Project 3:
Classification of Reddit Posts

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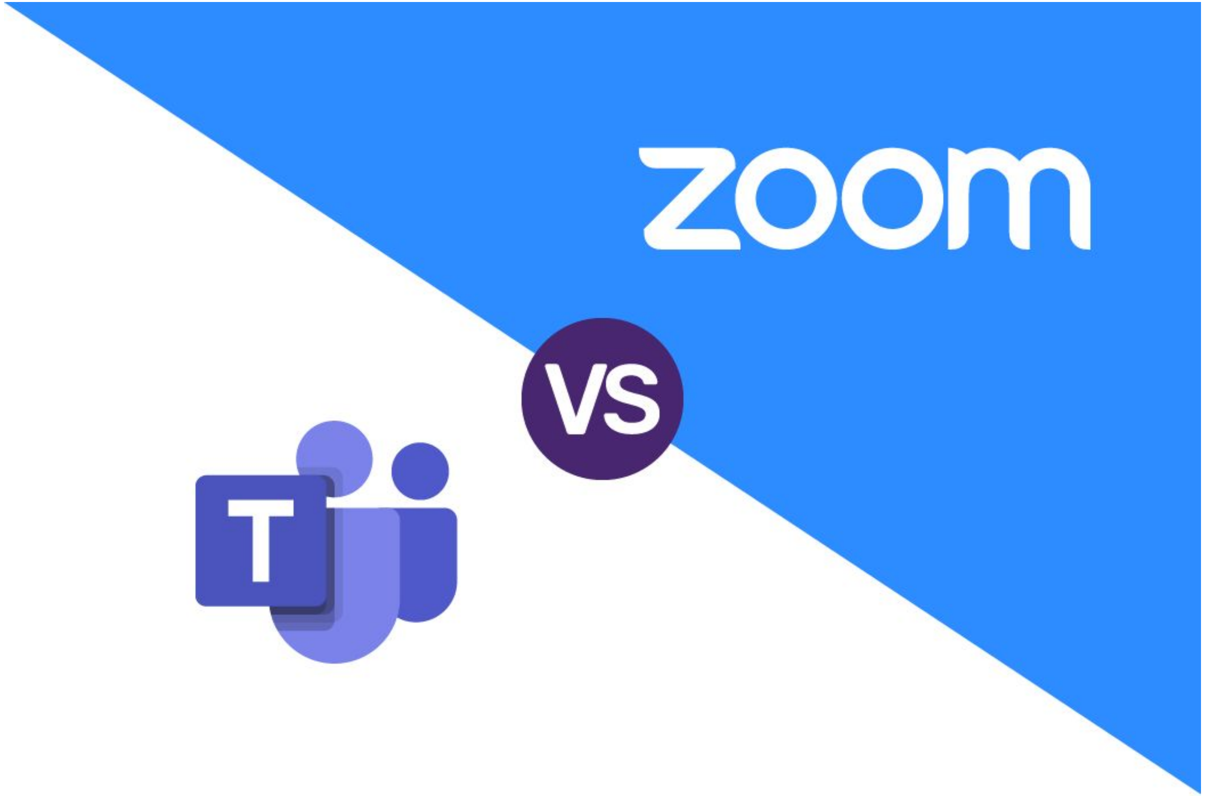
Yong Gui
Wee Hong

Introduction

Problem Statement



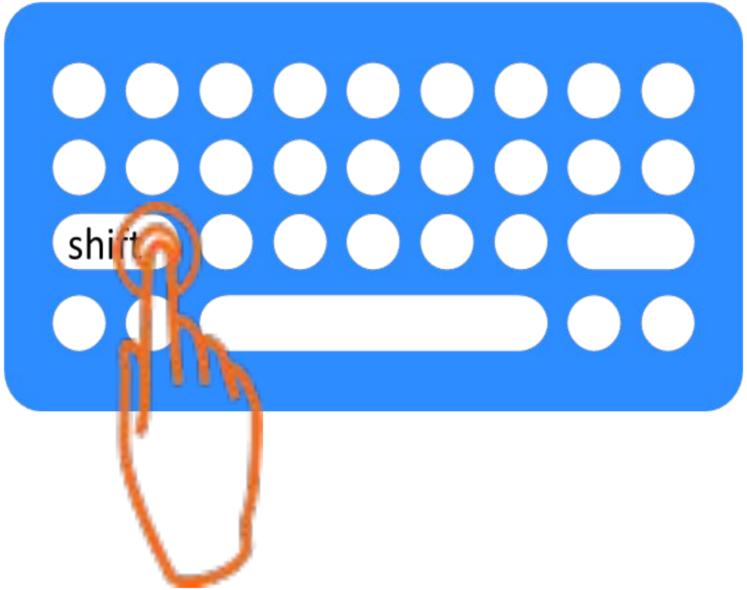
Collection
& Data Cleaning

Data Collection

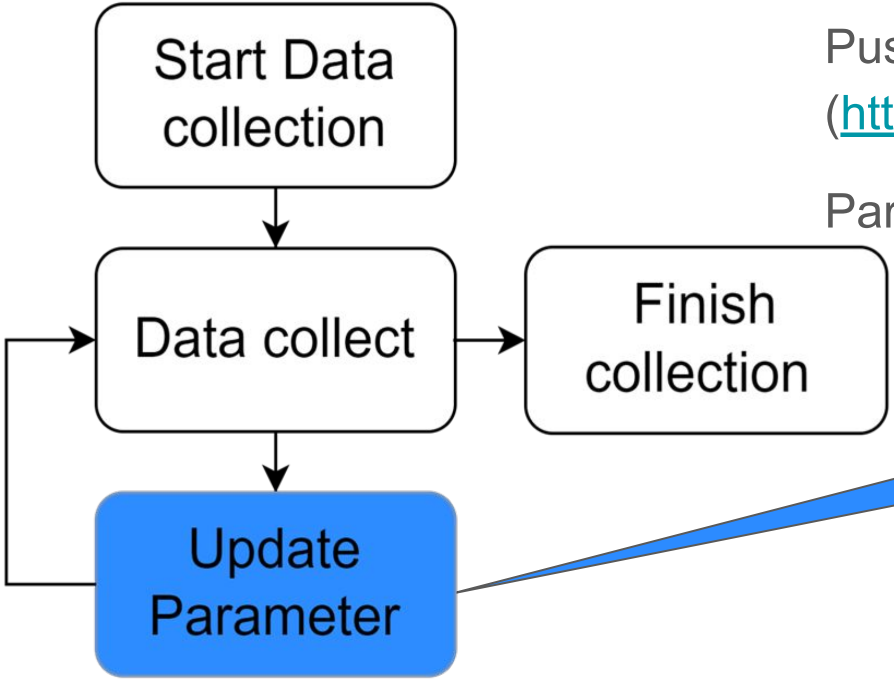
Pushshift API (https://github.com/pushshift/api)

Parameters:

1. subreddit: “Zoom” / “MicrosoftTeams”
2. size: 100 (maximum)
3. after: *epoch value*
   a. first value: 1577836800
   b. Data and Time (GMT): 1 Jan 2020, 00:00



Data Collection



Pushshift API
(https://github.com/pushshift/api)

Parameters:

1. subreddit
2. size
3. after

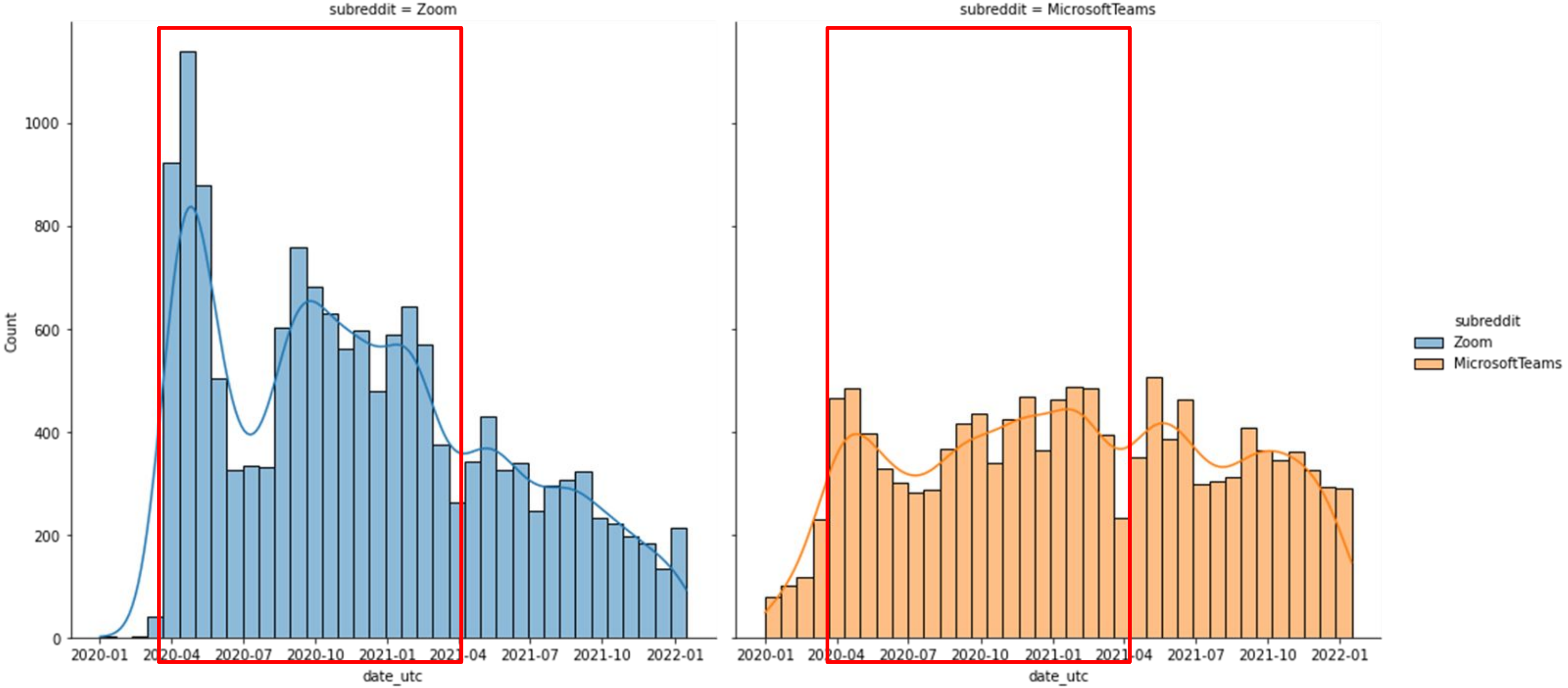
Cleaning

Cleaning of combined column of selftext and title:

- HTML Special entities (e.g. &amp)
- Hyperlinks
- Punctuation
- Whitespace
- Characters beyond Basic Multilingual Plane (BMP) of Unicode
- [removed]
- [deleted]

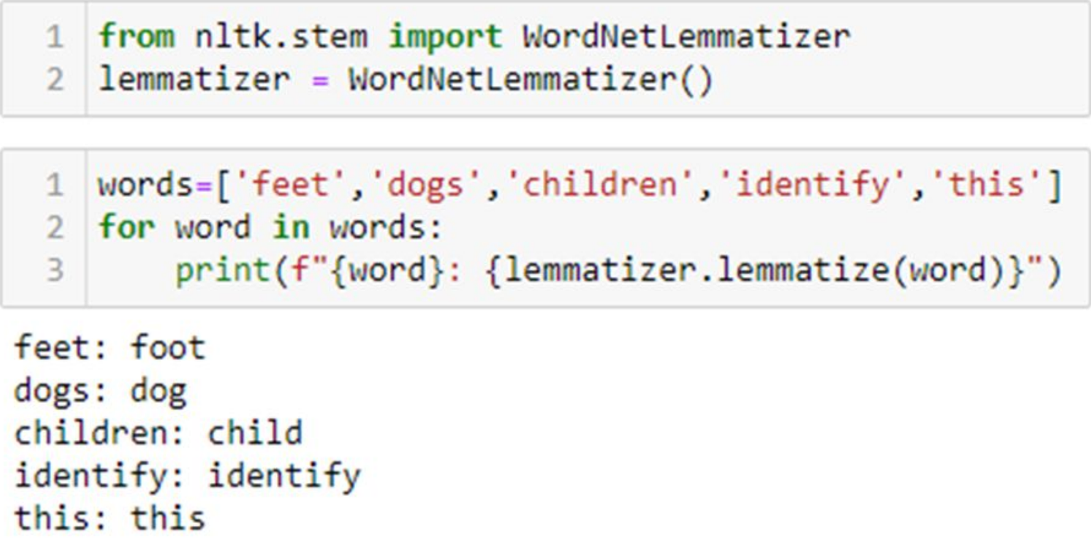
Time Period

Time Series graph for time frame selection



Preprocessing

Lemmatize



```
from nltk.stem import WordNetLemmatizer
lemmatizer = WordNetLemmatizer()
```

