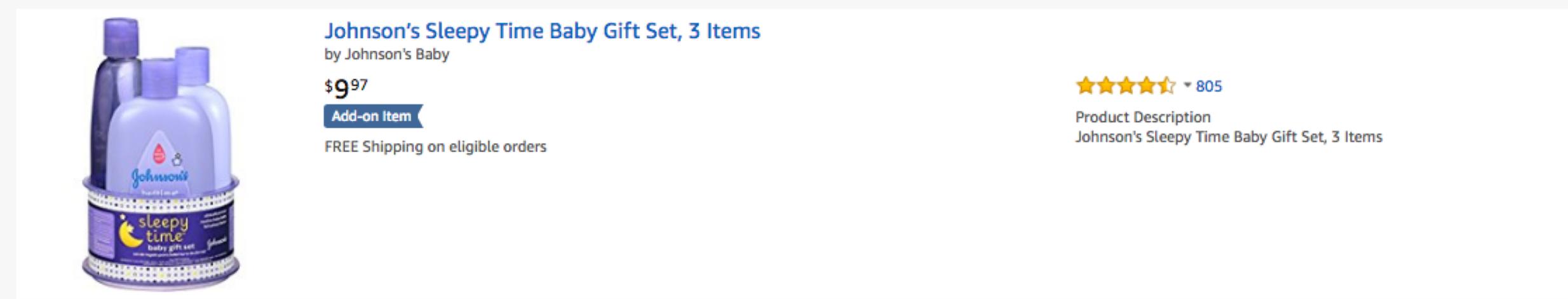
High

Impressed but
not purchased



Medium

Random



Low

Loss Function

- 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:

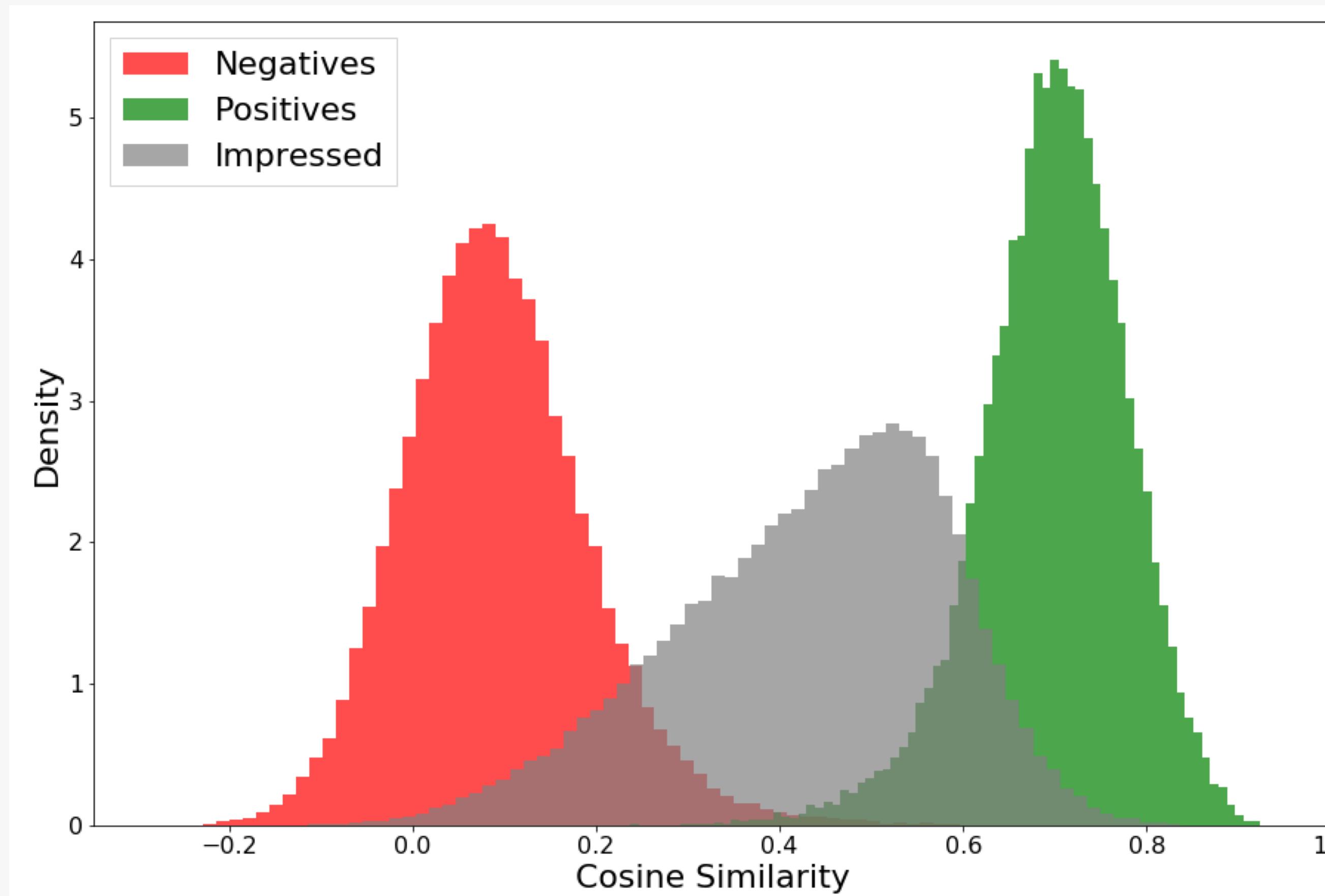
$$\text{loss}(y, \hat{y}) = \begin{cases} 0, & \hat{y} \leq 0.55 \\ (\hat{y} - 0.55)^2, & \hat{y} > 0.55 \end{cases}$$

- For randomly-sampled:

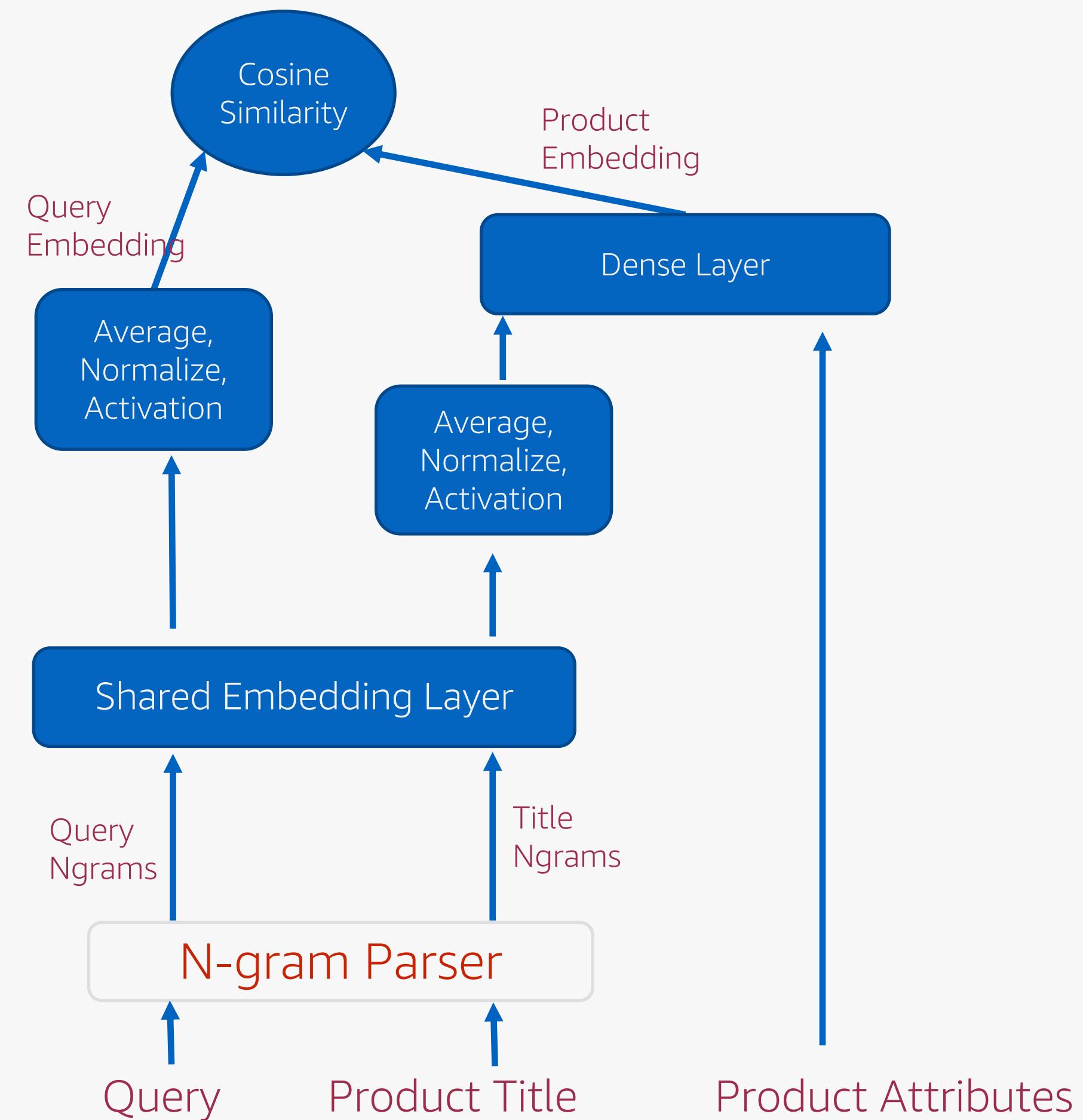
$$\text{loss}(y, \hat{y}) = \begin{cases} 0, & \hat{y} \leq 0.2 \\ (\hat{y} - 0.2)^2, & \hat{y} > 0.2 \end{cases}$$

