



# NoteLLM: A Retrievable Large Language Model for Note Recommendation

# Contexto

- En las redes sociales (Xiaohongshu o Lemon8) se comparten “notas”
- Objetivo: mantener a los usuarios
- Análisis sus posts



# Problema

- Recomendar contenido relevante
- Métodos basados en BERT no aprovechan la información
- No tienen la comprensión de los LLM

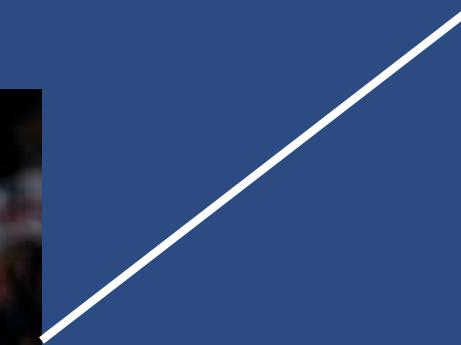
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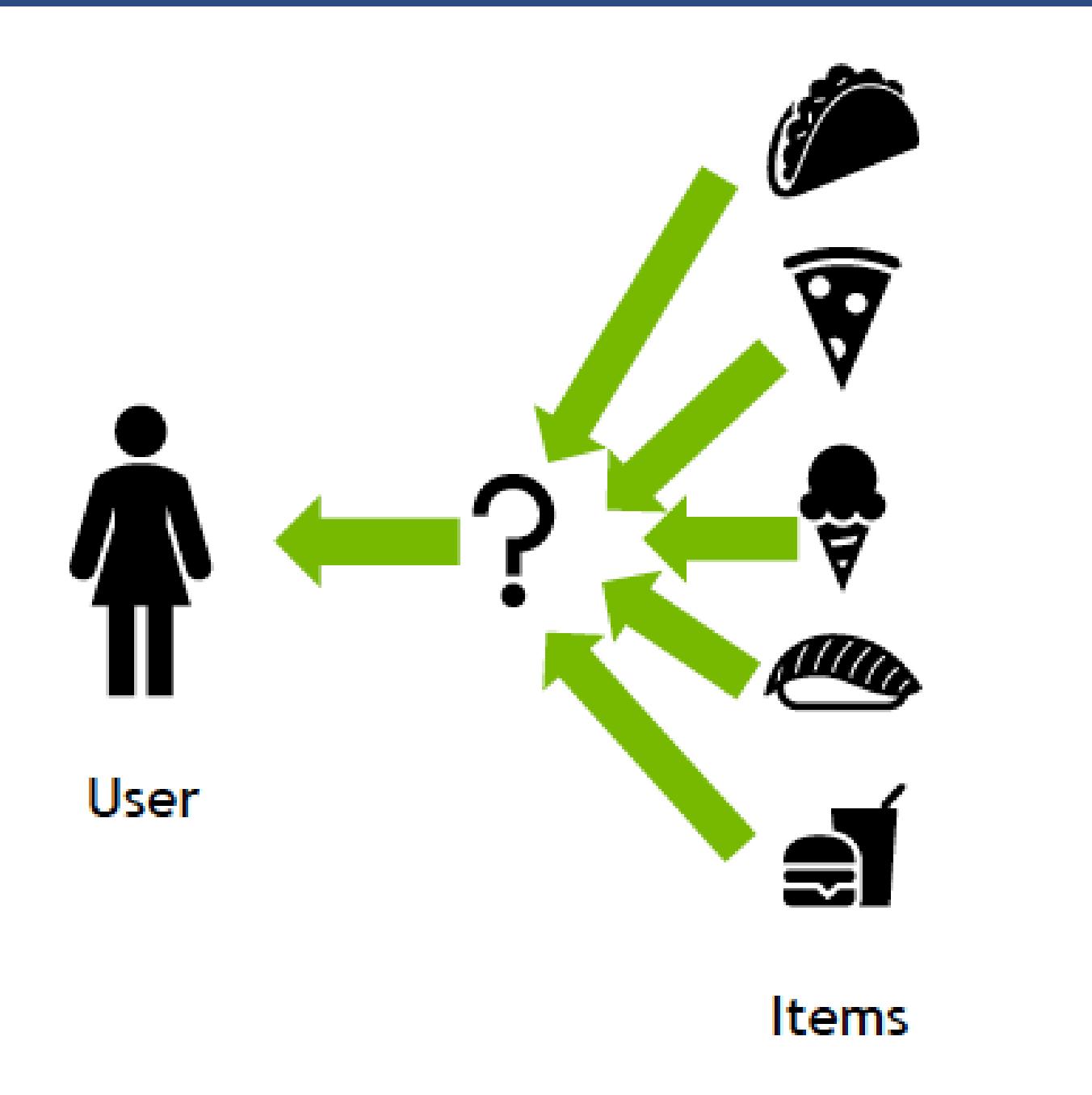


#suits



# Contribución: NoteLLM

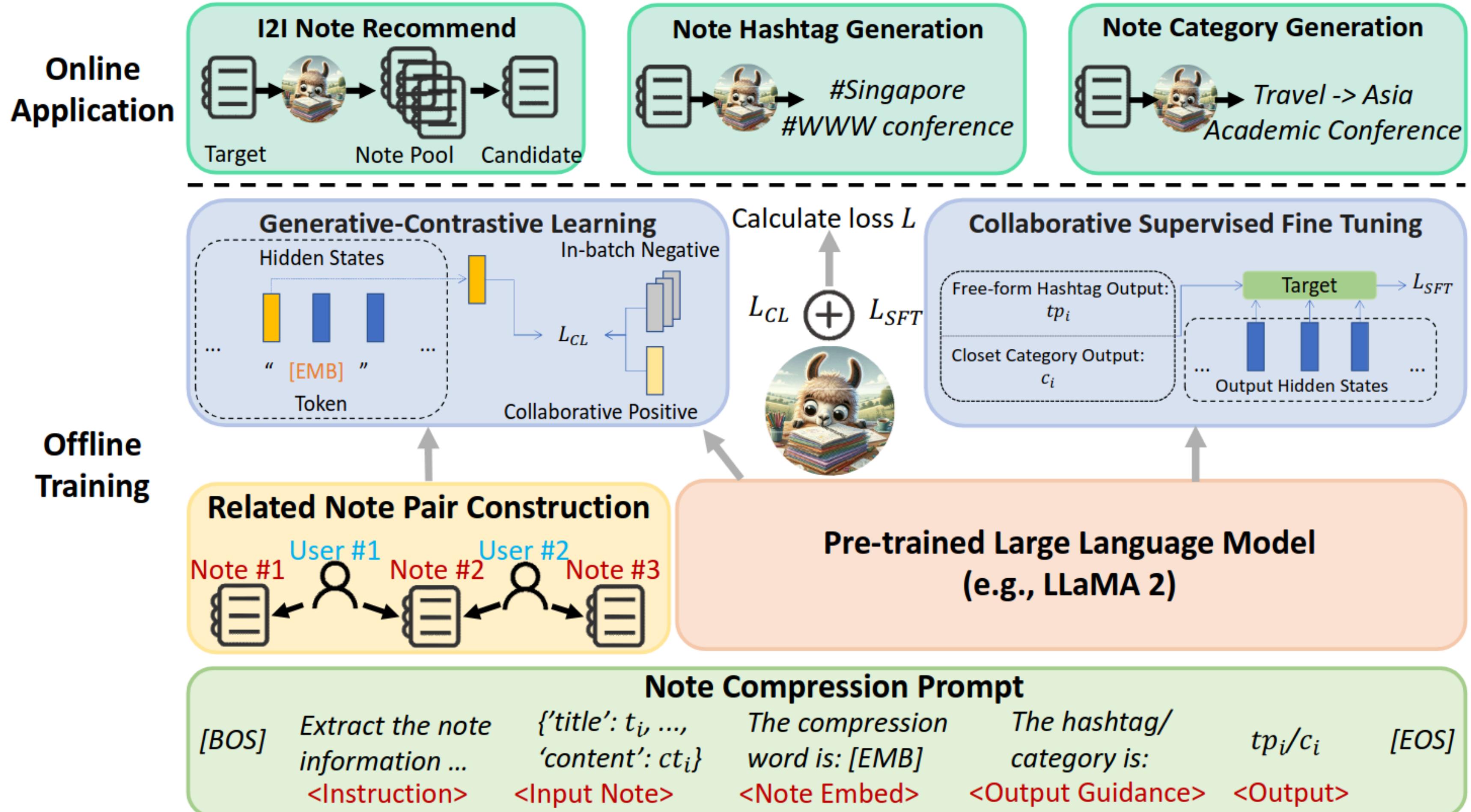
- Integra LLM's para mejorar la recomendación nota-nota
- 2 tareas a la vez: recomendación y generación de hashtags/categorías
- Demostraron que extraer conceptos clave, mejora la calidad de las recomendaciones
- Entender mejor el contenido y mejores recomendaciones

