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Review-Based Cross-Domain Collaborative Filtering: a Neural Framework

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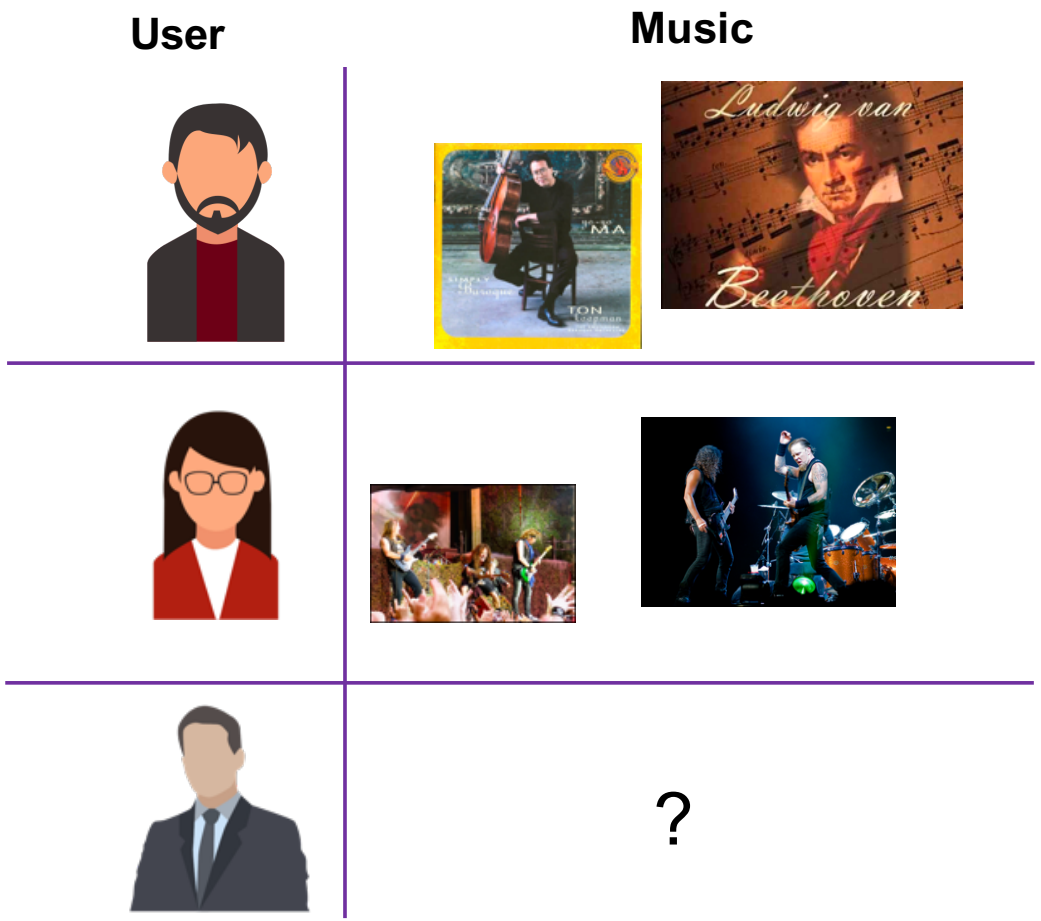
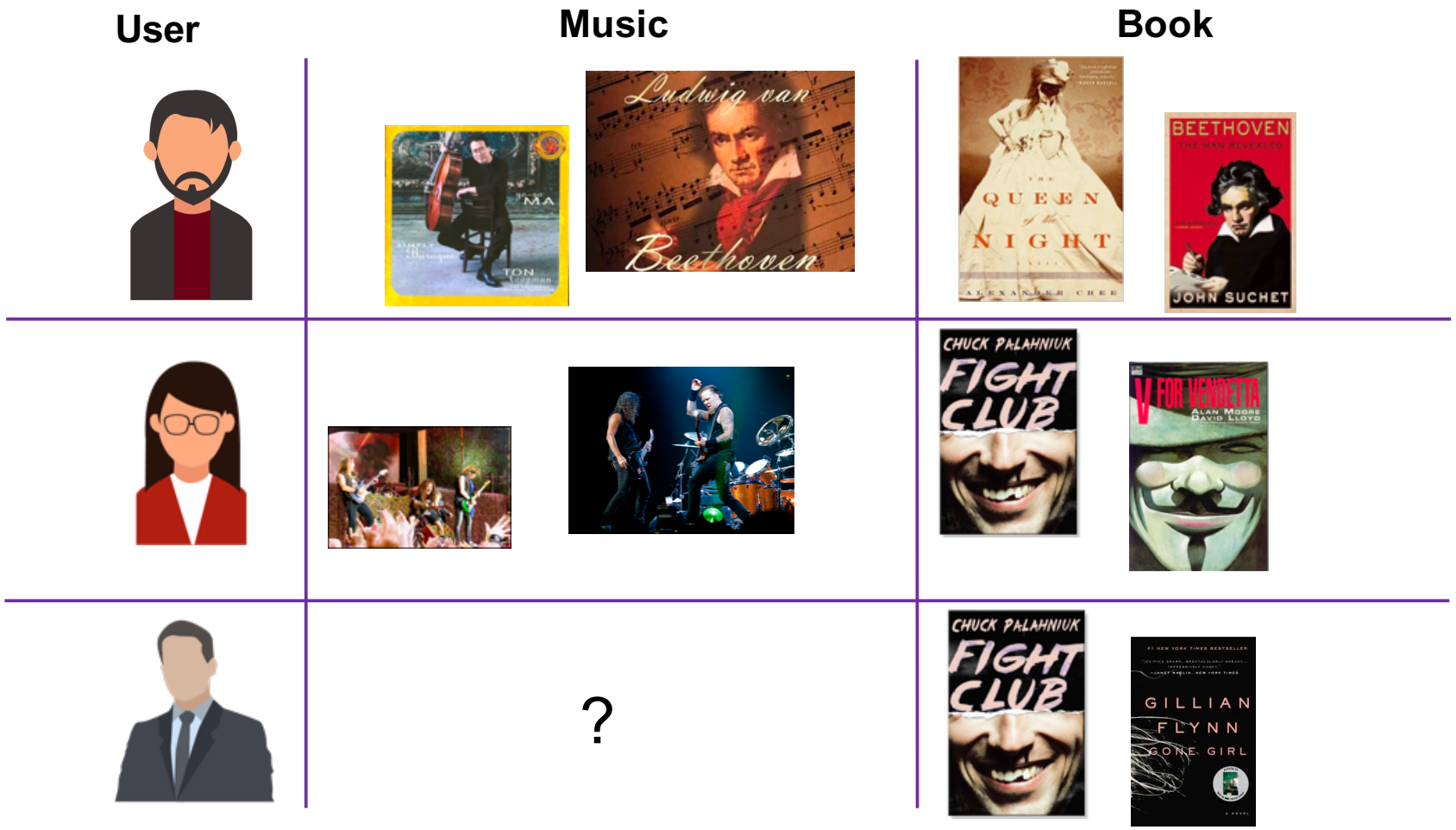
Cold-start scenario