- 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



N-gram Average Neural Network



N-gram Average Neural Network

"artistic iphone
6s case"



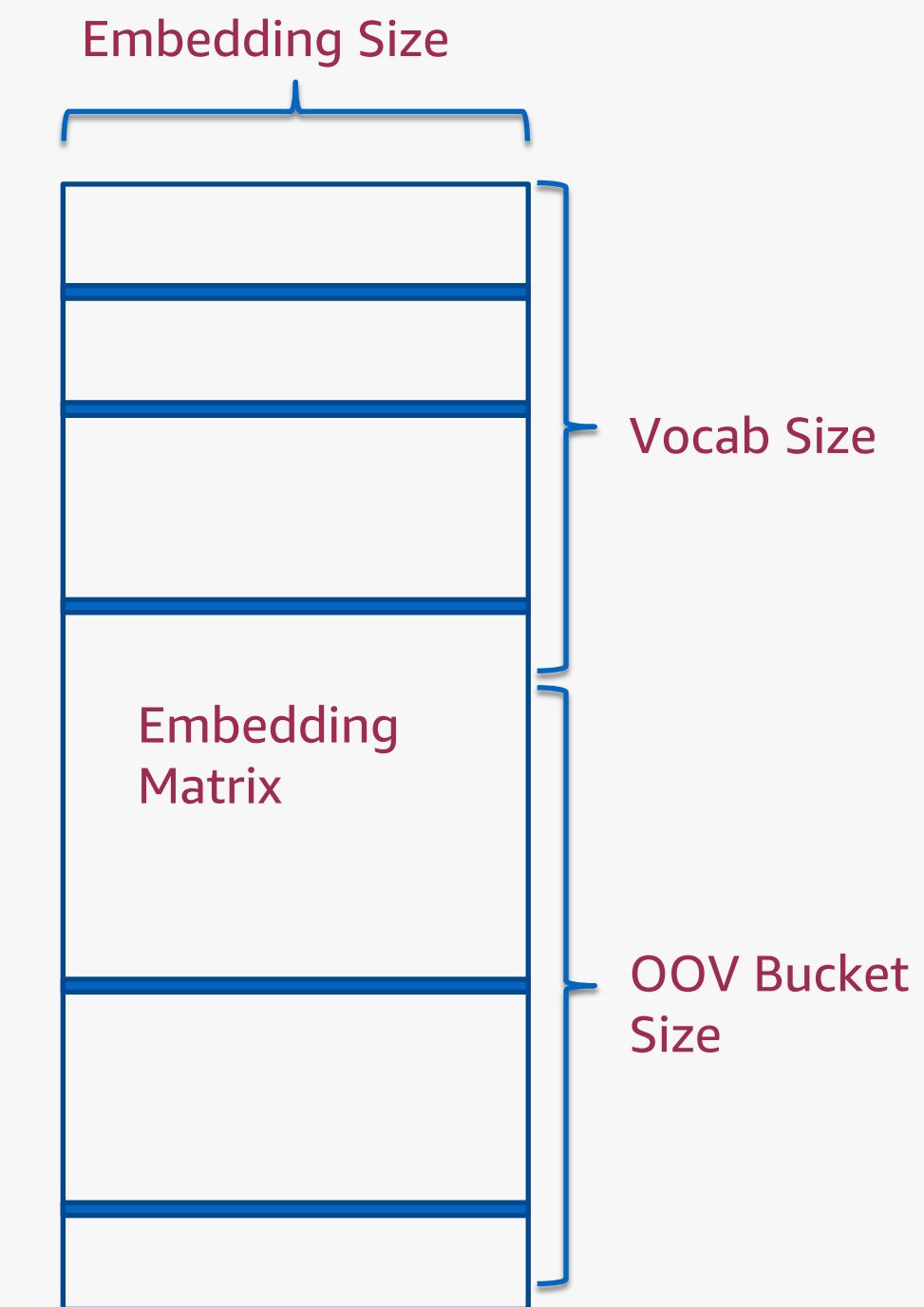
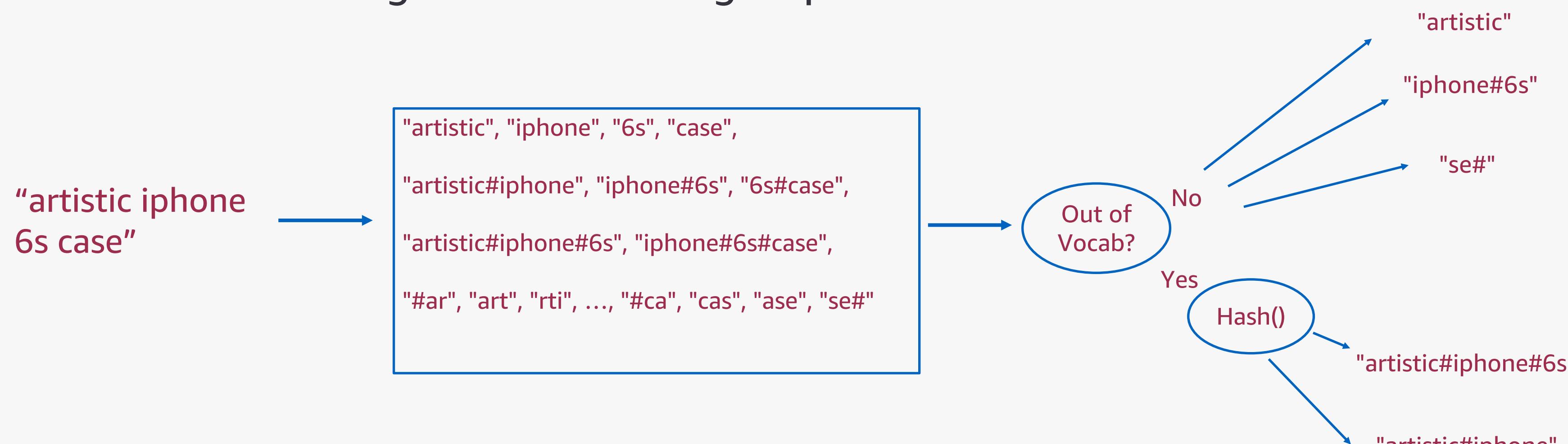
```
"artistic", "iphone", "6s", "case",  
  
"artistic#iphone", "iphone#6s", "6s#case",  
  
"artistic#iphone#6s", "iphone#6s#case",  
  
"#ar", "art", "rti", ..., "#ca", "cas", "ase", "se#"
```

- **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!

