# K12 Insight:
## Template Recommendation Engine

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# Meet Our Team

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# K12 Insight pioneers solutions in educational communication

Research shows the need for a strong partnership between stakeholders and schools for the success of pupil's academic performance and educational reforms



**Target Customer Group**

Primary customers are **K-12 school districts** across the country

**Customer Base Size**

More than **500** K-12 school districts actively choose K12 Insight as their go-to-partner for educational solutions

**Product Portfolio**

Let's Talk Communication Platform
Managed Research and Engage Surveys
Professional Development

**Let's Talk**

In the 2021-22 school year, **87%** of parents reached out to their school district more than once, with 44% of them reached out at least 6 times
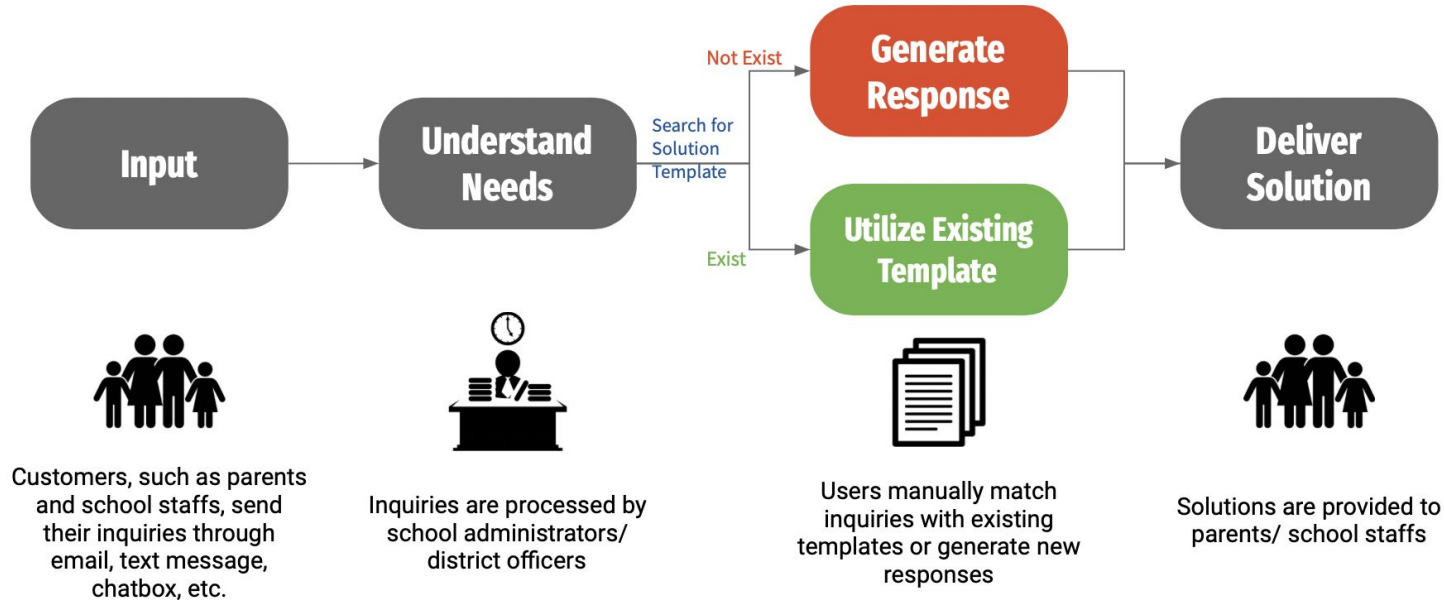
# Current customer inquiry handling process needs improvements

■ Time-Consuming Selection Process    ■ Overlooked Relevant Templates    ■ Inaccurate Keyword-Based Searches



**Input**

Customers, such as parents and school staffs, send their inquiries through email, text message, chatbox, etc.

**Understand Needs**

Inquiries are processed by school administrators/ district officers

Search for Solution Template

Not Exist

**Generate Response**

Exist

**Utilize Existing Template**

Users manually match inquiries with existing templates or generate new responses

**Deliver Solution**

Solutions are provided to parents/ school staffs

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# Our recommendation engine leverages NLP & LLMs to automate the template matching process

**Sign Up**

Sat, Dec 2, 13:30pm (3 Minutes Old)

⊞

**ORIGINAL MESSAGE**

Hello, how do I sign up for an account so I can access my student's information in the Aspen Family Portal?