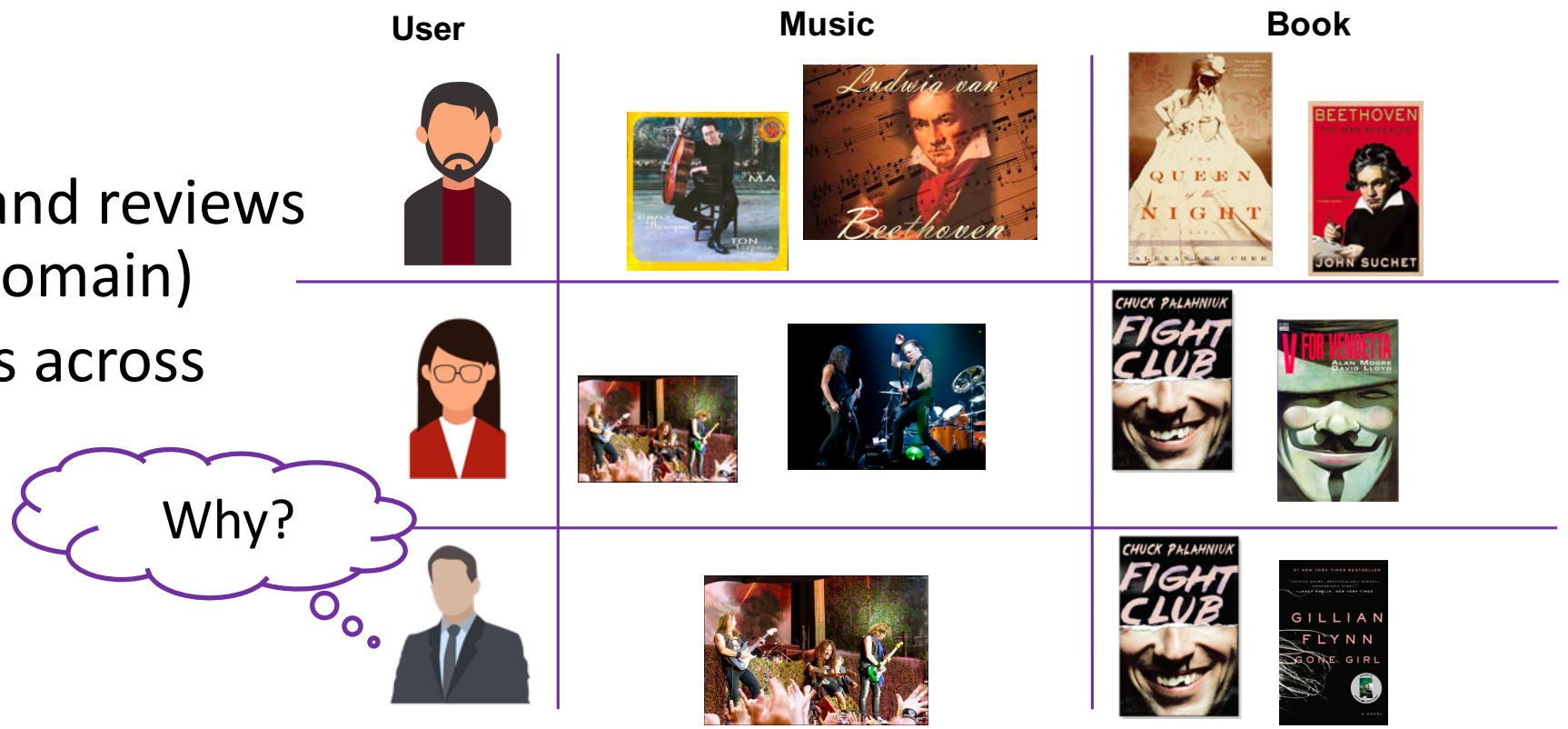
Cross-domain recommenders

- To address problems such as cold-start and sparsity
- Information transfer
- Mostly collaborative filtering



