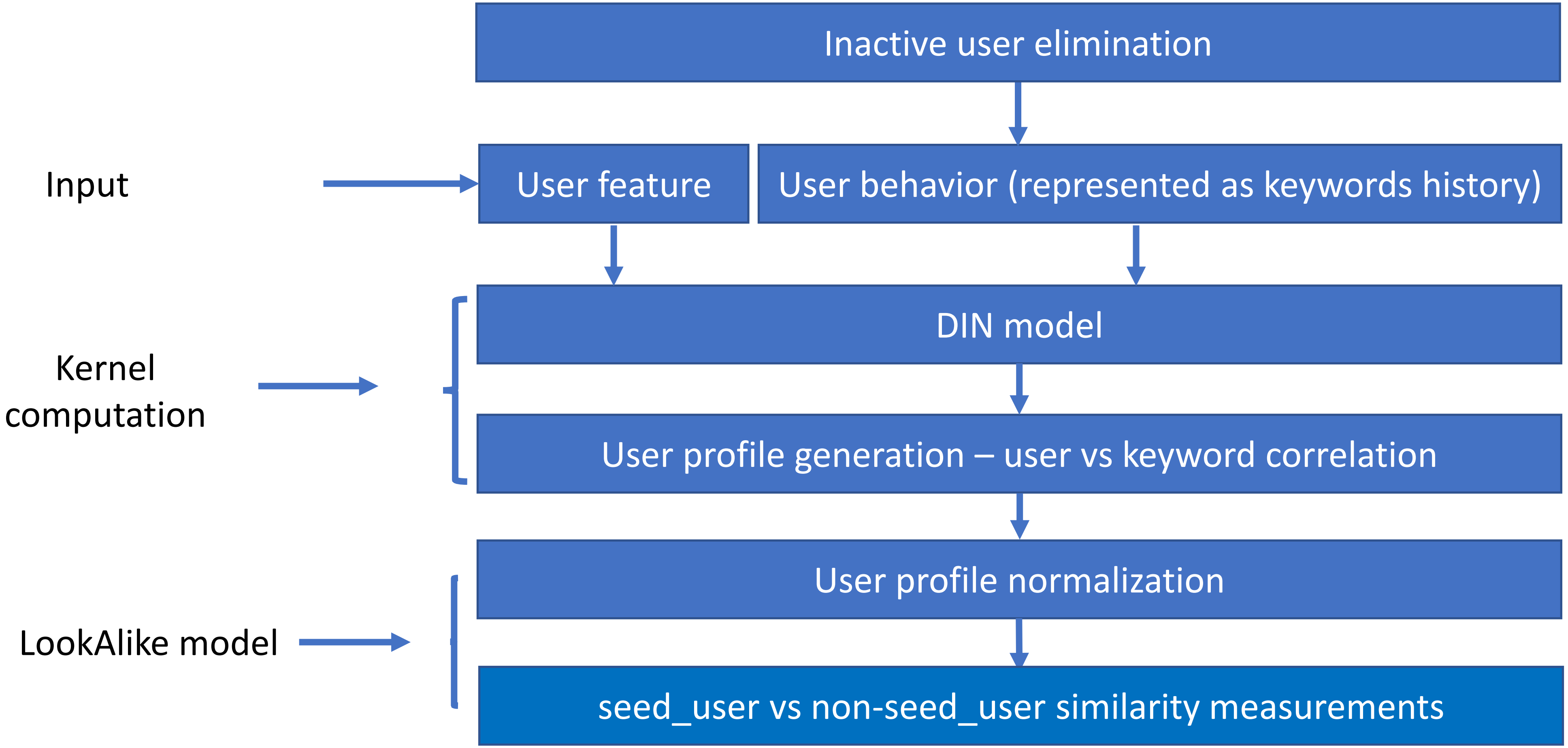
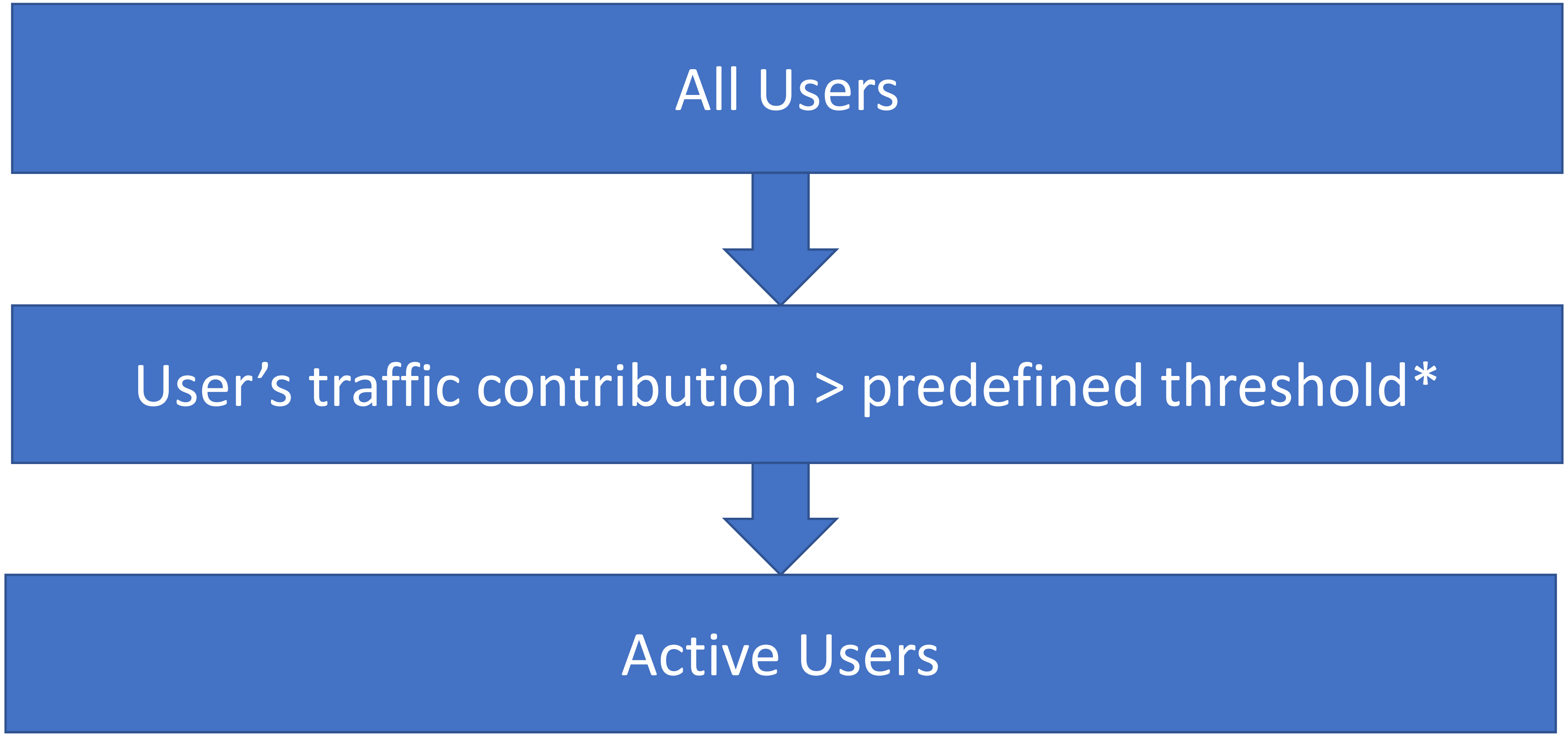
DIN based Look-Alike model

Workflow

- Necessary steps


Inactive user elimination
Input
User feature
User behavior (represented as keywords history)
Kernel computation
DIN model
User profile generation – user vs keyword correlation
User profile normalization
LookAlike model
seed_user vs non-seed_user similarity measurements

Inactive user elimination (user prescreen)



