



Search

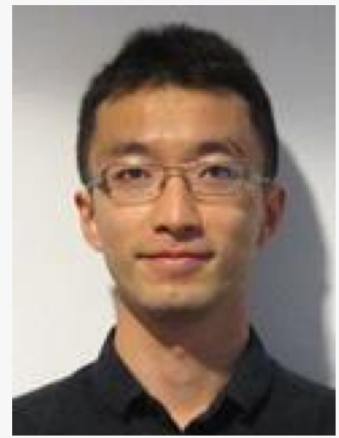
# Deep Semantic Matching for Amazon Product Search

Yiwei Song

Amazon Product Search

# Deep Semantic Matching for Amazon Product Search

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Yiwei Song



Priyanka Nigam



Vijai Mohan



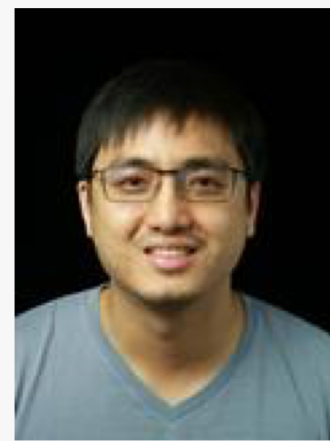
Vihan Lakshman



Weitian Ding



Ankit Shingavi



Choon Hui Teo



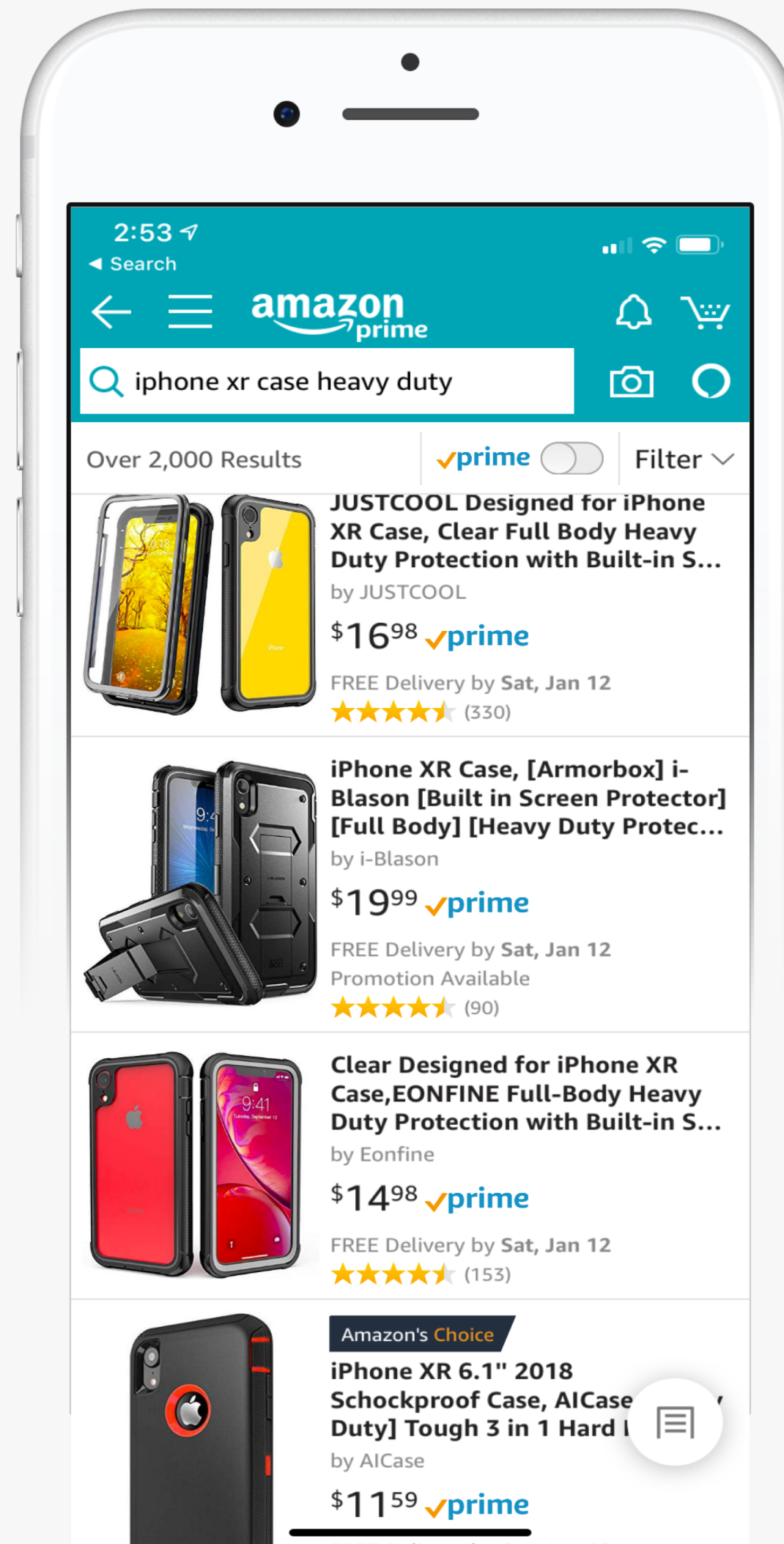
Hao Gu



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?

---

Lexical Match

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

“health shampoo”