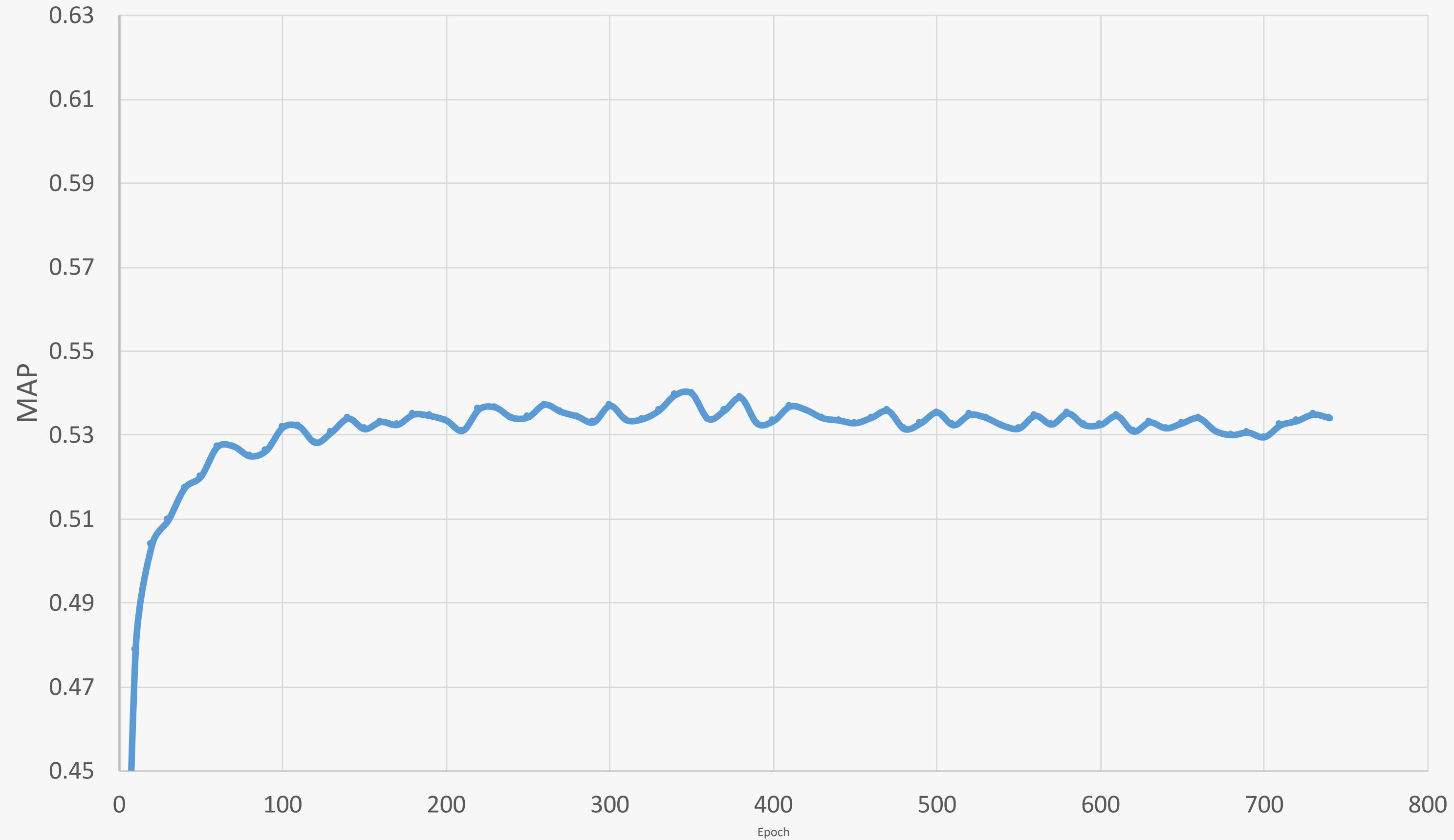
N-gram Average Neural Network

Build N-gram vocab by frequency

Hash OOV N-gram to a bin to group low count tokens

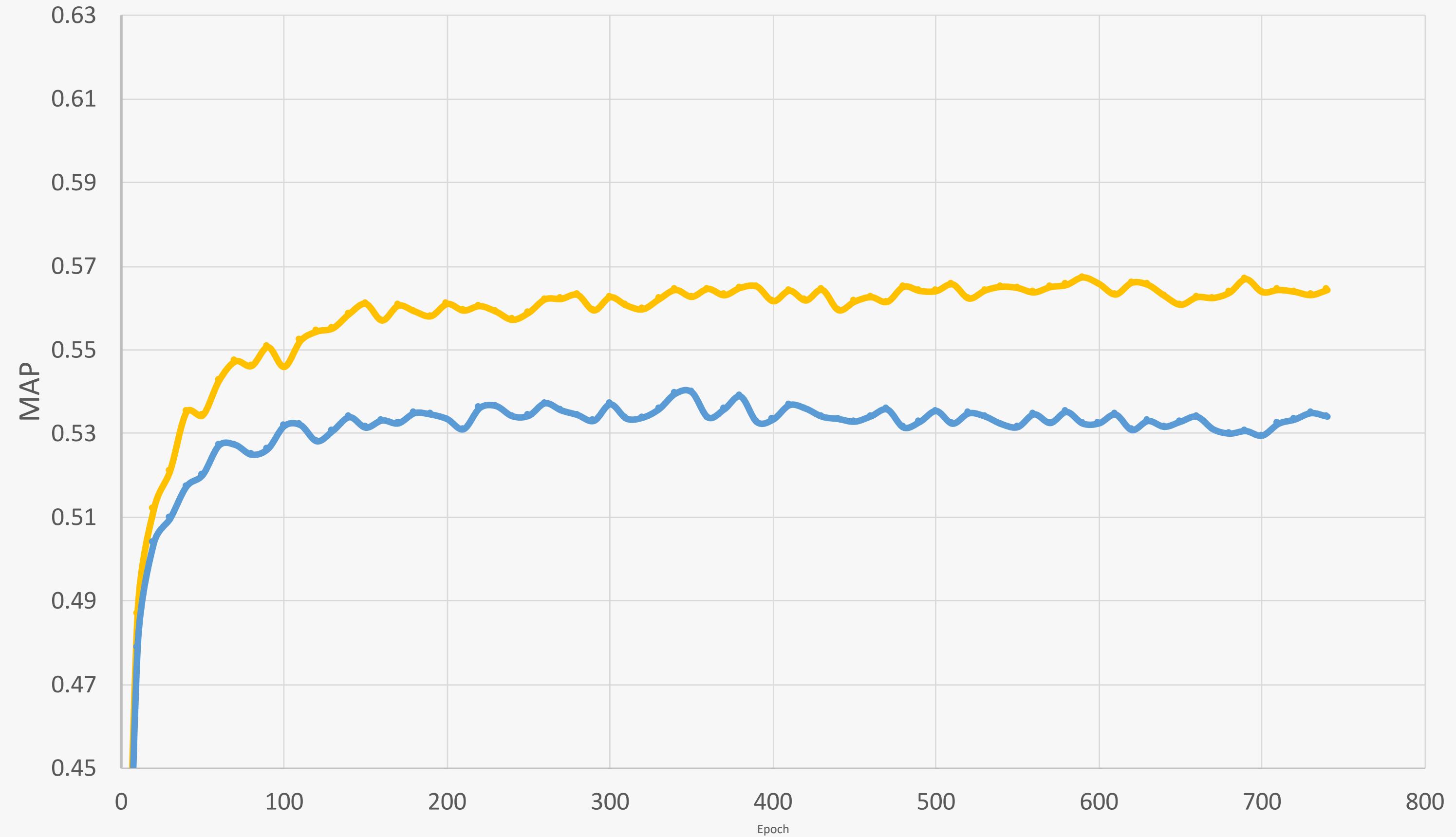


N-gram Average Neural Network