All Users

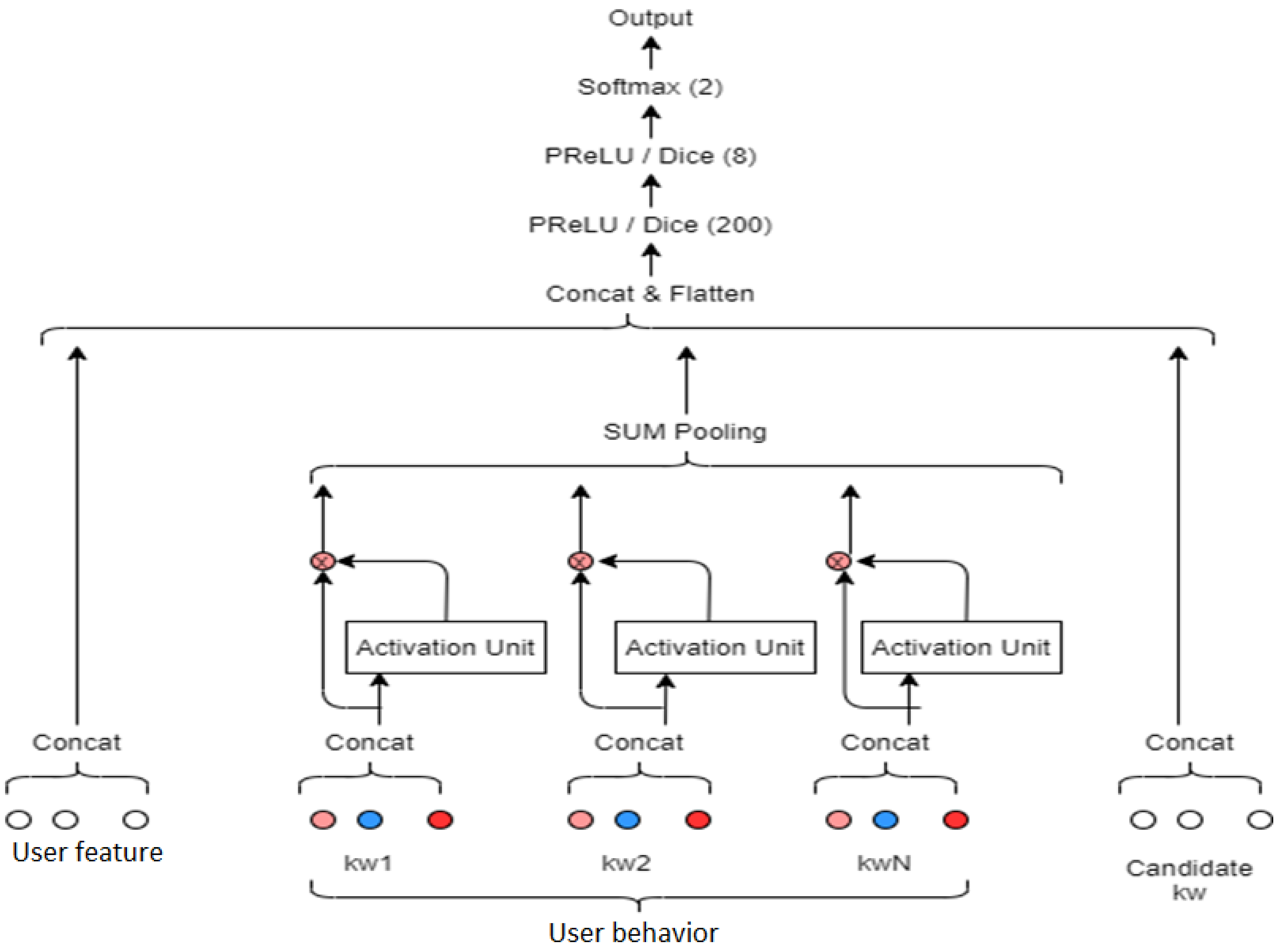
User's traffic contribution > predefined threshold*

Active Users

* "Prefined threshold" is defined as a range of normal traffic (with low and high bounds) to eliminate:

1. users with consistent low traffic (inactive user, traffic < low bound)
2. users with extremely high traffic for some specific period (robot user, traffic > high bound)

DIN Model


Output
Softmax (2)
PReLU / Dice (8)
PReLU / Dice (200)
Concat & Flatten
SUM Pooling
Activation Unit
Activation Unit
Activation Unit
Concat
Concat
Concat
Concat
Concat
User feature
kw1
kw2
kwN
Candidate kw
User behavior

DIN Model Output

– user vs keyword correlation (user profile generation)

	Keyword$_1$	Keyword$_2$	Keyword$_3$	Keyword$_4$	…	Keyword$_m$
User$_1$	score$_{11}$	score$_{12}$	score$_{13}$	score$_{14}$	…	score$_{1m}$
User$_2$	score$_{21}$	score$_{22}$	score$_{23}$	score$_{24}$	…	score$_{2m}$
…	…	…	…	…	…	…
User$_n$	score$_{n1}$	score$_{n2}$	score$_{n3}$	score$_{n4}$	…	score$_{nm}$

DIN

DIN Model Output

– user profile normalization

DIN

	Keyword$_1$	Keyword$_2$	Keyword$_3$	Keyword$_4$	…	Keyword$_m$
User$_1$	score$_{11}$	score$_{12}$	score$_{13}$	score$_{14}$	…	score$_{1m}$
User$_2$	score$_{21}$	score$_{22}$	score$_{23}$	score$_{24}$	…	score$_{2m}$
…	…	…	…	…	…	…
User$_n$	score$_{n1}$	score$_{n2}$	score$_{n3}$	score$_{n4}$	…	score$_{nm}$

Normalization constant
C$_1$
C$_2$
…
C$_n$

Score normalization

	Keyword$_1$	Keyword$_2$	Keyword$_3$	Keyword$_4$	…	Keyword$_m$
User$_1$	norm_score$_{11}$	norm_score$_{12}$	norm_score$_{13}$	norm_score$_{14}$	…	norm_score$_{1m}$
User$_2$	norm_score$_{21}$	norm_score$_{22}$	norm_score$_{23}$	norm_score$_{24}$	…	norm_score$_{2m}$
…	…	…	…	…	…	…
User$_n$	norm__Score$_{n1}$	norm_score$_{n2}$	norm_score$_{n3}$	norm_score$_{n4}$	…	norm_score$_{nm}$

$$norm\_score_{ij} = \frac{score_{ij}}{C_i}$$

$$C_i = \sqrt{\sum_{j=1}^{m} score_{ij}^2}$$

DIN Model Output

– user similarity measurement

$\boldsymbol{User_i's\ normalized\ profile}$:

$$S_i = \{norm\_score_{i1}, \quad norm\_score_{i2}, \quad \ldots \quad norm\_score_{im}\}$$

$\boldsymbol{Cross\ user\ similarity}$:

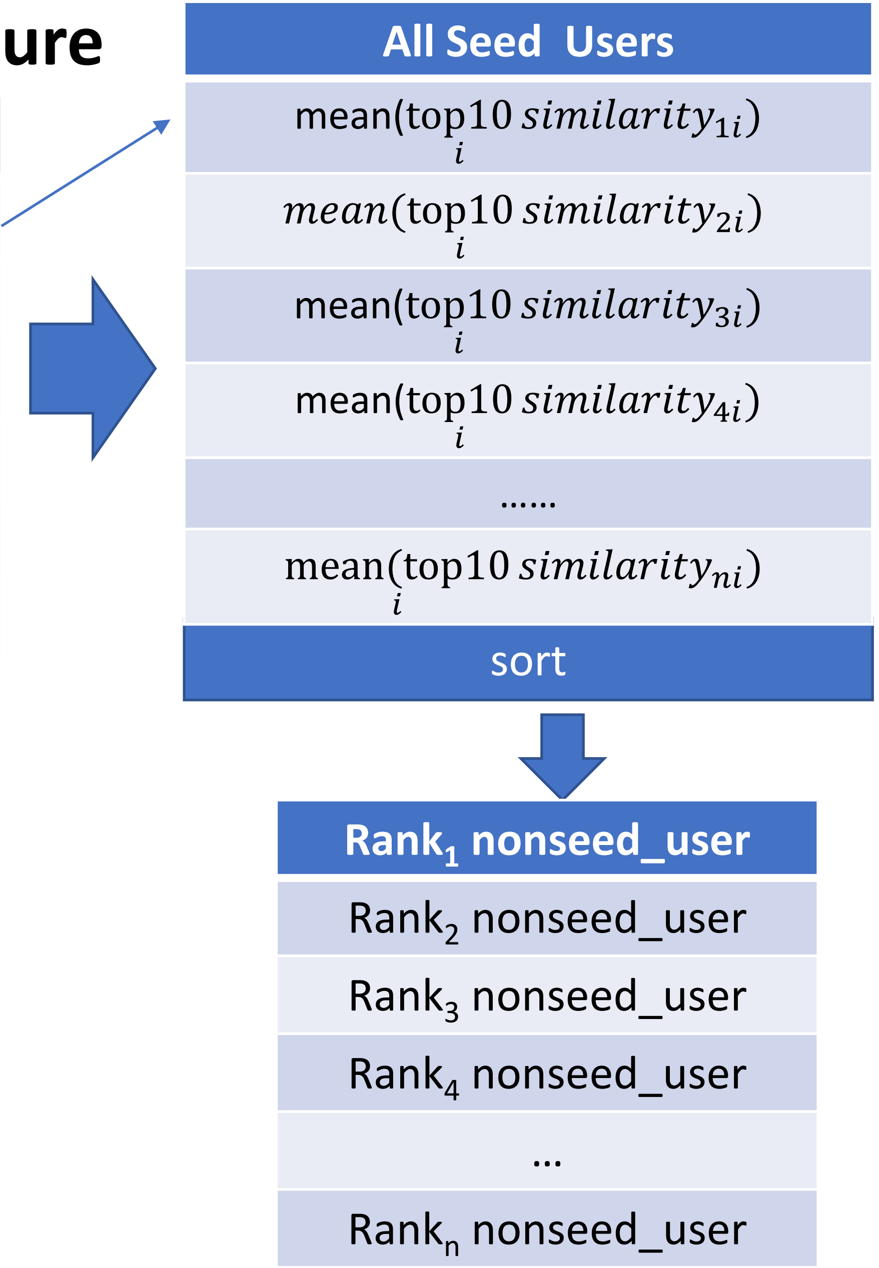
$$Similarity(S_i, \quad S_j) = S_i \quad \cdot \quad S_j = \sum_{k=1}^{m} norm\_score_{ik} \times norm\_score_{jk}$$

DIN based Look-Alike model

– seed_user vs non-seed_user similarity measure

	Seed_user$_1$	Seed_user$_2$	……	Seed_user$_m$
Nonseed_user$_1$	Similary$_{11}$	Similary$_{12}$	……	Similary$_{1m}$
Nonseed_user$_2$	Similary$_{21}$	Similary$_{22}$	……	Similary$_{2m}$
Nonseed_user$_3$	Similary$_{31}$	Similary$_{32}$	……	Similary$_{3m}$
Nonseed_user$_4$	Similary$_{41}$	Similary$_{42}$	……	Similary$_{4m}$
……	……	……	……	……
Nonseed_user$_n$	Similary$_{n1}$	Similary$_{n2}$	……	Similary$_{nm}$