# 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?

---

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

**"countertop wine fridge"**



# What is a match for a query?

---

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



**"countertop wine fridge"**

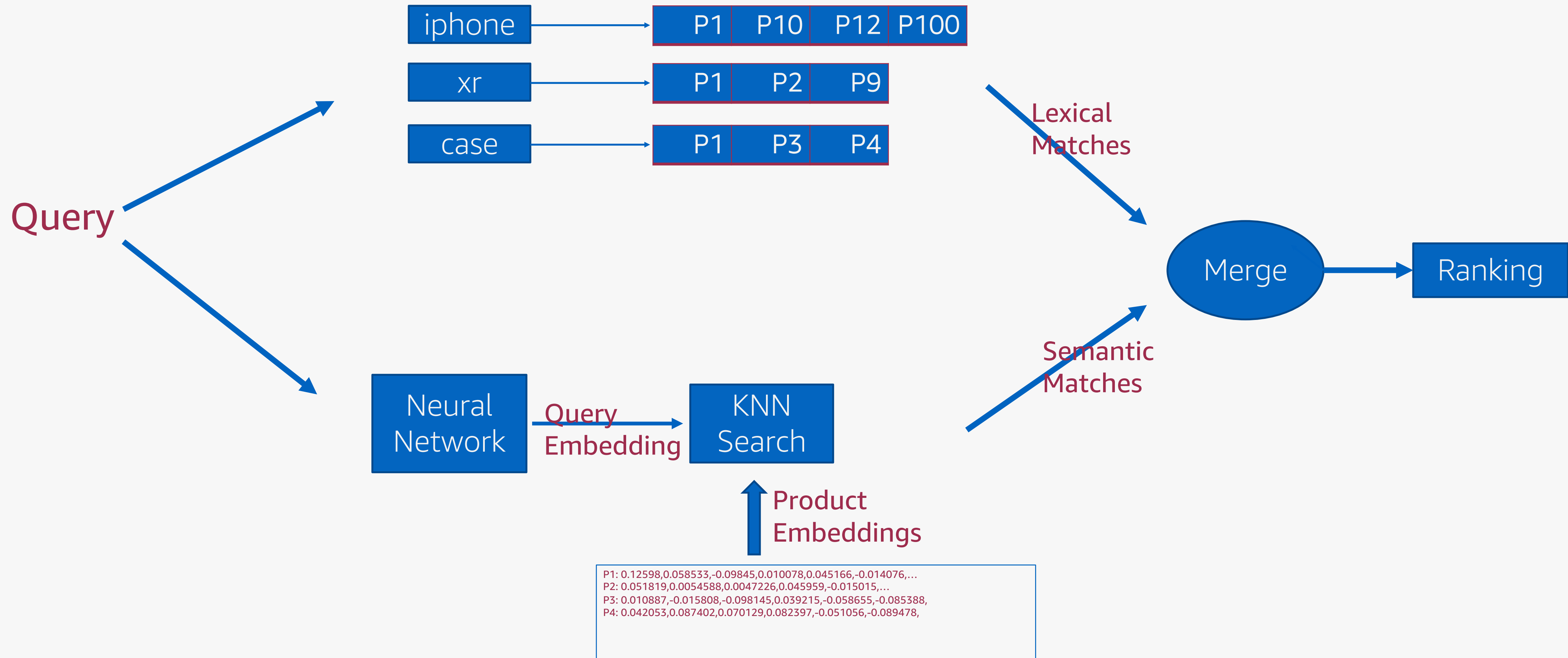
Semantic Match

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



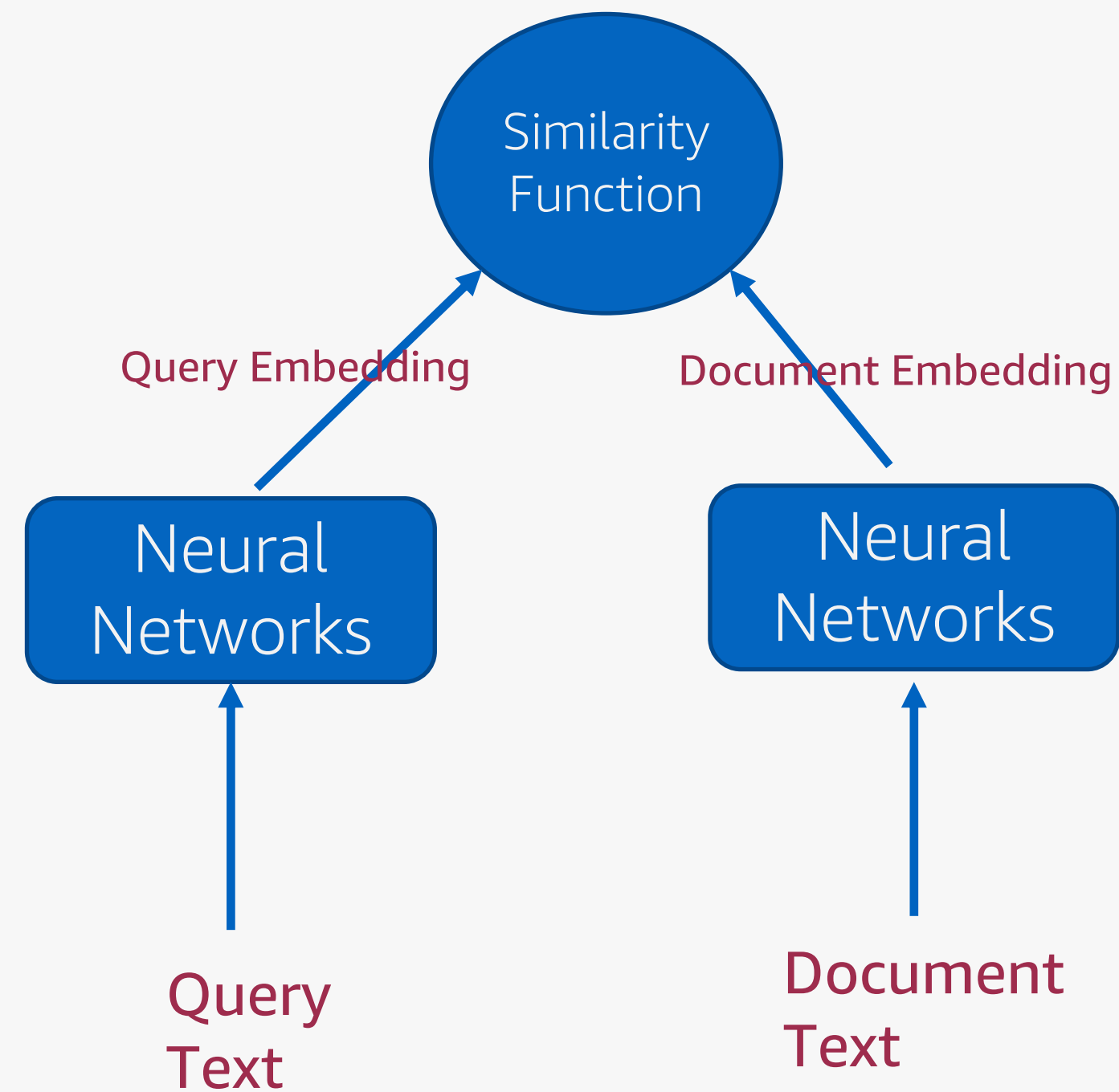


# Semantic Matching augments Lexical Matching



# Neural Network Representation Model

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Widely adopted in web search engines:  
Google, 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.


	<p>iPhone 6s Case Marble, iPhone 6 Case, ULAK 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 ULAK</p> <p><b>\$8<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders</p> <p>★★★★☆ * 1,449 Promotion Available and 1 more promotion * Product Features ... iPhone 6 case, iPhone 6s case designed for Apple iPhone 6 4. ...</p>
	<p>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</p> <p><b>\$6<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders More Buying Choices <b>\$2.00</b> (4 new offers)</p> <p>★★★★☆ * 64 Product Features Package: 1 iPhone 6S cases</p>
	<p>iPhone 6S Case, iPhone 6 Case, ULAK Slim Fit Dual Layer Soft Silicone &amp; Hard Back Cover Bumper Protective Shock-Absorption &amp; Skid-proof Anti-Scratch Hybrid Case, Artistic/Mint Green Marble by ULAK</p> <p><b>\$9<sup>49</sup></b> <small>Subscribe &amp; Save</small> Save more with monthly Subscribe &amp; Save deliveries.</p> <p><b>\$9<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders</p> <p>★★★★☆ * 1,386 Promotion Available and 1 more promotion * Product Features ... iPhone 6S case marble hybrid slim dual layer protective fit for Apple ...</p>
	<p>iPhone 6S Case: [SG] Frame BELK 2nd Gene - "FLEX Edge" Soft-Gel Shock-absorbing TPU Sided Hard Wood Case [Easy Snap-On] with Durable Reinforced PC Hybrid Back Case, Cherry by Belk</p> <p><b>\$13<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders Only 10 left in stock - order soon.</p> <p>★★★★☆ * 24 Product Features ... Artistic Live Edge Wood, Highly ... Friendly Wood Case with Nature ...</p>
	<p>iPhone 6s Case, iPhone 6 Case, 6s Wallet Case, ULAK Marble Wallet iPhone 6S Leather Case with 9 Card Slots Flip for Apple iPhone 6s/6 4.7 Inch, Artistic-marble pattern by ULAK</p> <p><b>\$9<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders</p> <p>★★★★☆ * 574 Promotion Available See Details Product Features ... iPhone 6s case for women compatible with iPhone 6s 4.7 inch 2015 ...</p>
	<p>iPhone 6 Plus Case, iPhone 6s Plus Case, ULAK 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 ULAK</p> <p><b>\$9<sup>99</sup></b> <small>prime</small> FREE Shipping on eligible orders</p> <p>★★★★☆ * 975 Promotion Available and 7 more promotions * Product Features ... hard PC back cover with cute pattern design marble iPhone 6/6S Plus case ...</p>

# 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, ULAK 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 ULAK

**\$8<sup>99</sup>** 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. ...
- 

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<sup>99</sup>** 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, ULAK Slim Fit Dual Layer Soft Silicone & Hard Back Cover Bumper Protective Shock-Absorption & Skid-proof Anti-Scratch Hybrid Case, Artistic/Mint Green Marble by ULAK


**\$9<sup>49</sup>** Subscribe & Save  
Save more with monthly Subscribe & Save deliveries.

**\$9<sup>99</sup>** 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 Case: [SG] Frame BELK 2nd Gene - "FLEX Edge" Soft-Gel Shock-absorbing TPU Sided Hard Wood Case [Easy Snap-On] with Durable Reinforced PC Hybrid Back Case, Cherry by Belk

**\$13<sup>99</sup>** 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, ULAK Marble Wallet iPhone 6S Leather Case with 9 Card Slots Flip for Apple iPhone 6s/6 4.7 Inch, Artistic-marble pattern by ULAK

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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 ...
- 

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**\$9<sup>99</sup>** 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

# Data

## "artistic iphone 6s case"


purchased

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

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iPhone 6s Case Marble, iPhone 6 Case, ULAK 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 ULAK


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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. ...
- 

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★★★★☆ \* 64  
Product Features  
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- 

iPhone 6S Case, iPhone 6 Case, ULAK Slim Fit Dual Layer Soft Silicone & Hard Back Cover Bumper Protective Shock-Absorption & Skid-proof Anti-Scratch Hybrid Case, Artistic/Mint Green Marble by ULAK

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★★★★☆ \* 24  
Product Features  
... Artistic Live Edge Wood, Highly ... Friendly Wood Case with Nature ...
- 

iPhone 6s Case, iPhone 6 Case, 6s Wallet Case, ULAK Marble Wallet iPhone 6S Leather Case with 9 Card Slots Flip for Apple iPhone 6s/6 4.7 Inch, Artistic-marble pattern by ULAK

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\$9<sup>99</sup> prime  
FREE Shipping on eligible orders

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

Best Seller

- 


Champ Grip. Strongest Grippers Map Broom Holders with 5 Ball Slots and 6 Hooks. Items Guaranteed Non Slide. Life-time Guarantee. by CHAMP GRIP®

\$12<sup>99</sup> 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<sup>97</sup>  
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

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Get it TODAY, Apr 19

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\$0<sup>00</sup>  
Free with Audible trial

Other Formats: Hardcover, Audio CD

★★★★☆ \* 72
- 

Amazon.com Gift Card in a Gold Reveal by Amazon


\$25<sup>00</sup> - \$40<sup>00</sup>  
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<sup>66</sup> 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<sup>99</sup> 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\_Embed and  
Product\_Embed

purchased

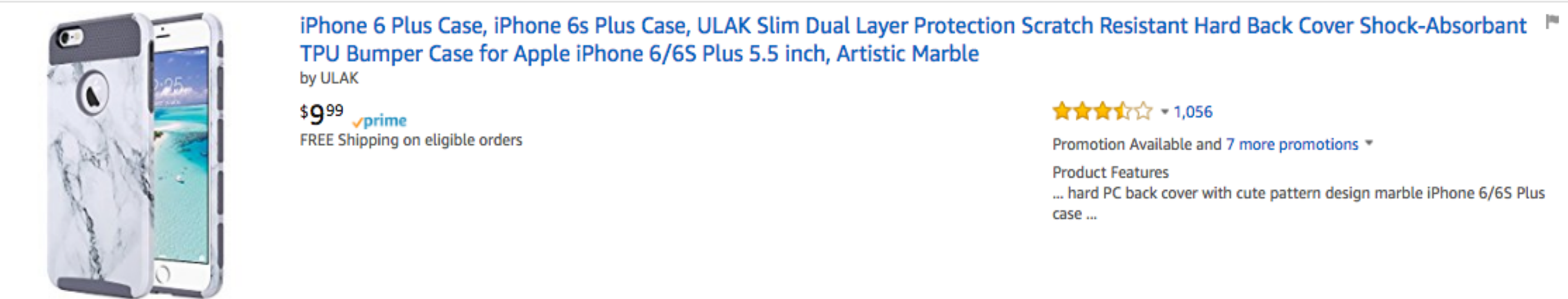



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by Freedom Fly  
\$6.99    
FREE Shipping on eligible orders  
More Buying Choices  
\$2.00 (4 new offers)