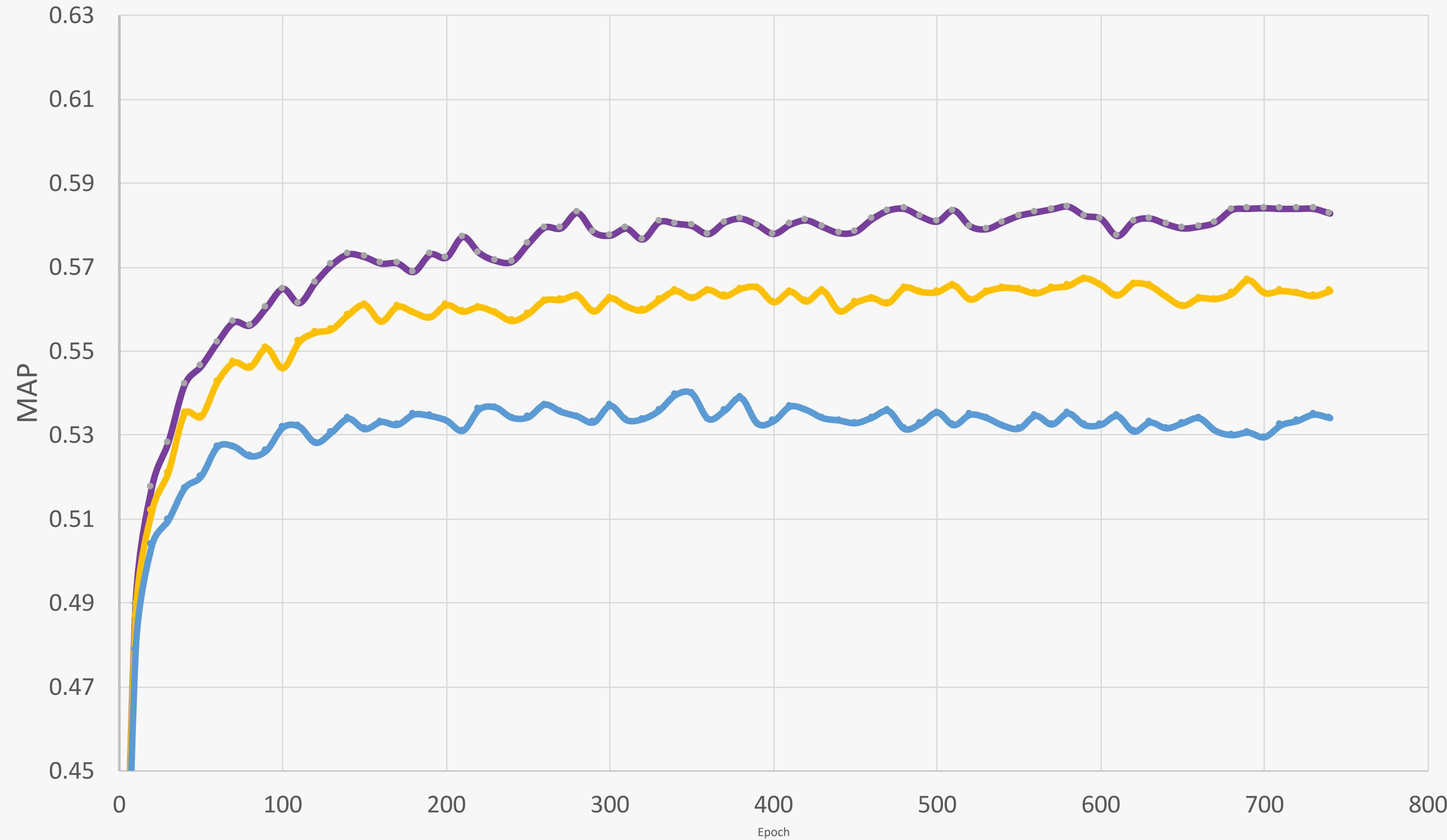
- Word Unigram baseline on small dataset

N-gram Average Neural Network



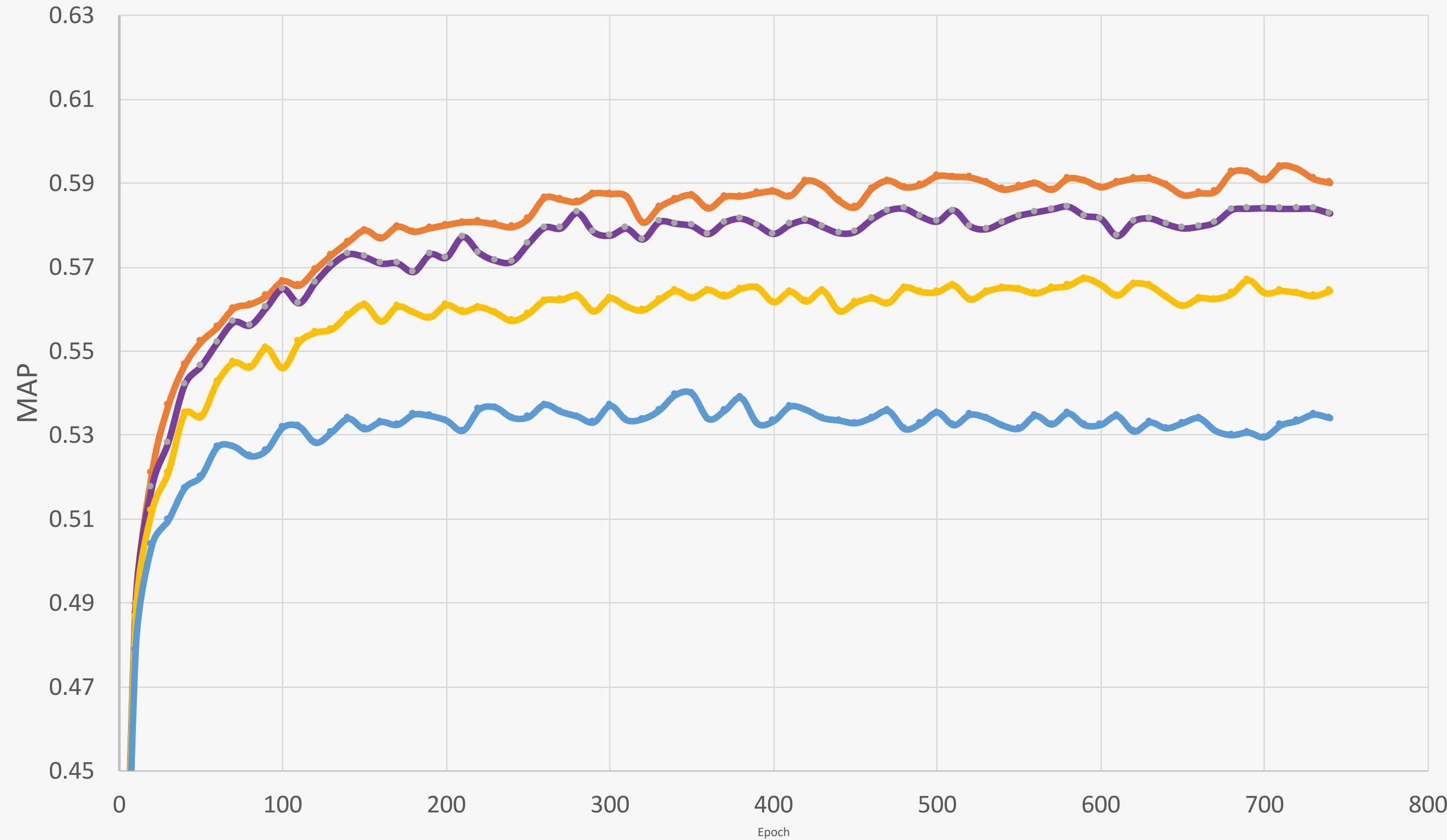
- Word Unigram baseline on small dataset
- Use more data