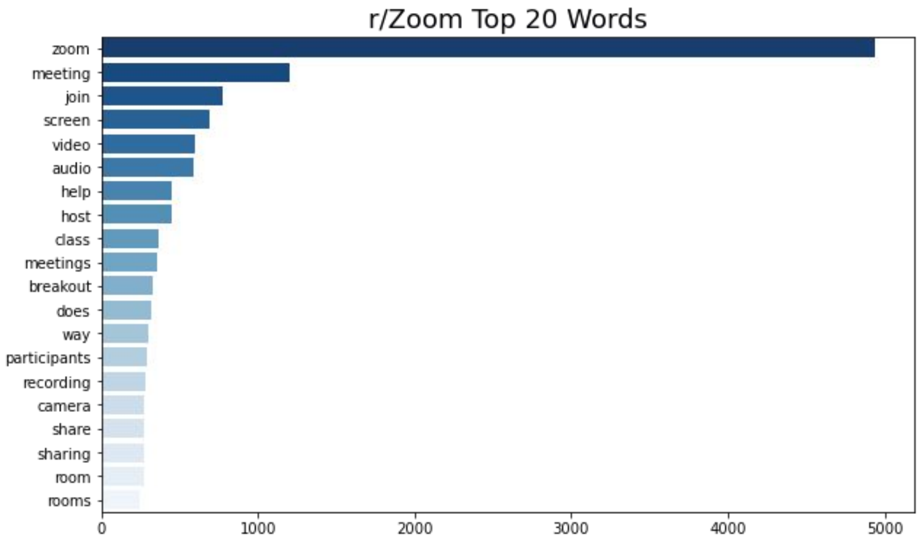
```
words=['feet','dogs','children','identify','this']
for word in words:
    print(f"{word}: {lemmatizer.lemmatize(word)}")
```

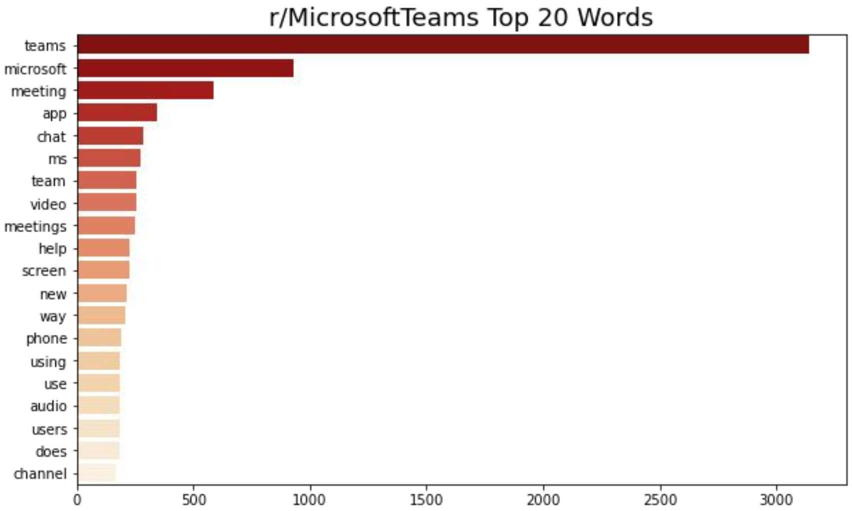
```
feet: foot
dogs: dog
children: child
identify: identify
this: this
```

**Image from*
https://karkig.medium.com/understand-stemming-and-lemmatization-with-python-nltk-package-77973a727040

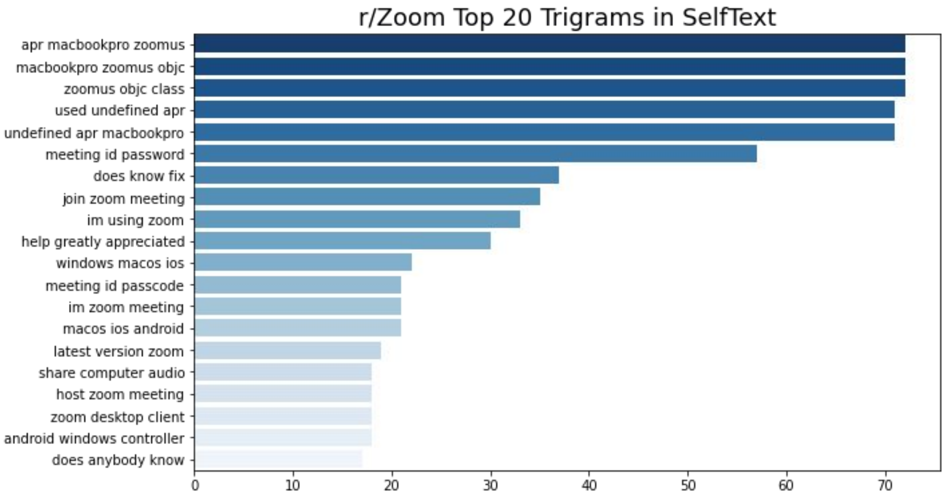
EDA

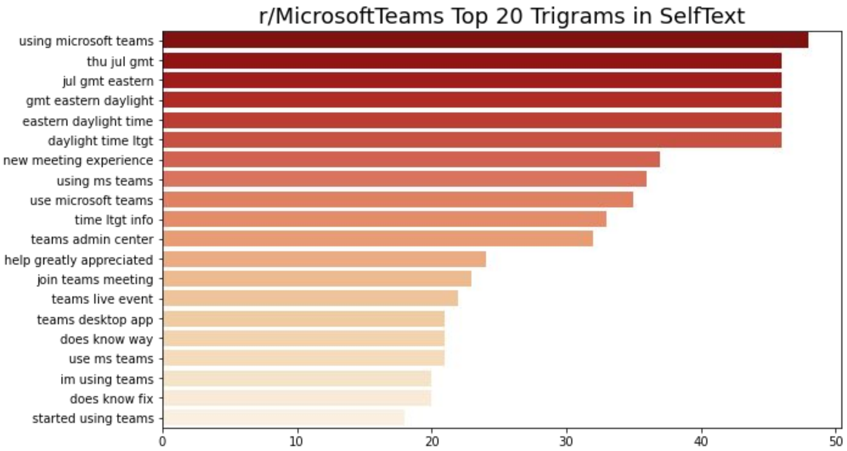
Analyzing Words in Title



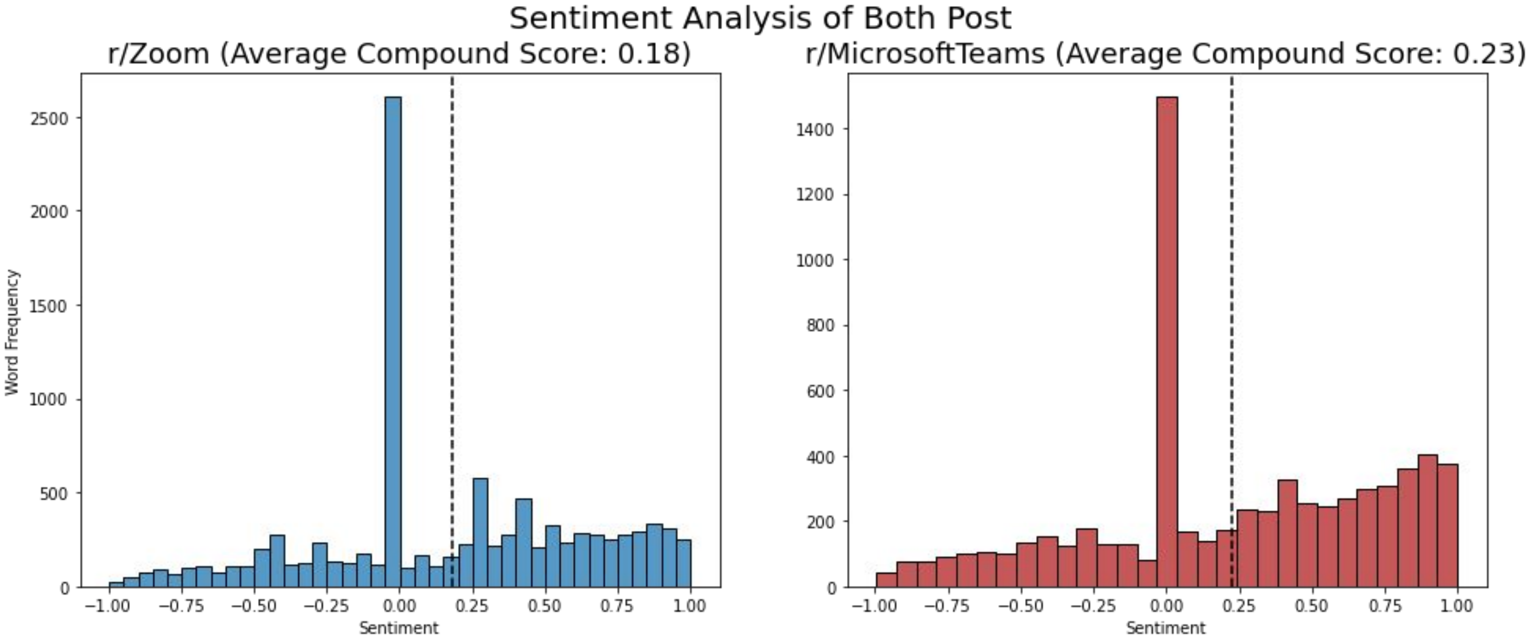


Analyzing Words in Selftext





Sentiment Analysis



Observation: Based on the average compound score computed, it seems to indicate that there are more positive posting on Team as compared to Zoom (this can also be observed in the distribution on the right.