★★★★☆ 64  
Product Features  
Package: 1\* iPhone 6S cases

High

Impressed but  
not purchased

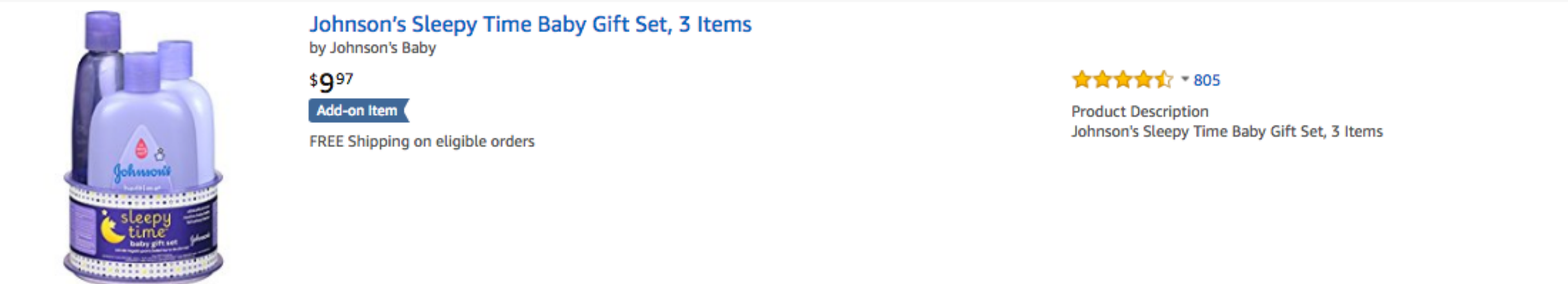


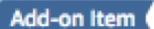
iPhone 6 Plus Case, iPhone 6s Plus Case, ULAK Slim Dual Layer Protection Scratch Resistant Hard Back Cover Shock-Absorbant TPU Bumper Case for Apple iPhone 6/6S Plus 5.5 inch, Artistic Marble  
by ULAK  
\$9.99    
FREE Shipping on eligible orders

★★★★☆ 1,056  
Promotion Available and 7 more promotions  
Product Features  
... hard PC back cover with cute pattern design marble iPhone 6/6S Plus case ...

Medium

Random



Johnson's Sleepy Time Baby Gift Set, 3 Items  
by Johnson's Baby  
\$9.97   
   
FREE Shipping on eligible orders

★★★★☆ 805  
Product Description  
Johnson's Sleepy Time Baby Gift Set, 3 Items

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:

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

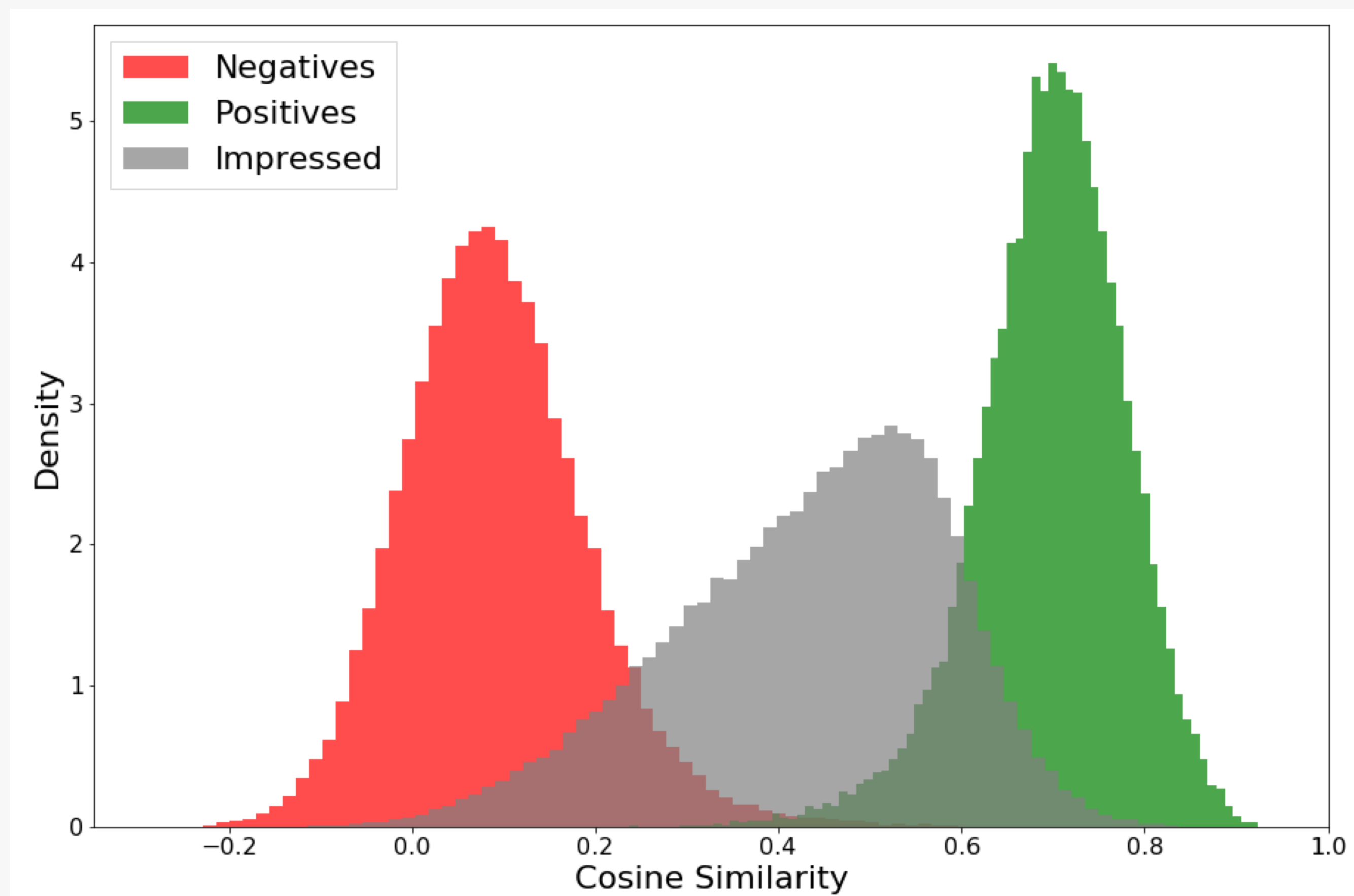
- For randomly-sampled:

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

- 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**

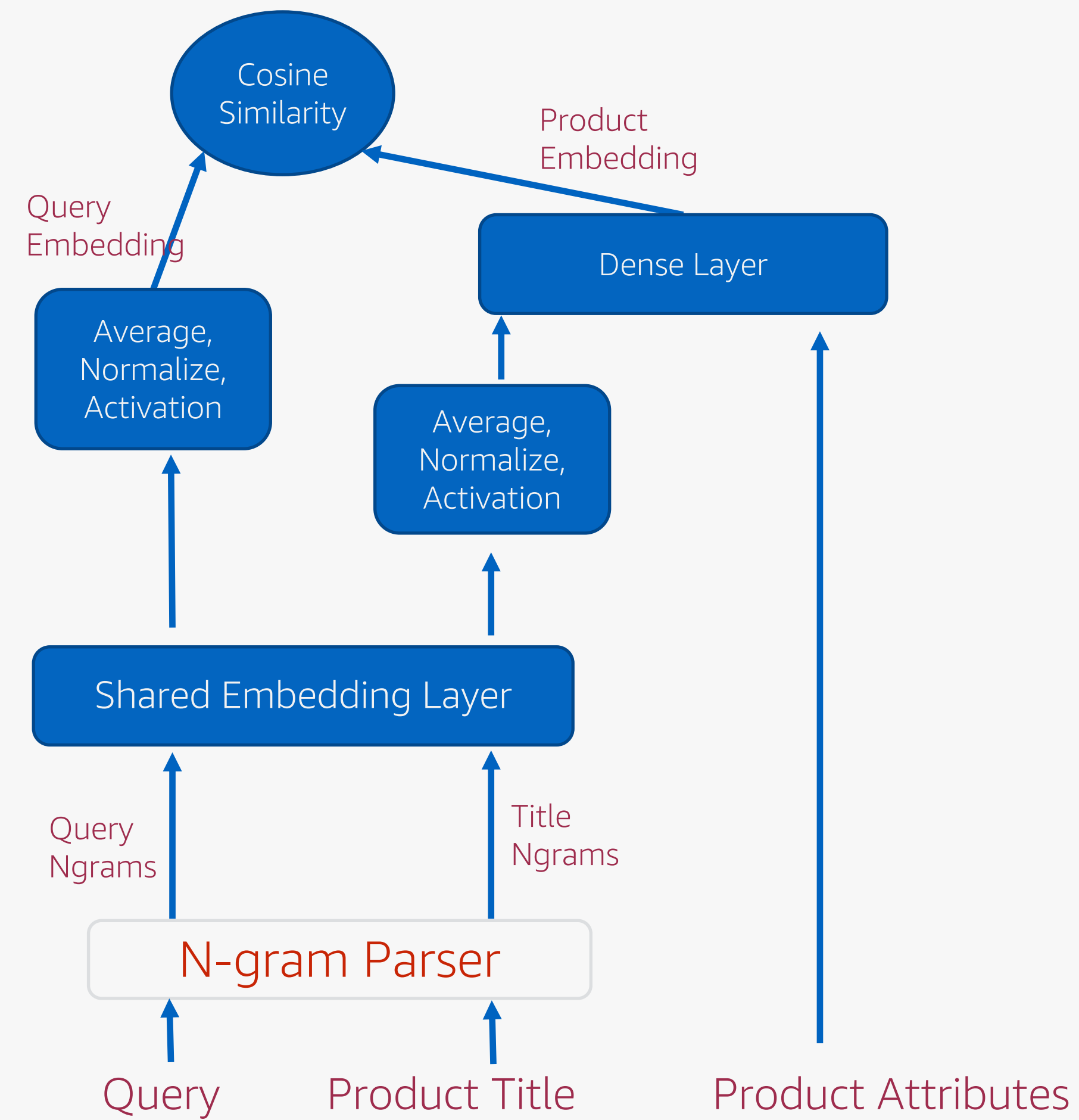
# Loss Function

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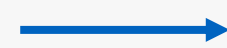