N-gram Average Neural Network



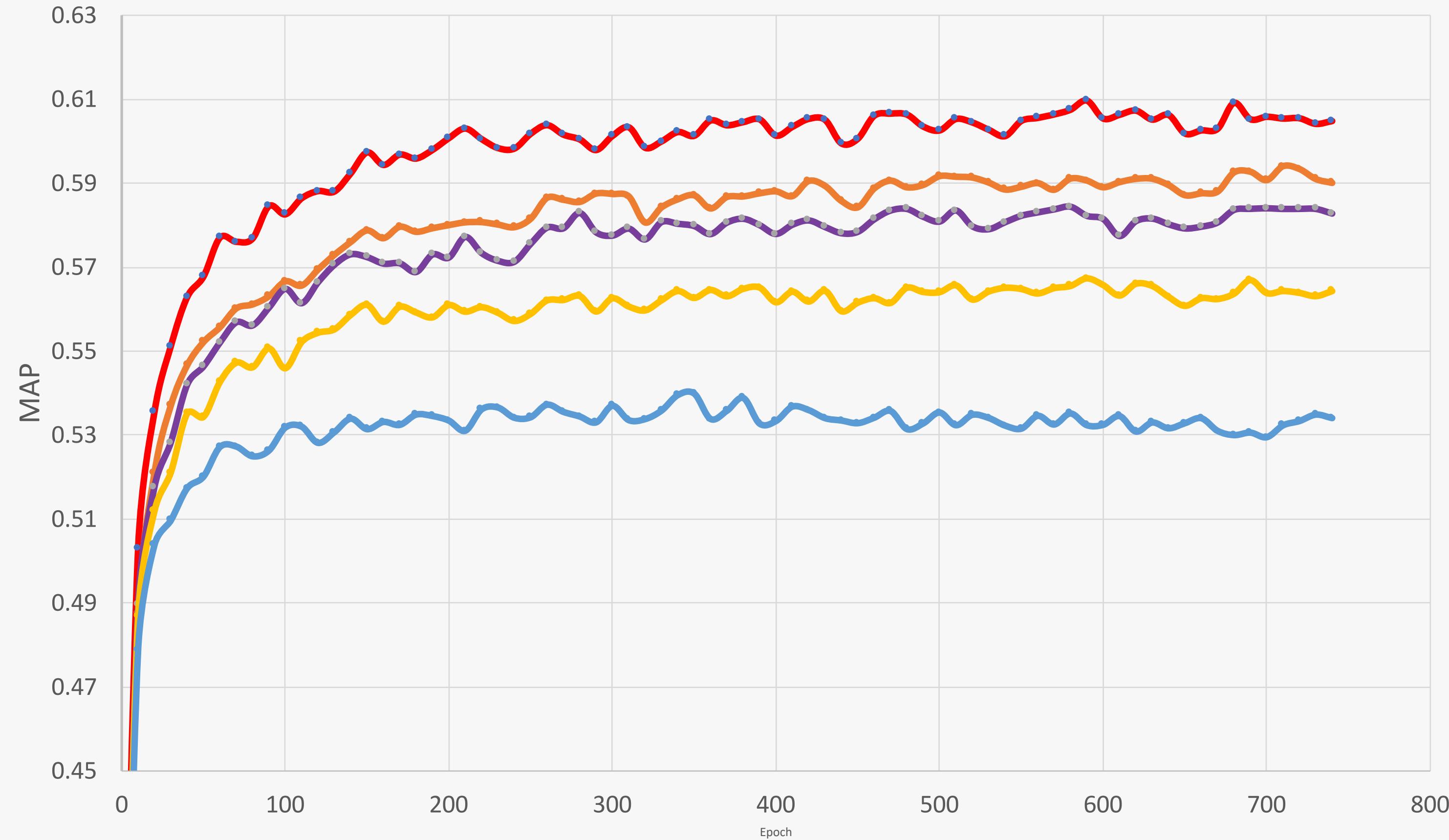
- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram

N-gram Average Neural Network



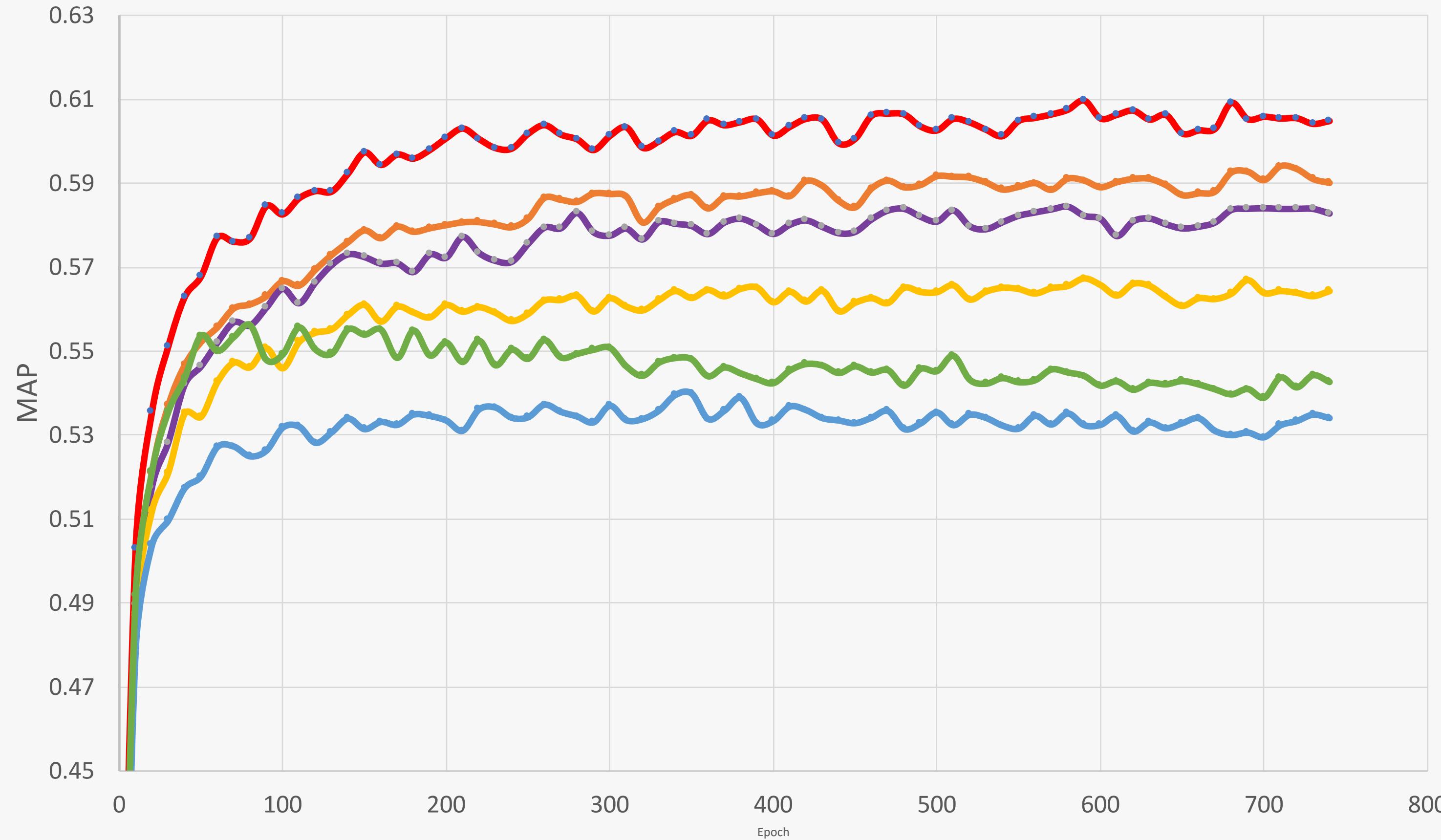
- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram