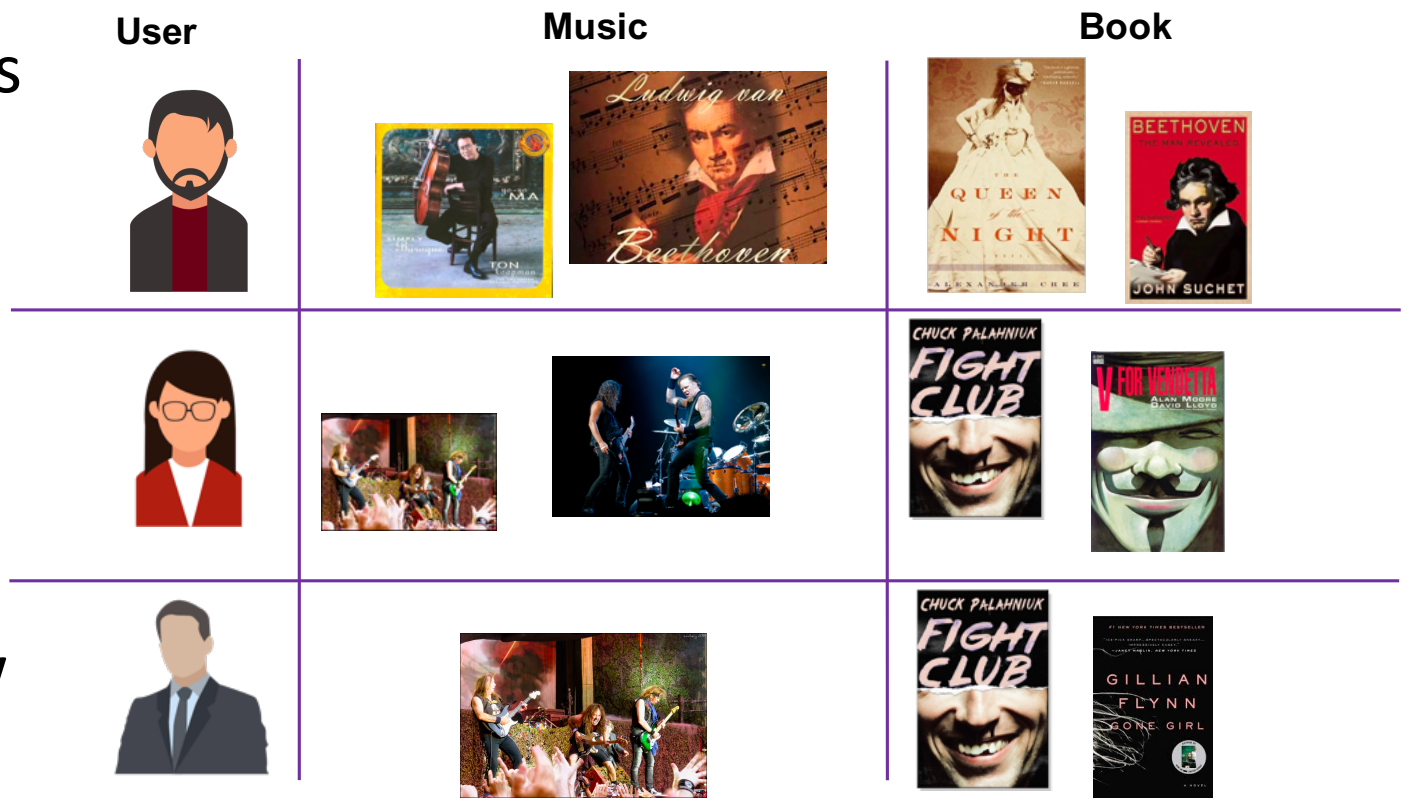
Problem: hard to justify!

- We propose:
  - using *both* ratings and reviews (hybrid and cross-domain)
  - to *generate* reviews across domains