# N-gram Average Neural Network



# N-gram Average Neural Network

“artistic iphone  
6s case”



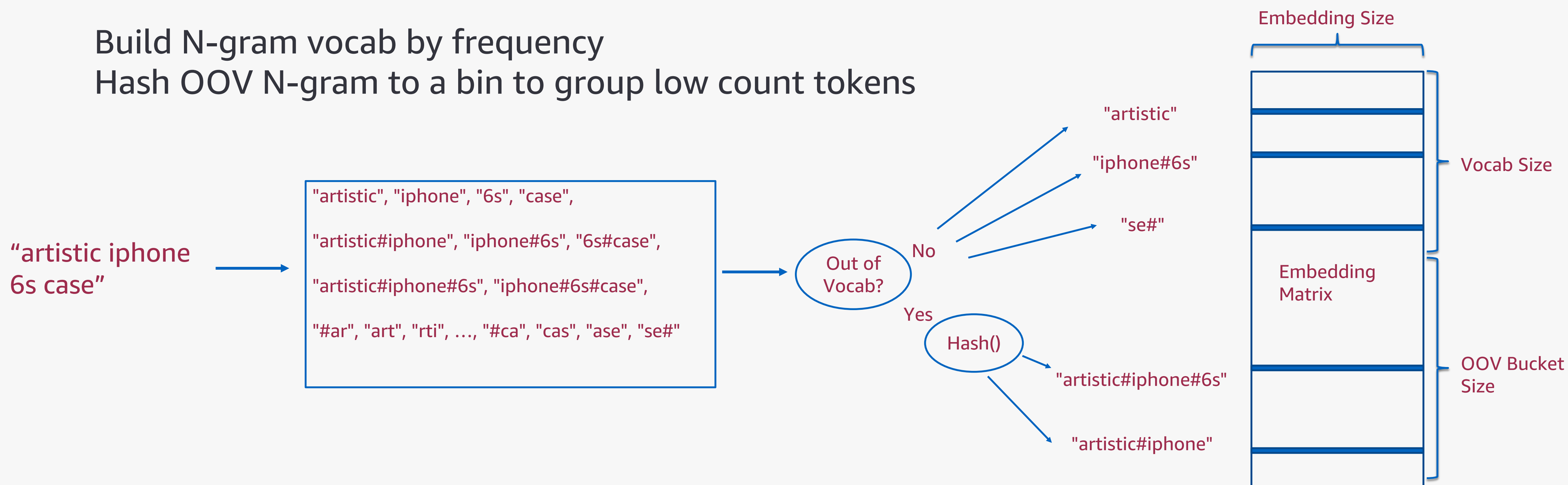
```
"artistic", "iphone", "6s", "case",  
"artistic#iphone", "iphone#6s", "6s#case",  
"artistic#iphone#6s", "iphone#6s#case",  
"#ar", "art", "rti", ..., "#ca", "cas", "ase", "se#"
```

- **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!