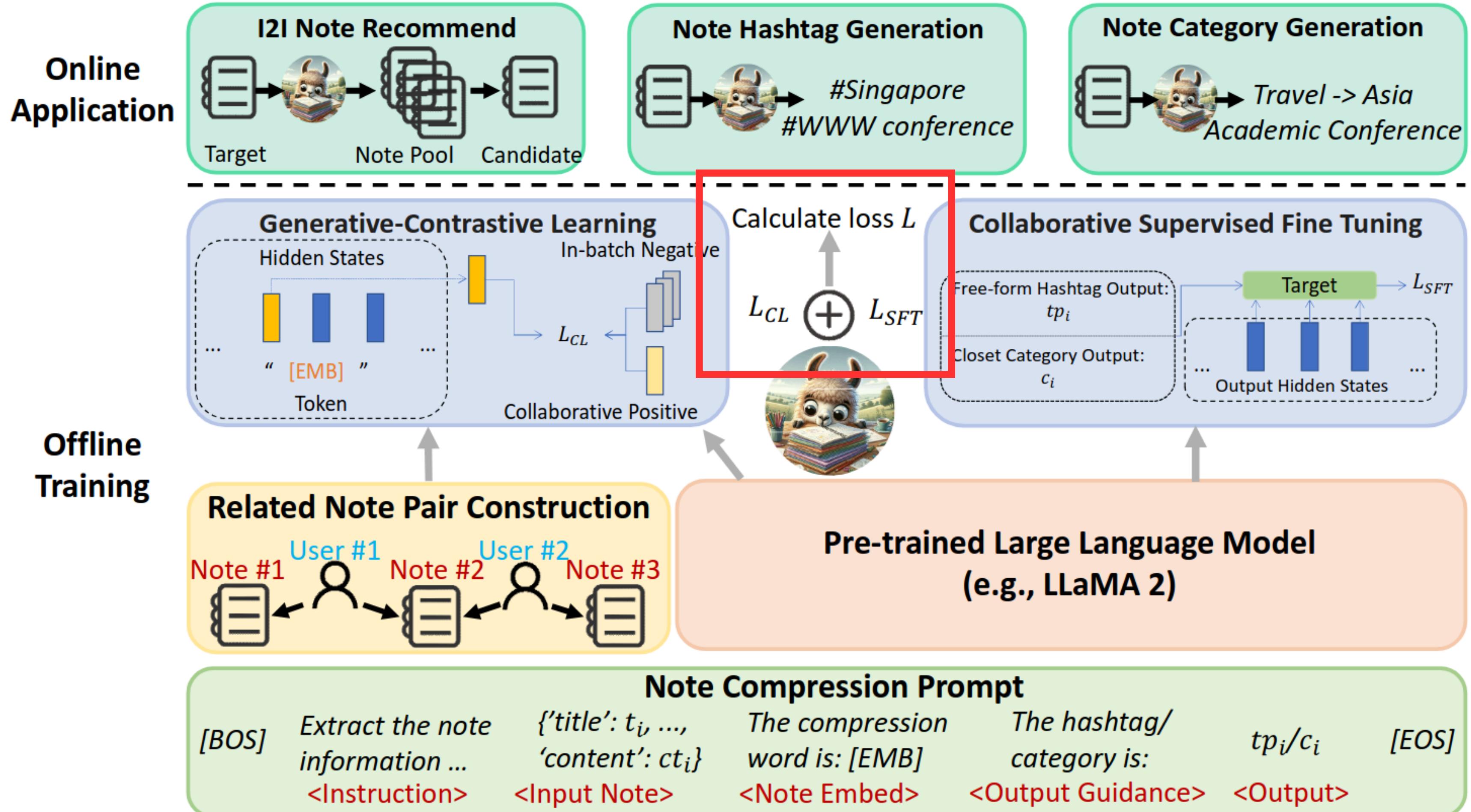


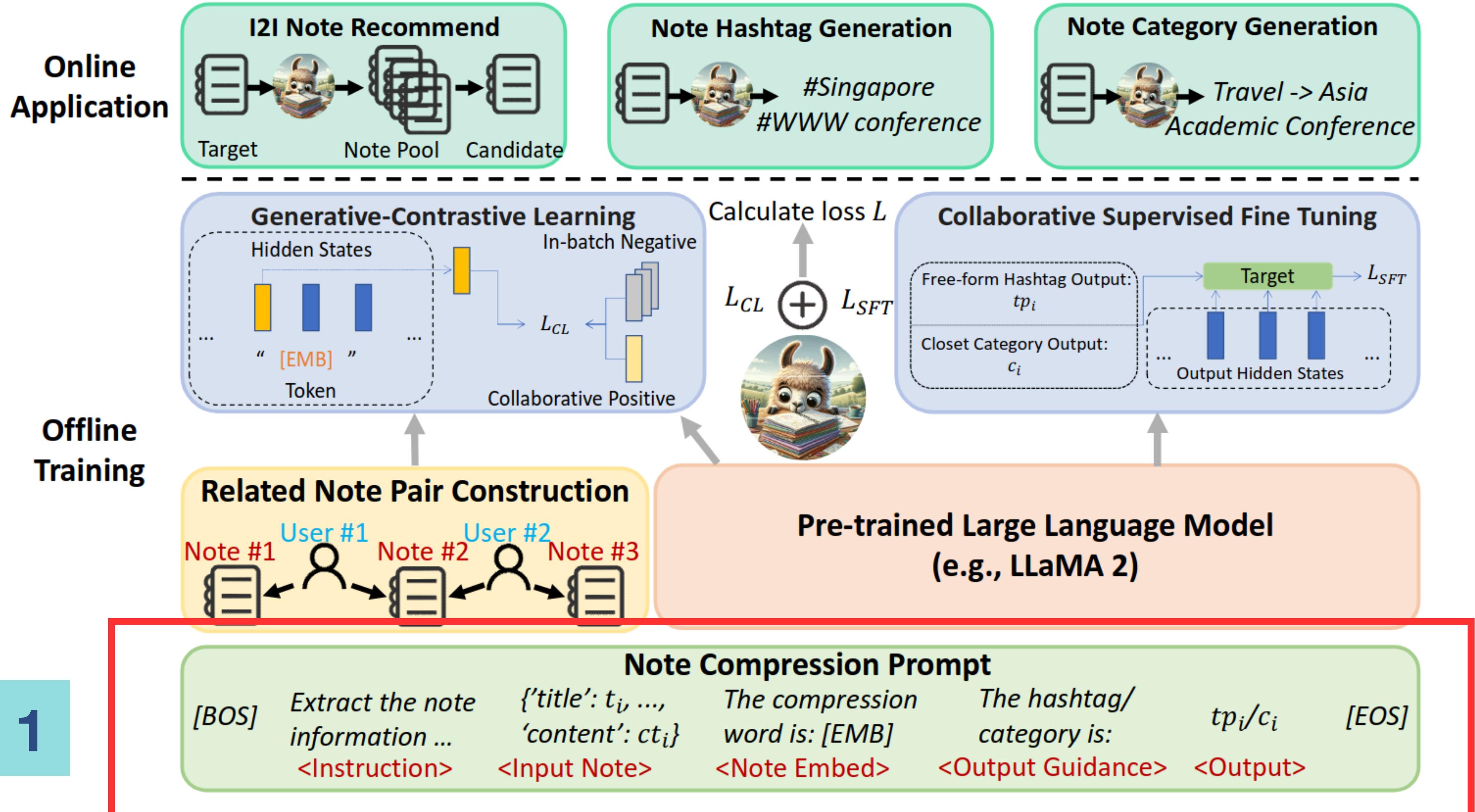
# Estado del arte y marco teórico

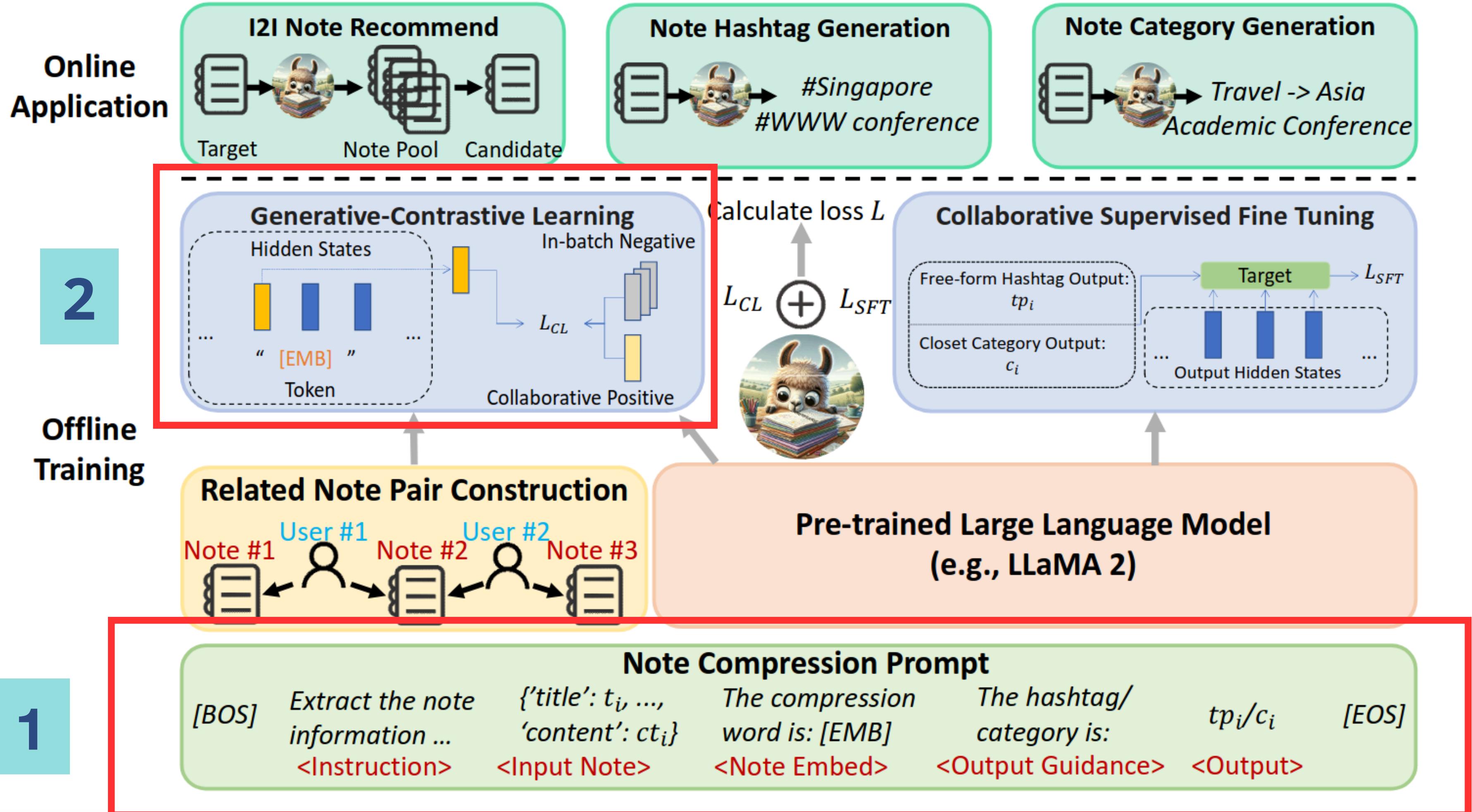
- Recomendación I2I: al usar BERT, fallan cuando hay pocos datos
- Uso de LLM's en recomendación, solo encoders o re-ranking
- Generación de hashtags o categorías junto con la recomendación