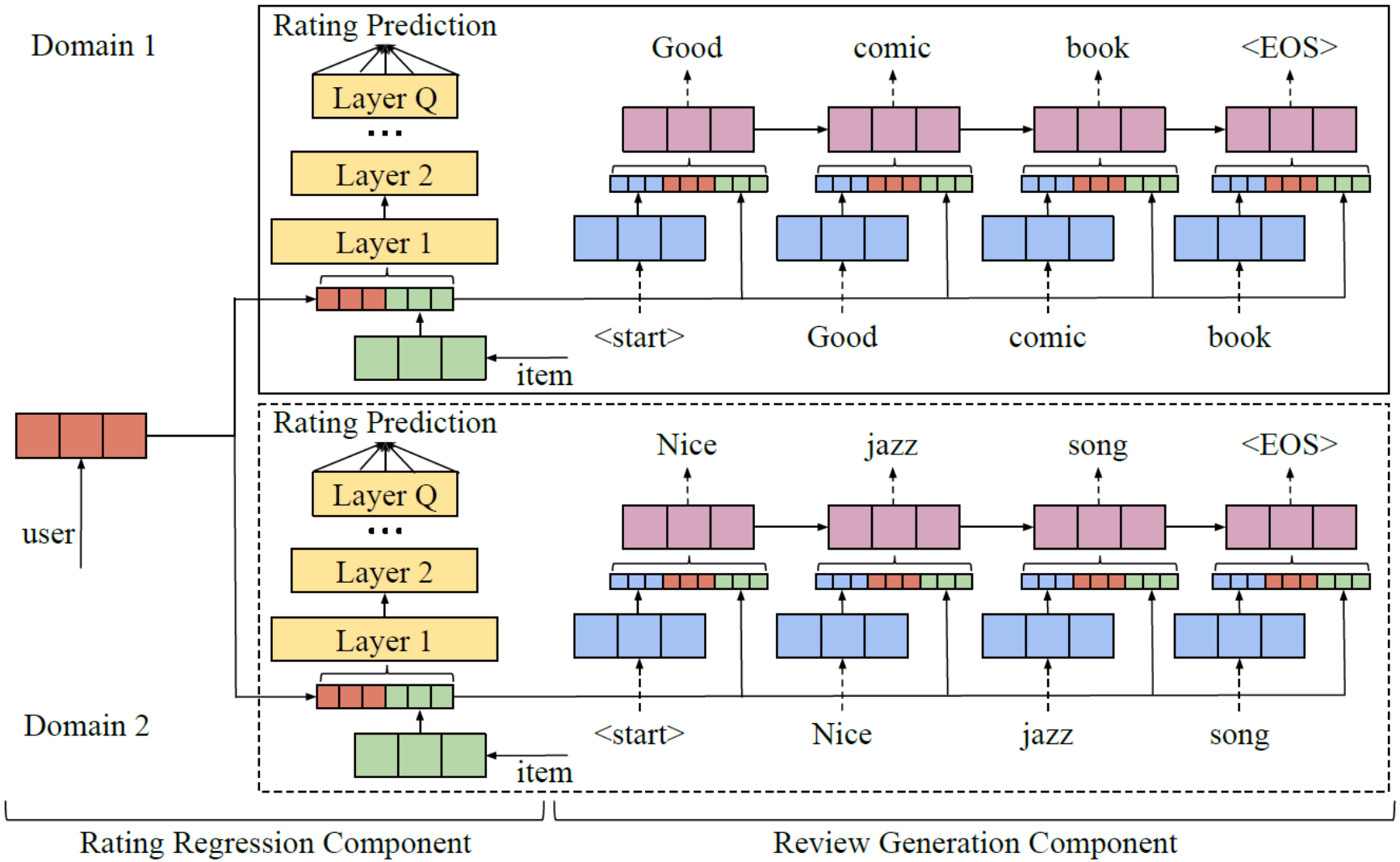


Problem: hard to justify!

- We propose:
  - using *both* ratings and reviews (hybrid and cross-domain)
  - to *generate* reviews across domains
- First step towards cross-domain hybrid recommendation and review generation



Deep Hybrid Cross Domain (DHCD)



Rating Regression Component

- We concatenate latent representations of user and item

$$x_{ui}^d = [v_u; v_i^d]$$

- We put it through Q layers

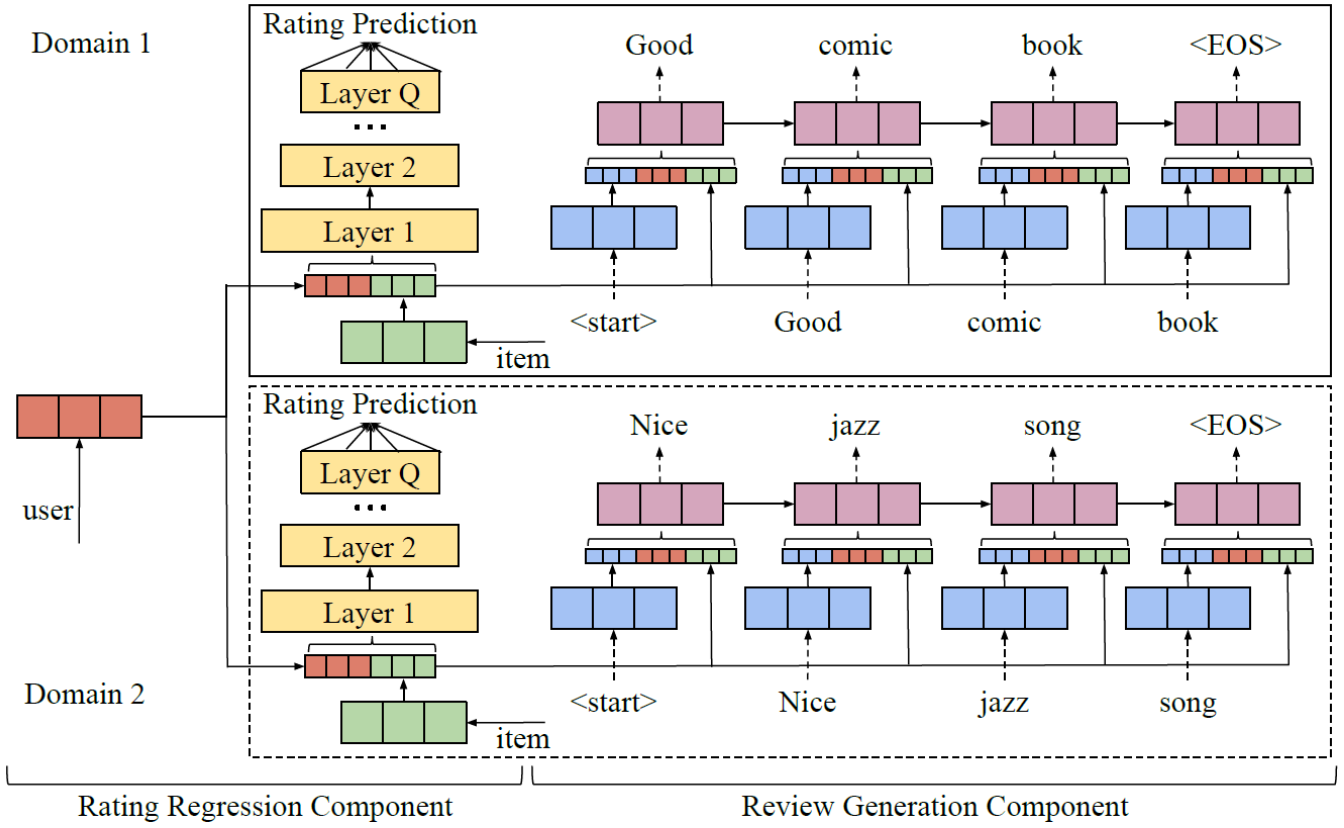
$$\hat{y}_Q^d = h_Q^d\left(h_{Q-1}^d\left(\ldots\left(h_1^d\left(x_{ui}^d\right)\right)\right)\right)$$