**ENTER CUSTOMER REPLY**

Subject Re: Sign Up ✎     Cc   Response Template

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Hello [[Customer's Name]],

Thank you for contacting the YCSD IT department. The first step is to get an **Aspen Family Portal** activation letter. If you have not gotten a portal activation letter, then you must contact your school. Schools issue the initial portal activation letter. If you have the portal activation letter then you simply **sign up for an account** using a computer, laptop or desktop. You cannot sign up for an account using a mobile device. (This is explained in the portal activation letter.) Once you have created an account, you can use either a computer or mobile device to access your student's information in Aspen.

# This project aims to transform educational communication

## Enhanced Communication

Effective communications is crucial for building positive relationships between schools and students

## Workflow Automation

Help streamline and automate processes for managing messages, which saves time and ensures that messages are handled consistently

## Trust-Building

Trust is built through transparent and effective communication, responsiveness, and engagement

## Stakeholder Engagement

Timely and appropriate responses help fosters a sense of collaboration, leading to improved stakeholder engagement and support for school initiatives

# PROJECT WORKFLOW

## Data Cleaning & EDA

Perform initial preprocessing of the data to ensure it is clean and formatted correctly. Conduct EDA to understand the distribution of key variables

## Text Encoding

Use a Sentence Transformer model to encode sentences into high-dimensional vectors while capturing the semantic meaning of sentences

## Similarity Matching

Employ various similarity indexes to measure the similarity between different text vectors

## Model Building

Test multiple machine learning models and perform hyperparameter tunings to find the most effective model configuration

## Evaluation

Evaluate the model using appropriate metrics
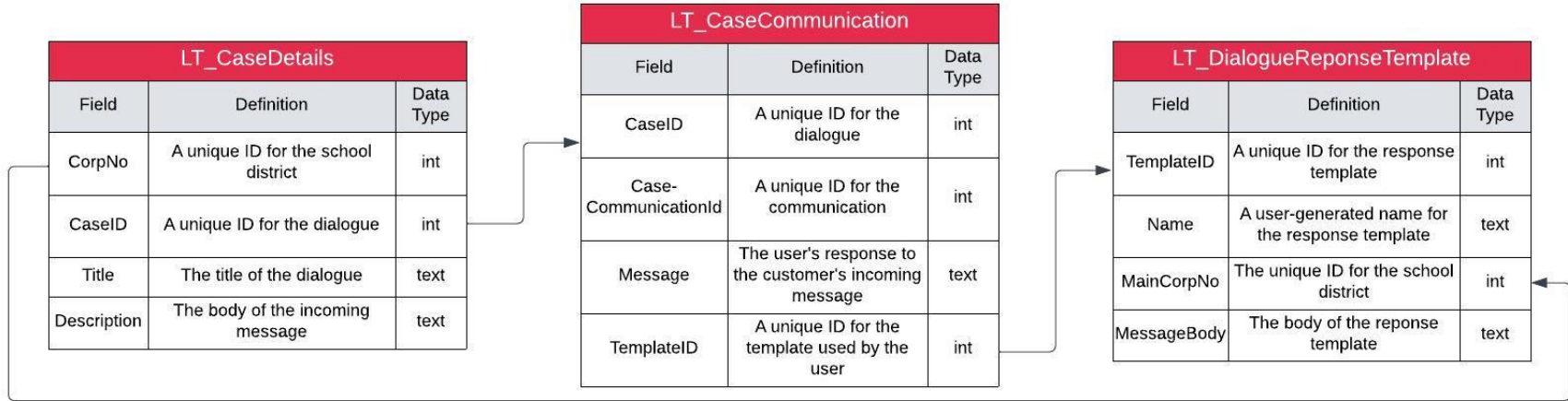
# Three main tables are joined for modeling

**Key Terms:**
**Customer:** The person sending an incoming message to the Let's Talk application
**User:** An employee of the school district who is responding to the customer's message
**Dialogue:** A dialogue represents a single interaction between a customer and the user(s)
**Communication:** A user's response to the customer