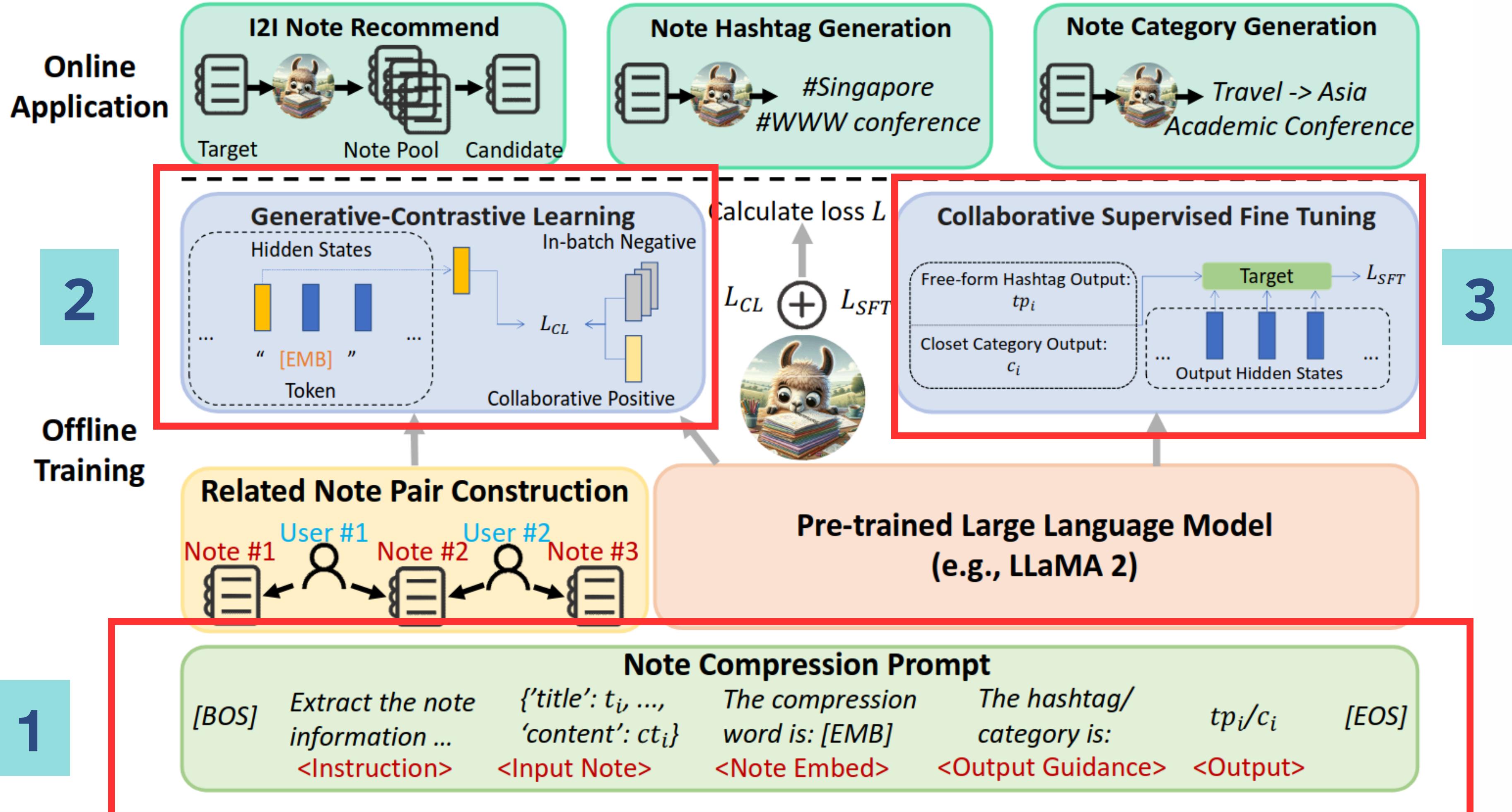
# Detalle Solución











# Note compression prompt

**Prompt:** [BOS]<Instruction> <Input Note> The compression word is:"[EMB]". <Output Guidance> <Output>[EOS]

Donde:

- [BOS], [EMB] y [EOS]: special tokens.
- <Instruction>, <Input Note>, <Output Guidance>, <Output>: placeholders, reemplazados por contenido en específico.

### **Note Compression Prompt for Category Generation.**

**<Instruction>**: Extract the note information in json format, compress it into one word for recommendation, and generate the category of the note.

**<Input Note>**: {’title’:  $t_i$  , ’topic’:  $tp_i$  , ’content’:  $ct_i$ }.

**<Output Guidance>**: The category is:

**<Output>**:  $c_i$

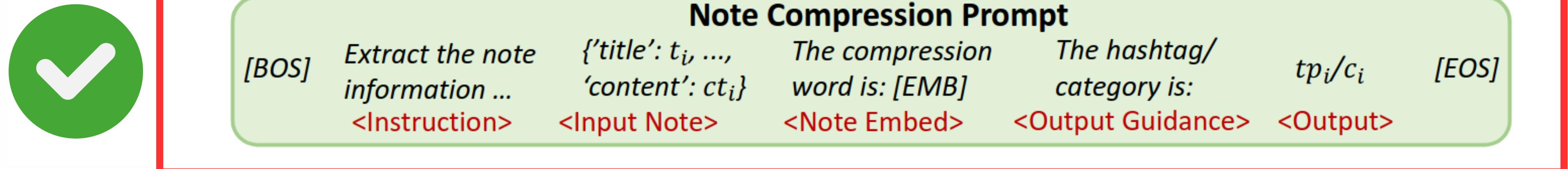
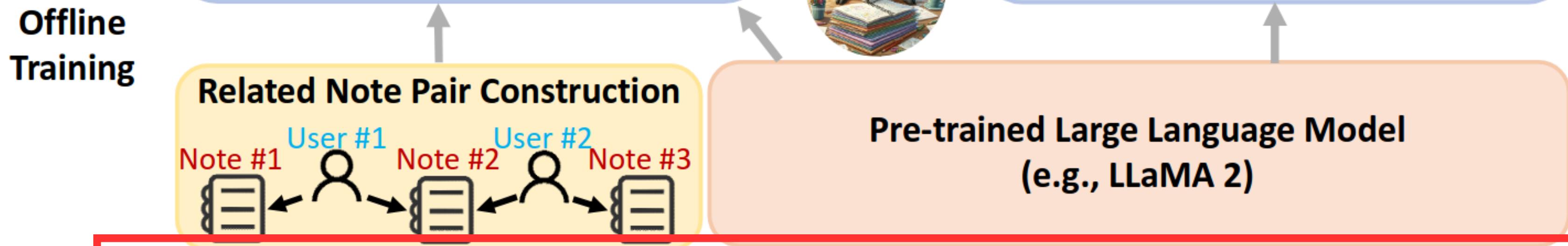
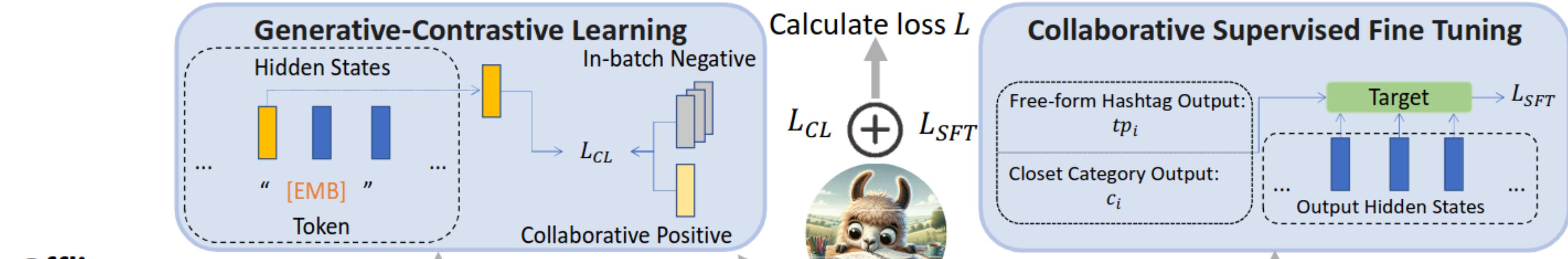
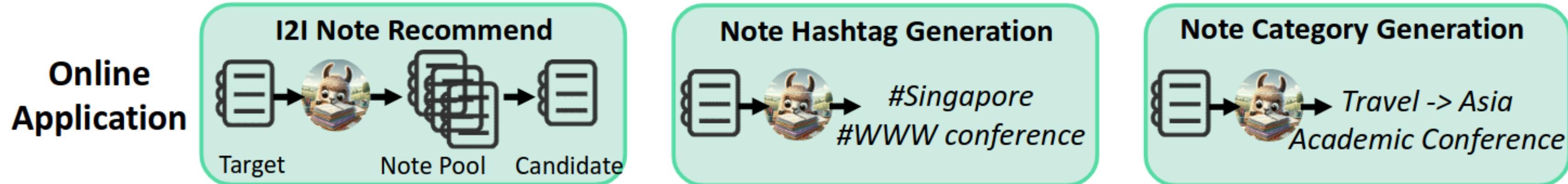
### **Note Compression Prompt for Hashtag Generation.**