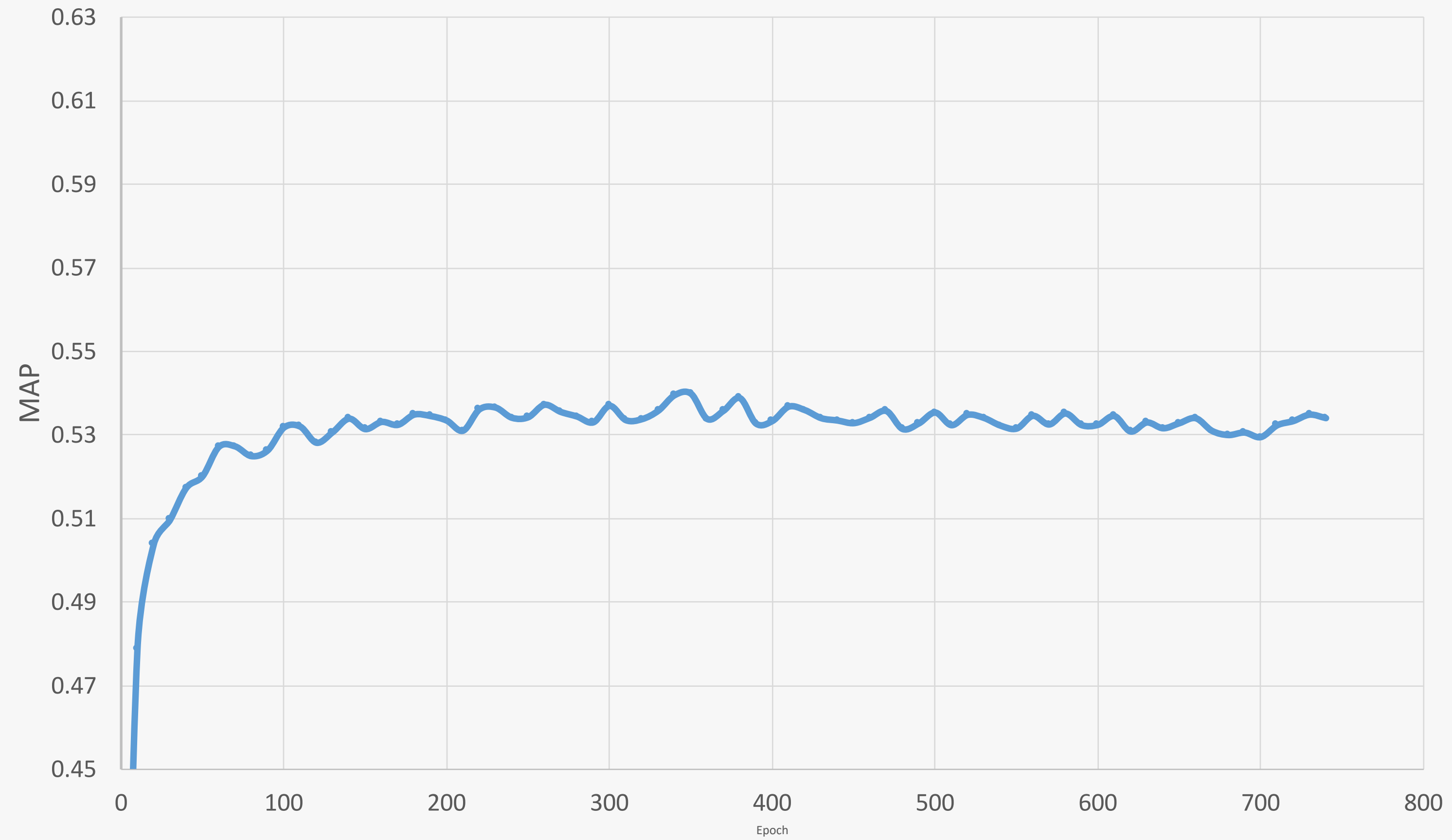
# N-gram Average Neural Network

Build N-gram vocab by frequency

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

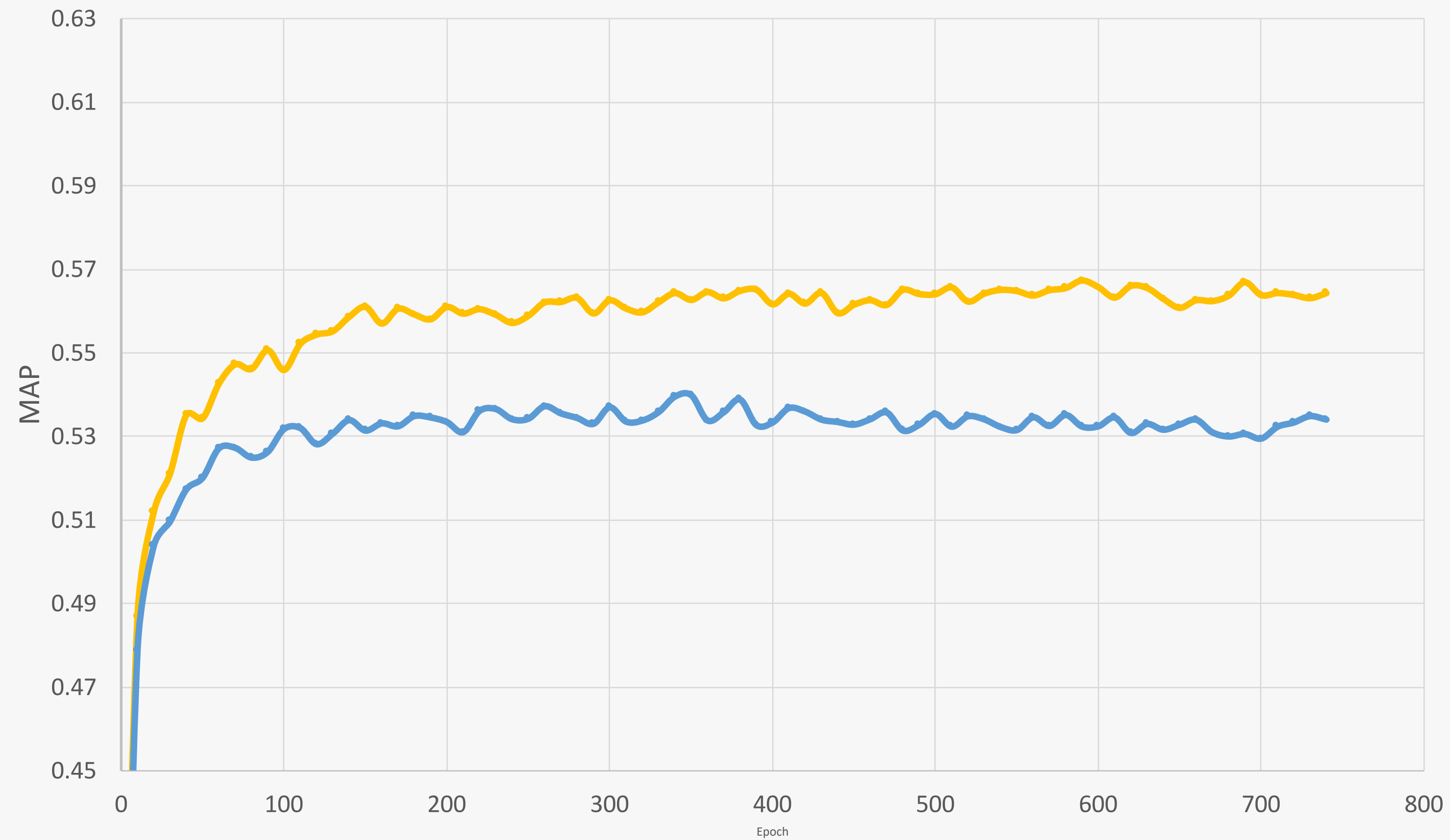


# N-gram Average Neural Network



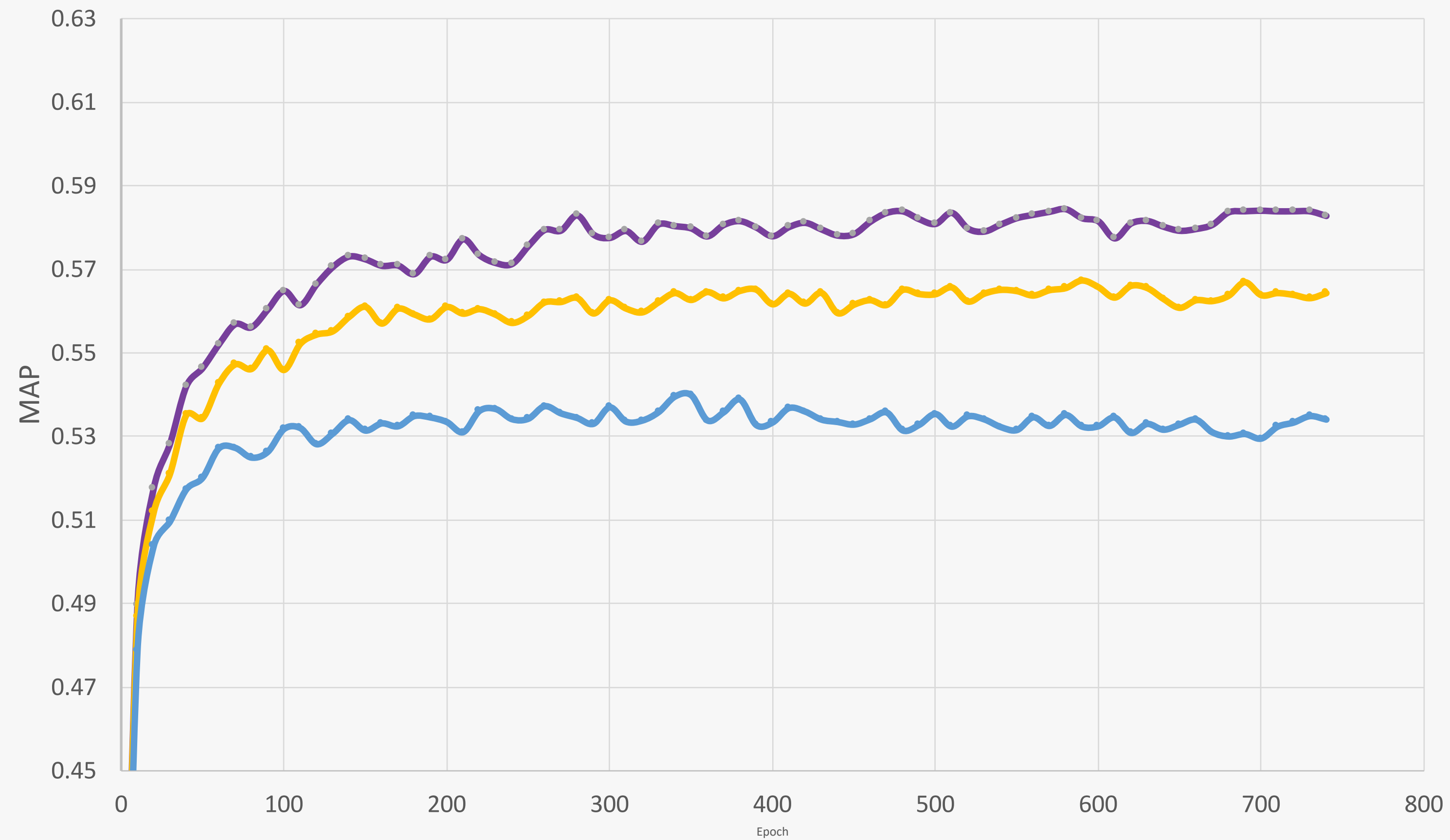
- Word Unigram baseline on small dataset

# N-gram Average Neural Network



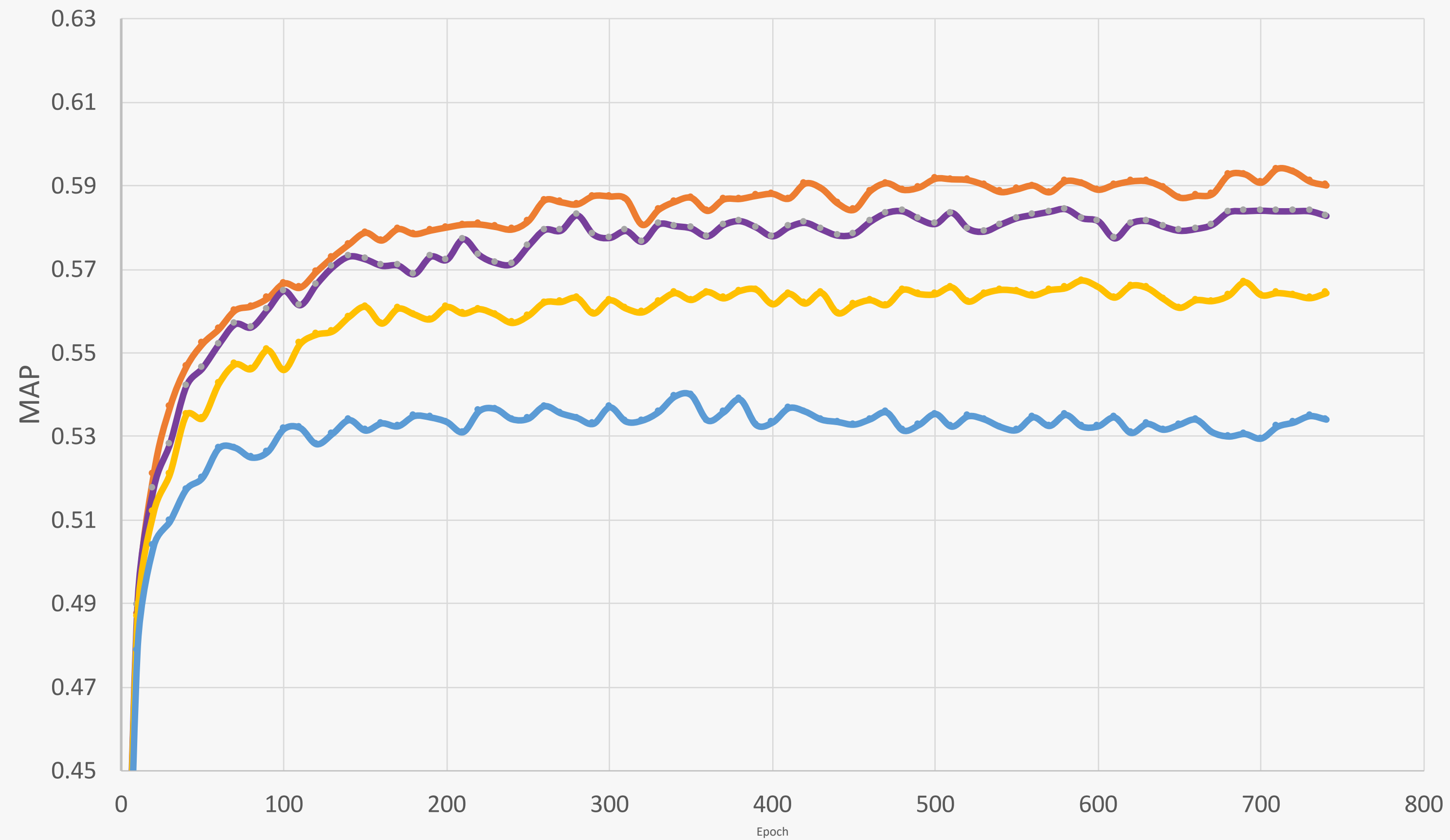
- Word Unigram baseline on small dataset
- Use more data