Parallel computed and only maximum value for each row need to be stored



All Seed Users

$\text{mean}(\underset{i}{\text{top10}}\, similarity_{1i})$

$mean(\underset{i}{\text{top10}}\, similarity_{2i})$

$\text{mean}(\underset{i}{\text{top10}}\, similarity_{3i})$

$\text{mean}(\underset{i}{\text{top10}}\, similarity_{4i})$

……

$\underset{i}{\text{mean}}(\text{top10}\, similarity_{ni})$

sort

Rank$_1$ nonseed_user

Rank$_2$ nonseed_user

Rank$_3$ nonseed_user

Rank$_4$ nonseed_user

…

Rank$_n$ nonseed_user

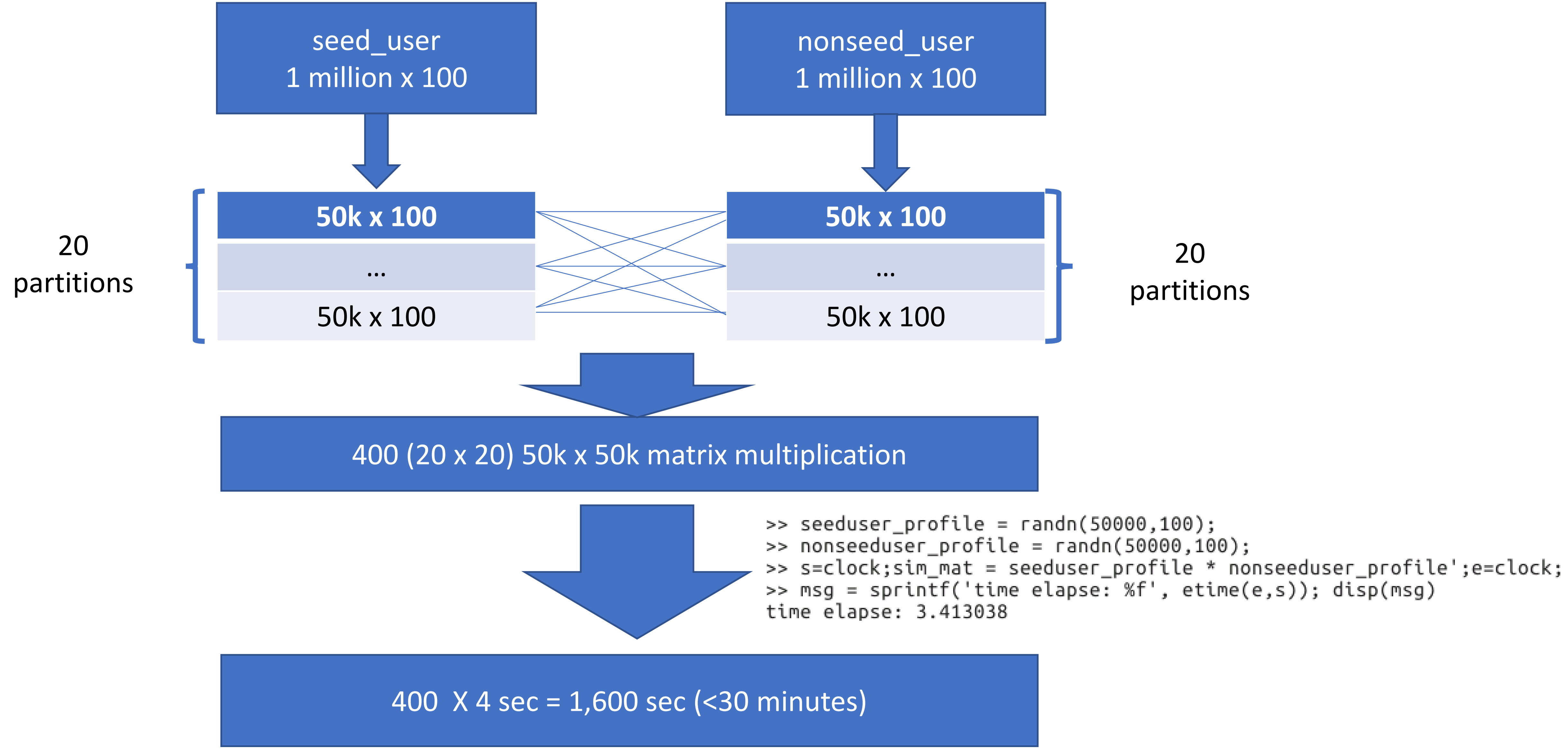
Similarity computation estimation

$$M_{seed} = \begin{bmatrix} norm\_score_{1,1} & \cdots & norm\_score_{1,m} \\ \cdots & \cdots & \cdots \\ norm\_score_{n_{seed},1} & \cdots & norm\_score_{n_{seed},m} \end{bmatrix}$$

$$M_{nonseed} = \begin{bmatrix} norm\_score_{1,1} & \cdots & norm\_score_{1,m} \\ \cdots & \cdots & \cdots \\ norm\_score_{n_{nonseed},1} & \cdots & norm\_score_{n_{nonseed},m} \end{bmatrix}$$

$$M_{similarity} = M_{seed} \quad \times \quad M_{nonseed}^{T}$$

Similarity computation estimation



seed_user
1 million x 100

nonseed_user
1 million x 100

20
partitions

50k x 100

…

50k x 100

50k x 100

…

50k x 100

20
partitions

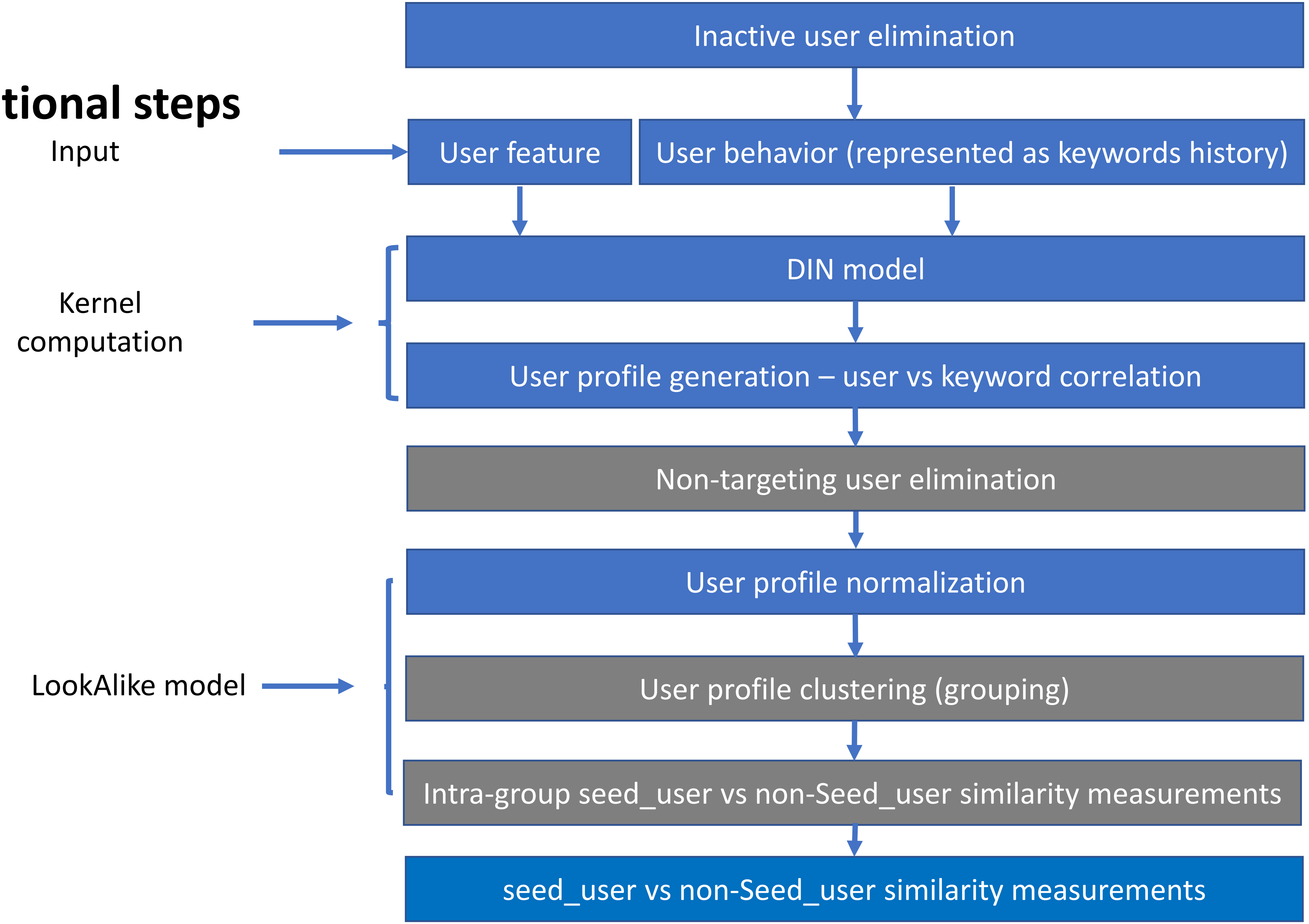
400 (20 x 20) 50k x 50k matrix multiplication

```
>> seeduser_profile = randn(50000,100);
>> nonseeduser_profile = randn(50000,100);
>> s=clock;sim_mat = seeduser_profile * nonseeduser_profile';e=clock;
>> msg = sprintf('time elapse: %f', etime(e,s)); disp(msg)
time elapse: 3.413038
```

400 X 4 sec = 1,600 sec (<30 minutes)

Workflow

- Necessary + optional steps



Input

Kernel computation

LookAlike model

Inactive user elimination

User feature

User behavior (represented as keywords history)

DIN model

User profile generation – user vs keyword correlation

Non-targeting user elimination

User profile normalization

User profile clustering (grouping)