**<Instruction>**: Extract the note information in json format, compress it into one word for recommendation, and generate  $\langle j \rangle$  topics of the note.

**<Input Note>**: {’title’:  $t_i$  , ’content’:  $ct_i$ }.

**<Output Guidance>**: The  $\langle j \rangle$  topics are:

**<Output>**:  $\langle j \rangle$  topics from  $tp_i$



# Generative contrastive learning

Algo interesante es saber cómo se relacionan las notas...

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“Co-occurrence score”

$$s_{n_A \rightarrow n_B} = \sum_{i=1}^U \frac{1}{N_i}$$

Ni: el número de notas total con que el usuario interactuó en el log.

Para todas las veces que se encuentra una transición de la nota A a la nota B, sumamos este 1/Ni dependiendo del usuario que hizo esa transición.

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Tomamos cada co-ocurrence score y creamos un set para cada nota...

$$S_{n_i} = \{ s_{n_i \rightarrow n_j} \mid 1 \leq j \leq m, i \neq j \}$$

Finalmente, filtramos y seleccionamos las mejores t notas. Estas son las notas que se relacionan mejor con ni.

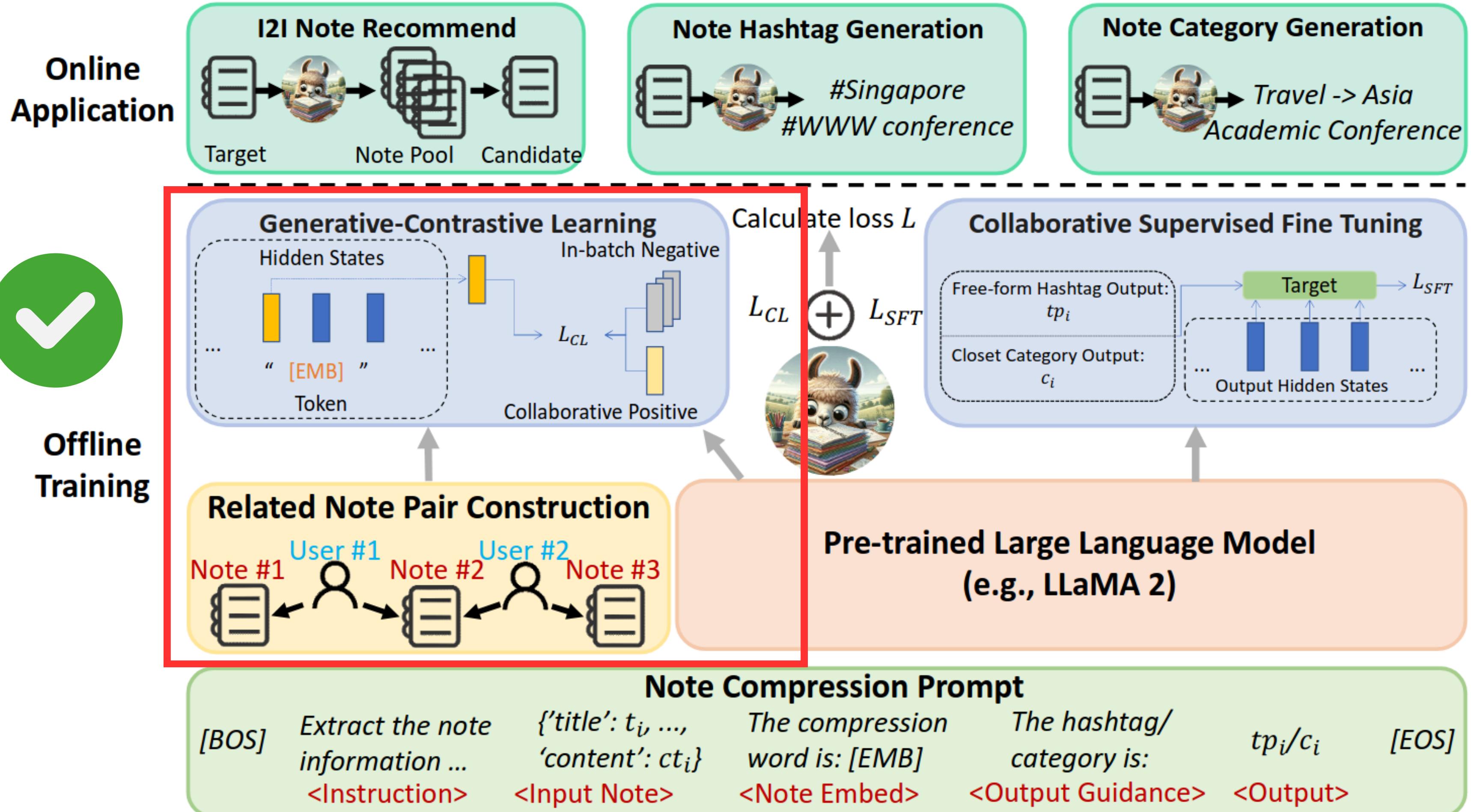
# Generative contrastive learning

- La idea sigue siendo obtener una función de pérdida.
- Para ello, tomamos el último *hidden state* del token previo a [EMB], proveniente de nuestro LLM. Gracias a la propiedad autoregresiva de los transformers, este *hidden state* es el que representa de manera más completa a nuestra nota.
- Este *hidden state* es usado como input para un “linear layer” que retorna los embeddings de las notas.
- A estos embeddings se les compara la similitud con las notas que mejor se relacionan a ellos, aquellas que fueron obtenidas en el set anterior.

