SCRUF - D ARCHITECTURE

1. Computed Recommendations :

- **Description** : Recommendation list, ls, generated for each user/context.

- **Attributes** :
  - item_name
  - item_id
  - item_rating
  - item_predicted_rating
  - item_tag_1
  - item_tag_2
  - item_tag_n
  - item_rank
  - user_id
  - user_profile_tag_1
  - user_profile_tag_2
  - ⋮
  - user_profile_tag_n
  - time_stamp

  list → ls

  | map |

  list → w_j^o

- **Functions** :
  - store_ls_DB
  - store_w_j^o_DB

  - $U(u) \rightarrow$ users
  - $V(v) \rightarrow$ items
  - $\phi = \langle \phi_1, \dots \phi_K \rangle \rightarrow$ Item features
  - $w = \langle w_1, \dots w_j \rangle \rightarrow$ user profile
  - $\phi^s \subseteq \phi \rightarrow$ sensitive item features
  - $w^s \subseteq w \rightarrow$ sensitive user features
  - $R_i(w,v) \rightarrow \{v, \hat{r}_o\} \rightarrow$ predicted rating $\hat{r}_o \in \mathbb{R}_+$
  - $l < \{v_1, \hat{r}_o\}, \dots \{v_i, \hat{r}_o\}\}$
  - sort $(R_i(w,V)) \rightarrow ls$

2. Database (DB)

- Description: Stores all the generated lists & historical data
- NoSql

All the lists to be stored:

a) l_s : recommendation list generated by the recommender system. (with item attributes & user profile key)

b) w_j^o : user profile list generated by the recommender system (with key to l_s)

c) f_i^o : m & c of each fairness agent : Table 1

d) R_i / l_F : predicted ratings : Table 2

e) f_i^* : m, c & β values for each fairness agent : Table 3

f) $\vec{H}$: Allocation History

g) $\vec{L}$: Choice History

h) l_c : final recommended list.

3. Fairness Agents

- **Description** : These agents are associated with specific fairness concerns, assessing different aspects of the item, users and the LS.

- **Attributes:**

  agent_name

  agent_fairness_type

  agent_fairness_logic

  agent_fairness_side

  agent_fairness_label

  agent_fairness_score

  agent_fairness_compatibility_user_id

  agent_fairness_preference_item_id

  historical_lf

  agent_predicted_rating_R_i

- **Functions :**

  evaluate_m_score

  evaluate_compatibility_agent_user

  evaluate_preference_score_item

  generate_lf

  evaluate_historical_state

  measure_historical_efficacy

  evaluate_protection_tag

  evaluate_efficacy

- $\tilde{F} = \{f_1, ..., f_i\} \rightarrow$ set of fairness agents
- $f_i = \{m_i, c_i, R_i\} \rightarrow$ fairness agent i, m_i = fairness metric, c_i = compatibility metric, R_i = Ranking function
- **efficacy :** $\quad \overline{P} \rightarrow$ desired recommendation for proposed $\rightarrow 0.5$

  $$P_* \rightarrow \frac{\# \text{ items protected appeared}}{\# \text{ rec given}}$$

  $$\min \left(1 - \frac{\overline{P} - P_*}{\overline{P}} \right)$$

- **m_score** : (librec - auto) : difference in exposure of the protected (vs) unprotected items.

  $\left[m_i(\vec{L}, \vec{H}) \to [0,1] \right]$

  * $\vec{L} \to$ choice history
  * $\vec{H} \to$ allocation history

$0 \to$ minimally fair
$1 \to$ very fair

$(\ast)$ $\dfrac{\sum \text{protected item in } \ell_{S/F/C}}{\text{total items in } \ell_{S/F/C}} - \dfrac{\sum \text{unprotected items in } \ell_{S/F/C}}{\text{total items in } \ell_{S/F/C}}$

↗ define a ℓ_S distribution
↗ define a $\ell_{\tilde{F}}$ distribution
→ define a ℓ_C distribution
↗ evaluate distance between 2 distributions.

- $\underline{C_i^\circ(\omega)} \to$ consider 1 || Experiment with Bossiness.

- $\underline{R_i(\omega, \nu)} \longrightarrow \{\nu, \hat{r}\}$ || Fairness agent's Recommendation function

- $\underline{\ell_F} = \{ R_1(\omega, V), \dots R_i(\omega, V)\}$ || Set of fairness agent recommendation lists, indexed by fairness label, i.