- The prediction is

$$\hat{r}_{ui}^d = w_y^d\,\hat{y}_Q^d + b_y^d$$

- The regression loss is

$$L^r = \sum_{d\in D}\sum_{u\in U, i\in I^d}\left(r_{ui}^d - \hat{r}_{ui}^d\right)^2$$



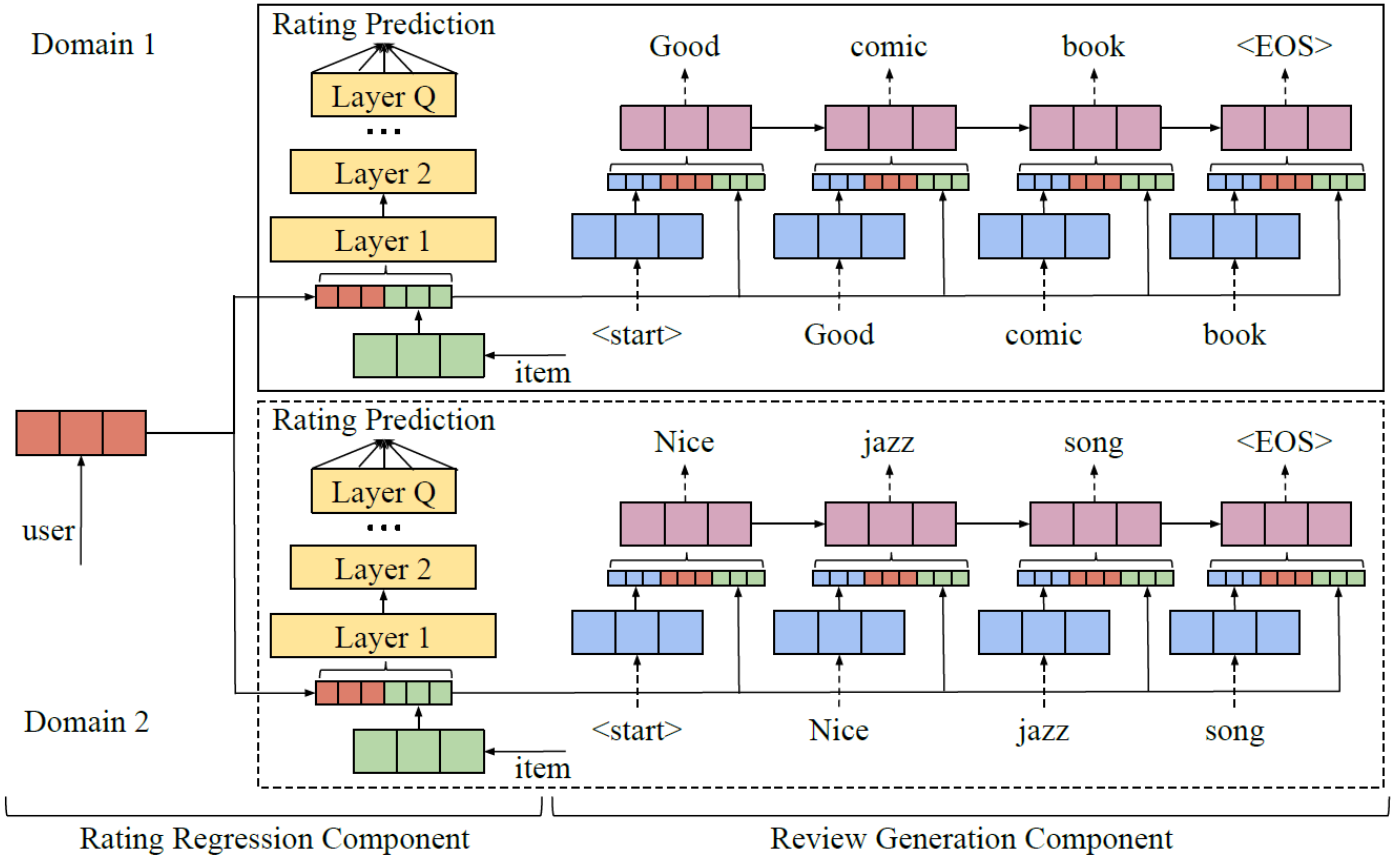
Review Generation Component

- We concatenate latent representations of user and item

$$p\left(t_j \middle| t_{<j}, \Phi^d\right) = \delta(\bar{h}_j^d)$$

- The review generation loss is

$$L^S = -\sum_{d \in D} \sum_{u \in U, i \in I^d} \sum_{j=1}^{J_{ui}} \log p(t_j | t_{<j}, \Phi^{\mathrm{d}})$$