# Generative contrastive learning

$$L_{cl} = -\frac{1}{2B} \sum_{i=1}^{2B} \log \frac{e^{\text{sim}(n_i, n_i^+) \cdot \tau}}{\sum_{j \in [2B] \setminus \{i\}} e^{\text{sim}(n_i, n_j) \cdot \tau}}$$

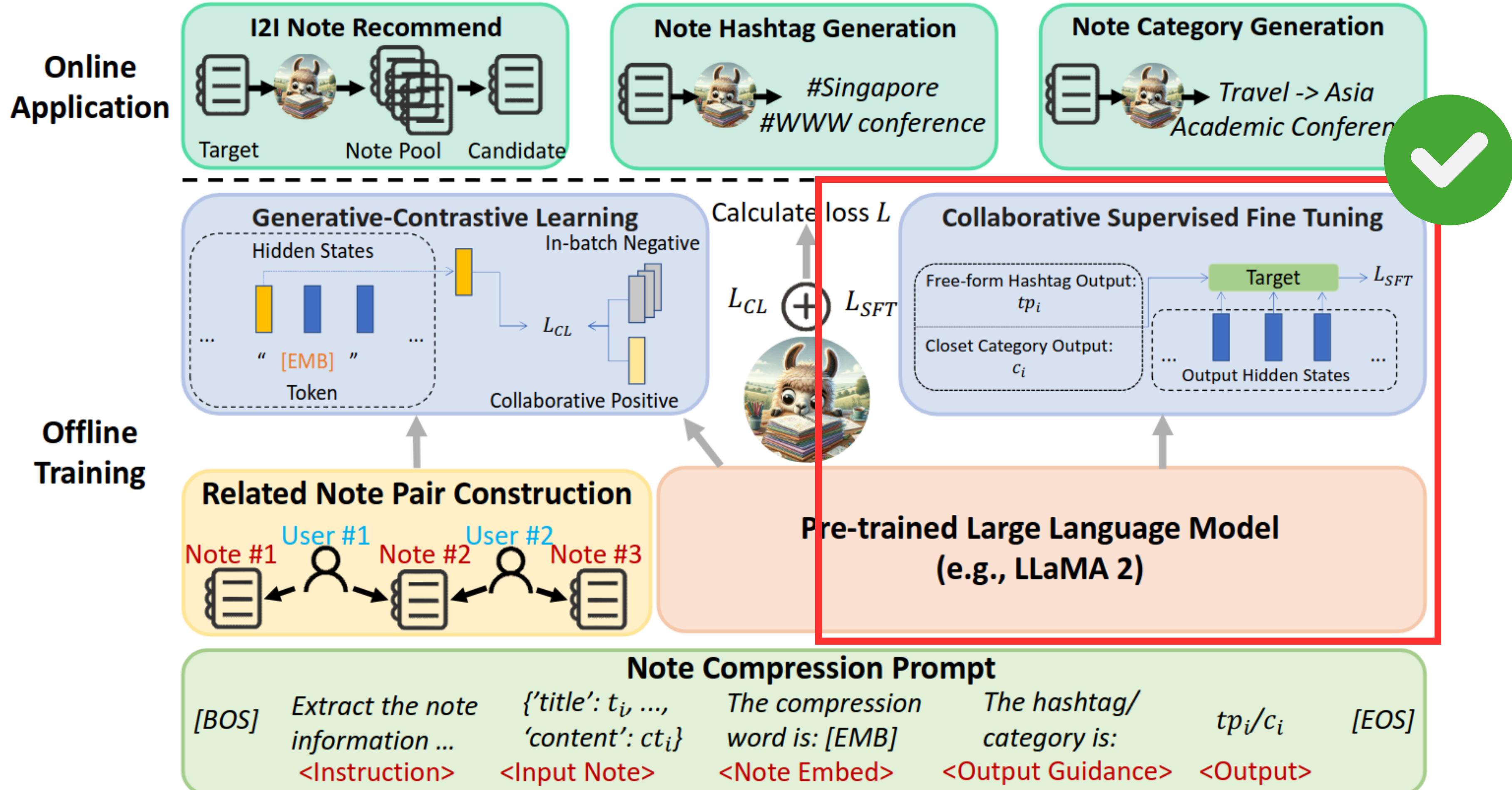
| Symbol                               | Description   |
|--------------------------------------|---|
| $B$                                  | Mini-batch contains $B$ <i>positive pairs</i> of notes; hence $2B$ individual notes.  |
| $\mathbf{n}_i$                       | 128-dimensional embedding of the $i$ -th note, produced by the LLM (last hidden state before [EMB] $\rightarrow$ linear layer). |
| $\mathbf{n}_i^+$                     | Embedding of the note designated as <i>related</i> to $\mathbf{n}_i$ (the positive partner).                                    |
| $\mathbf{n}_j$                       | Embedding of any other note in the same batch; serves as an in-batch <i>negative</i> when $j \neq i, i^+$ .                     |
| $\text{sim}(\mathbf{a}, \mathbf{b})$ | Cosine similarity $\frac{\mathbf{a}^\top \mathbf{b}}{\ \mathbf{a}\  \ \mathbf{b}\ }$ .  |
| $\tau$                               | Learnable temperature that rescales similarities before the soft-max; small $\tau \rightarrow$ sharper distribution.            |



# Collaborative Supervised Fine-Tunning

- Se seleccionan  $r$  notas para la generación de hashtags, y las restantes se asignan a generación de categoría.
- Para cada secuencia de largo  $T$  y cada token  $o_i$

$$L_{gen} = -\frac{1}{T} \sum_{i=1}^T \log(p(o_i | o_{<i}, i)),$$



# Combinando...

$$L = \frac{L_{cl} + \alpha L_{gen}}{1 + \alpha}$$

# Evaluación

## Experimentos y Resultados

```
if _operation == "MIRROR_X":  
    mirror_mod.use_x = True  
    mirror_mod.use_y = False  
    mirror_mod.use_z = False  
  
elif _operation == "MIRROR_Y":  
    mirror_mod.use_x = False  
    mirror_mod.use_y = True  
    mirror_mod.use_z = False  
  
elif _operation == "MIRROR_Z":  
    mirror_mod.use_x = False  
    mirror_mod.use_y = False  
    mirror_mod.use_z = True  
  
    #selection at the end -add back the deselected mirror modifier o  
mirror_ob.select= 1  
modifier_ob.select=1  
bpy.context.scene.objects.active = modifier_ob  
print("Selected" + str(modifier_ob)) # modifier ob is the active ob  
    mirror_ob.select = 0  
bone = bpy.context.selected_bones[0]  
bpy.ops.object.select_all(action='DESELECT')  
modifier_ob.select = 1  
bpy.ops.object.select_all(action='SELECT')
```