### LT_CaseDetails

| Field | Definition | Data Type |
|---|---|---|
| CorpNo | A unique ID for the school district | int |
| CaseID | A unique ID for the dialogue | int |
| Title | The title of the dialogue | text |
| Description | The body of the incoming message | text |

### LT_CaseCommunication

| Field | Definition | Data Type |
|---|---|---|
| CaseID | A unique ID for the dialogue | int |
| Case-CommunicationId | A unique ID for the communication | int |
| Message | The user's response to the customer's incoming message | text |
| TemplateID | A unique ID for the template used by the user | int |

### LT_DialogueReponseTemplate

| Field | Definition | Data Type |
|---|---|---|
| TemplateID | A unique ID for the response template | int |
| Name | A user-generated name for the response template | text |
| MainCorpNo | The unique ID for the school district | int |
| MessageBody | The body of the reponse template | text |

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# The template feature is widely overlooked by platform users

Among all cases, only a small fraction of them are resolved using pre-written response templates
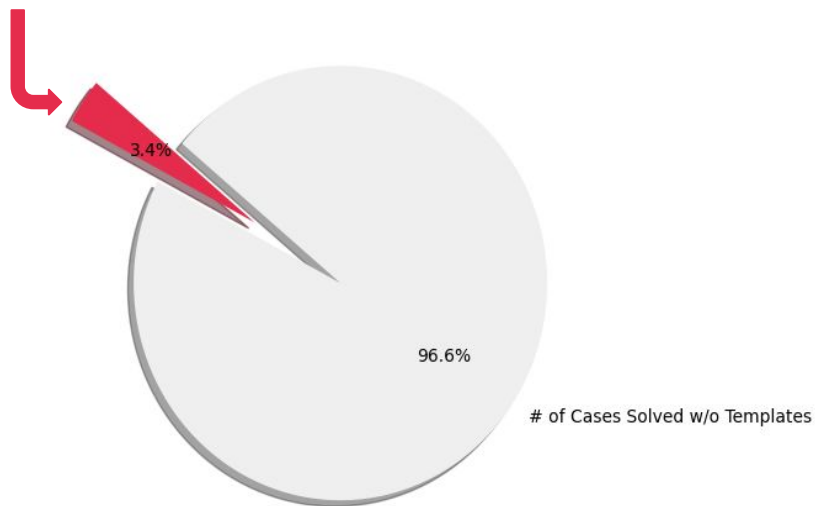


Even school districts that receive the most number of cases underutilize text templates
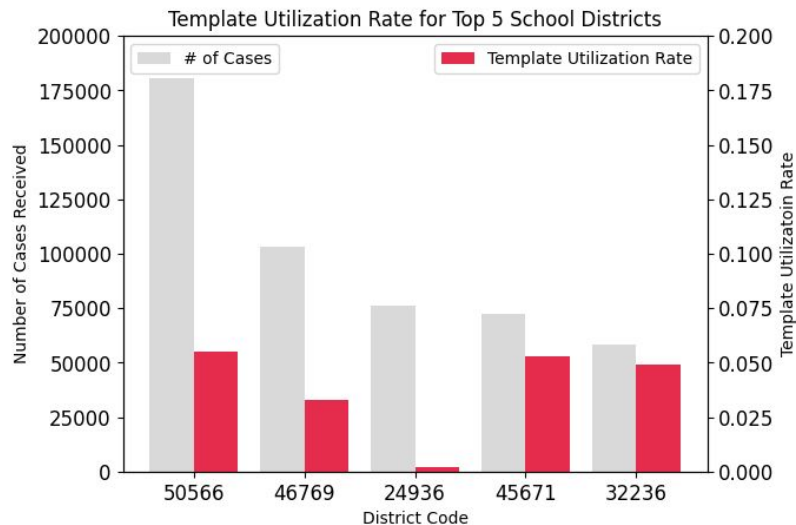


Among 1.7M cases, only 57K of them can be used for model training

# Implementing a hybrid approach by computing multiple scores for each query-template pair

**Major Components**

### Collaborative Filtering

Enhancing the relevance of template matching by integrating **insights from similar past queries and their corresponding template usage**



### Content-Based Filtering

The **dot product** between the embeddings of customer inquiries and text templates is used to quantify the degree of similarity