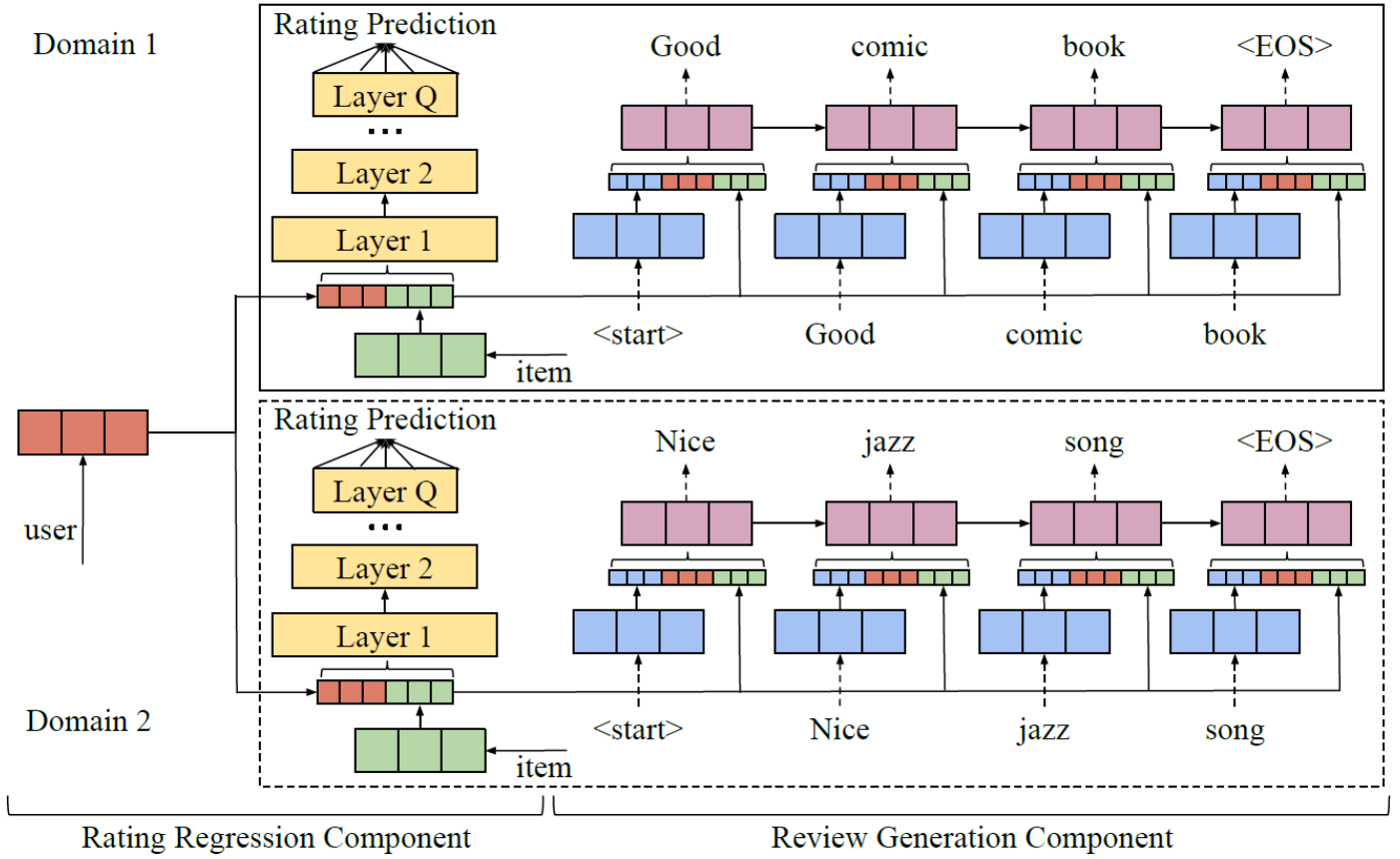


Joint Model Learning

$$L = \lambda_r L^r + \lambda_s L^s + \lambda \left(\left| |V_u| \right|_2^2 + \left| |V_i| \right|_2^2 + \left| |\Phi| \right|_2^2 \right)$$

Where

- $\frac{\lambda_r}{\lambda_s}$ controls the trade off between RRC and RGC
- λ is to avoid overfitting



The evaluation of DHCD Model

- Performance in rating prediction
  - Cold and hot-start
- Performance in review generation
- Training convergence performance
- Trade-off between review generation and rating prediction

Dataset

- Amazon dataset from 1996 to 2004
- Three categories: Book, Digital Music and Office Products
- First 80% of user ratings for training and last 20% for testing

Dataset	#users	#items	#ratings	Avg. Review Len.
Book + Digital Music	3,054	100,055	186,160	163.87
Book + Office Products	4,187	172,484	413,463	146.65
Digital Music + Office Products	186	2,375	4,739	143.53

Experiment Setup - Baselines

Two setups for each algorithm: single and cross-domain (e.g., cdCDL)

	Model		Input		Design		Generate Reviews
	MF-based	NN-based	Ratings	Reviews	Single-domain	Cross-Domain	
Matrix Factorization (MF)	✓		✓		✓		
Neural Collaborative Filtering (NCF)		✓	✓		✓		
Collaborative Deep Learning (CDL)	✓	✓	✓	✓	✓		
Collaborative Filtering with Generative Concatenative Net-works (CF-GCN)		✓	✓	✓	✓		✓
Cross-domain neural network (CDN)		✓	✓			✓	
Our Model (DHCD)		✓	✓	✓		✓	✓

Performance in rating prediction

- DHCD outperforms single-domain baselines, in each separate domain

	Book(B) + Digital Music(DM)									
	r@10		r@50		r@100		MAE		RMSE	
	B	DM	B	DM	B	DM	B	DM	B	DM
MF	0.03	0.031	0.110	0.122	0.159	0.159	0.95	0.98	1.18	1.16
NCF	0.057	0.059	0.233	0.206	0.30	0.292	0.766	0.732	0.98	0.95
CDL	0.055	0.061	0.244	0.242	0.318	0.322	0.771	0.781	0.97	0.92
CF-GCN	0.070	0.068	0.245	0.248	0.301	0.35	0.752	0.745	0.94	0.911
CDN	0.043	0.049	0.219	0.234	**0.312**	0.339	0.772	0.751	0.991	0.933
DHCD	**0.071***	**0.077****	**0.25***	**0.257***	0.31	**0.342***	**0.749***	**0.735***	**0.93***	**0.902***