N-gram Average Neural Network



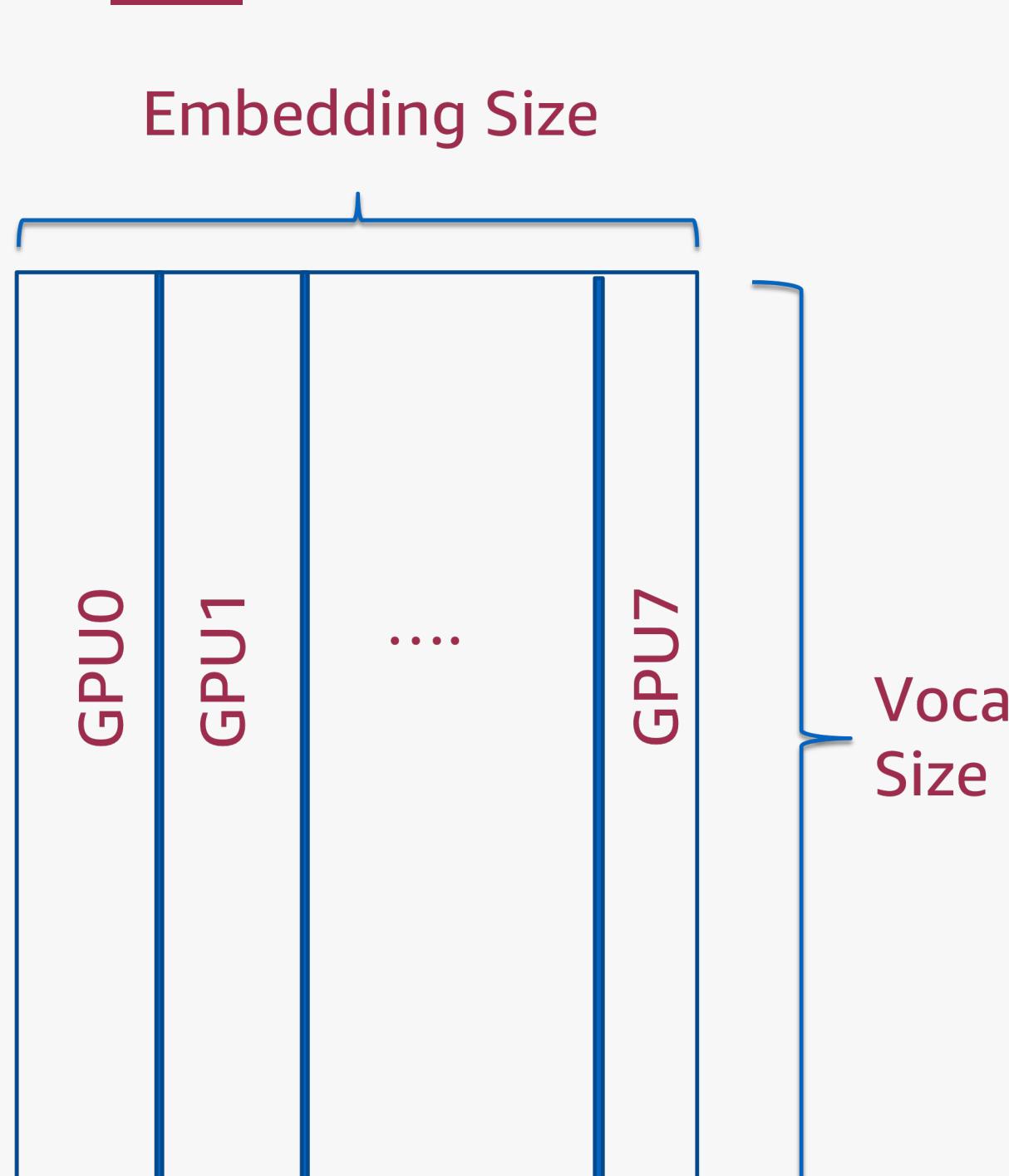
- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram
- Add OOV hashing for ngrams