Example of Negative & Positive Posting about Zoom

Negative Posting about Zoom:

zoom troubleshooting help alright i have a weird issue i have one student in a class of that can join the zoom meeting but is then dropped seconds after   no other student is experiencing this issue the teacher is not having any network lag the student can access and watch other classes just fine student is using a chromebook student is using a hotspot student hasnt indicated this has been a problem for the last month issue only occurs at am class father is adamant that the issue is with zoom or the teacher but i believe that can be ruled out since no other student is having the same problem the device can be ruled out as a problem since connection with other classes is fine my thought is the hotspot they are currently using a sprint mifi unlimited plan after some quick research i found that sprint deprioritizes connections after theyve used gb in a billing cycle i am assuming the am time is a busy network for the tower any other potential ideas what it could be

Positive Posting about Zoom:

trying to host workouts on zoom and i cant figure out how to play spotify in my meeting without screen share apparently there is a program called loopback that does exactly this but im hoping someone knows of a free option thanks in advance

Example of Negative & Positive Posting about Teams

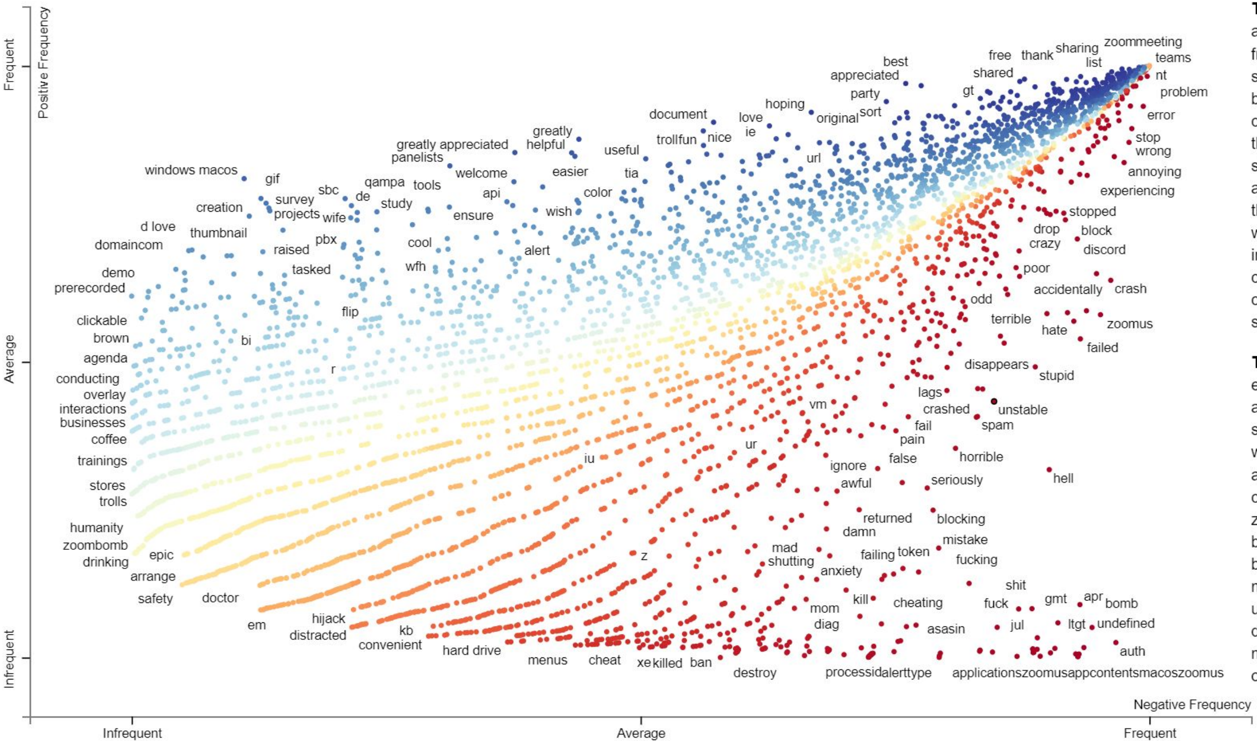
Negative Posting about Team:

problems when logging in on laptop with error code whenever i want to start ms teams i always get a error code and it asks me to restart the application whenever i restart my application it again gives me the same error if i log in on my other computer via google chrome or with a clean install it will work and i dont seem to have any problems does someone know whats the problem here

Positive Posting about Team:

generate report of all microsoft teams users hello is it possible to create a report of all active microsoft teams users from the teams admin portal ideally i would like to create a report that includes usernamesemails of all the microsoft teams users   thanks

Scattertext Visualization



Top Positive

appreciated
free
shared
best
create
thank
sharing
advance
thanks
webinar
invite
channel
channels
support

Top Negative

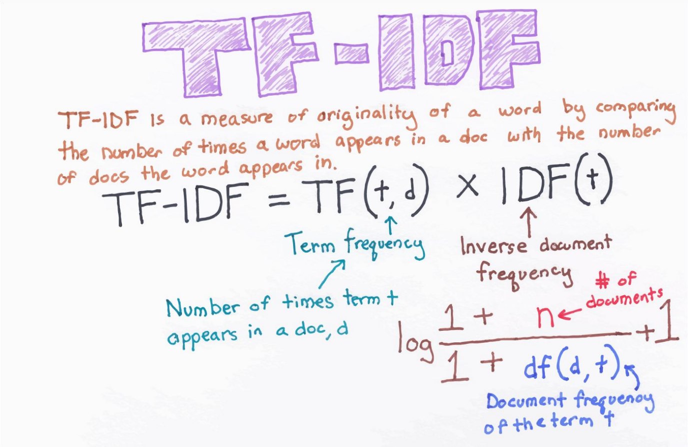
error
auth
stop
wrong
annoying
crash
zoomus
bomb
bad
missing
undefined
discord
macbookpro
objc

Characteristic

ipad
iphone
youtube
unmute
android
breakout
zoom
cohost
chromebook
teams
muted
zooms
covid
zoomus
powershell
nt
macbook
webinar
mute
airpods
reddit
app
spotify
facebook
muting
reinstalled
unmuted
reinstalling
onprem
screenshare

Modelling & Evaluation

Text Vectorization



TF-IDF

TF-IDF is a measure of originality of a word by comparing the number of times a word appears in a doc with the number of docs the word appears in.

$$\text{TF-IDF} = \underbrace{TF(t,d)}_{\text{Term frequency}} \times \underbrace{IDF(t)}_{\text{Inverse document frequency}}$$

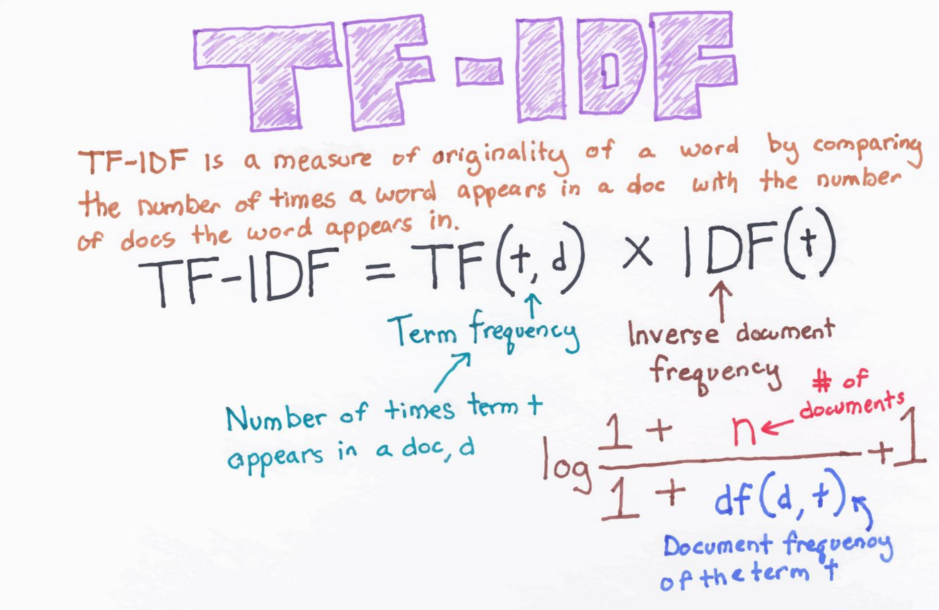
Number of times term t appears in a doc, d

$$\log\frac{1+n}{1+df(d,t)}+1$$

# of documents

Document frequency of the term t

Text Vectorization - TfidfVectorizer



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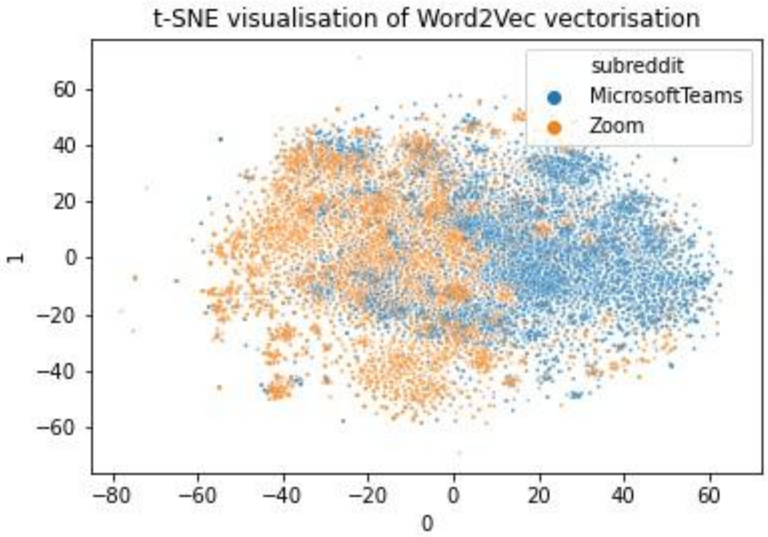
$$\text{TF-IDF} = \text{TF}(t, d) \times \text{IDF}(t)$$

$$\log \frac{1 + n}{1 + df(d, t)} + 1$$

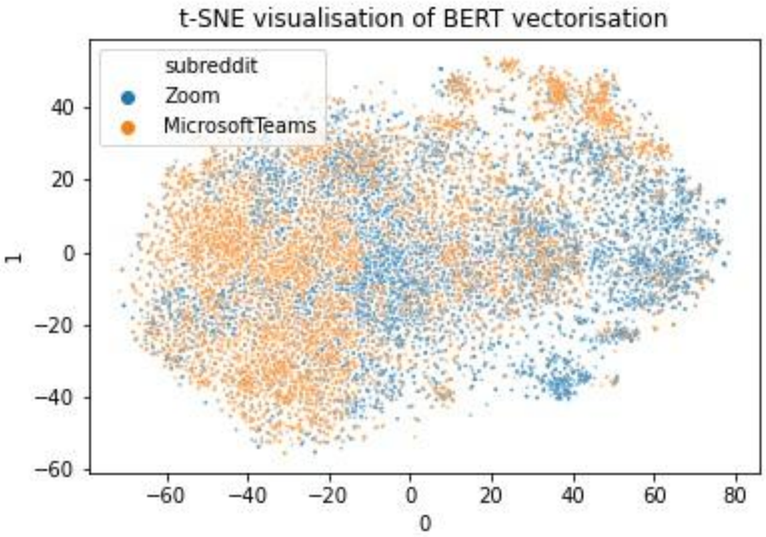
Term frequency
Number of times term t appears in a doc, d
Inverse document frequency
# of documents
Document frequency of the term t

	I	like	cats	me
I like cats	0.1	0.1	0.1	0
Cats like me	0	0.1	0.1	0.1

Further EDA



t-SNE visualisation of Word2Vec vectorisation



t-SNE visualisation of BERT vectorisation

We can also employ t-SNE for dimensionality reduction. We observe that the clusters are denser when using Word2Vec and clusters are better separated.

Further EDA

We will experiment with 3 classifiers:

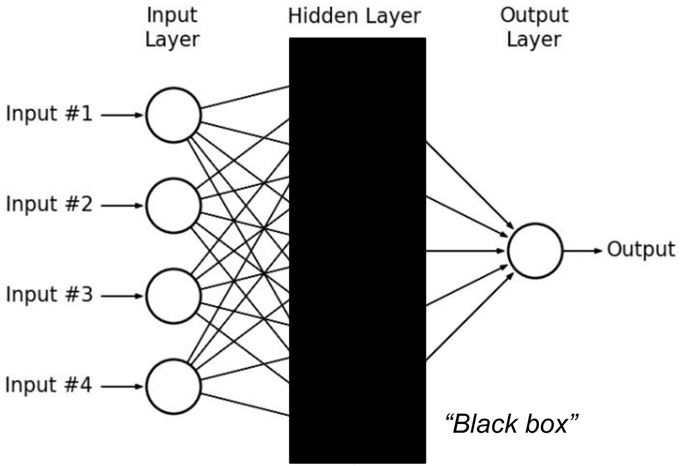
- Logistic Regression (LR)
- Random Forest (RF)
- MultiLayer Perceptron Classifier (MLP)

Baseline:

Checking whether submission contains the word “microsoft” or “teams”