Intra-group seed_user vs non-Seed_user similarity measurements

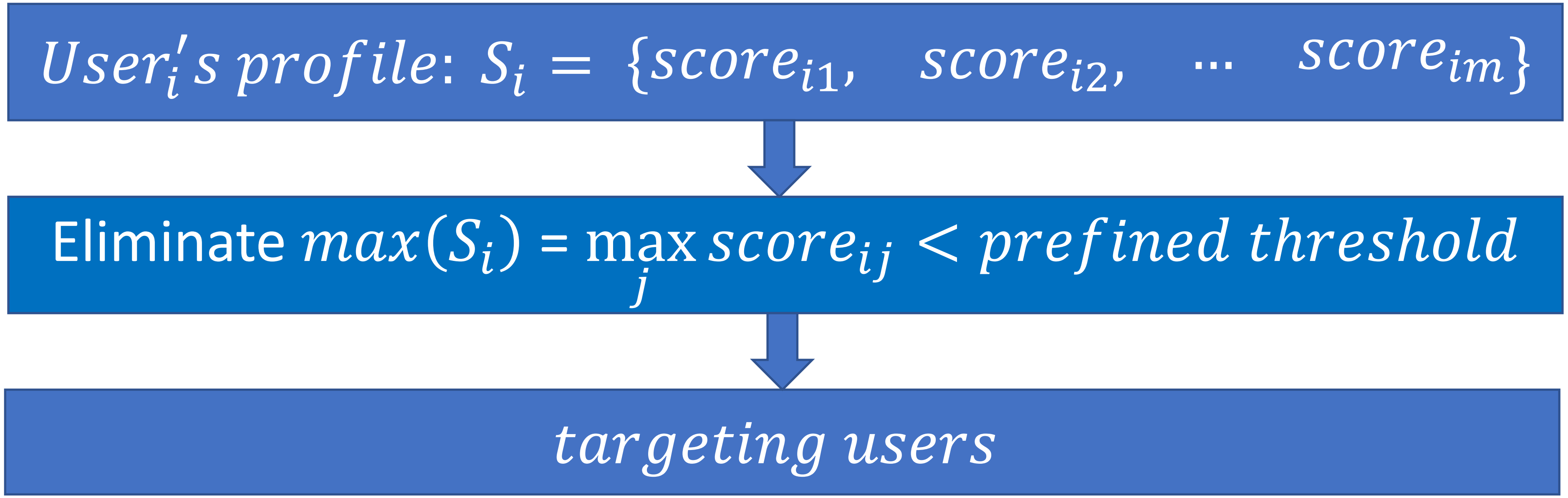
seed_user vs non-Seed_user similarity measurements

DIN Model Output

– non-targeting user elimination

	Keyword$_1$	Keyword$_2$	Keyword$_3$	Keyword$_4$	…	Keyword$_m$
User$_1$	score$_{11}$	score$_{12}$	score$_{13}$	score$_{14}$	…	score$_{1m}$
User$_2$	score$_{21}$	score$_{22}$	score$_{23}$	score$_{24}$	…	score$_{2m}$
…	…	…	…	…	…	…
User$_n$	score$_{n1}$	score$_{n2}$	score$_{n3}$	score$_{n4}$	…	score$_{nm}$

DIN



$User_i' s\ profile:\ S_i = \{score_{i1},\ \ score_{i2},\ \ \cdots\ \ score_{im}\}$

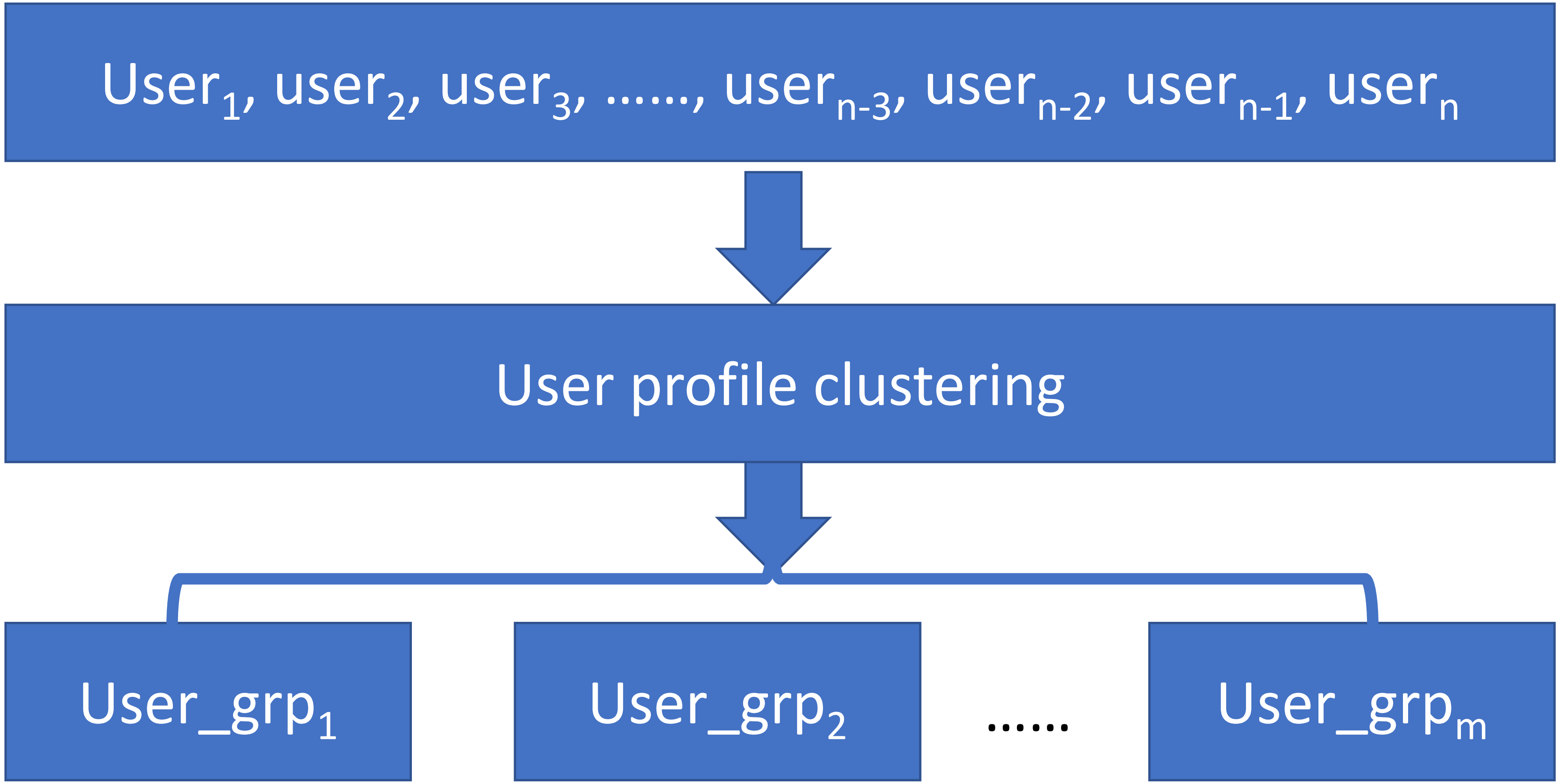
Eliminate $max(S_i)$ = $\max_j score_{ij} < prefined\ threshold$

$targeting\ users$

* The purpose is to eliminate users that have no interest of any keywords (ineffective traffic)

DIN Model Output

– user clustering



User$_1$, user$_2$, user$_3$, ……, user$_{n-3}$, user$_{n-2}$, user$_{n-1}$, user$_n$

User profile clustering

User_grp$_1$ User_grp$_2$ …… User_grp$_m$

DIN based Look-Alike model

– group-wise seed_user vs non-seed_user similarity measure (active user only)

	Seed user in grp$_1$	Seed user in grp$_2$	……	Seed user in grp$_m$
Nonseed user in grp$_1$	similarity matrix$_{11}$	0	……	0
Nonseed user in grp$_2$	0	similarity matrix$_{22}$	……	0
……	……	……	……	0
Nonseed user in grp$_m$	0	0	……	similarity matrix$_{mm}$