### Text Similarity

**Jaccard Similarity** score is used to evaluate how closely an inquiry aligns with a predefined text template
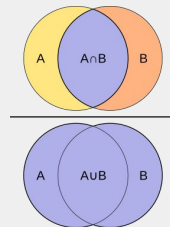
# Fine-tuning Sentence Transformer proofs to generate more precise and contextually relevant embeddings

Multi-qa-mpnet-base-dot-v1 is fine-tuned to address the complex nature of customer inquiries

**Inquiry**

Request to join **Classroom Teachers Group.**

**Response**

To prevent students from incidentally signing up to Google Classroom as a teacher, and teachers incidentally signing up as Students, Google Classroom membership is a GIPS managed Group. You recently applied for membership as a **Google Classroom Teacher.** Your Teacher application has been reviewed and accepted. When you next log into Google Classroom, you may enter as a GIPS Teacher.

**Similarity Score**

*Before fine-tuning*
*24.15*

*Now*

**26.57**

# All scoring components are used jointly for downstream classification tasks

**Scoring components for Query M**

*Collaborative Filtering Result*

| Template 4535 | Template 1481 | Template 1456 |
|---|---|---|
| 0.0000 | 0.5589 | 3.8836 |

*Content-Based Result*

| Template 4535 | Template 1481 | Template 1456 |
|---|---|---|
| 10.5696 | 13.7951 | 13.1870 |

*Text Similarity Result*

| Template 4535 | Template 1481 | Template 1456 |
|---|---|---|
| 0.0232 | 0.0540 | 0.0361 |

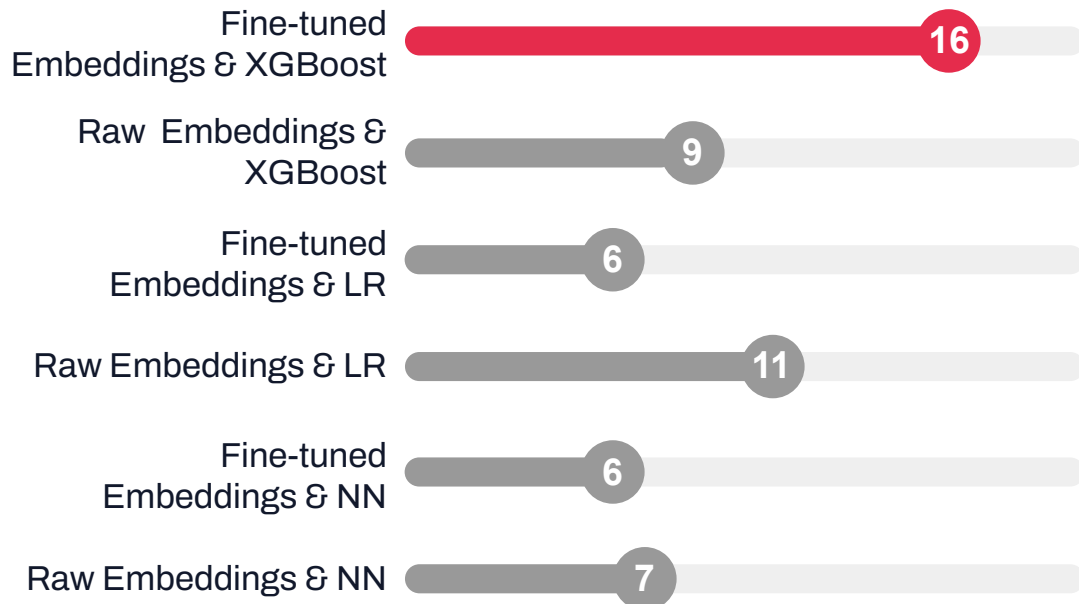| Similarity Score | Collaborative Score | Jaccard Score | Matched |
|---|---|---|---|
| 10.5696 | 0.0000 | 0.0232 | 0 |
| 13.7951 | 0.5589 | 0.0540 | 0 |
| 13.1870 | 3.8836 | 0.0361 | 1 |
| ... | | | |