Performance in rating prediction

- DHCD outperforms cross-domain baselines in mixed-domains

	Book + Digital Music					Book + Office Products					Digital Music + Office Products				
	r@10	r@50	r@100	MAE	RMSE	r@10	r@50	r@100	MAE	RMSE	r@10	r@50	r@100	MAE	RMSE
cdMF	0.028	0.116	0.158	0.91	1.15	0.046	0.146	0.183	0.895	1.21	0.021	0.083	0.214	1.031	1.327
cdNCF	0.05	0.215	0.301	0.812	0.96	0.056	0.203	0.297	0.824	0.982	0.033	0.102	0.258	0.825	1.211
cdCDL	0.052	0.235	0.318	0.796	0.98	0.061	0.241	0.315	0.771	0.969	0.037	0.11	0.274	0.78	1.19
cdCF-GCN	0.062	0.243	0.325	0.765	0.977	0.07	0.256	0.324	0.772	0.921	0.046	0.135	0.288	0.705	1.107
CDN	0.047	0.226	0.328	0.762	0.974	**0.08**	0.204	0.296	0.773	0.976	0.041	0.144	0.302	0.754	1.084
DHCD	**0.073****	**0.252***	**0.335***	**0.741***	**0.914***	**0.08***	**0.279***	**0.356***	**0.745***	**0.891***	**0.05***	**0.157***	**0.324***	**0.698***	**1.013***

Cold-start Prediction

- DHCD outperforms the best baseline in cold-start setting (users with 5 or less ratings)

	Book + Digital Music		Book + Office Products		Digital Music + Office Products	
	MAE	RMSE	MAE	RMSE	MAE	RMSE
CDN	0.767	0.97	0.767	0.986	0.743	1.052
DHCD	**0.751***	**0.94***	**0.75***	**0.922***	**0.725***	**1.031***

Review Generation Analysis

- Compared to
  - character LSTM, word LSTM, CF-GCN
- DHCD has better perplexity in review generation

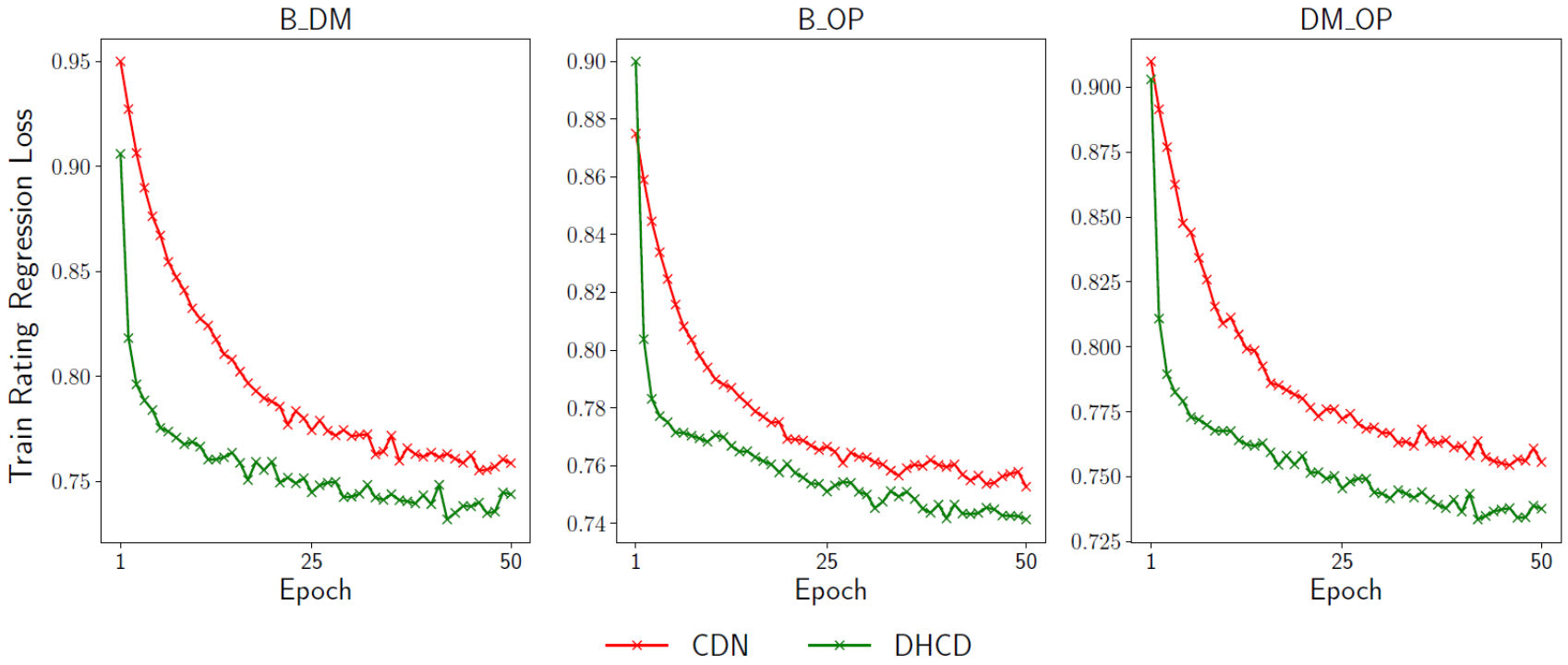
	Book + Digital Music	Book + Office Products	Digital Music + Office Products
C-LSTM	3.10	3.09	3.05
W-LSTM	3.12	3.06	3.02
CF-GCN	3.02	2.99	2.95
DHCD	**2.93**	**2.95**	**2.88**