  └─ └─ └─ items
        └─ user profile
      fairness agent index

f_i°		m	c
	f_1		
	f_2		
	f_3		

Table 1

	f_1	f_2	$f_3 \cdots$
ν_1	$\hat{r}_{11}$	$\hat{r}_{12}$	$\hat{r}_{13}$
ν_2	$\hat{r}_{21}$		
ν_3		$\hat{r}_{32}$	

R_i°

ℓ_{f_1}

Table 2

4. Allocation Mechanism

- **Description :** Determines which fairness agents will be active in responding to a given recommendation opportunity. (Comparing the agent valuations of both the current system fairness & compatibility)

- **Attributes**

  set_of_fairness_agents_$\mathcal{F}$
  agent_fairness_metric_evaluation
  agent_compatibility_evaluation

- **Functions**

  agent_allocation ($\mathcal{A}$)
  format_allocation_history(H)

→ for users w_g at time t

	m	C	β
f_1			
f_2			
f_3			
f^*_i			

Table 3

→ **agent_allocation**

- probability distribution over the fairness agents interpreted as weights.

- $\mathcal{A}\left(\mathcal{F}, m_{\mathcal{F}}(\vec{L}, \vec{H}), c_{\mathcal{F}}(w)\right) \rightarrow \beta \in R_+^{|\mathcal{F}|}$

→ **allocation_history (H)**

- ordered list of agent allocations $\bowtie$ at time t.

- **Allocation History :** $\vec{H} = \langle \beta^1, \ldots, \beta^t \rangle$

5. Choice Mechanism

- **Description:** The set of allocated agents & their preferences (& weights) are combined with the current user, u to form the final recommendation list, l_c

- **Attributes:**

  → agent_preference_score
  recommendation_list_l_s
  agent_allocation_β
  recommendation_list_l_F
  → agent_ranking_function —

- **Functions:**

  evaluate_recommendation_list_l_c
  format_choice_history_T

	P_{f_1} P_{f_2} ... P_{f_n}		f_1 f_2 f_3 ...	R_i^o Table 2	m C β	f_i^* Table 3
v_1			v_1 $\hat{r}_{11}$ $\hat{r}_{12}$ $\hat{r}_{13}$		f_1	
v_2			v_2 $\hat{r}_{21}$		f_2	
v_3			v_3 $\hat{r}_{32}$		f_3	

l_{f_1}

Preference   Ranking

why do we need both?

- Choice Function :

$$C(l_s, \beta, l_{\hat{F}}) \rightarrow l_c$$

combined list.

↓ recommendation list

↗ agent allocation

fairness agent recommendation list(s) $l_{\hat{F}}$
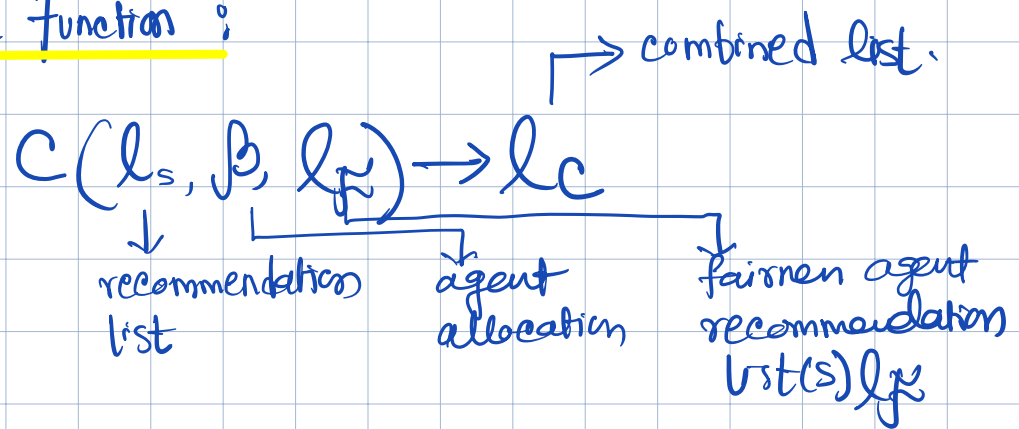
- Each fairness agent expresses preferences over set of items for a particular user

$$R_i(u, v) \longrightarrow \{v, \hat{p}\}$$

- $l_{\hat{F}} = \{R_1(u, v), \ldots, R_i(u, v)\}$

- β used as either $\begin{bmatrix} \text{lottery} \\ \text{weighting Scheme} \end{bmatrix}$

- Choice History :

$$\overrightarrow{L} \langle l^b, l_{\hat{p}}^t, l_c^t \rangle$$