# N-gram Average Neural Network



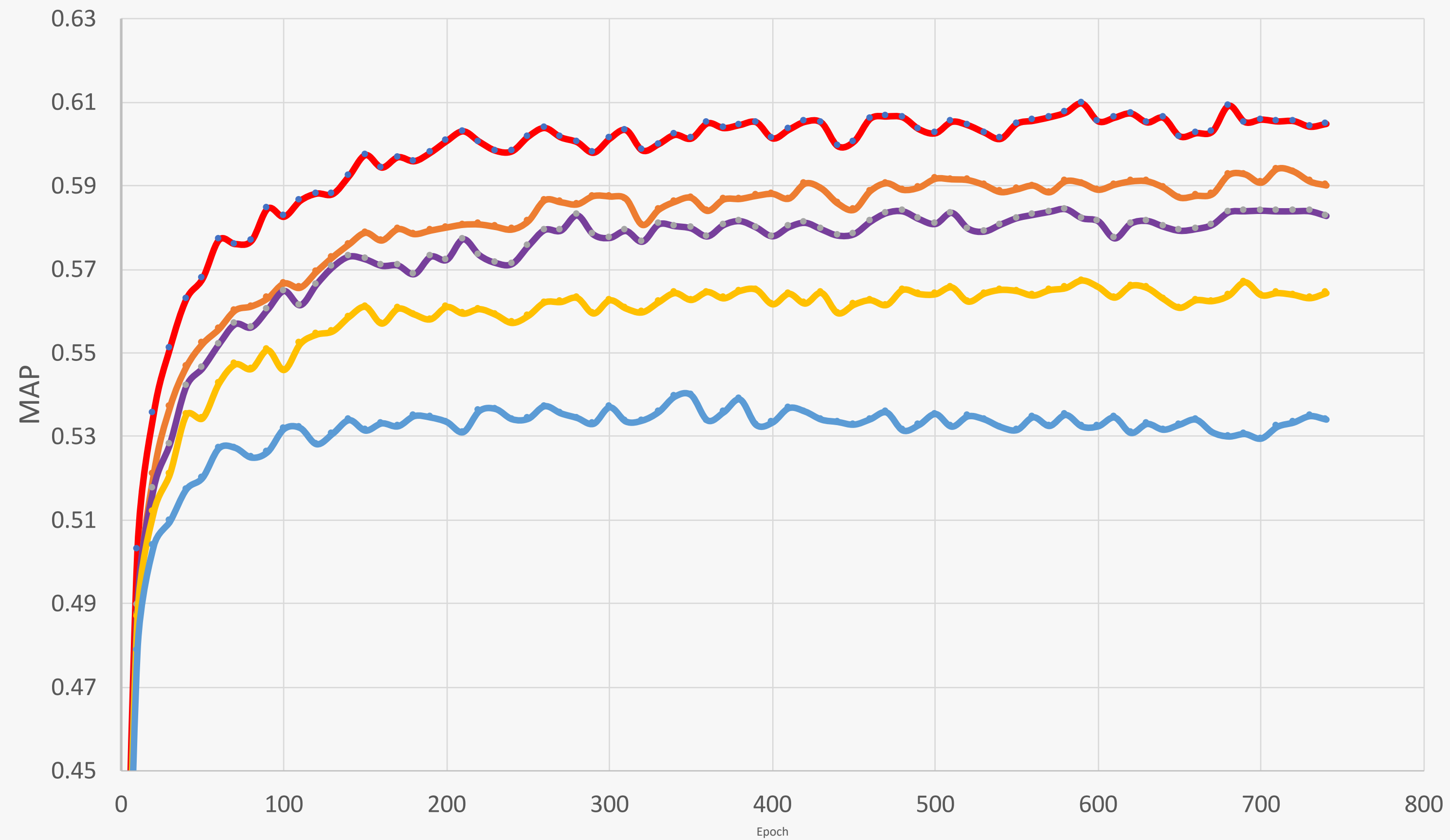
- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram

# N-gram Average Neural Network



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

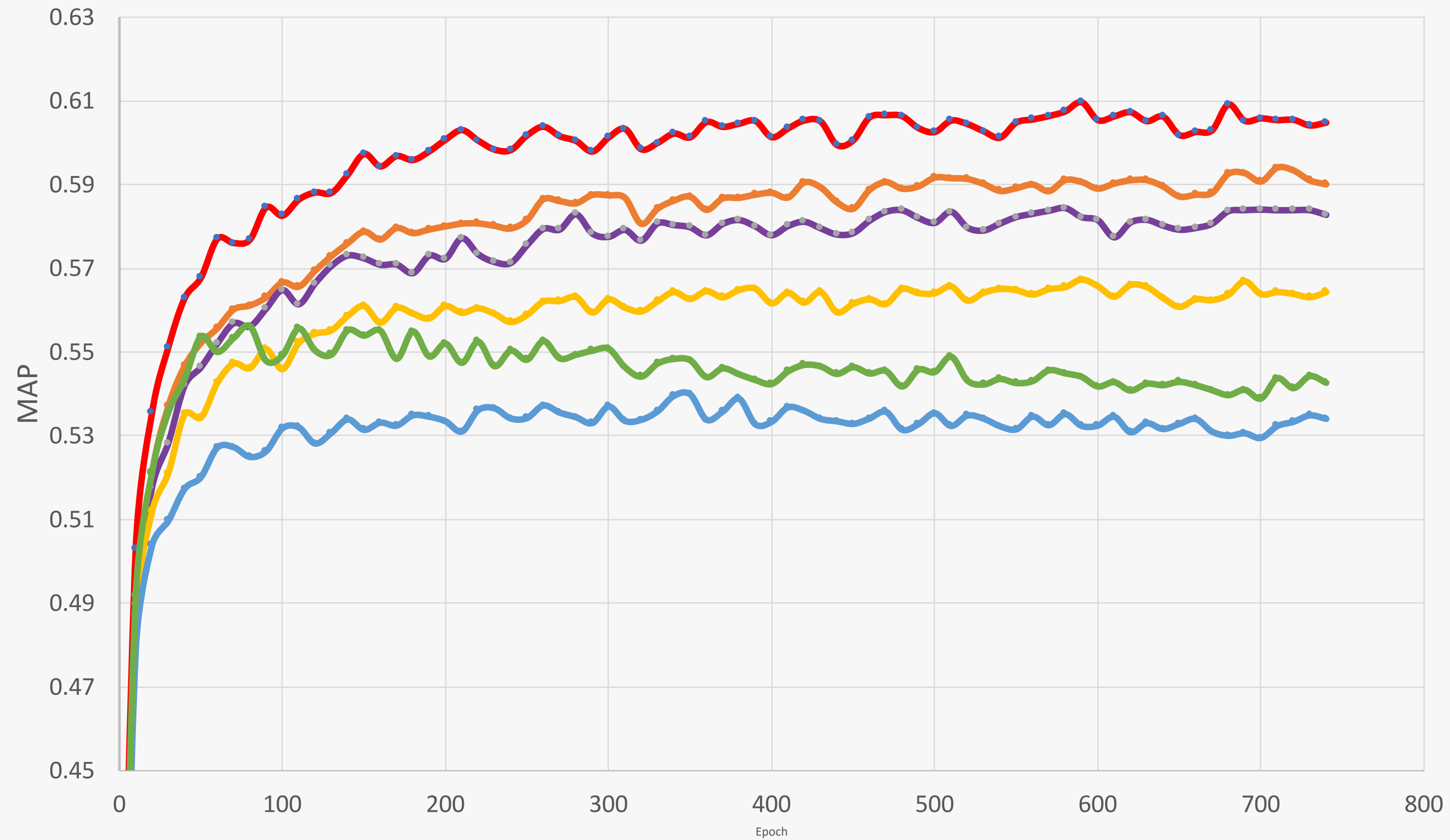
# N-gram Average Neural Network



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

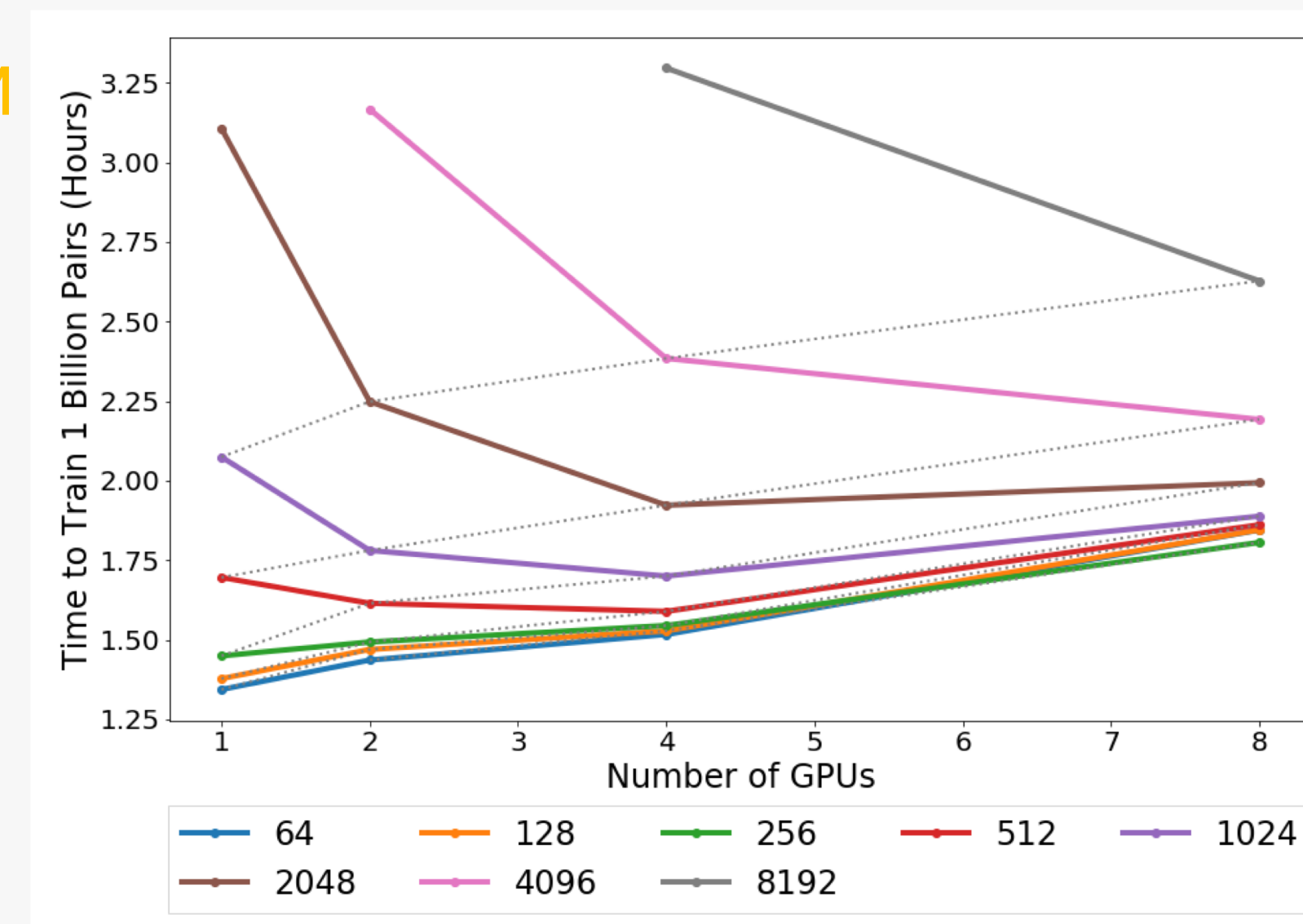
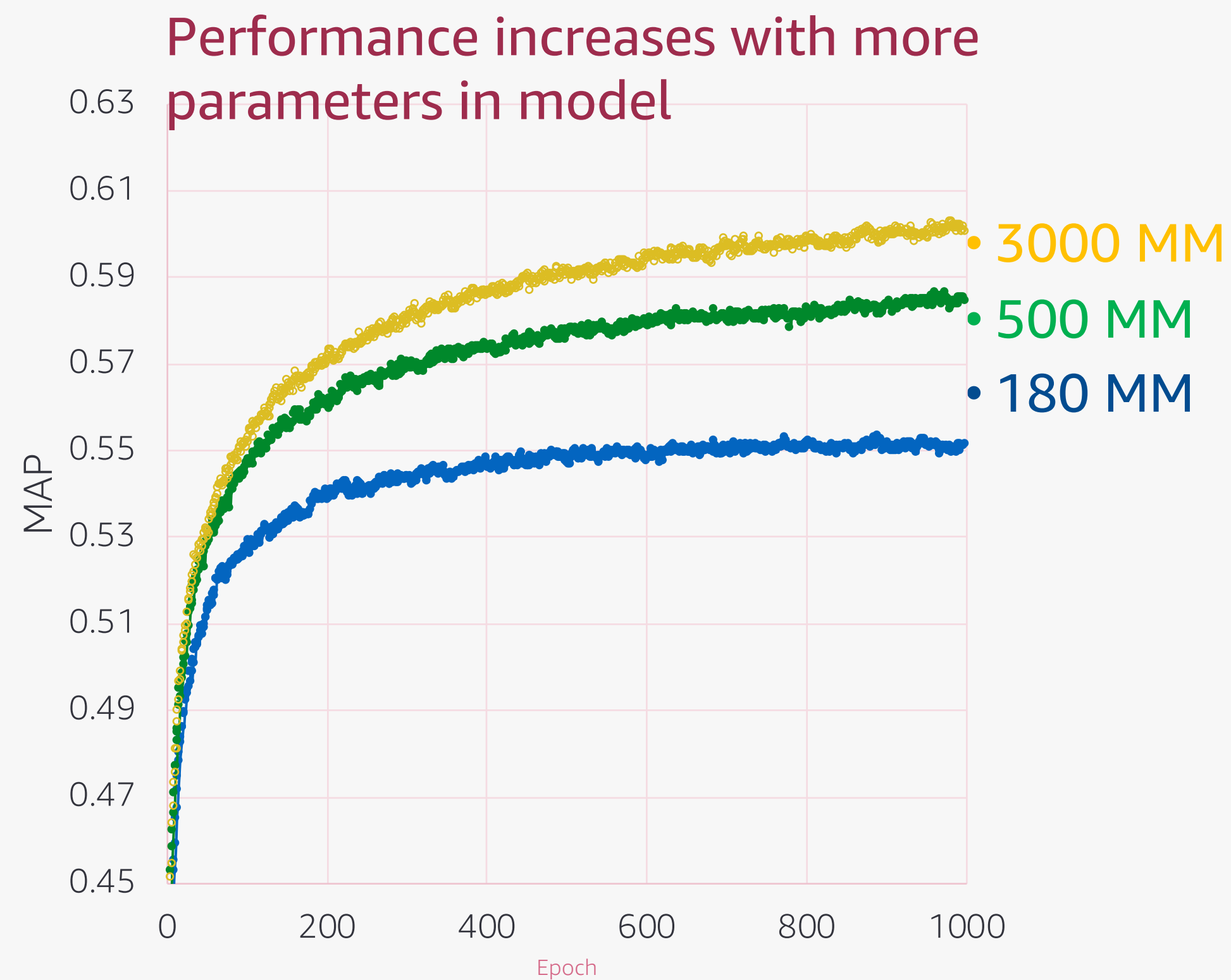
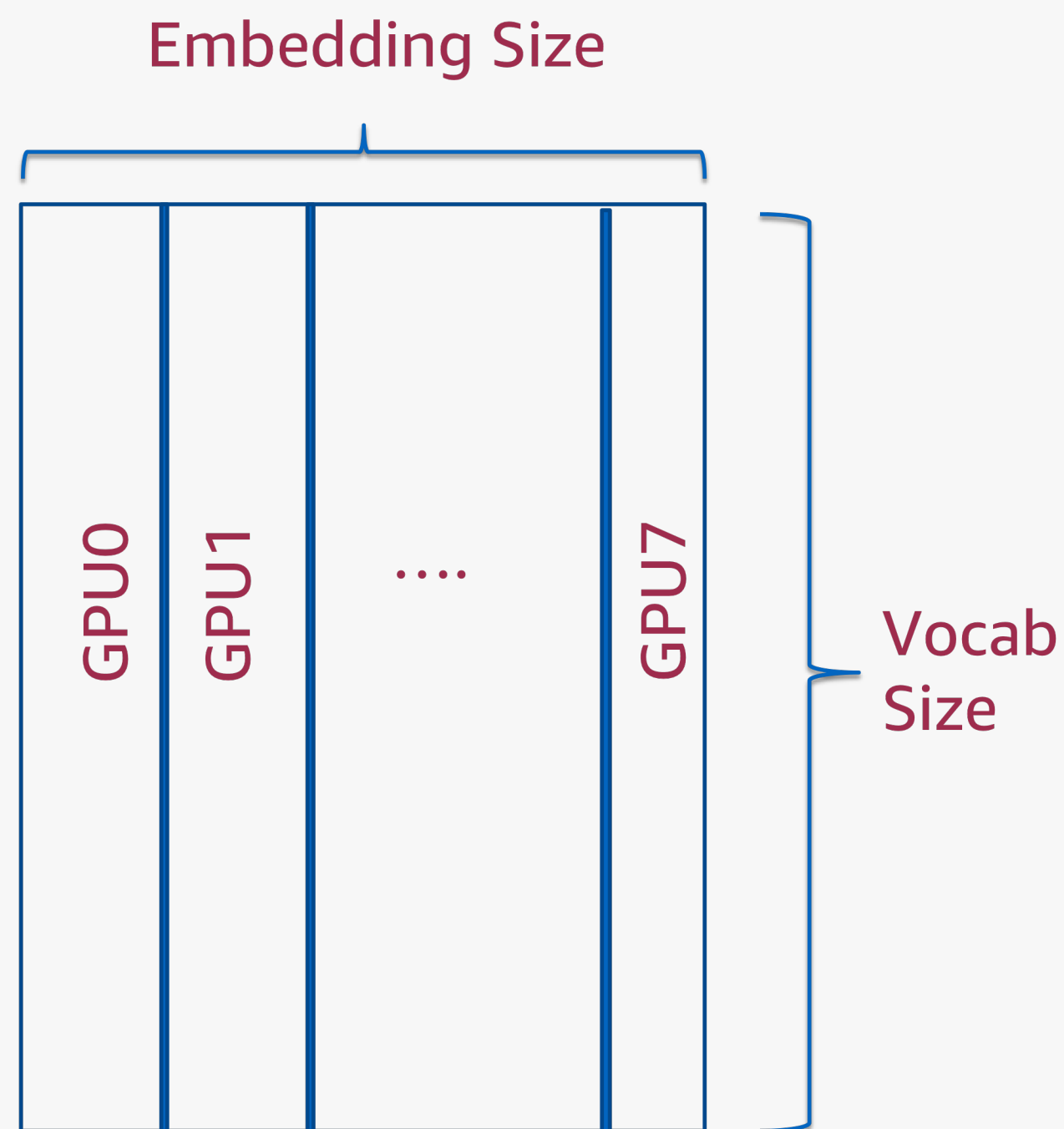