Examples of Generated Reviews: Digital Music and Book

	Negative Review	Positive Review
Real Review	This album has terrible sound. Its very tinny and distant. Nothing like vol 1. I was very disappointed with it. Lightfoot should re release this after firing his producer as there are several great songs on it.	Another superb album by Herb Alpert and the Tijuana Brass. Their music is so happy and full of fun. Love them.
DHCD	It not good, awful. Just poor quality that means it bring after the purchase. Nothing like before. should not good.	the simplistic. nice **jazz** of the band, happy with this purchase and enjoy the **story**, what a sweet voice for me.
CF-GCN	The song is terrible and need to be better, some every dissatisfied and undevelopment. not like it and enjoy song.	tribes followers see the awesome song and the lyrics is as always. great recommendation to buy and enjoy the song.

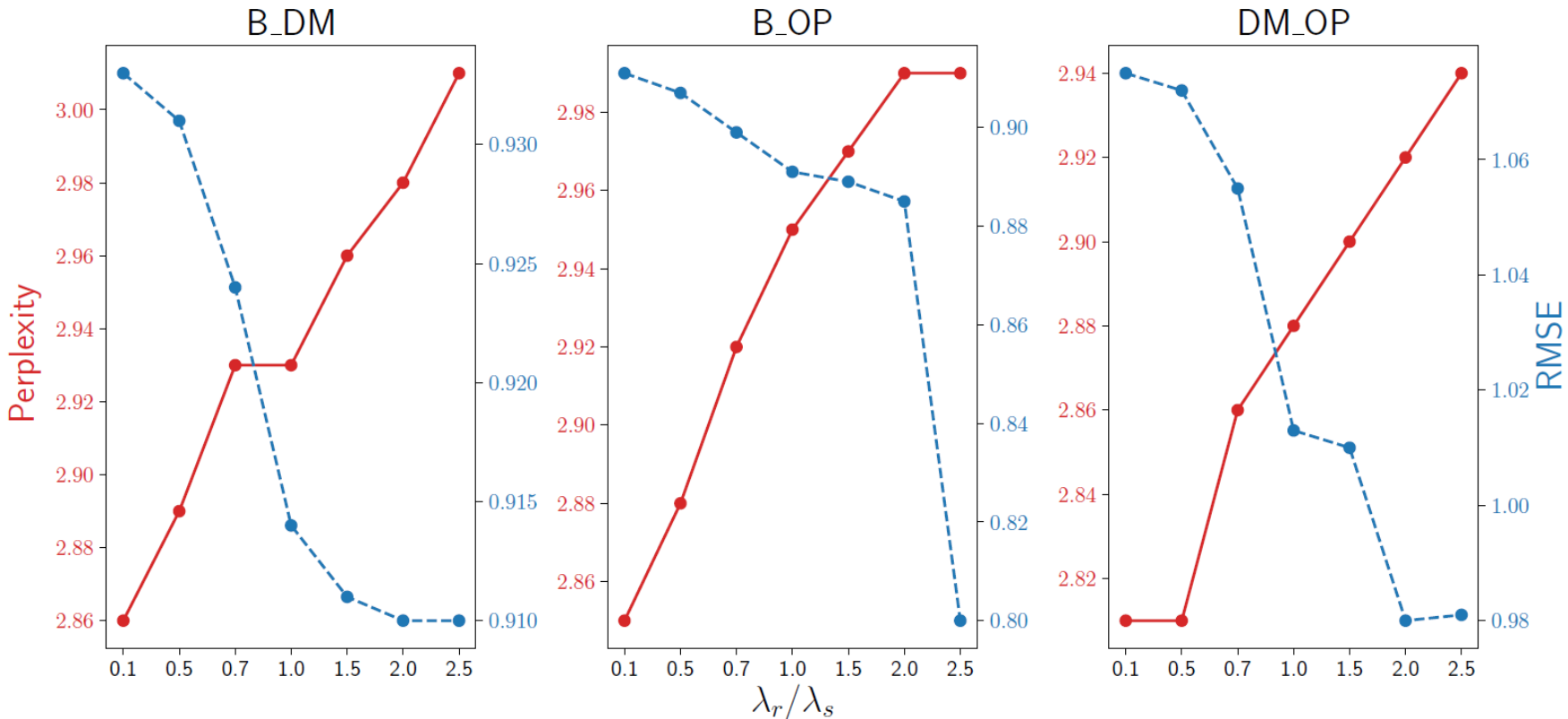
The Effect of Reviews in Training

- Compare the rating regression *training* loss of CDN and DHCD through epochs
- DHCD has a faster convergence



Trade-off between Rating Prediction and Review Generation

- λ_r/λ_s controls the trade off between rating prediction and review generation tasks
- $\lambda_s = 1$ and use various values of λ_r for training
- Increasing λ_r/λ_s leads to better RMSE but worse perplexity



Conclusion

- Deep Hybrid Cross Domain (DHCD)
  - first step towards cross-domain review generation and justification
  - can capture some between-domain relations
  - has better rating prediction than single-domain baselines -> adding cross-domain information helps
  - has better rating prediction and faster convergence than rating-only baselines -> adding review data helps
  - has a good performance in cold-start setting
- There is a trade-off between review generation and rating prediction

Thank you!

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code: https://github.com/ssahebi/Neural_Hybrid_Cross_Domain