# Dataset



Xiaohongshu

**Table 1: Detailed statistics of training and testing dataset.**

| training dataset        |         |                         |         |
|-------------------------|---------|-------------------------|---------|
| #notes                  | 458,221 | #note pairs             | 312,564 |
| avg. #words per title   | 11.54   | avg. #hashtag per note  | 3.02    |
| avg. #words per hashtag | 4.19    | avg. #words per content | 47.67   |
| testing dataset         |         |                         |         |
| #notes                  | 257,937 | #note pairs             | 27,999  |
| avg. #words per title   | 13.70   | avg. #hashtag per note  | 5.49    |
| avg. #words per hashtag | 4.53    | avg. #words per content | 182.45  |

# Offline Performance Evaluation

| Método        | ¿Se usó prompt? | ¿Fine-Tuned? | ¿Contrastive? | Tipo de modelo     |
|---------------|-----------------|--------------|---------------|--------------------|
| Zero-shot     | ✗               | ✗            | ✗             | LLM (sólo encoder) |
| PromptEOL     | ✓ (una palabra) | ✗            | ✗             | LLM (zero-shot)    |
| SentenceBERT  | ✗               | ✓            | ✓             | BERT               |
| PromptEOL+CSE | ✓               | ✓            | ✓             | LLM                |
| RepLLaMA      | ✗               | ✓            | ✓             | LLM (bi-encoder)   |

# Performance de los métodos

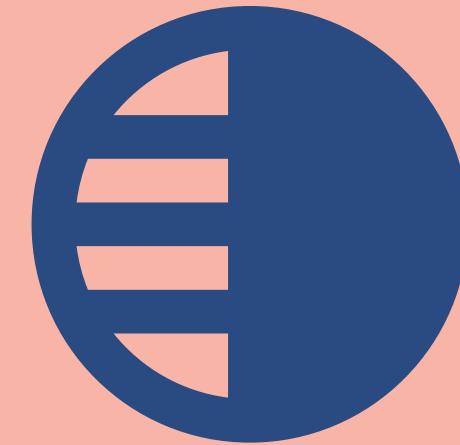


**Table 2: Performance of different methods in I2I recommendation tasks (%).**

|                            | Model Size | Recall@100   | Recall@1k    | Recall@10k   | Recall@100k  | Avg.         |
|----------------------------|------------|--------------|--------------|--------------|--------------|--------------|
| LLaMA 2 zero-shot          | 7B         | 11.94        | 19.44        | 32.53        | 68.81        | 33.18        |
| PromptEOL zero-shot [10]   | 7B         | 55.27        | 74.47        | 88.71        | 98.04        | 79.12        |
| SentenceBERT (Online) [36] | 110M       | 70.72        | 87.88        | 96.29        | 99.62        | 88.63        |
| PromptEOL+CSE [10]         | 7B         | 83.28        | <b>95.26</b> | 99.20        | <b>99.96</b> | 94.43        |
| RepLLaMA [26]              | 7B         | 83.63        | 95.10        | <b>99.27</b> | 99.94        | 94.49        |
| NoteLLM                    | 7B         | <b>84.02</b> | 95.23        | 99.23        | <b>99.96</b> | <b>94.66</b> |

# Tareas de recomendación I2I

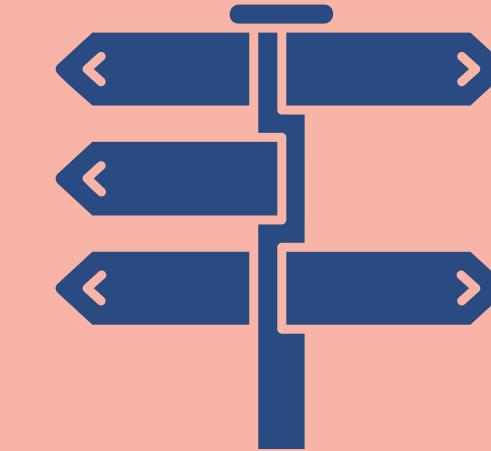
CON BAJA Y ALTA EXPOSICIÓN



**Table 3: Performance of different methods for low exposure notes and high exposure notes in I2I recommendation tasks (%).**

|                            | Low Exposure |              | High Exposure |              | Overall      |              |
|----------------------------|--------------|--------------|---------------|--------------|--------------|--------------|
|                            | Recall@100   | Recall@1k    | Recall@100    | Recall@1k    | Recall@100   | Recall@1k    |
| SentenceBERT (Online) [36] | 75.00        | 90.54        | 59.03         | 81.91        | 70.72        | 87.88        |
| PromptEOL+CSE [10]         | 86.28        | <b>96.63</b> | 72.46         | <b>91.40</b> | 83.28        | <b>95.26</b> |
| RepLLaMA [26]              | 86.54        | 96.18        | 72.64         | 91.37        | 83.63        | 95.10        |
| NoteLLM                    | <b>87.85</b> | <b>96.63</b> | <b>73.46</b>  | 91.26        | <b>84.02</b> | 95.23        |

# Estudios de ablación



- Sin CSFT: Sólo emplea el módulo **GCL**.
- Sin **GCL** ( $r = 40\%$ ): Sólo adopta el módulo **CSFT** para guiar LLMs para generar hashtags y categorías.
- Sin **GCL** ( $r = 0\%$ ): Sólo genera la categoría.
- Sin **GCL** ( $r = 100\%$ ): Sólo genera hashtags.

**Table 4: Ablation study for NoteLLM in I2I recommendation, category generation and hashtag generation tasks (%).**

| Model                   | R@100        | R@1k         | R@10k        | R@100k       | Avg.         | Acc.         | Ill.        | BLEU4       | ROUGE1       | ROUGE2       | ROUGEL       |
|-------------------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|--------------|--------------|--------------|
| NoteLLM                 | <b>84.02</b> | 95.23        | <b>99.23</b> | <b>99.96</b> | <b>94.66</b> | 66.17        | 0.50        | <b>1.38</b> | 22.31        | 8.02         | 21.03        |
| w/o CSFT                | 83.28        | <b>95.26</b> | 99.20        | <b>99.96</b> | 94.43        | 0.00         | 100.00      | 0.01        | 0.00         | 0.00         | 0.00         |
| w/o GCL ( $r = 40\%$ )  | 75.38        | 90.33        | 97.09        | 98.93        | 90.43        | 75.12        | 2.27        | 1.28        | 26.50        | 13.02        | 23.27        |
| w/o GCL ( $r = 0\%$ )   | 60.38        | 83.22        | 96.13        | 98.84        | 84.64        | <b>80.64</b> | <b>0.07</b> | 0.00        | 1.54         | 0.00         | 1.54         |
| w/o GCL ( $r = 100\%$ ) | 71.98        | 87.86        | 95.59        | 98.51        | 88.49        | 0.18         | 99.70       | 1.30        | <b>27.66</b> | <b>14.19</b> | <b>24.11</b> |

# Impacto de la diversidad de los datos en el módulo CSFt

Table 5: Performance of NoteLLM under different data diversity in CSFT module for I2I recommendation, category generation and hashtag generation tasks (%).