N-gram Average Neural Network

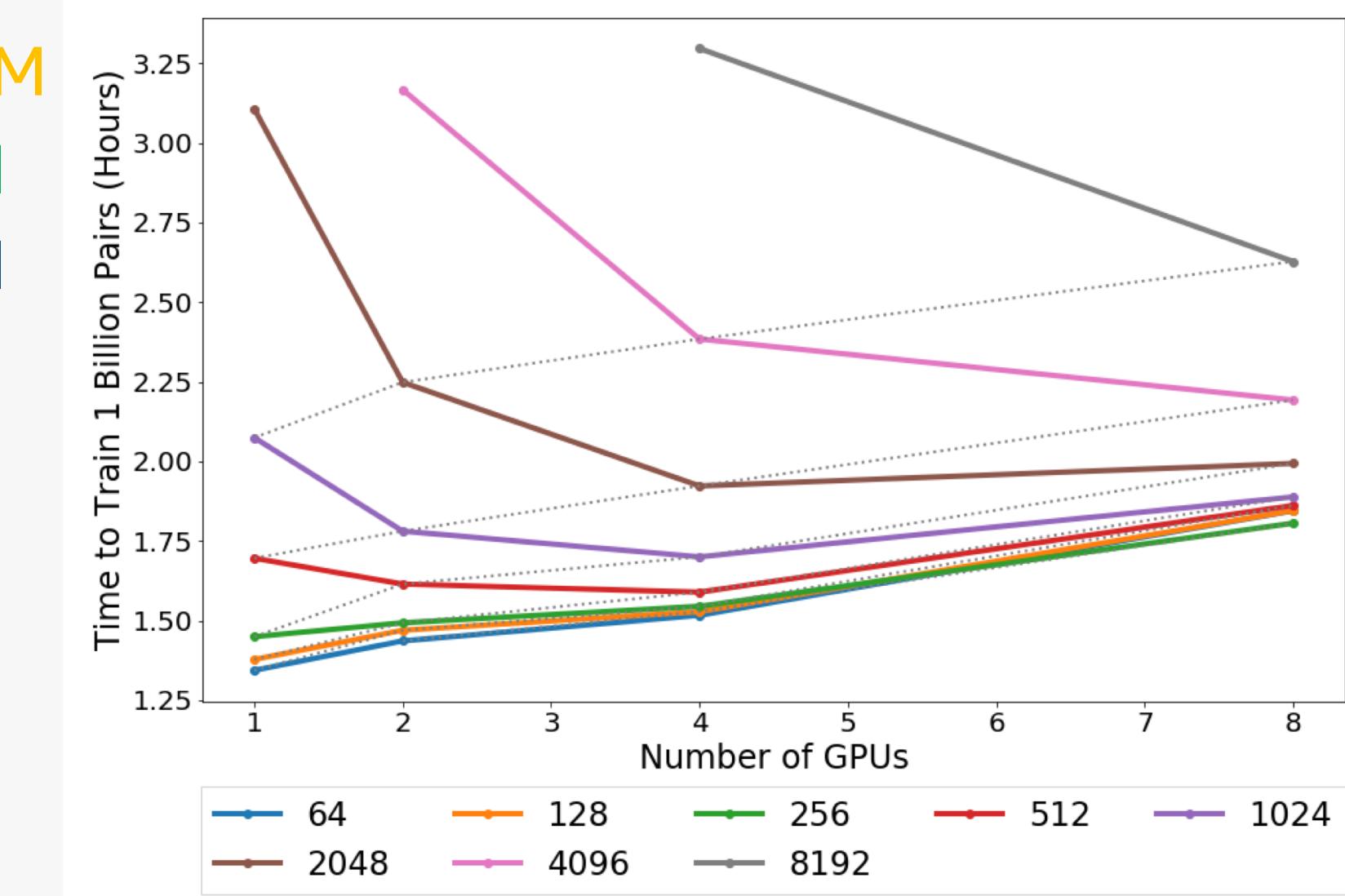
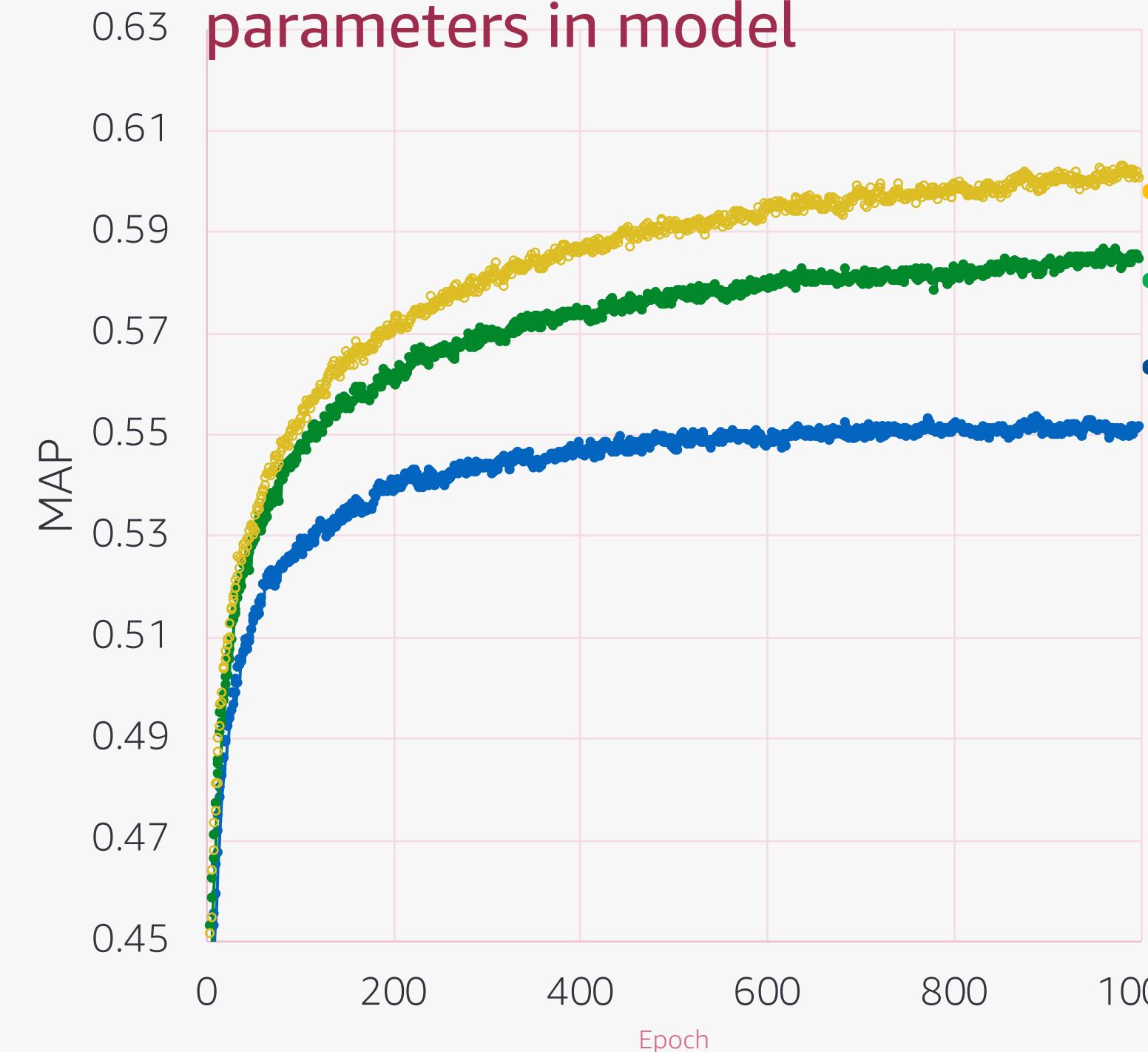


- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram
- Add OOV hashing for ngrams
- More tokens/parameters overfits on small dataset