Logistic Regression

Neural Network

dmlc
**XGBoost**

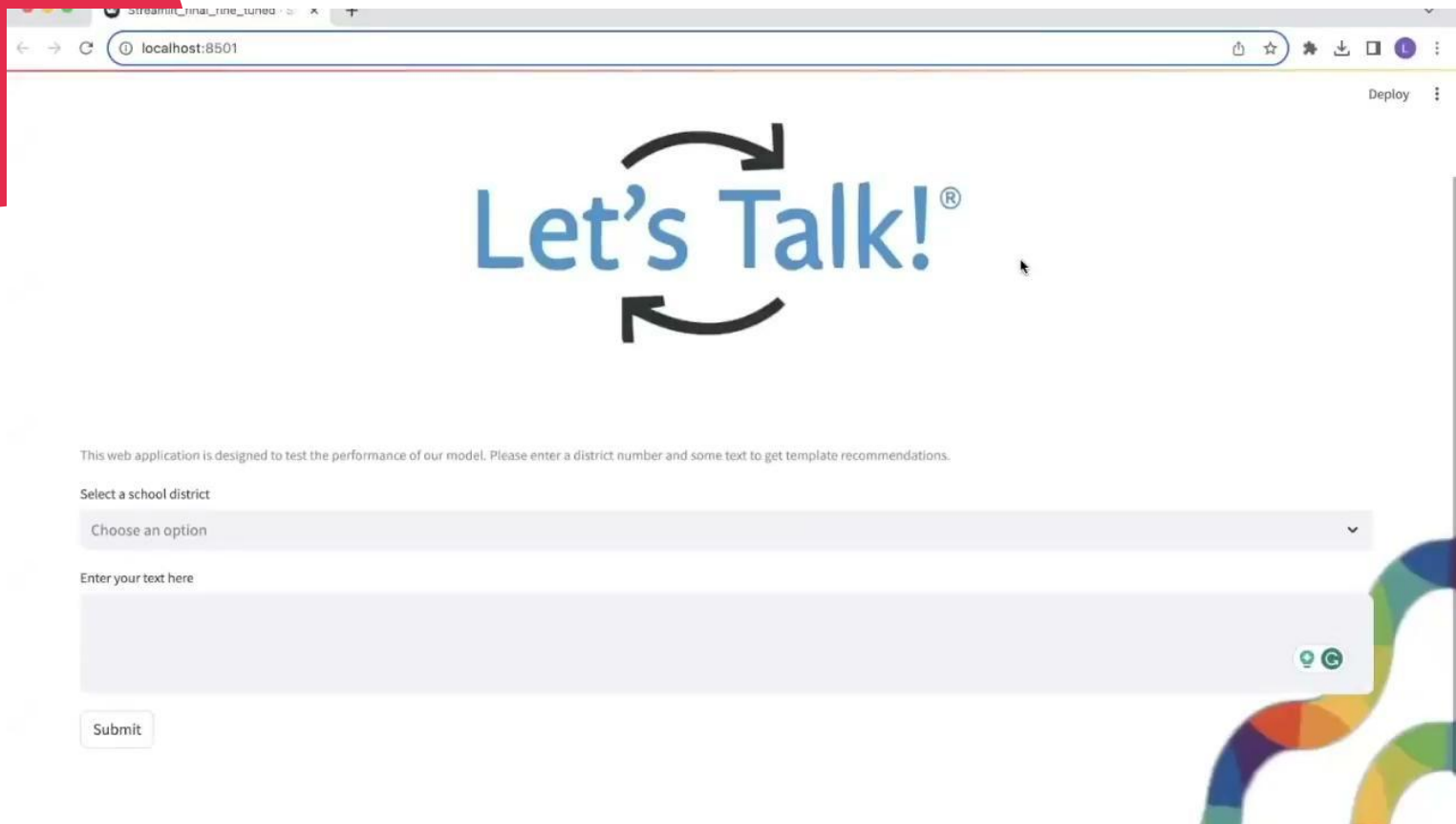# A combination of fine-tuned embeddings & XGBoost demonstrates the best classification result

## Model Performance on District 45671

| Recall Rate | | |
|---|---|---|
| | **No Fine-tuning** | **Fine-tuning** |
| **XGBoost** | 0.71 | **0.80** |
| **Logistic Regression (LR)** | 0.64 | 0.69 |
| **Neural Network (NN)** | 0.64 | 0.60 |