DIN based Look-Alike model

– within group seed_user vs non-seed_user similarity measure

Similarity matrix$_{ij}$

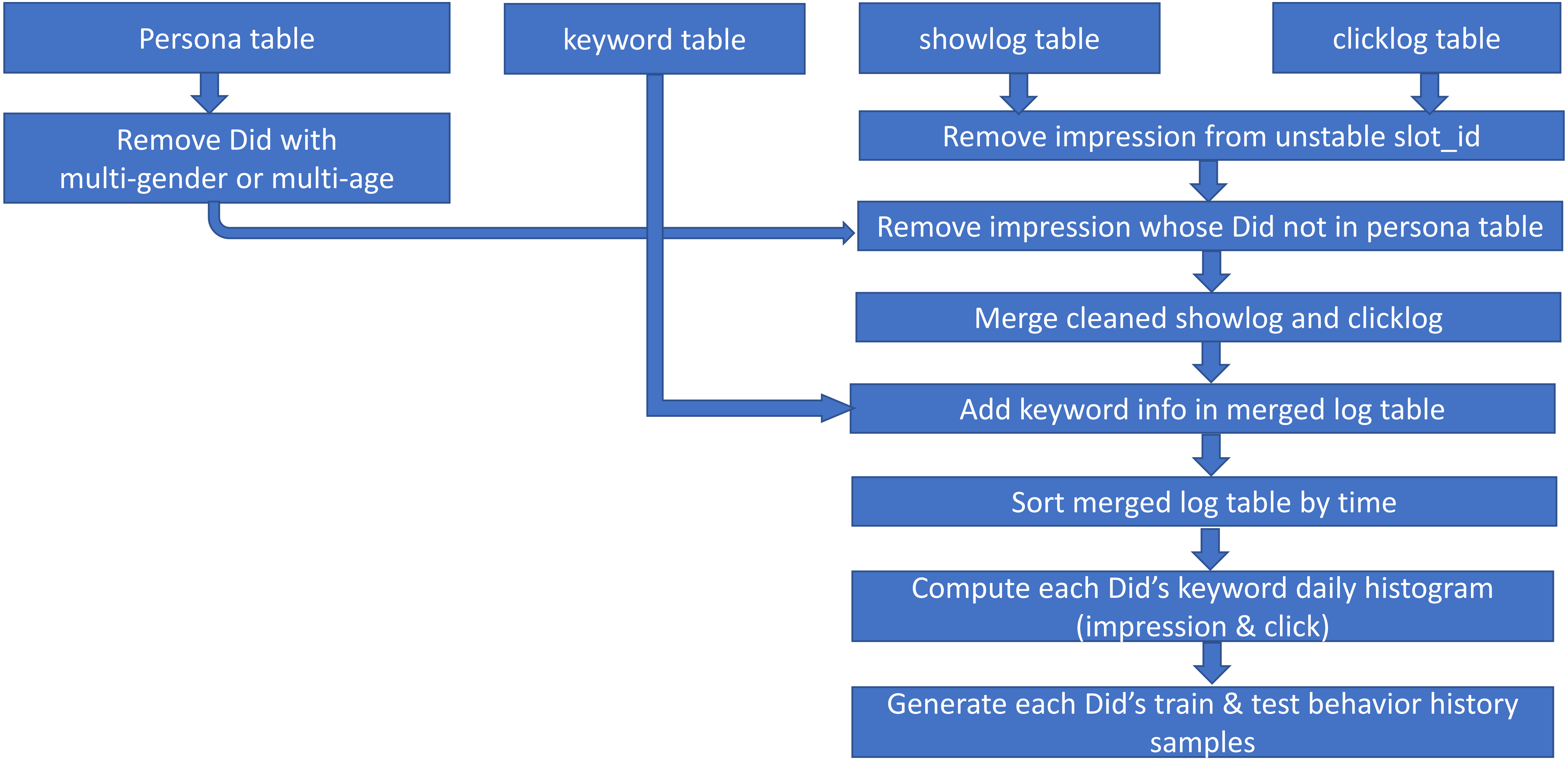
	Seed_user$_{grpi,1}$	Seed_user$_{grpi’2}$	……	Seed_user$_{grpi’m}$
Nonseed_user$_{grpi’1}$	Similary$_{11}$	Similary$_{12}$	……	Similary$_{1m}$
Nonseed_userg$_{rpi’2}$	Similary$_{21}$	Similary$_{22}$	……	Similary$_{2m}$
Nonseed_user$_{grpi’3}$	Similary$_{31}$	Similary$_{32}$	……	Similary$_{3m}$
Nonseed_user$_{grpi’4}$	Similary$_{41}$	Similary$_{42}$	……	Similary$_{4m}$
……	……	……	……	……
Nonseed_user$_{grpi’n}$	Similary$_{n1}$	Similary$_{n2}$	……	Similary$_{nm}$

Parallel computed and top 10 values
for each row need to be stored

All Seed Users in grpi
$\mathrm{mean}(\underset{i}{\mathrm{top}10}\, similarity_{1i})$
$mean(\underset{i}{\mathrm{top}10}\, similarity_{2i})$
$\mathrm{mean}(\underset{i}{\mathrm{top}10}\, similarity_{3i})$
$\mathrm{mean}(\underset{i}{\mathrm{top}10}\, similarity_{4i})$
……
$\mathrm{mean}(\underset{i}{\mathrm{top}10}\, similarity_{ni})$
sort

Rank$_1$ nonseed_user
Rank$_2$ nonseed_user
Rank$_3$ nonseed_user
Rank$_4$ nonseed_user
…
Rank$_n$ nonseed_user

Log preprocessing steps for DIN model training/validation



Persona table

Remove Did with multi-gender or multi-age

keyword table

showlog table

clicklog table

Remove impression from unstable slot_id

Remove impression whose Did not in persona table

Merge cleaned showlog and clicklog

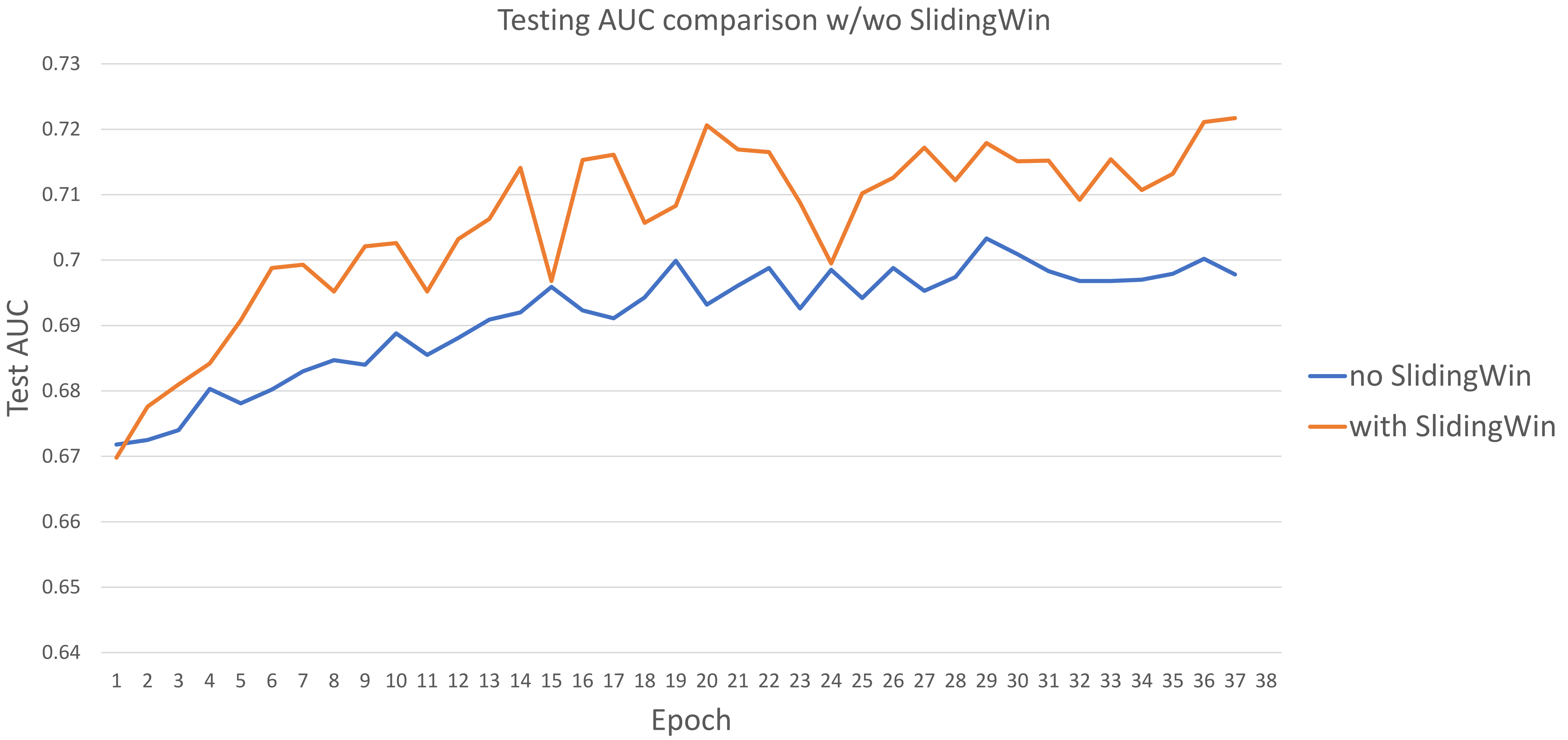
Add keyword info in merged log table

Sort merged log table by time

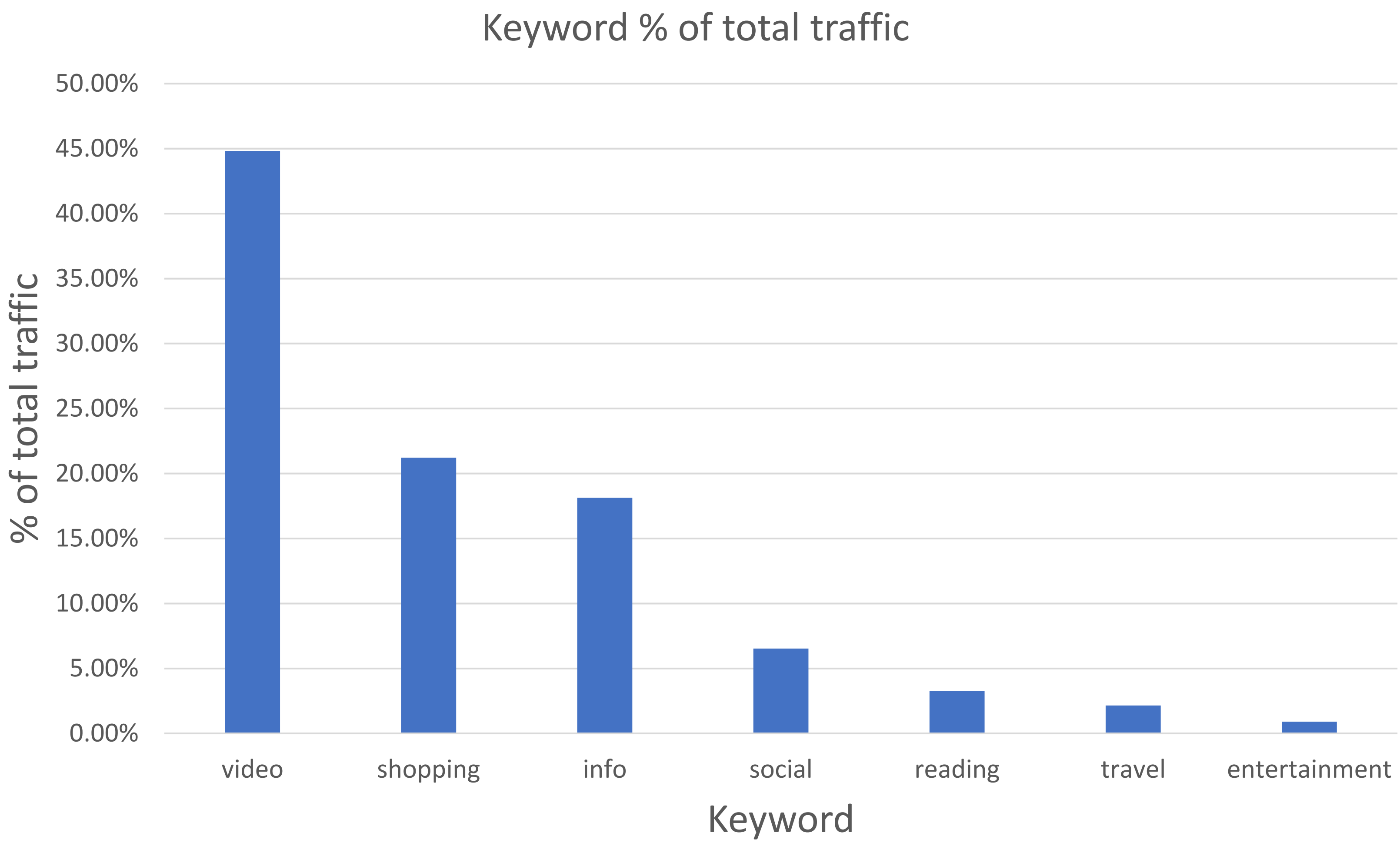
Compute each Did's keyword daily histogram (impression & click)