# N-gram Average Neural Network



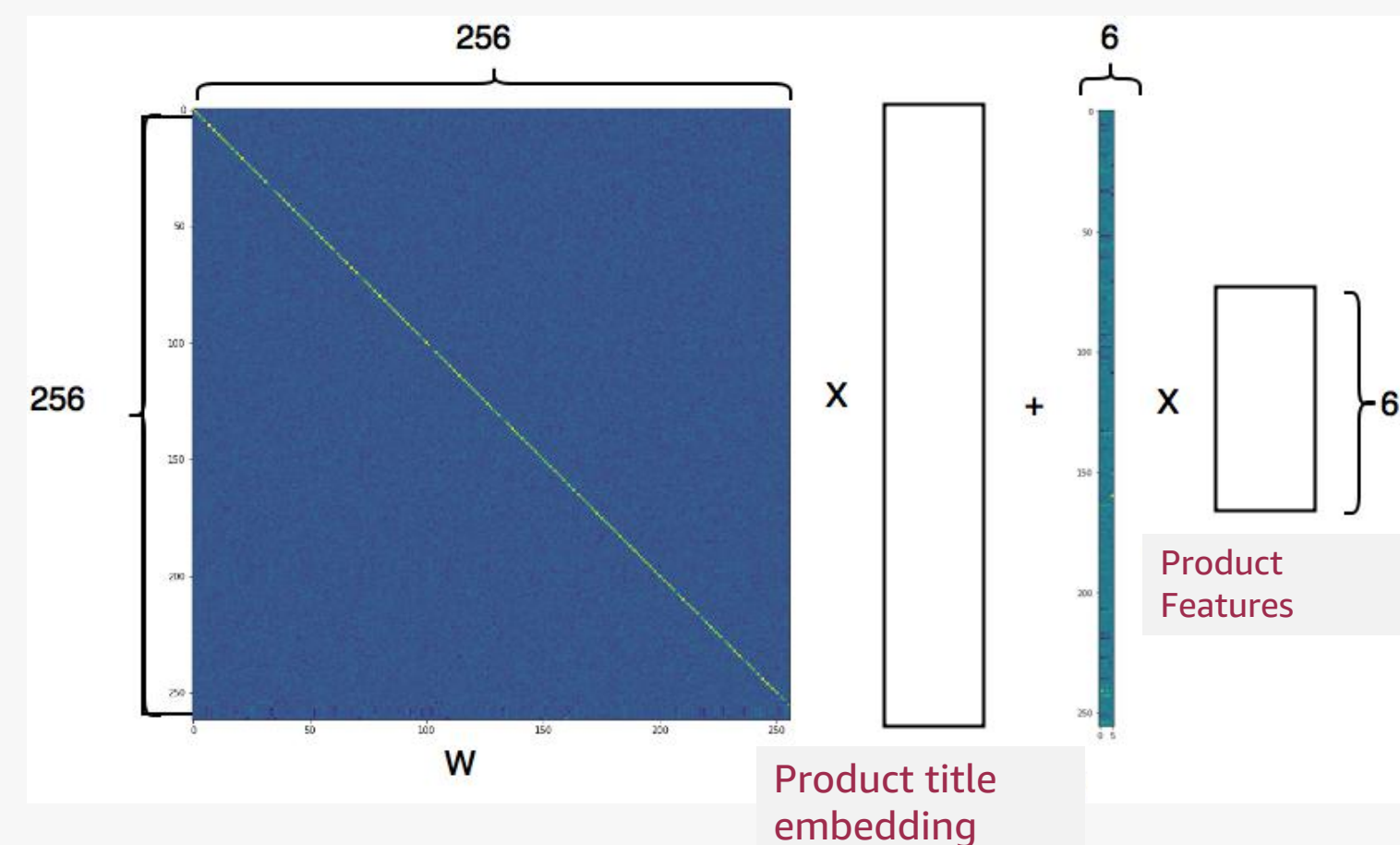
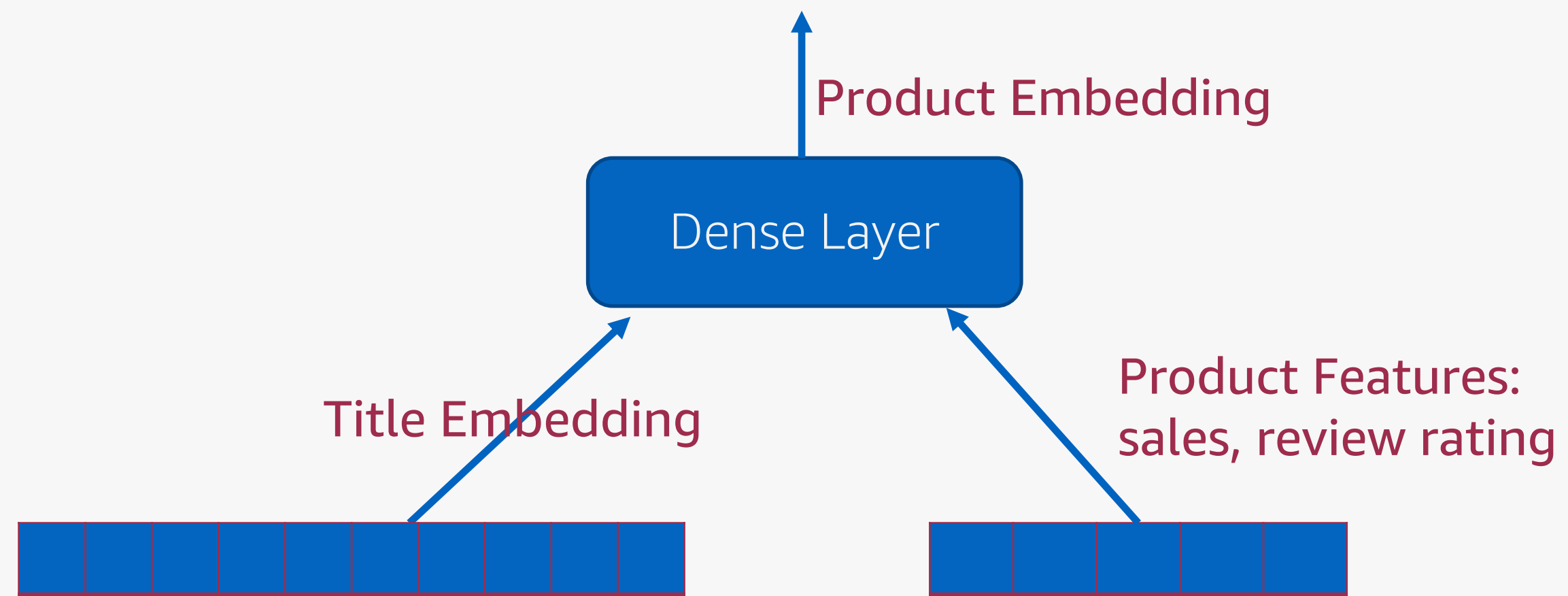
- Word Unigram baseline on small dataset
- Use more data
- Add Word Bigram
- Add Character Trigram
- Add OOV hashing for ngrams
- More tokens/parameters overfits on small dataset

# Increase Vocab Size by Model Parallelism

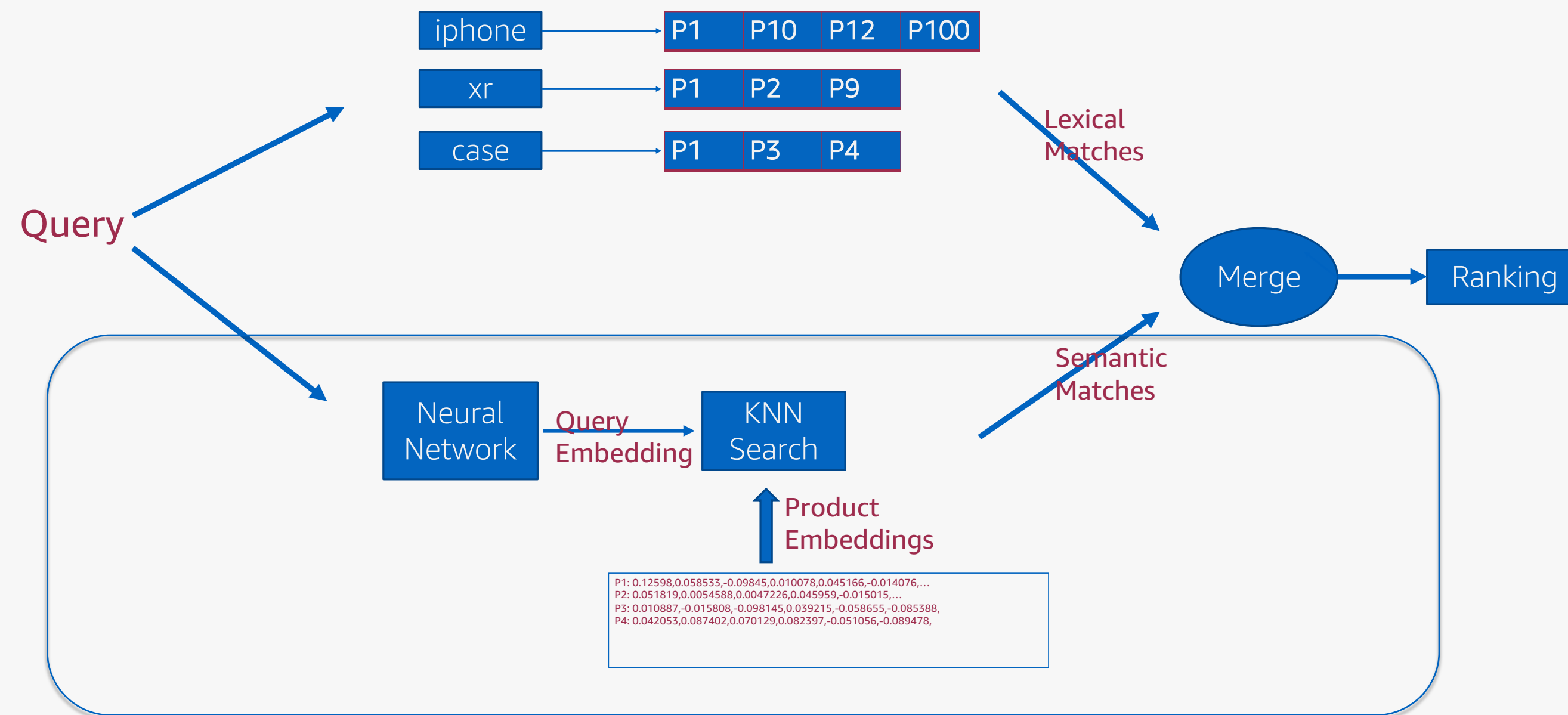


# Structured Product Features

- 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>