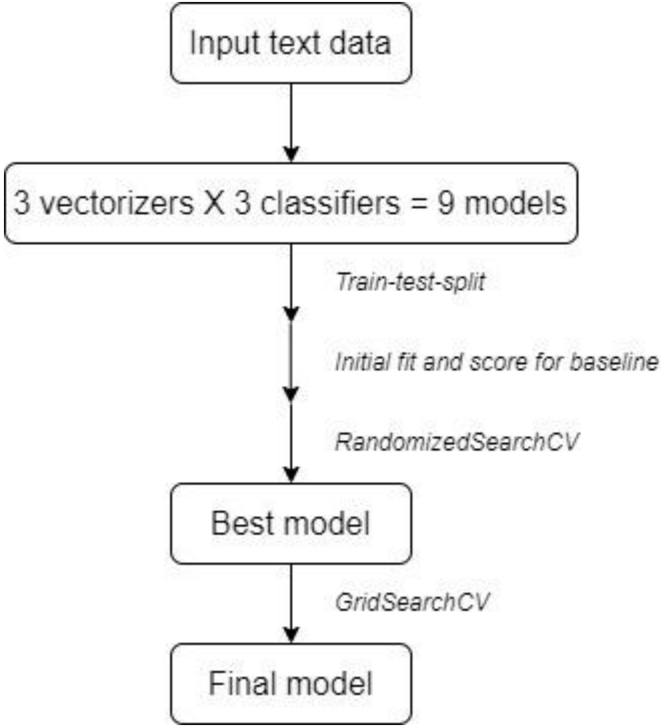
Baseline score: **87%**

MLP Architecture



“Black box”

Data Modeling



Input text data

3 vectorizers X 3 classifiers = 9 models

Train-test-split

Initial fit and score for baseline

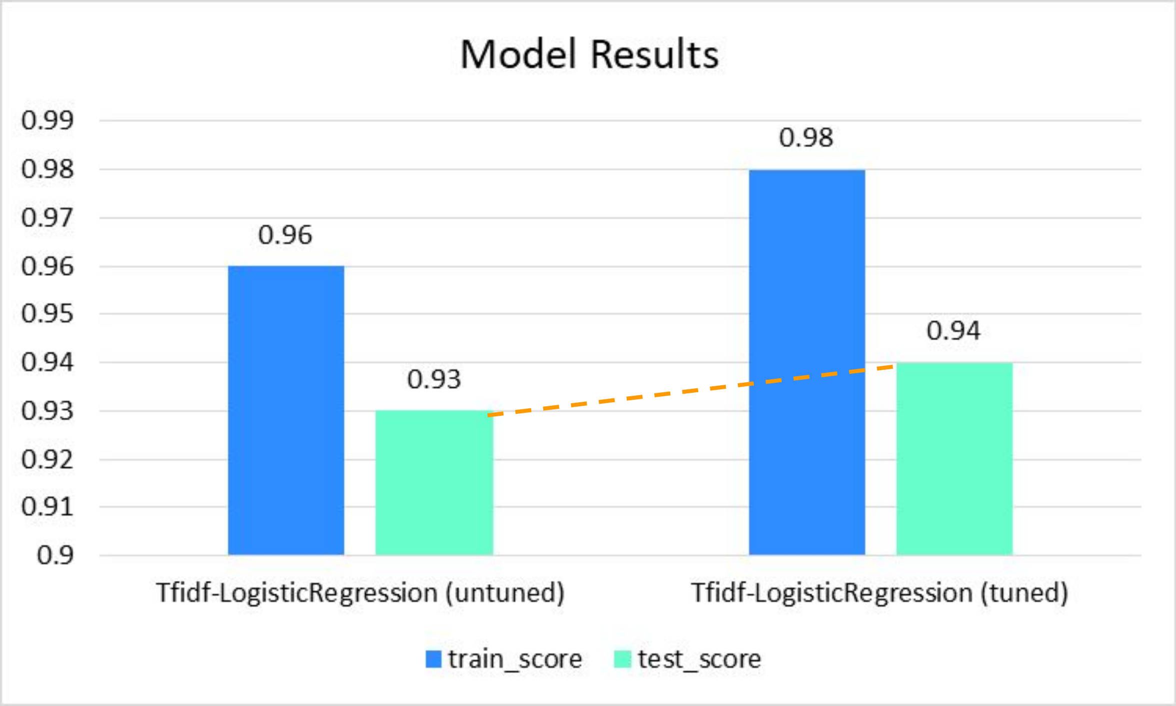
RandomizedSearchCV

Best model

GridSearchCV

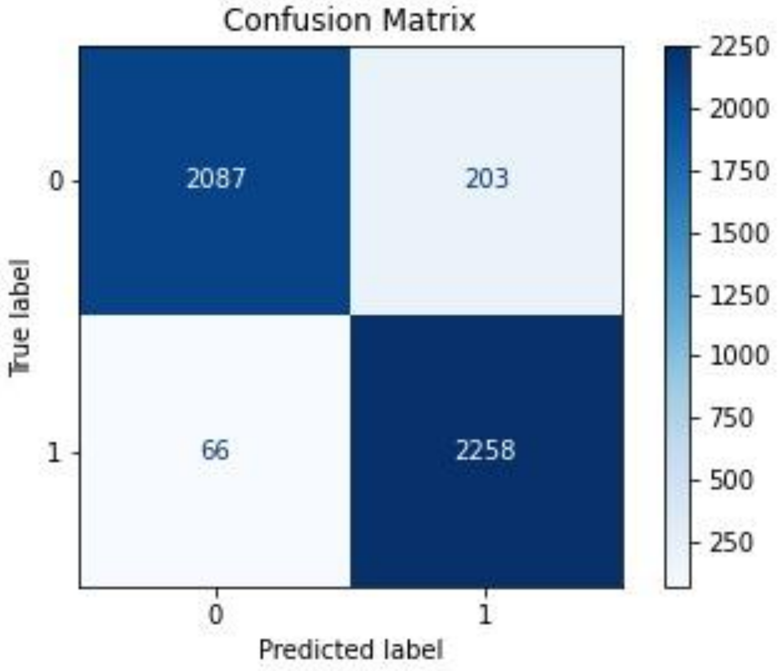
Final model

Model Evaluation



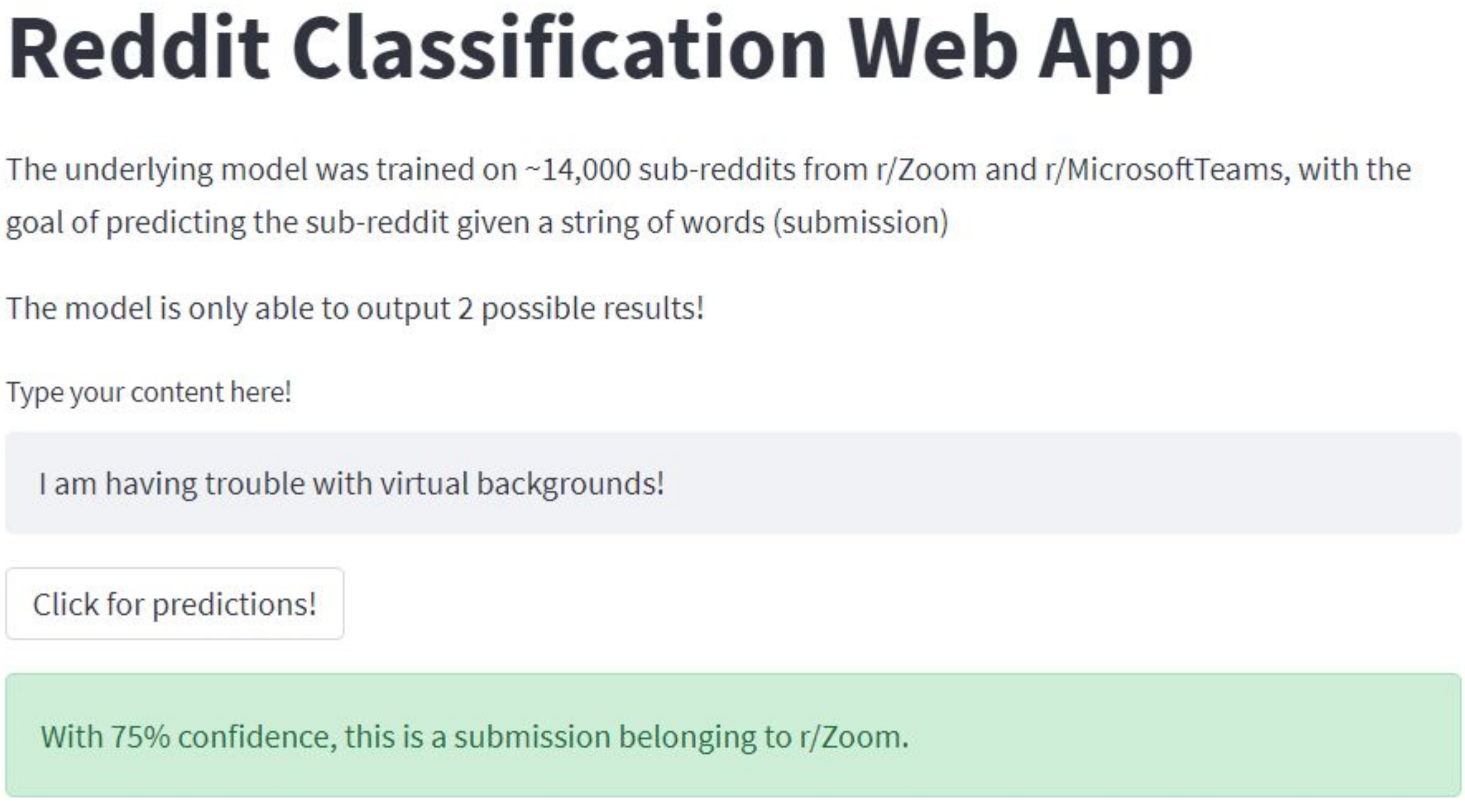
We managed to improve our score by ~1% which is decent, given that our untuned model already has 93% accuracy!

Model Evaluation



	Confidence
Predicting MST	88%
Predicting Zoom	84%

Deploying the Model



Reddit Classification Web App

The underlying model was trained on ~14,000 sub-reddits from r/Zoom and r/MicrosoftTeams, with the goal of predicting the sub-reddit given a string of words (submission)

The model is only able to output 2 possible results!

Type your content here!

I am having trouble with virtual backgrounds!

With 75% confidence, this is a submission belonging to r/Zoom.