## Number of Passed Test Cases Across Districts (Out of 20)

Fine-tuned Embeddings & XGBoost: **16**

Raw Embeddings & XGBoost: **9**

Fine-tuned Embeddings & LR: **6**

Raw Embeddings & LR: **11**

Fine-tuned Embeddings & NN: **6**

Raw Embeddings & NN: **7**

# Streamlit demonstration

# Our solution delivers more than just efficiency

**Template Relevancy**

**90%** relevant templates are delivered to 70% of school districts, reducing response time by 60%

**Operational Costs**

Reduce annual operational costs by **$0.7M**

**Customer Base**

Enhanced efficiency in addressing inquiries attracts more school districts, targeting a **60%** expansion in customer base

# Future work to elevate model performance

Collect feedbacks from users, including explicit ratings, comments as well as implicit feedback drawn from user interactions and behaviors within the system.

Continuously update the model by adding new scoring components and try alternative classification algorithms for better performance

Develop a model to create templates for frequently used answers that haven't yet been templated.

# Our sincere thanks and appreciation to

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K12 *Insight*        THE UNIVERSITY OF
CHICAGO

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## for the opportunity to contribute to the field of educational communication

# Any Questions?

# Appendix

# DATA CLEANING

Remove HTML tags, emails address, websites from text

Drop rows with less than 5 words

**01**  **02**  **03**  **04**

Remove rows with empty case descriptions, communication message, or template message body
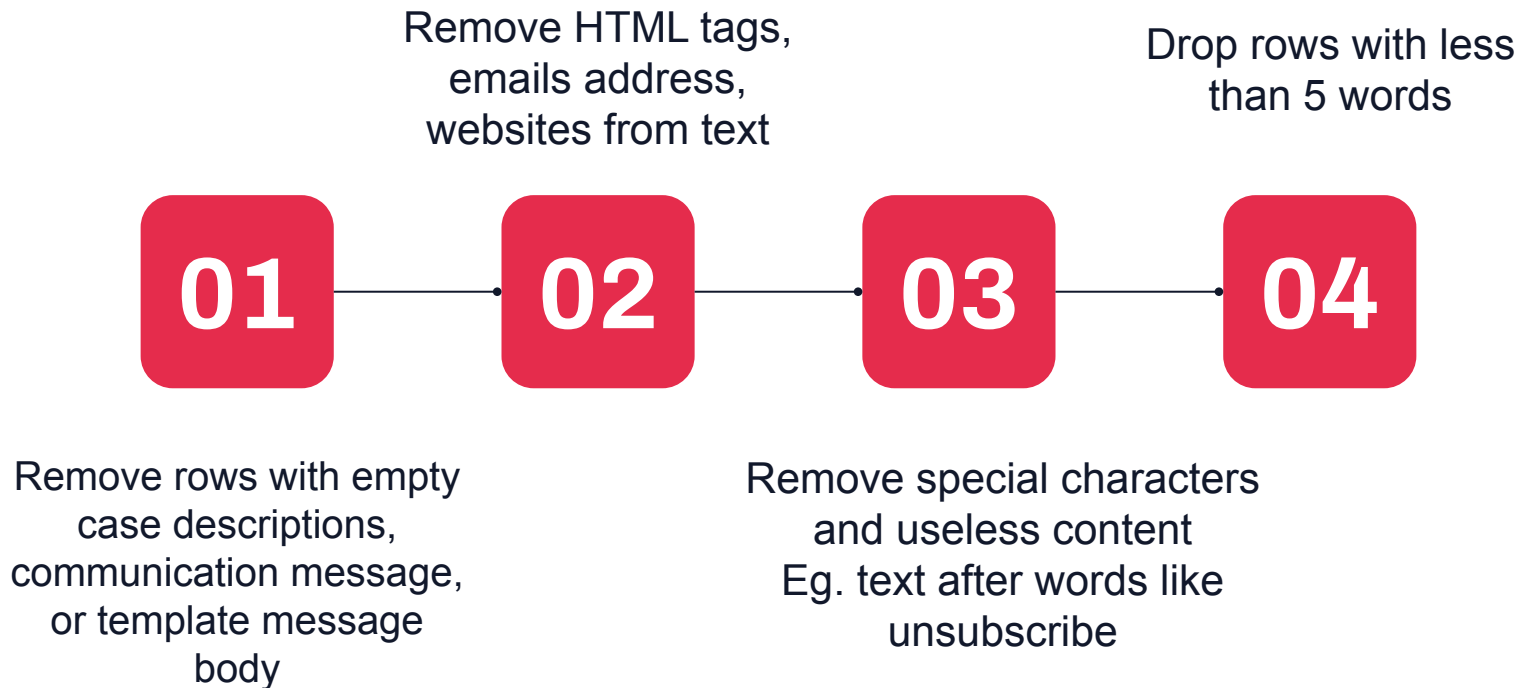
Remove special characters and useless content Eg. text after words like unsubscribe