Increase Vocab Size by Model Parallelism

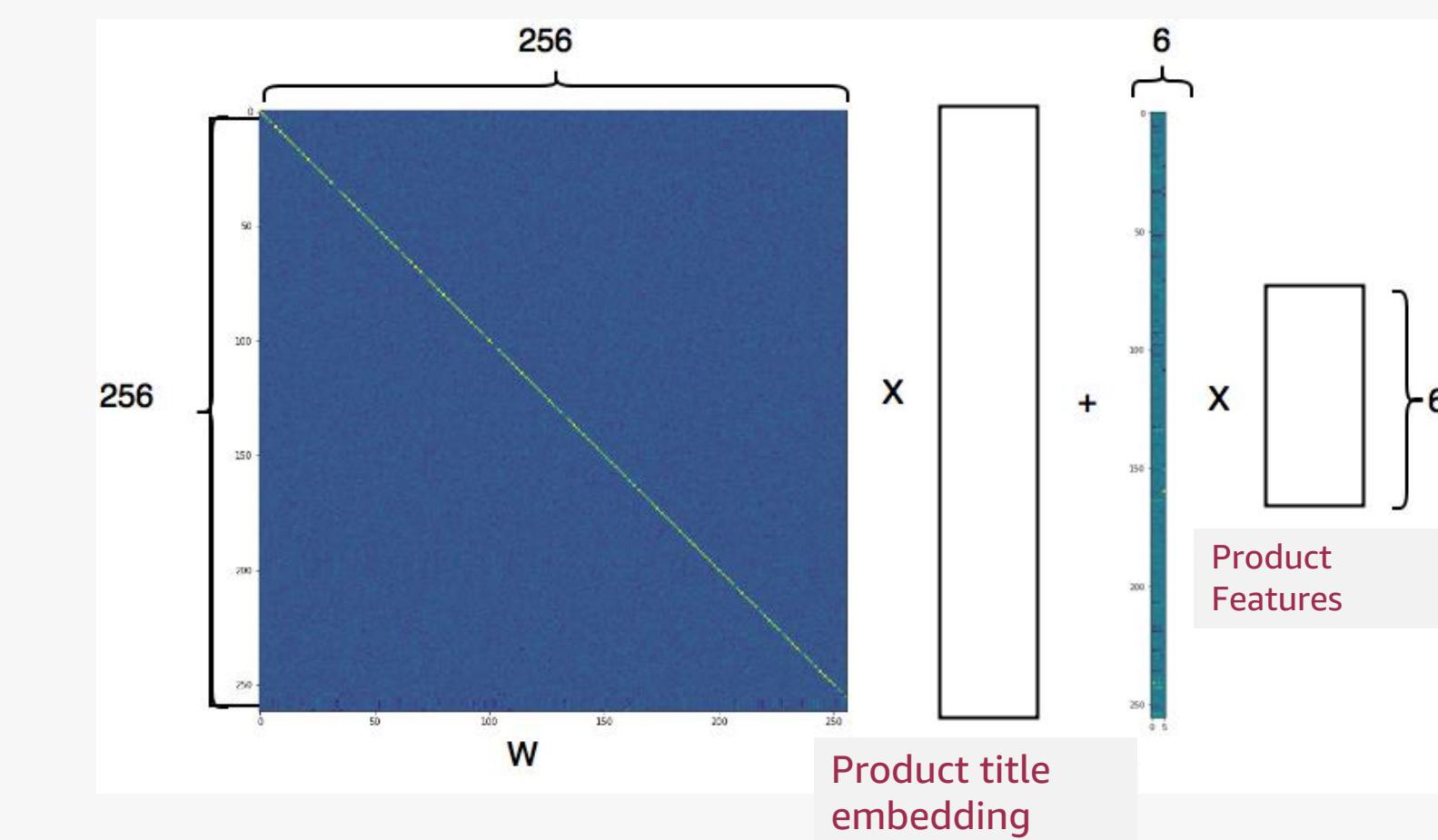
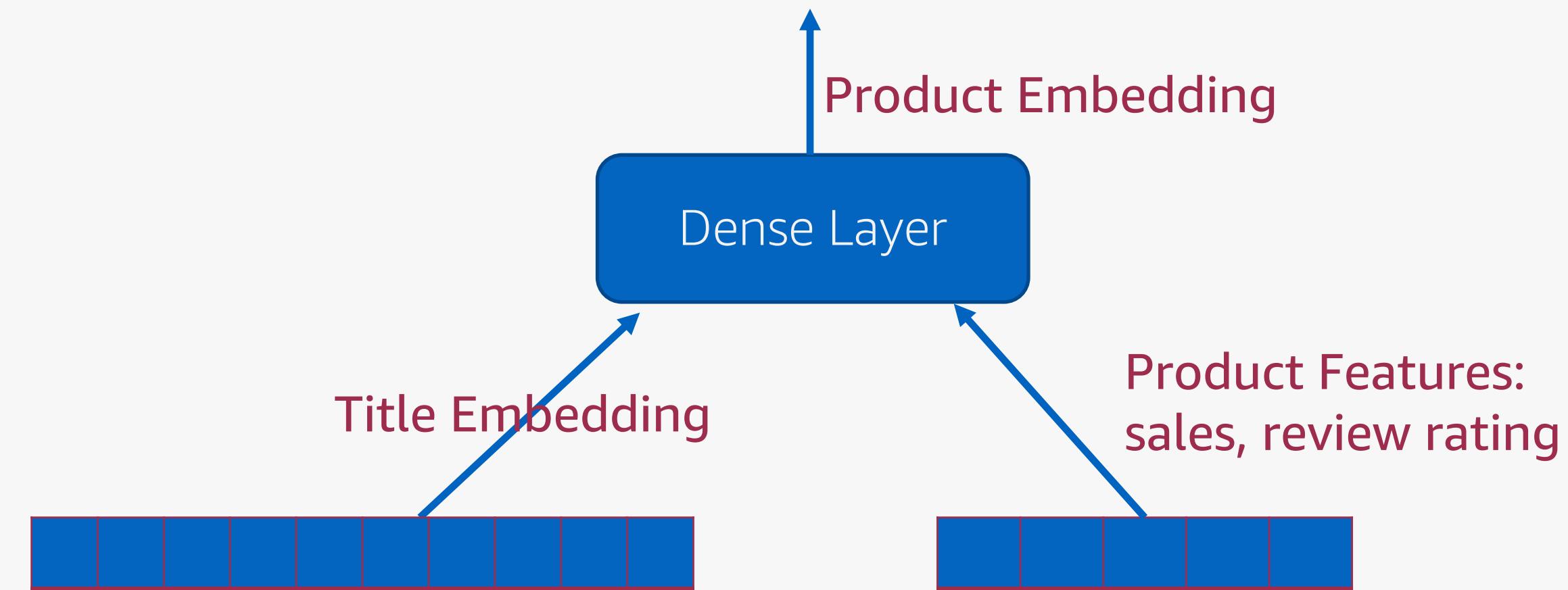


Performance increases with more parameters in model

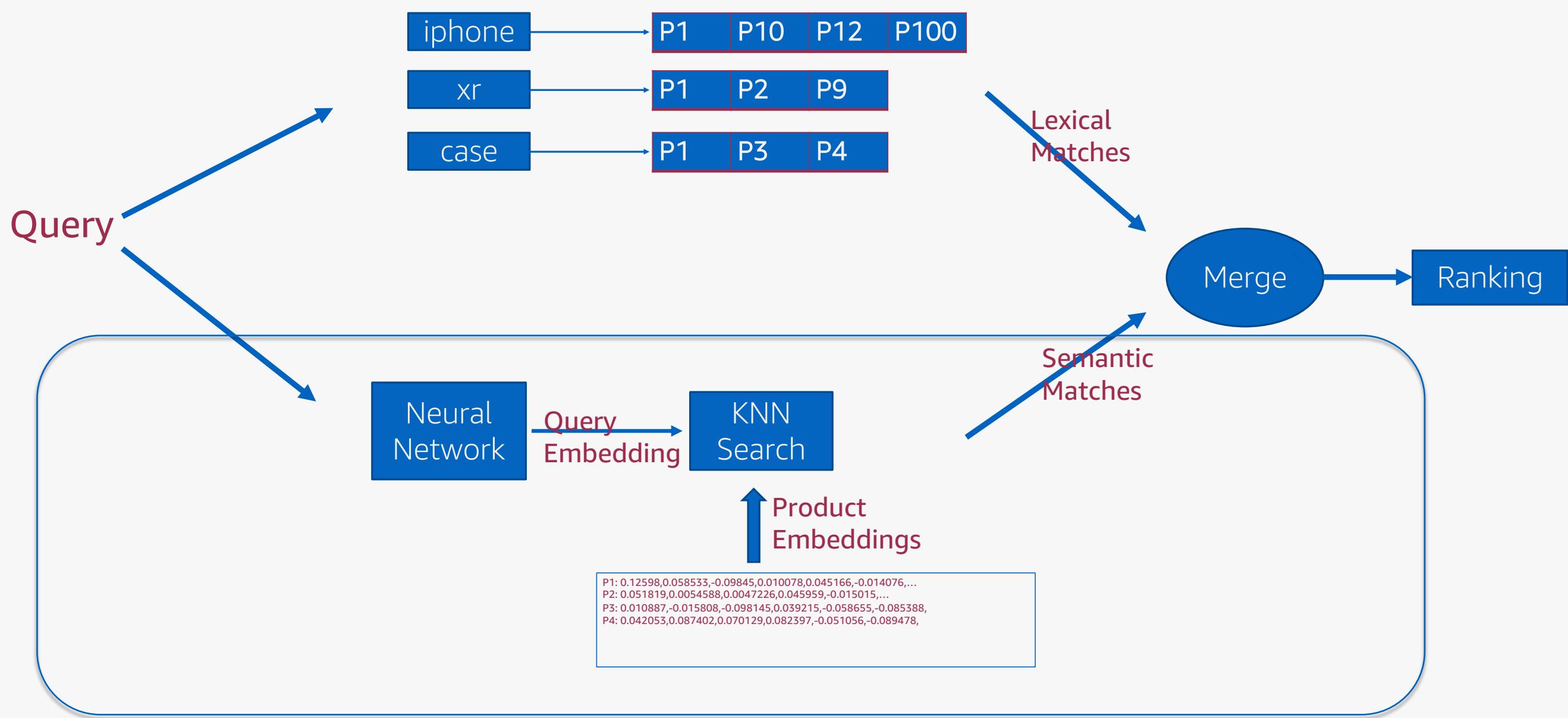


Structured Product Features

- 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



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
 - Image feature
 - 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>