Conclusion

Recommendation for Software Development Team

Pain points for users

1. Stopped
2. Drop
3. Crash
4. Reinstall
5. Error

Keep an eye on

Discord

a VoIP, instant messaging and digital distribution platform

zoom

Recommendation for Digital Marketing Team

Top words for Zoom

1. Zoom
2. Password
3. Host
4. Join
5. Participant
6. Class
7. Virtual
8. Breakout
9. Room
10. Id

Top words for MST

1. Team
2. Guest
3. Microsoft
4. Channel
5. User
6. Assignment
7. Call
8. Notification
9. Chat
10. Feature

Zooming ahead

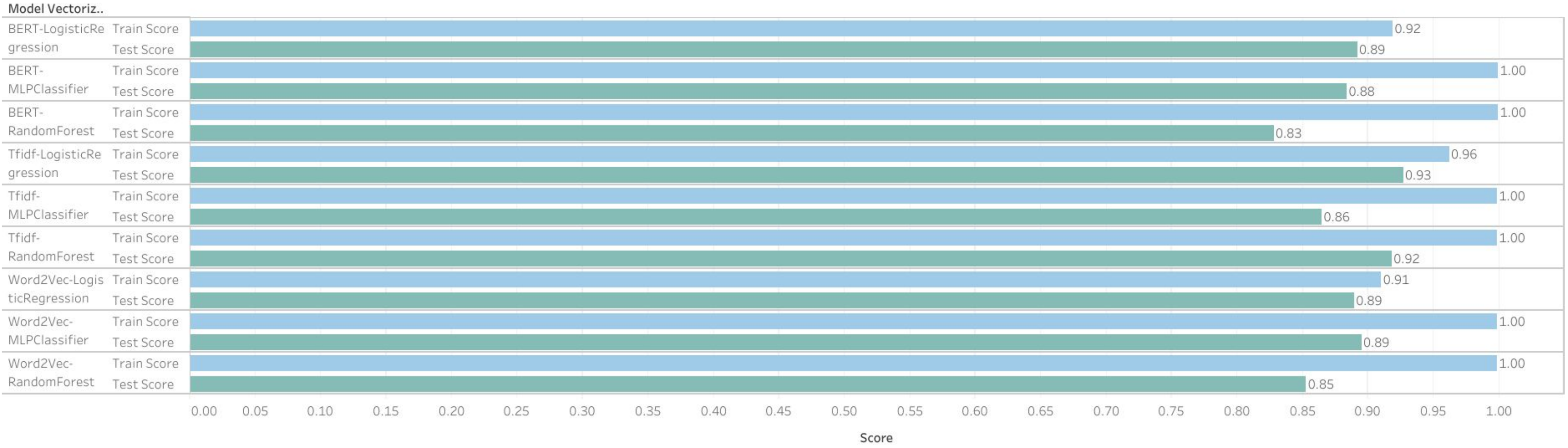
Refining our current model

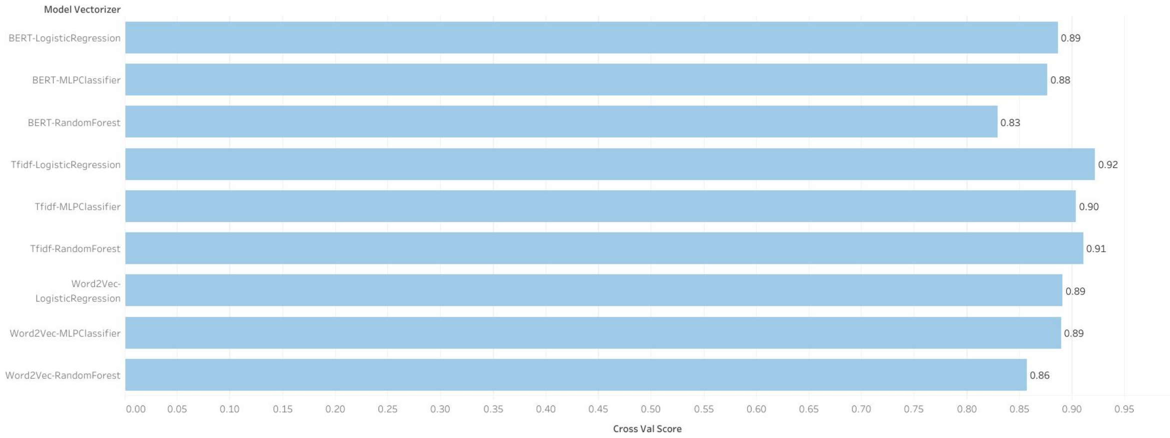
Training our model to recognise words unique to subreddit.

Running the refined model on other competitor pairing

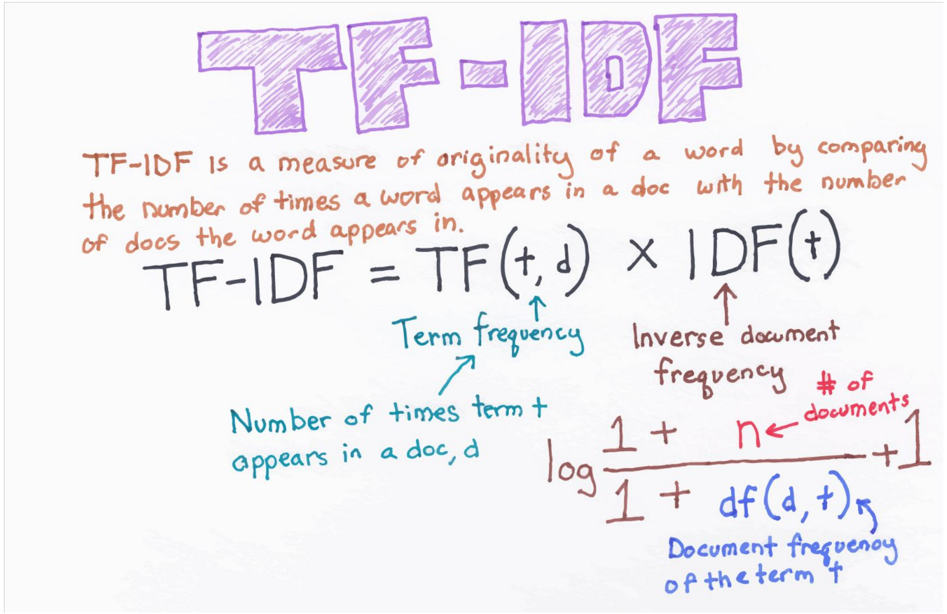
Zoom vs Google, Zoom vs Skype

Annex


Model Vectoriz..
BERT-LogisticRegression
Train Score 0.92
Test Score 0.89
BERT-MLPClassifier
Train Score 1.00
Test Score 0.88
BERT-RandomForest
Train Score 1.00
Test Score 0.83
Tfidf-LogisticRegression
Train Score 0.96
Test Score 0.93
Tfidf-MLPClassifier
Train Score 1.00
Test Score 0.86
Tfidf-RandomForest
Train Score 1.00
Test Score 0.92
Word2Vec-LogisticRegression
Train Score 0.91
Test Score 0.89
Word2Vec-MLPClassifier
Train Score 1.00
Test Score 0.89
Word2Vec-RandomForest
Train Score 1.00
Test Score 0.85
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
Score


Model Vectorizer
BERT-LogisticRegression 0.89
BERT-MLPClassifier 0.88
BERT-RandomForest 0.83
Tfidf-LogisticRegression 0.92
Tfidf-MLPClassifier 0.90
Tfidf-RandomForest 0.91
Word2Vec-LogisticRegression 0.89
Word2Vec-MLPClassifier 0.89
Word2Vec-RandomForest 0.86
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95
Cross Val Score

Text Vectorization and Further EDA - TfidfVectorizer



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$$\log \frac{1 + n}{1 + df(d, t)} + 1$$

TF-IDF
Term frequency
Number of times term t appears in a doc, d
Inverse document frequency
# of documents
Document frequency of the term t

	I	like	cats	me
I like cats	0.1	0.1	0.1	0
Cats like me	0	0.1	0.1	0.1

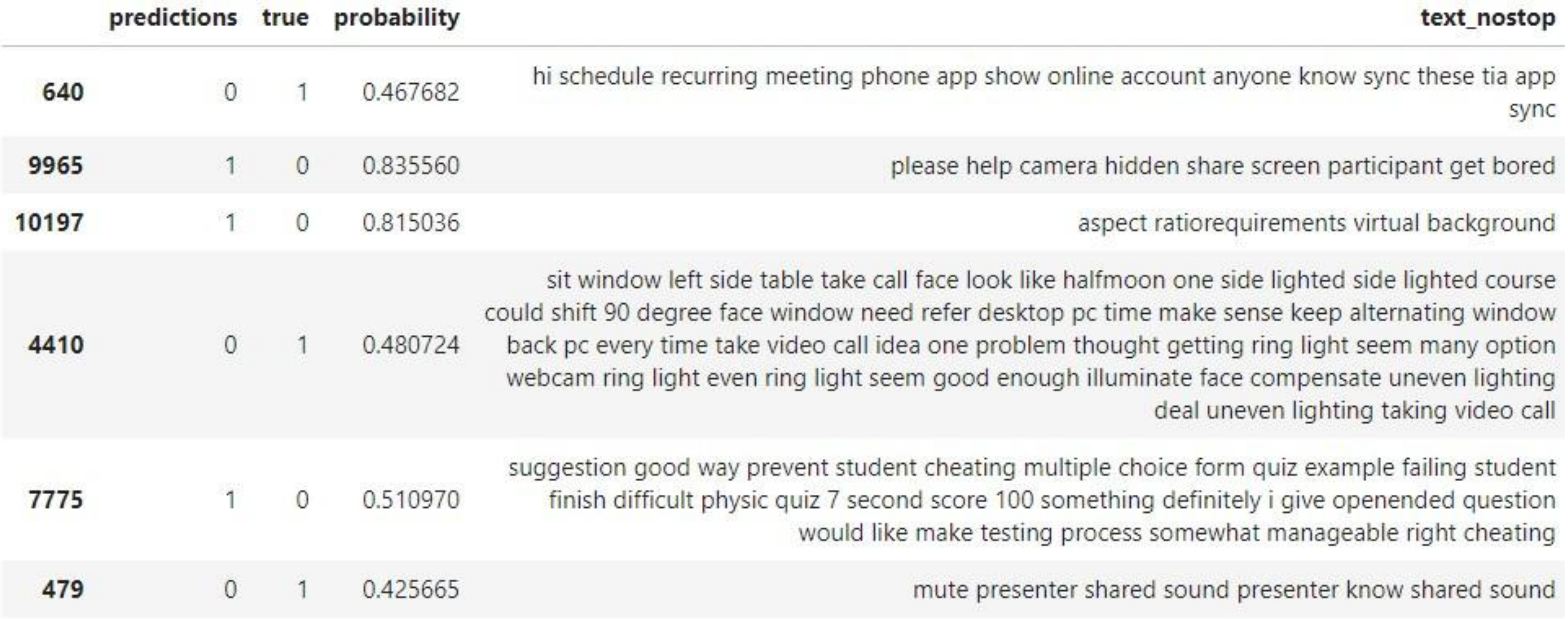
Text Vectorization and Further EDA - Word2Vec

	Dim 1	Dim 2	…	Dim 300
I like cats	0.01	0.01	…	0.01
Cats like me	0.01	0.01	…	0.01

Text Vectorization and Further EDA -
Bi-directional Encoder Representations from Transformers

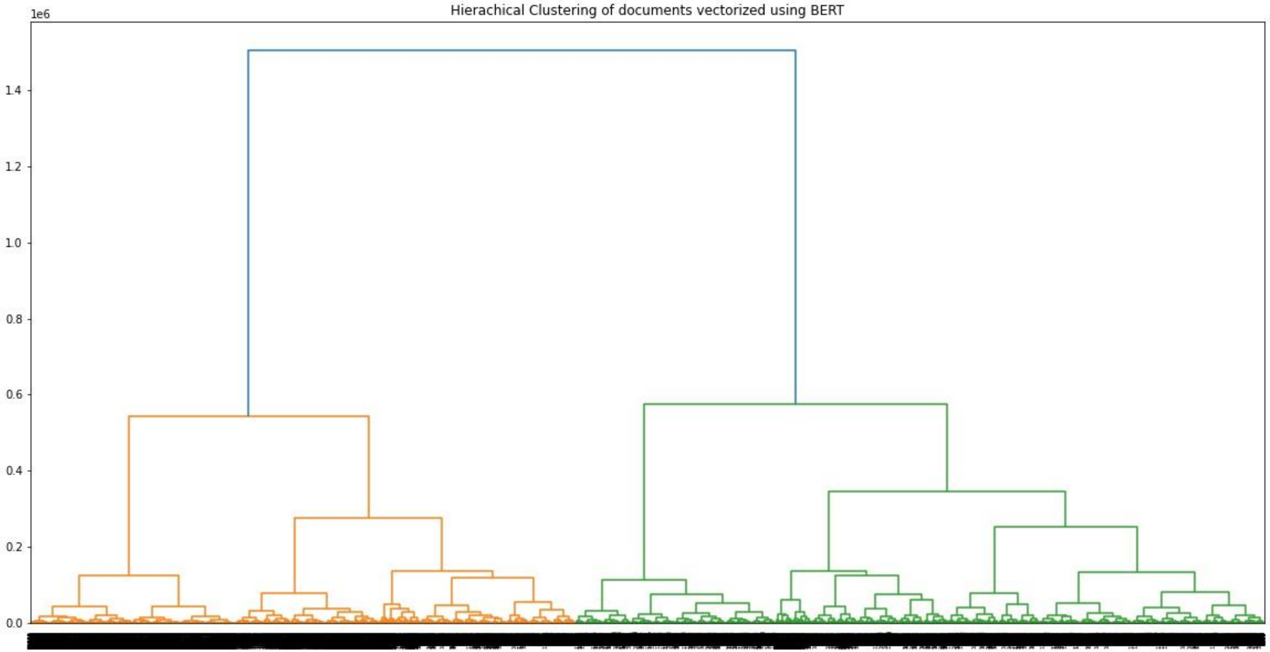
	Dim 1	Dim 2	…	Dim 768
I like cats	0.01	0.01	…	0.01
Cats like me	0.01	0.01	…	0.01