Generate each Did's train & test behavior history samples

DIN model test performance

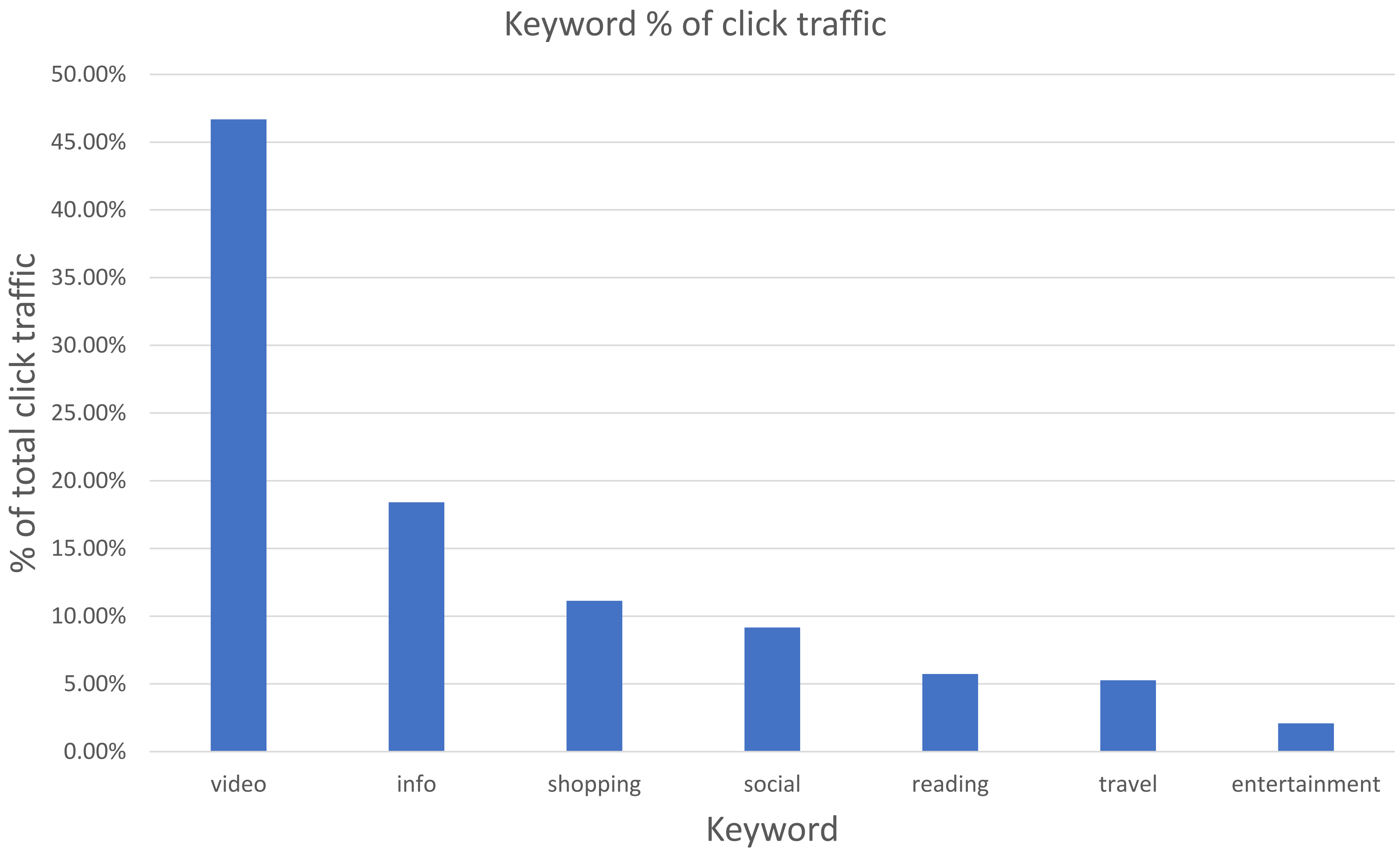


Keyword traffic contribution (impression)



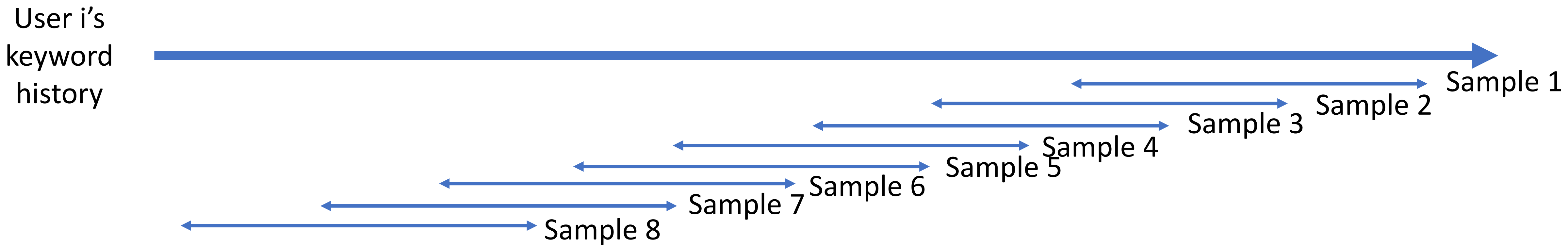
keyword	% of total traffic
video	44.83%
shopping	21.21%
info	18.13%
social	6.53%
reading	3.27%
travel	2.15%
entertainment	0.91%
Total	**97.03%**

Keyword traffic contribution (click)



keyword	% of click traffic
video	46.69%
info	18.41%
shopping	11.14%
social	9.16%
reading	5.73%
travel	5.27%
entertainment	2.09%
Total	**98.48%**

User profile generation (DIN model output)