# MODELING - SCORE COMPONENTS

Score = queryM-templateN similarity

  $+ \sum$(top10 similar queries of queryM * interaction with templateN)

  + Text Similarity

  + …

## QueryM-TemplateN Similarity

Definition:
- The dot product of query and template

Models:
- Multi-QA-MPNet-Base-Dot
- Multi-QA-DistilBert-Cos
- Multi-QA-MiniLM-L6-Cos

## $\sum$(Top10 Similar Queries of QueryM* Interaction with TemplateN)

Definition:
- Measure the similarity of this template with queries similar to QueryM

Steps:
- Identify top 10 similar queries for QueryM
- For each template, calculate the total # of times it was used among top 10 relevant templates

## Text Similarity

Definition:
- Measure how closely an inquiry aligns with a predefined text template

Methods:
- Jaccard Similarity Score

# MODELING - SENTENCE TRANSFORMER

Pretrained models from sentence_transformers will be used to encode queries and pre-written templates into high-dimensional word embeddings for similarity matching.

## Q&Q Matching with 'all-mpnet-base-v2'

To identify semantically similar customer inquiries within the database. This component aids in understanding the effectiveness of past responses and in optimizing future responses.

- Scoring: Dot-Product

## Q&A Matching with 'multi-qa-mpnet-base-dot-v1'

To compare the semantic content of customer inquiries against a set of pre-written text templates. This approach aims to provide direct and accurate responses to customer inquiries.

- Scoring: Dot-Product

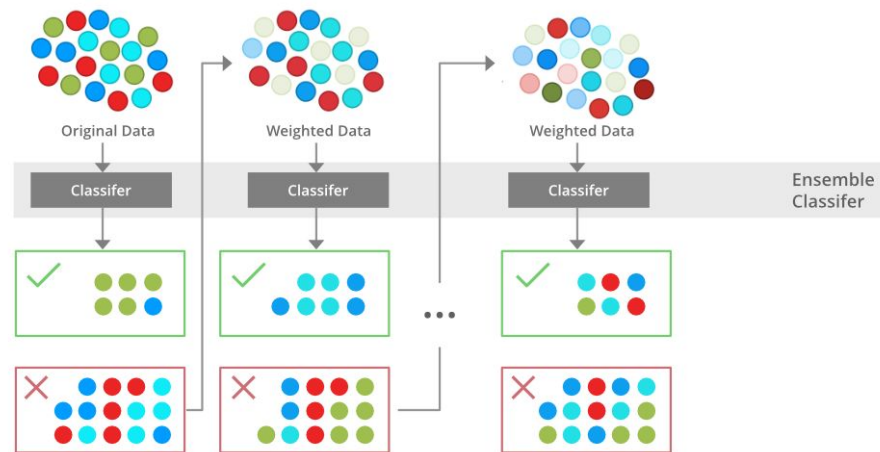# MODELS AND ERROR METRICS

**Candidate Models**

- Logistic Regression

- Feedforward Neural networks

- XGBOOST

**Choices of Error Metrics**

- Recall

- Precision

- F1 Score

**Model Selection Criteria**

- High Recall: True template is recommended

- Precision Not Too High: Up to five templates are recommended



Original Data    Weighted Data    Weighted Data

Classifer    Classifer    Classifer    Ensemble Classifer

$$F1\ Score = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}}$$

$$= \frac{2 \times Precision \times Recall}{Precision + Recall}$$

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# ANNUAL COST REDUCTION CALCULATION

**Hours saved per day :**

(original response time per query(min) - new response time per query(min)) / 60  * number of queries per day

= (5 - 2) / 60 * 2700 = 135H


**Annual cost reduction:**

**Hours saved per day * working day per year * salary per hour**

 **= 135 * 264 * 20  =  712,800 ~ $0.7M**