Exploring Misclassifications



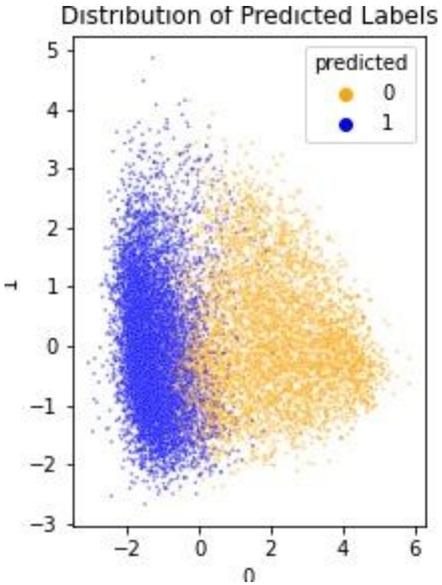
	predictions	true	probability	text_nostop
640	0	1	0.467682	hi schedule recurring meeting phone app show online account anyone know sync these tia app sync
9965	1	0	0.835560	please help camera hidden share screen participant get bored
10197	1	0	0.815036	aspect ratiorequirements virtual background
4410	0	1	0.480724	sit window left side table take call face look like halfmoon one side lighted side lighted course could shift 90 degree face window need refer desktop pc time make sense keep alternating window back pc every time take video call idea one problem thought getting ring light seem many option webcam ring light even ring light seem good enough illuminate face compensate uneven lighting deal uneven lighting taking video call
7775	1	0	0.510970	suggestion good way prevent student cheating multiple choice form quiz example failing student finish difficult physic quiz 7 second score 100 something definitely i give openended question would like make testing process somewhat manageable right cheating
479	0	1	0.425665	mute presenter shared sound presenter know shared sound

Further EDA



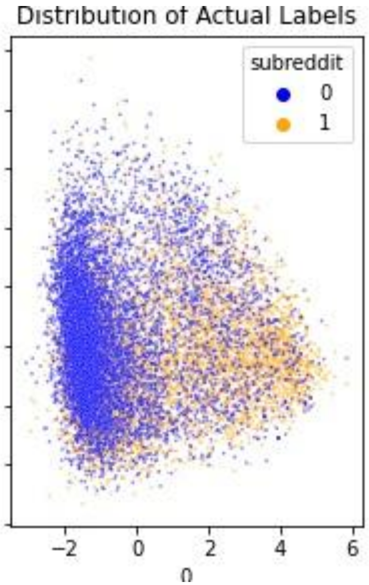
Agglomerative clustering shows that there are 2 distinct clusters in our word vectors (BERT), although this may not necessarily correspond to our Zoom and MST sub-reddits.

Further EDA



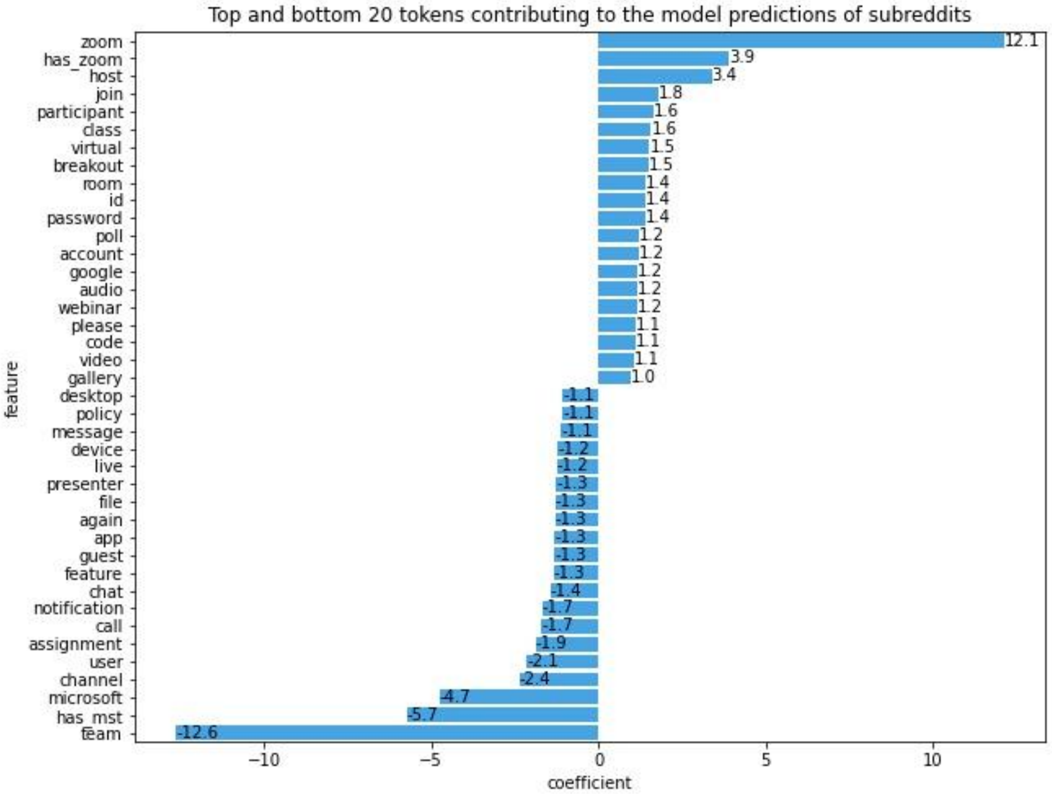
The clustering earlier has nicely separated the data into 2 clusters, although the overall accuracy is not high.

The labels have also been "inverted", although we can be fairly certain that 0 (actual) = 1 (predicted)



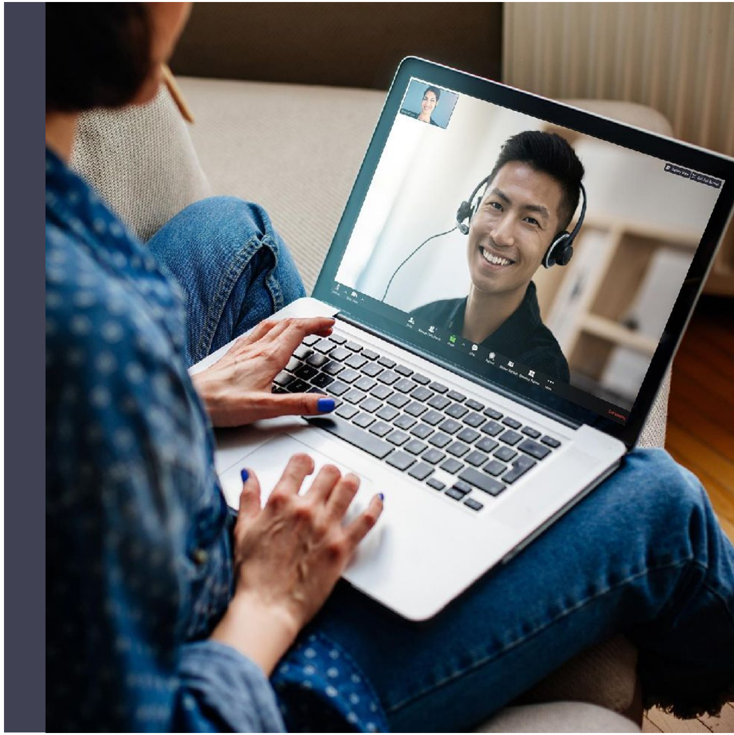
We see a rather messy overlap of points from Zoom (blue) and MST (yellow) texts, although there is a strong Zoom cluster on the left. This is expected given that we have "over-simplified" the data

Understanding the Final Model


Top and bottom 20 tokens contributing to the model predictions of subreddits

Zoom Video Communications

Q1 FY21 Earnings June 2, 2020



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In addition to the financials presented in accordance with U.S. generally accepted accounting principles ("GAAP"), this presentation includes the following non-GAAP metrics: non-GAAP gross margin, non-GAAP operating expenses, non-GAAP operating margin, non-GAAP operating income, non-GAAP EPS and non-GAAP Free Cash Flow. Non-GAAP metrics have limitations as analytical tools and you should not consider them in isolation or as a substitute for or superior to the most directly comparable financial measures prepared in accordance with U.S. GAAP. There are a number of limitations related to the use of non-GAAP metrics versus their nearest GAAP equivalents. Other companies, including companies in our industry, may calculate non-GAAP metrics differently or may use other measures to evaluate their performance, all of which could reduce the usefulness of our non-GAAP metrics as tools for comparison. We urge you to review the reconciliation of Zoom's non-GAAP metrics to the most directly comparable GAAP financial measures, and not to rely on any single financial measure to evaluate our business. See the Appendix for reconciliation between each non-GAAP metric and the most comparable GAAP measure.

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Zoom Video Communications

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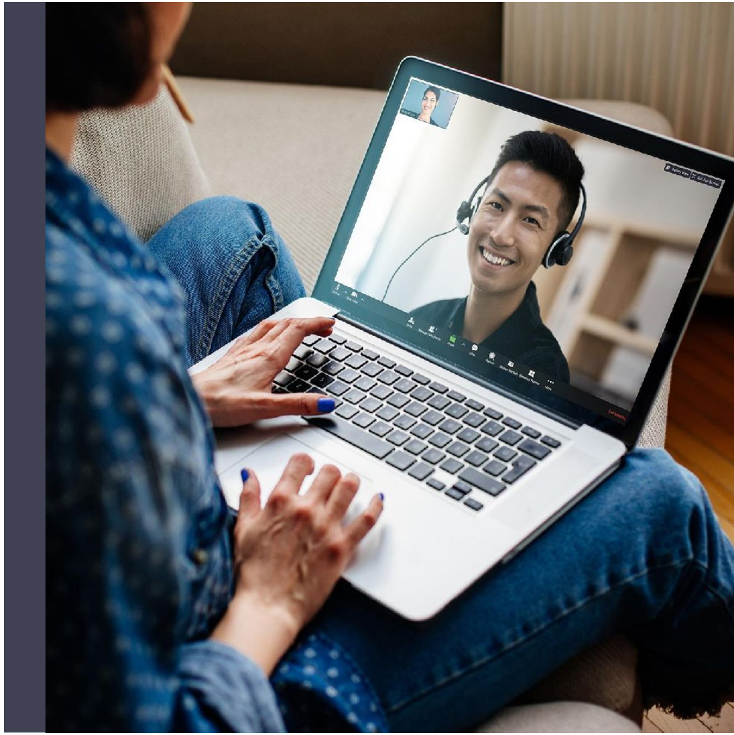


Meeting the Increased Demand

354%

Growth in Customers with > 10 employees

175K

Number of licenses deployed for a new customer

+200%

Q/Q growth of minutes for the Global 2000 customers

+300M

Peak number of daily meeting participants

+Two Trillion

Annualized meeting minutes run rate

Challenges and Commitment to Security and Privacy

- ✓ Enacted 90-day security plan initiative
- ✓ Acquired Keybase to add engineering expertise in encryption
- ✓ Released Zoom 5.0 with new security features and enhancements including support for AES 256-bit GCM encryption