| $r$  | R@100        | R@1k         | R@10k        | R@100k       | Avg.         | Acc.         | Ill.        | BLEU4       | ROUGE1       | ROUGE2      | ROUGEL       |
|------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|--------------|-------------|--------------|
| 0%   | 83.29        | 95.07        | 99.14        | 99.96        | 94.37        | <b>71.00</b> | 0.12        | 0.00        | 0.00         | 0.00        | 0.00         |
| 20%  | 83.81        | <b>95.28</b> | 99.26        | 99.96        | 94.58        | 69.70        | <b>0.09</b> | <b>1.59</b> | <b>22.57</b> | 7.73        | <b>21.64</b> |
| 40%  | <b>84.02</b> | 95.23        | 99.23        | 99.96        | <b>94.66</b> | 66.17        | 0.50        | 1.38        | 22.31        | 8.02        | 21.03        |
| 60%  | 83.37        | 95.03        | 99.25        | 99.96        | 94.40        | 63.37        | 0.90        | 1.33        | 21.92        | 7.88        | 20.62        |
| 80%  | 83.15        | 95.06        | <b>99.27</b> | <b>99.97</b> | 94.36        | 53.60        | 2.67        | 1.34        | 22.48        | <b>8.31</b> | 21.10        |
| 100% | 82.49        | 94.49        | 99.11        | 99.96        | 94.01        | 0.00         | 100.00      | 1.33        | 21.88        | 7.99        | 20.47        |

# Impacto de la magnitud de CSFt

Table 6: Performance of NoteLLM under varying CSFT module magnitudes for I2I recommendation, category generation and hashtag generation tasks (%).

| Model            | R@100        | R@1k         | R@10k        | R@100k       | Avg.         | Acc.         | Ill.        | BLEU4       | ROUGE1       | ROUGE2       | ROUGEL       |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|--------------|--------------|--------------|
| $\alpha = 0$     | 83.42        | 95.13        | <b>99.31</b> | 99.96        | 94.46        | 0.00         | 100.00      | 0.05        | 0.91         | 0.01         | 0.87         |
| $\alpha = 0.001$ | 83.73        | 95.09        | 99.26        | <b>99.97</b> | 94.51        | 49.04        | 6.84        | <b>1.82</b> | 15.13        | 3.23         | 14.80        |
| $\alpha = 0.01$  | <b>84.02</b> | <b>95.23</b> | 99.23        | 99.96        | <b>94.66</b> | 66.17        | 0.50        | 1.38        | 22.31        | 8.02         | 21.03        |
| $\alpha = 0.1$   | 83.51        | 95.18        | <b>99.31</b> | 99.96        | 94.49        | 73.33        | <b>0.04</b> | 1.33        | 24.44        | 10.42        | 22.28        |
| $\alpha = 1$     | 83.79        | 94.79        | 99.26        | <b>99.97</b> | 94.45        | 74.69        | 0.82        | 1.33        | 26.94        | 13.21        | 23.90        |
| $\alpha = 10$    | 82.92        | 94.28        | 98.94        | 99.96        | 94.03        | <b>75.15</b> | 2.08        | 1.30        | <b>27.63</b> | <b>13.95</b> | <b>24.21</b> |

# Casos de Estudio

|  |  |  |  |   |
|--|--|--|--|---|
| <p><b>Query Note</b></p> <p><b>Title:</b> 10 Types of Summer Clothes I Will No Longer Buy</p> <p><b>Category:</b> Dressing</p> <p><b>Hashtag:</b> #SummerOutfit #CleanfitSimpleOuting #Minimalism</p> <p><b>Content:</b> ① Tight clothes...</p>  | <p><b>SentenceBERT(online)</b></p> <p><b>Title:</b> 🌸May Outfit Collection Share Summer Outfit Inspiration</p> <p><b>Category:</b> Dressing</p> <p><b>Hashtag:</b> #SummerOutfit</p> <p><b>Content:</b> Share I'm here to share my May outfit collection ☺</p>   | <p><b>PromptEOL</b></p> <p><b>Title:</b> A total of 96 sets of summer outfits☀️ enough to last a whole summer!</p> <p><b>Category:</b> Dressing</p> <p><b>Hashtag:</b> #summerwear</p> <p><b>Content:</b> Summer outfit guide, a total of 96 looks! ✨...</p>   | <p><b>RepLLaMA</b></p> <p><b>Title:</b> A total of 96 sets of summer outfits☀️ enough to last a whole summer!</p> <p><b>Category:</b> Dressing</p> <p><b>Hashtag:</b> #summerwear</p> <p><b>Content:</b> Summer outfit guide, a total of 96 looks! ✨...</p>  | <p><b>NoteLLM</b></p> <p><b>Title:</b> I've Stopped Shopping for Clothes</p> <p><b>Category:</b> Dressing</p> <p><b>Hashtag:</b> #Simple living #Streamlined living #Cleanfit</p> <p><b>Content:</b> Why downsize your wardrobe? One is that I hope I won't buy clothes randomly...</p> |
| <p><b>Query Note</b></p> <p><b>Title:</b> Don't let strangers into your own rabbit🐰</p> <p><b>Category:</b> Toys</p> <p><b>Hashtag:</b> #Keep strangers away</p> <p><b>Content:</b> I went to the mall and bought two rabbits toy...</p>   | <p><b>SentenceBERT(online)</b></p> <p><b>Title:</b> Raising rabbits🐰</p> <p><b>Category:</b> Rabbits</p> <p><b>Hashtag:</b> #Rabbitdaily</p> <p><b>Content:</b> Changed to a larger cage and kept cleaning it 2-3 times a day. With rabbit food ...</p>  | <p><b>PromptEOL</b></p> <p><b>Title:</b> How to raise rabbits?</p> <p><b>Category:</b> Rabbits</p> <p><b>Hashtag:</b> #Rabbit</p> <p><b>Content:</b> It's a very small one, it feels like it's just one month old...</p>   | <p><b>RepLLaMA</b></p> <p><b>Title:</b> Mother Rabbit plucked all her fur, maternal love is the greatest</p> <p><b>Category:</b> Rabbits</p> <p><b>Hashtag:</b> #petRabbit</p> <p><b>Content:</b> Pregnant mother rabbit pluck...</p>  | <p><b>NoteLLM</b></p> <p><b>Title:</b> Keep strangers away from the circus sell or change</p> <p><b>Category:</b> Toys</p> <p><b>Hashtag:</b> #Keep strangers away #circus performer #blind box</p> <p><b>Content:</b> Brand new and unopened rabbit toy box for sell...</p>            |
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# Experimentos Online

Comparación con  
SentenceBERT(online)

|  |        |
|--|--------|
| Tasa de clicks                               | +16.2% |
| Comentarios                                  | +1.1%  |
| Comentarios en nuevas<br>notas               | +3.58% |
| Nuevos creadores de<br>contenidos por semana | +0.41% |



# NoteLLM: A Retrievable Large Language Model for Note Recommendation

# Anexo: Transformers