User i's keyword history

Sample 1

Sample 2

Sample 3

Sample 4

Sample 5

Sample 6

Sample 7

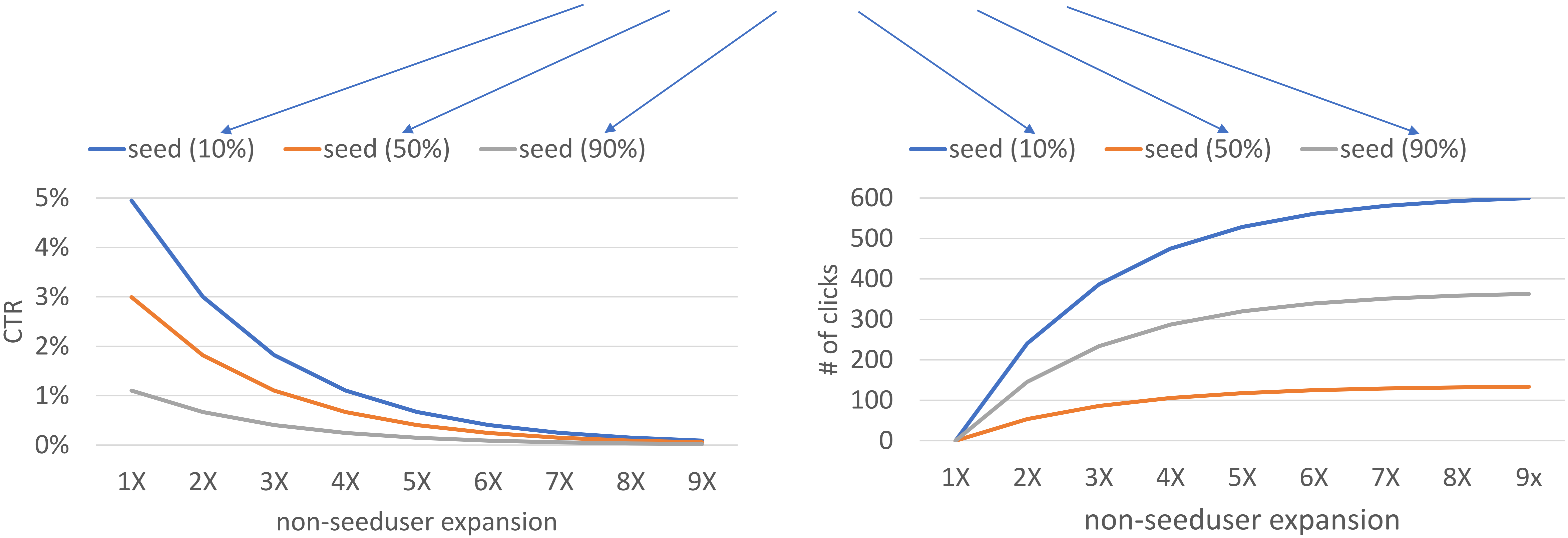
Sample 8

	keyword$_1$	keyword$_2$	keyword$_3$	keyword$_4$	keyword$_5$	……	keyword$_m$
Sample$_1$	score$_{11}$	score$_{12}$	score$_{13}$	score$_{14}$	score$_{15}$	……	score$_{1m}$
Sample$_2$	score$_{21}$	score$_{22}$	score$_{23}$	score$_{24}$	score$_{25}$	……	score$_{2m}$
Sample$_3$	score$_{31}$	score$_{32}$	score$_{33}$	score$_{34}$	score$_{35}$	……	score$_{3m}$
Sample$_4$	score$_{41}$	score$_{42}$	score$_{43}$	score$_{44}$	score$_{45}$	……	score$_{4m}$
……	……	……	……	……	……	……	……
Sample$_n$	score$_{n1}$	score$_{n2}$	score$_{n3}$	score$_{n4}$	score$_{n5}$	……	score$_{nm}$
Profile	$\overline{\{score_{1..n,1}\}}$	$\overline{\{score_{1..n,2}\}}$	$\overline{\{score_{1..n,3}\}}$	$\overline{\{score_{1..n,4}\}}$	$\overline{\{score_{1..n,5}\}}$	……	$\overline{\{score_{1..n,m}\}}$

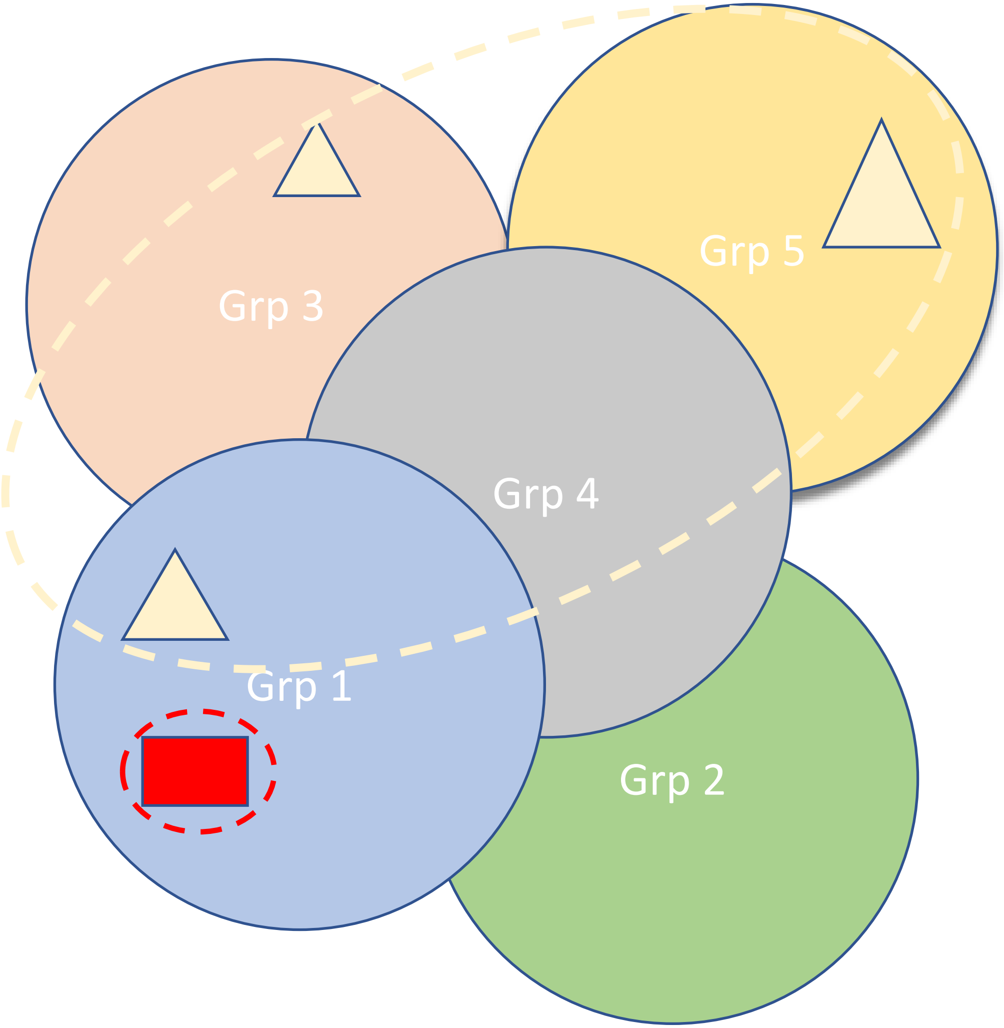
Validation

LookAlike model test results - expected

% seed users in total of extendable users



Test scenario illustration (Definable audience)



User clusters

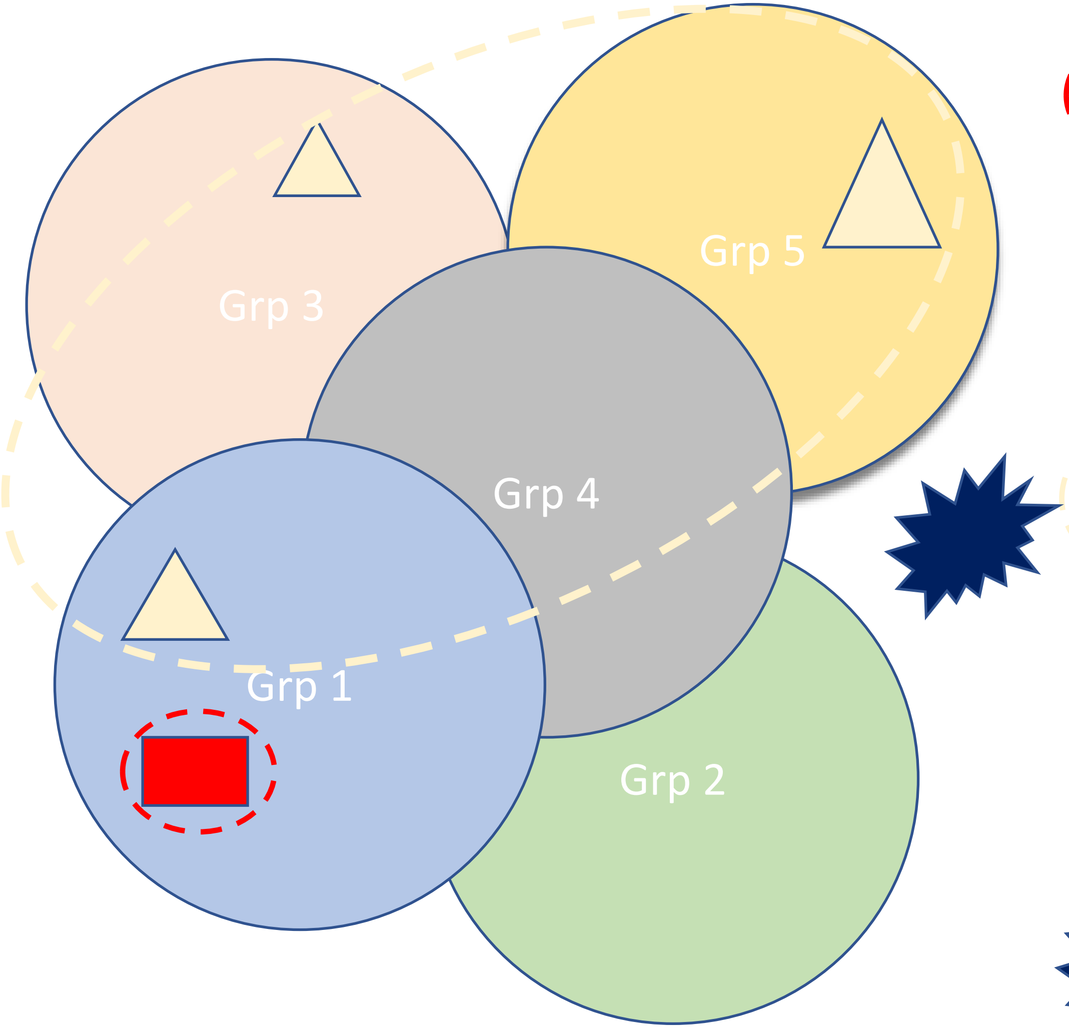
🟥 Scenario 1: homogeneous seed users (focused within single group)

Seed user % in total extendable users:10% -> 90%

△ Scenario 2: heterogeneous seed users (across multiple groups)

Seed user % in total extendable users:10% -> 90%

Test scenario illustration (non-definable audience)



User clusters

🟥 Scenario 1: matched homogeneous seed users (focused within single group)

Seed user % in total extendable users: 10% -> 90%

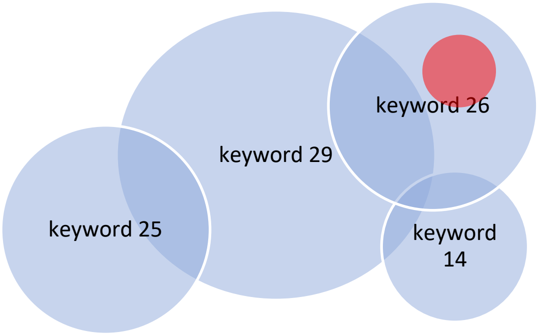
△ Scenario 2: matched heterogeneous seed users (across multiple groups)