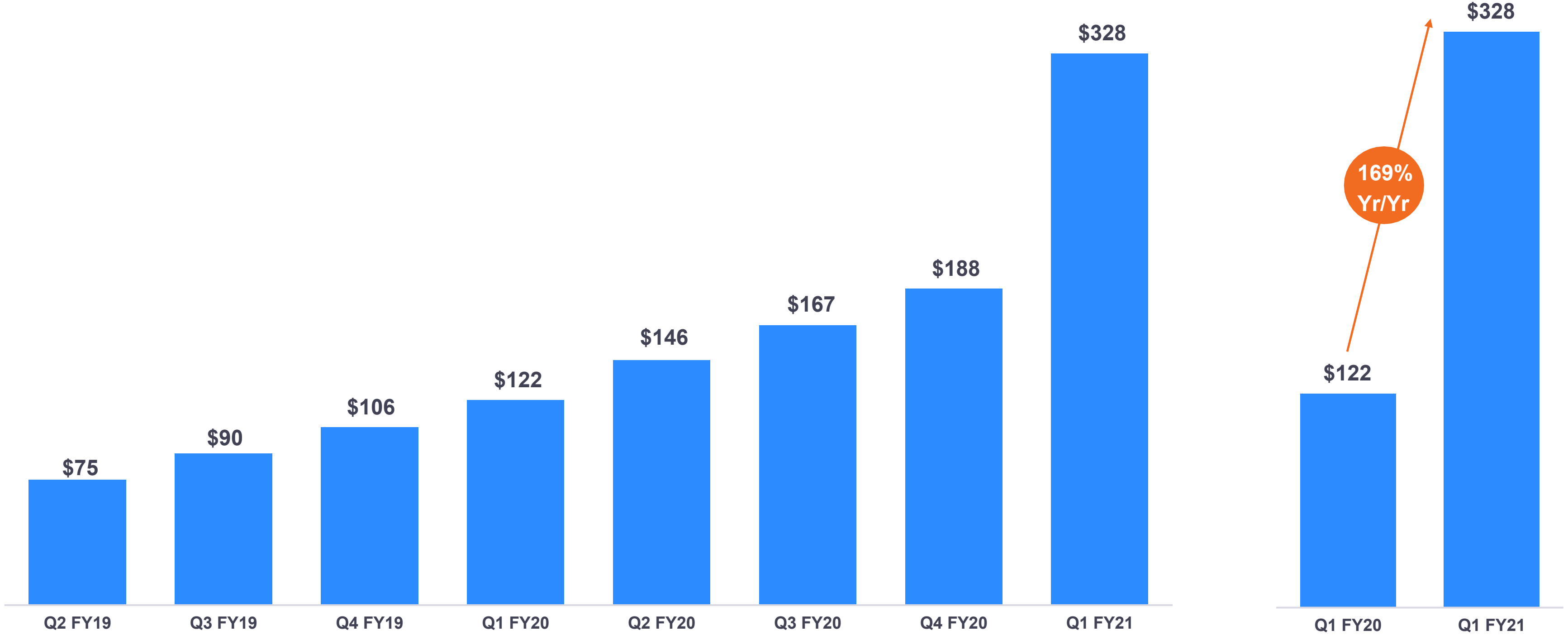
Happy Zoom Customers

arm

Baker
McKenzie.

Rapid Revenue Growth

(In Millions)



Zooming ahead

In the pipeline

1. Zoom

2. has_zoom
3. Host
4. Join
5. Participant
6. Class
7. Virtual
8. Breakout
9. Room
10. Id

Keep an eye on

Discord

a VoIP, instant messaging and digital distribution platform

Recommendation for Digital Marketing Team

Top words for Zoom

1. Zoom
2. has_zoom
3. Host
4. Join
5. Participant
6. Class
7. Virtual
8. Breakout
9. Room
10. Id

Top words for MST

1. Team
2. has_mst
3. Microsoft
4. Channel
5. User
6. Assignment
7. Call
8. Notification
9. Chat
10. Feature

Zooming ahead

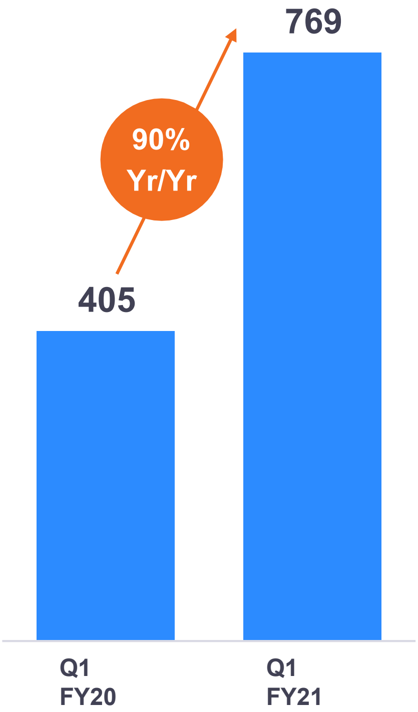
Refining our current model

Training our model to recognise words unique to subreddit.

Running the refined model on other competitor pairing

Zoom vs Google, Zoom vs Skype

Recommendation for Software Development Team



Growth in Customers[1] with >$100K ARR

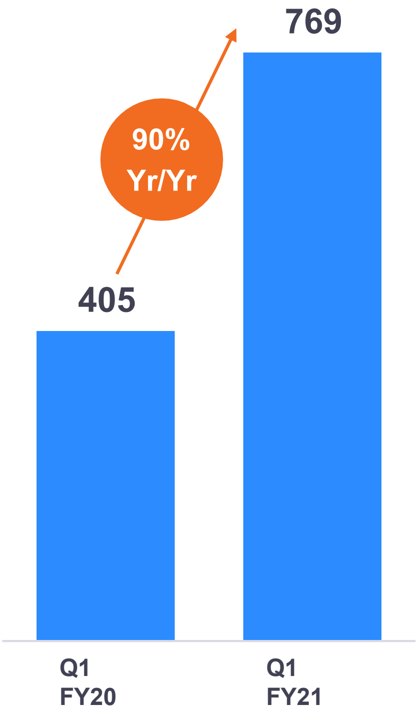
+500

New customers[1] with >$100K ARR in Q1’21 from Q4’20

[1] The number of customers are rounded down to the nearest hundred

Gaining Enterprise Traction

Growth in Customers with >$100K in Trailing 12-Month Revenue



Growth in Customers[1] with >$100K ARR

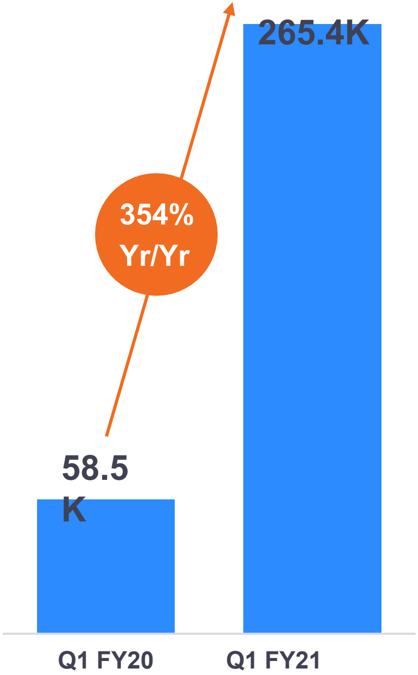
+500

New customers[1] with >$100K ARR in Q1’21 from Q4’20

[1] The number of customers are rounded down to the nearest hundred

Rapidly Growing Customer Base

Customers[1] with more than 10 Employees



Revenue from customers with 10 or fewer employees

Q1’21: 30%
Q4’20: 20%

[1]The number of customers are rounded down to the nearest hundred

Strong Q1 Net Dollar Expansion Rate

TTM Net Dollar Expansion Rate[1]

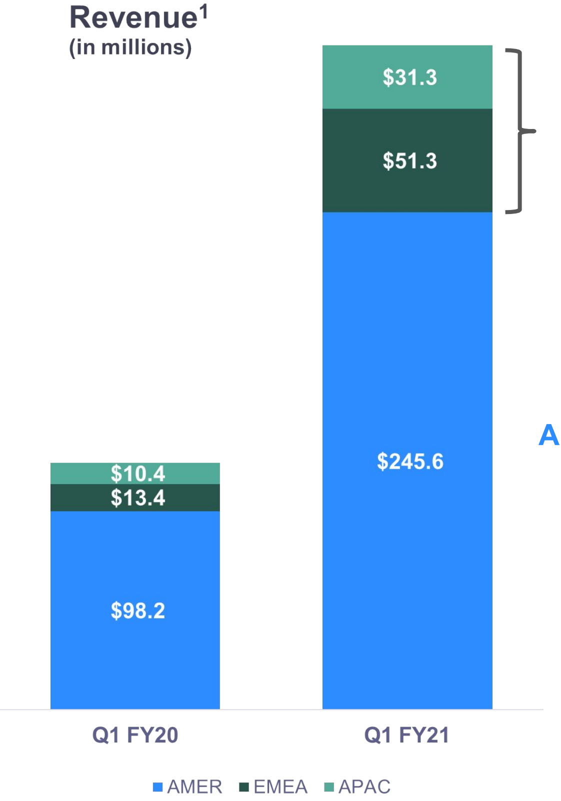
+130%

in Q1 FY21

- 8th consecutive quarter above 130%
- Demonstrated Ability to Land and Expand
- Reflects Trust and Loyalty with Existing Customer

[1] We calculate net dollar expansion rate as of a period end by starting with the ARR from customers with greater than 10 employ ees as of the 12 months prior to such period end (Prior Period ARR). We then calculate the ARR from these customers as of the current period end (Cur rent Period ARR). The calculation of Current Period ARR includes any upsells, contraction and attrition. We then divide the total Current Period AR R by the total Prior Period ARR to arrive at the net dollar expansion rate. For the trailing 12 -months calculation, we take an average of this calculation over the trailing 12 months.

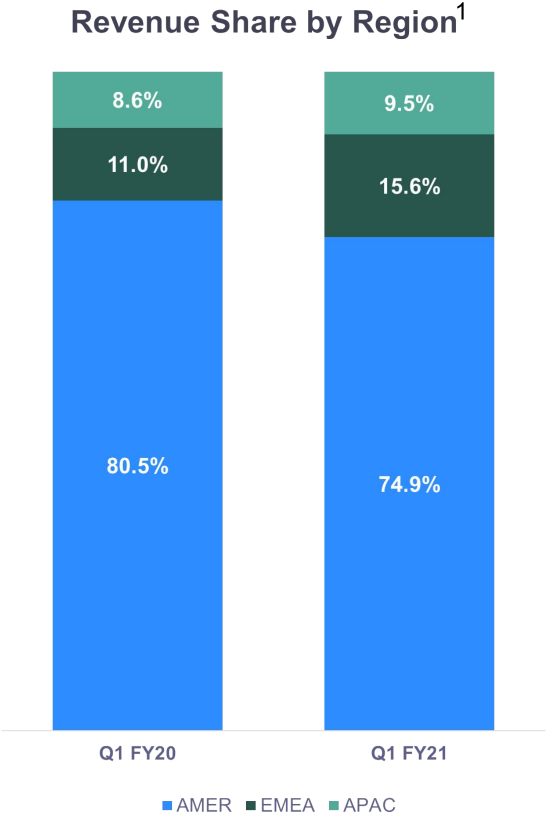
Growing International Presence



Yr/Yr

ROW 246%

Americas 150%



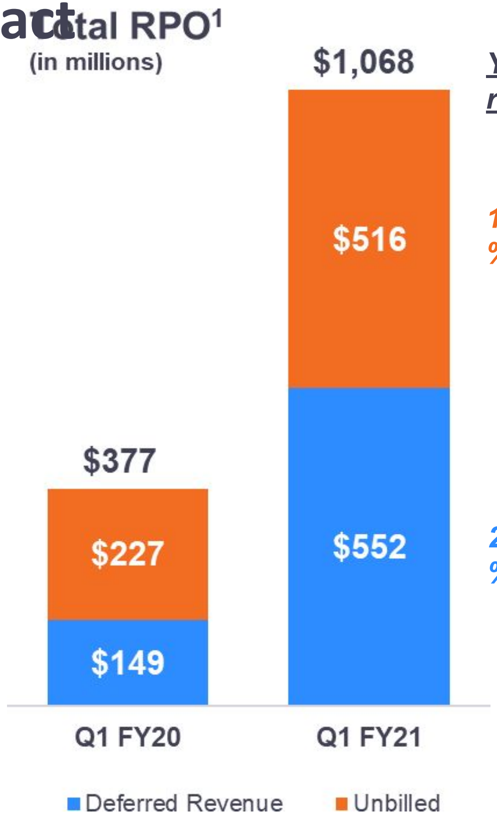
[1] Subtotal revenue has been rounded

Q1 FY21 Expenses and Margins

	Q1 FY21			
	GAAP Results	Yr/Yr	Non-GAAP[1] Results	Yr/Yr
Revenue	$328 million	169%	$328 million	169%
Gross Margin	68.4%	(1,184bps)	69.4%	(1,149bps)
Research & Development	8.0%	(326bps)	6.4%	(395bps)
Sales & Marketing	37.0%	(1,546bps)	31.5%	(1,880bps)
General & Administrative	16.2%	+102bps	14.8%	+134bps
Operating Margin	7.1%	+585bps	16.6%	+991bps

[1] Note - A reconciliation of non-GAAP guidance measures to corresponding GAAP measures is not available on a forward-looking basis without unreasonable effort due to the uncertainty of expenses that may be incurred in the future.

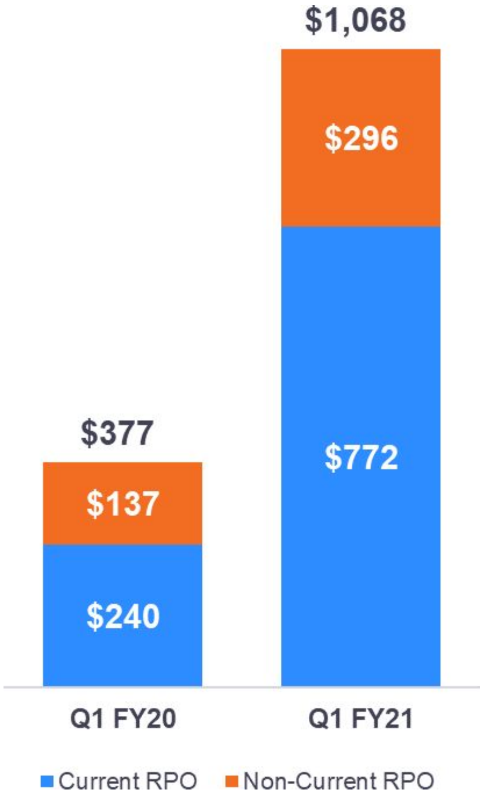
Growing Future Revenue Under Contract



Yr/Yr

127%

270%



Yr/Yr

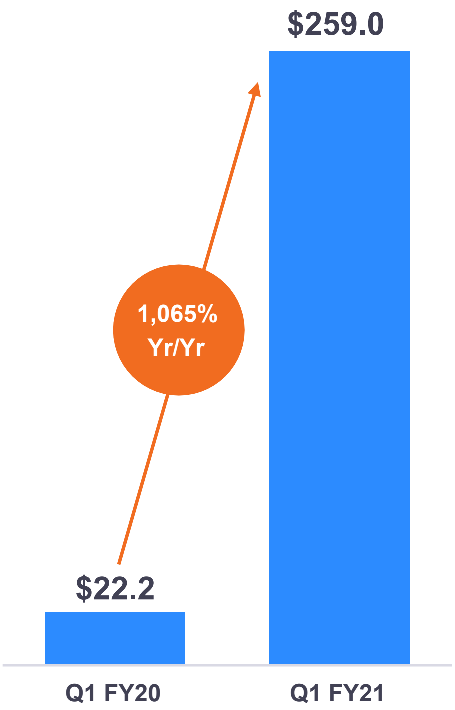
116%

222%

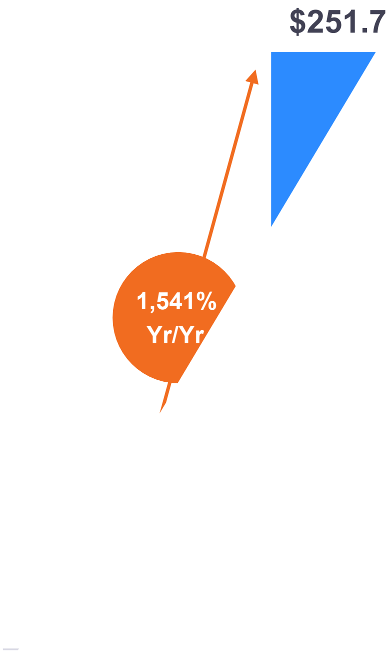
[1] Remaining performance Obligations (RPO) consists of both billed considerations and unbilled considerations that we expect to recognize as revenue, which grew 184% year-over-year. We expect to recognize approximately 72% or $772 million dollars of the total RPO as revenue over the next 12 months compared to 64% or $240 million dollars in Q1 last year. Subtotals have been rounded.

Rapid Cash Flow Growth

Operating Cash Flow
(in millions)



Free Cash Flow[1]
(in millions)



[1] See appendix for a reconciliation of non-GAAP to GAAP financial measures. We define FCF as GAAP net cash provided by operating activities less purchases of property and equipment. We ended Q1'21 with approximately $1.1 billion dollars in cash, cash equivalents and marketable se curities, excluding restricted cash

Full Year and Q2 FY21 Outlook

	Q2FY21	FY21
Revenue	$495 - $500 million	$1,775 - $1,800 million
Non-GAAP Operating Income	$130 - $135 million	$355 - $380 million
Weighted Average Share Count	299 million	300 million
Non-GAAP EPS	$0.44 - $0.46	$1.21 - $1.29

[1] A reconciliation of non-GAAP guidance measures to corresponding GAAP measures is not available on a forward-looking basis without unreasonable effort due to the uncertainty of expenses that may be incurred in the future .

Questions

Thank you

Appendix

GAAP to Non-GAAP Reconciliation

Gross Profit

($ in thousands)	QTD – Q1FY20	QTD – Q1FY21
Total Revenue	$121,988	$328,167
GAAP Gross Profit	$97,884	$224,460
(+) Stock-based compensation expense and related payroll taxes	$830	$3,382
Non-GAAP Gross Profit	$98,714	$227,842
Non-GAAP Gross Margin	80.9%	69.4%

R&D Expenses

GAAP R&D	$13,783	$26,389
(-) Stock-based compensation expense and related payroll taxes	$1,164	$5,403
Non-GAAP R&D	$12,619	$20,986

S&M Expenses

GAAP S&M	$64,041	$121,556
(-) Stock-based compensation expense and related payroll taxes	$2,627	$18,025
Non-GAAP S&M	$61,414	$103,531

G&A Expenses

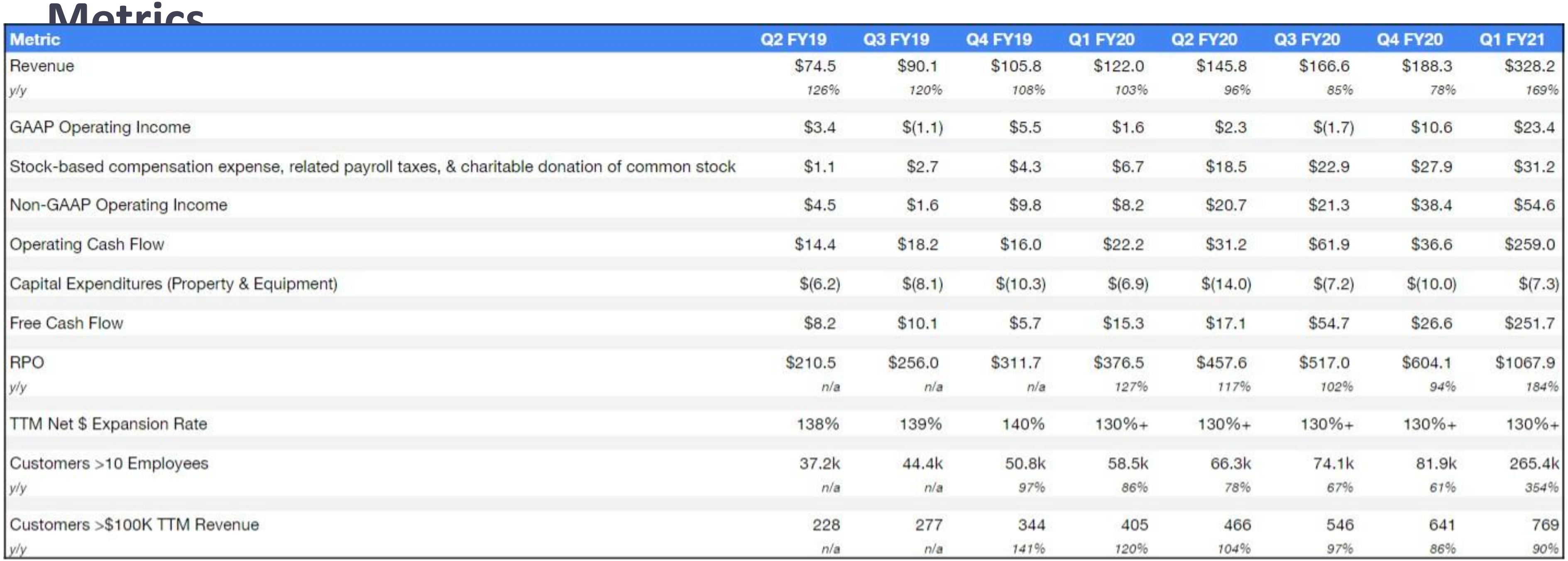
GAAP G&A	$18,503	$53,130
(-) Stock-based compensation expense, related payroll taxes, and charitable donation of common stock	$2,041	$4,436
Non-GAAP G&A	$16,462	$48,694

GAAP to Non-GAAP Reconciliation

Operating Margin

($ in thousands)	QTD – Q1FY20	QTD – Q1FY21
Total revenue	$121,998	$328,167
GAAP operating profit	$1,557	$23,385
(+) Stock-based compensation expense, related payroll taxes, and charitable donation of common stock	$6,662	$31,246
Non-GAAP operating profit	$8,219	$54,631
Non-GAAP operating margin	6.7%	16.6%
Net Income		
GAAP net income attributable to common stockholders	$198	$27,036
(+) Stock-based compensation expense, related payroll taxes, and charitable donation of common stock	$6,662	$31,246
(+) Undistributed earnings attributable to participating securities	$2,016	$39
Non-GAAP net income	$8,876	$58,321
Earnings Per Share		
GAAP net income per share – diluted	$0.00	$0.09
Non-GAAP net income per share – diluted	$0.03	$0.20
Weighted Average Shares		
GAAP weighted-average – diluted	136M	295M
Non-GAAP weighted-average - diluted	290M	295M

Historic Metrics



Metric	Q2 FY19	Q3 FY19	Q4 FY19	Q1 FY20	Q2 FY20	Q3 FY20	Q4 FY20	Q1 FY21
Revenue	$74.5	$90.1	$105.8	$122.0	$145.8	$166.6	$188.3	$328.2
y/y	*126%*	*120%*	*108%*	*103%*	*96%*	*85%*	*78%*	*169%*
GAAP Operating Income	$3.4	$(1.1)	$5.5	$1.6	$2.3	$(1.7)	$10.6	$23.4
Stock-based compensation expense, related payroll taxes, & charitable donation of common stock	$1.1	$2.7	$4.3	$6.7	$18.5	$22.9	$27.9	$31.2
Non-GAAP Operating Income	$4.5	$1.6	$9.8	$8.2	$20.7	$21.3	$38.4	$54.6
Operating Cash Flow	$14.4	$18.2	$16.0	$22.2	$31.2	$61.9	$36.6	$259.0
Capital Expenditures (Property & Equipment)	$(6.2)	$(8.1)	$(10.3)	$(6.9)	$(14.0)	$(7.2)	$(10.0)	$(7.3)
Free Cash Flow	$8.2	$10.1	$5.7	$15.3	$17.1	$54.7	$26.6	$251.7
RPO	$210.5	$256.0	$311.7	$376.5	$457.6	$517.0	$604.1	$1067.9
y/y	*n/a*	*n/a*	*n/a*	*127%*	*117%*	*102%*	*94%*	*184%*
TTM Net $ Expansion Rate	138%	139%	140%	130%+	130%+	130%+	130%+	130%+
Customers >10 Employees	37.2k	44.4k	50.8k	58.5k	66.3k	74.1k	81.9k	265.4k
y/y	*n/a*	*n/a*	*97%*	*86%*	*78%*	*67%*	*61%*	*354%*
Customers >$100K TTM Revenue	228	277	344	405	466	546	641	769
y/y	*n/a*	*n/a*	*141%*	*120%*	*104%*	*97%*	*86%*	*90%*