Seed user % in total extendable users: 10% -> 90%

✸ Scenario 3: random seed users (mismatch between advertiser’s user definition and system user definition, may include non-targeting seed users)

Scenario 1- same group seed users

- Test case 1:
  - All users clicked on keyword 26 at least one time in the last 10 days
  - Total number of users in this groups: 5325

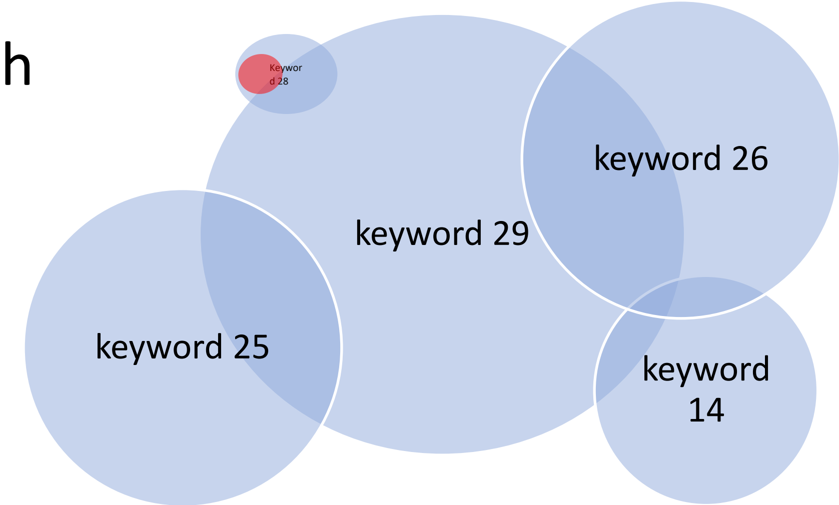


# of seed users = 1000 did % of seed users : 18.77 %	2X extension = 2000 dids	3X extension = 3000 dids
#Click – based on model	17	20
#Click – based on random selection	7	12

Scenario 1- same group seed users

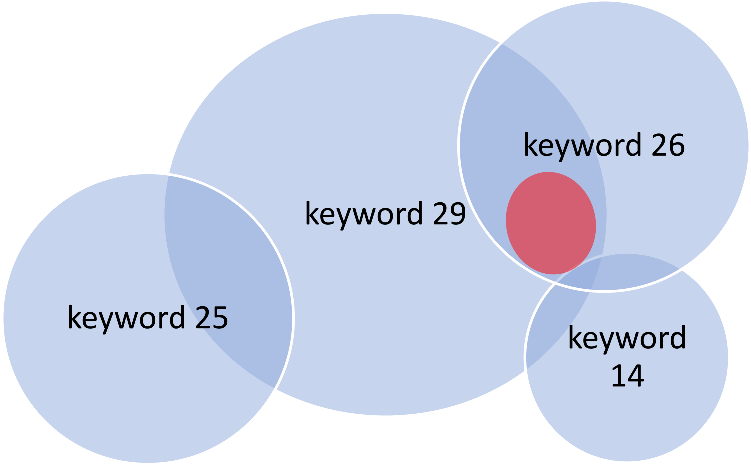
- Test case 2:
  - All seed users clicked on keyword 28 at least one time in the last 10 days
  - The total number of users in this group is 250. With selecting 100 as a seed users the chance of model selecting the 150 users is extremely low.

# of seed users = 100 did % of seed users = 40%	2X extension = 200 dids	3X extension = 300 dids
#Click – based on model	1	1
#Click – based on random selection	0	0



Scenario 1- same group seed users

- Test case 3:
  - All users clicked on both keyword 26 and keyword 29 at least once in the last 10 days
  - Total number of users in these groups : 6485



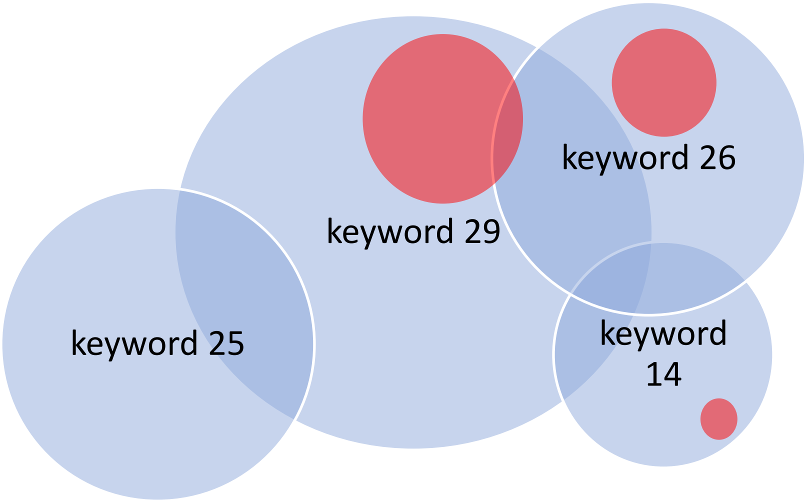
# of seed users = 500 did % of seed users = 7.71 %	2X extension = 1000 dids	3X extension = 1500 dids
#Click – based on model	109	153
#Click – based on random selection	78	140

Scenario 2- different groups seed users

- Test case 1:
  - Seed users are from three different groups:

    1. Seed users who clicked on keyword 26
    2. Seed users who clicked on keyword 14
    3. Seed users who clicked on keyword 29

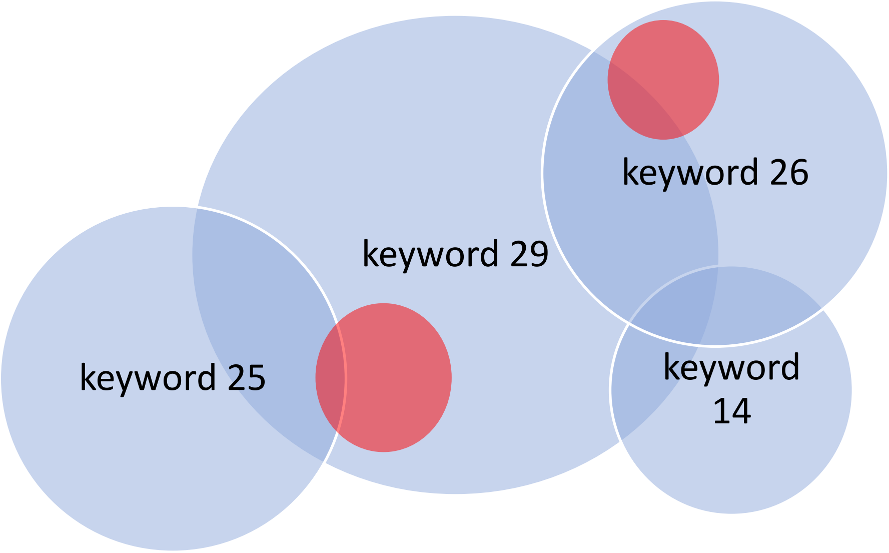
    - Total number of users in these groups : 12562



# of seed users = 800 did	2X extension = 1600 dids	3X extension = 2400 dids
#Click – based on model	201	304
#Click – based on random selection	151	207

Scenario 2- different groups seed users

- Test case 2:
  - Seed users are from three different groups:
    1. Seed users who clicked on keyword 26
    2. Seed users who clicked on keyword 29
  - Total number of users in these groups : 11301



# of seed users = 1000 did	2X extension = 2000 dids	3X extension = 3000 dids
#Click – based on model	196	289
#Click – based on random selection	165	244

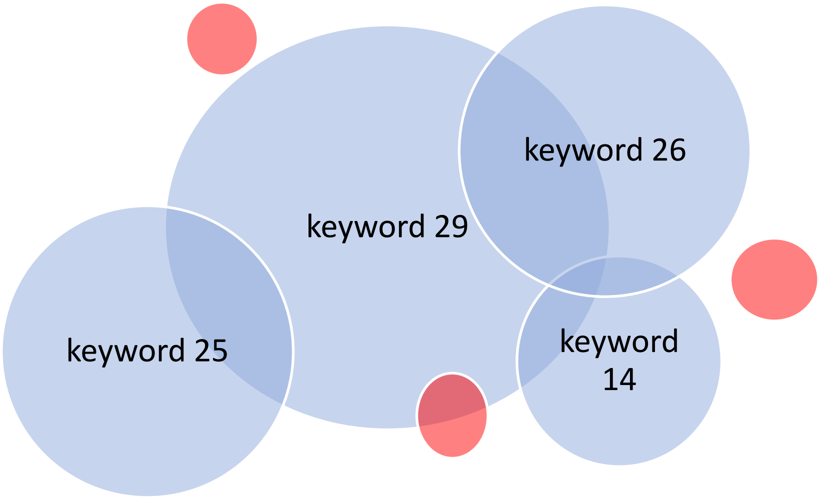
Scenario 3 – Random seed users

- When the seed users are chosen randomly there is no specific behavior pattern. In this scenario, the model is not expected to perform well.

- These is a test case with random seed users which shows mixed result compare to random extension.

Scenario 3 – Random seed users

- The click result for Random users is also random



	2X extension = 2000 dids		
# of seed users = 1000 did	**Keyword = 26**	**keyword = 29**	**keyword = 14**
Click – based on model	7	235	13
Click – based on random selection	28	207	26

Conclusion

- The look alike model, similar to any other AI based model needs a quality input data.
- The higher the quality of the input data, the better the result of the model.
- In the first scenario when all seed users are from one cluster, the result of look alike extension users has higher click rate.
- In the last scenario when users are picked randomly, there is no ground choose to evaluate the performance.