

# Learning Personalized Itemset Mapping for Cross-Domain Recommendation

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# Agenda

- Background
- CGN Model
- Experimental Results
- Conclusion

# Recommendation Systems in Our daily life

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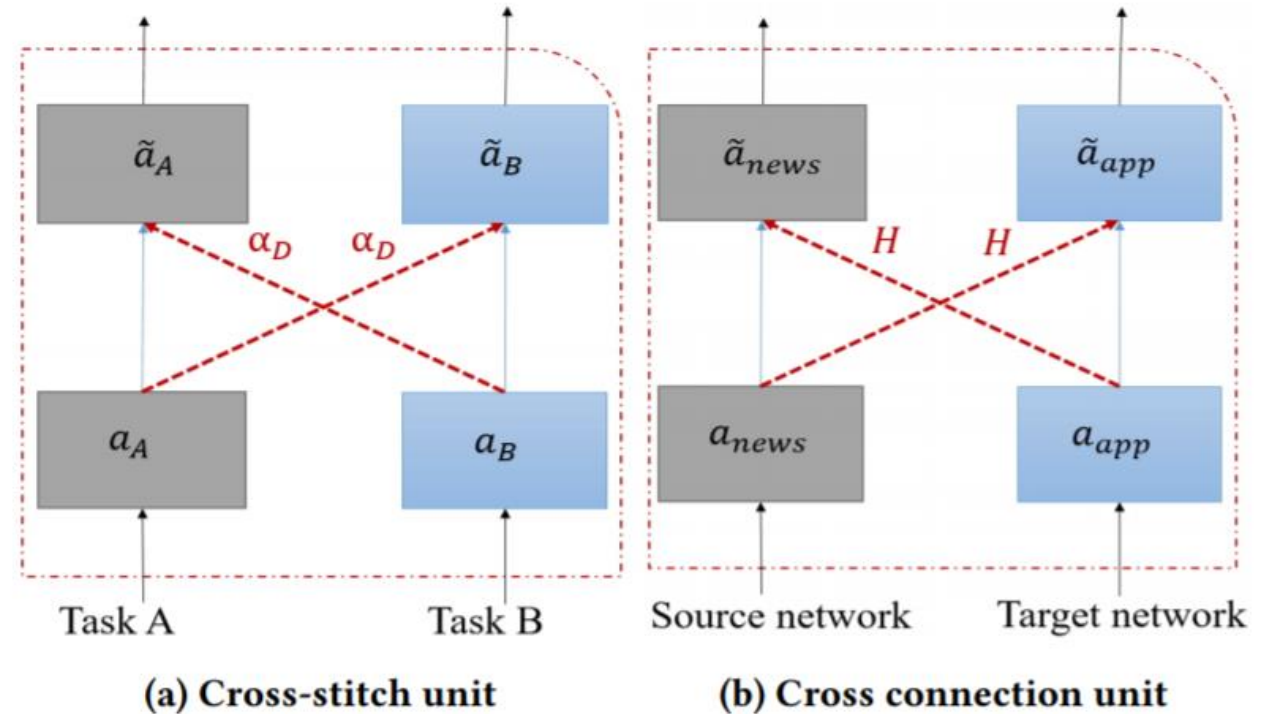
# Cross-Domain Recommendation Systems

## ✓ Transfer Learning

Existing methods usually transfer knowledge across different domains **implicitly**.

➤ In practice, users' interests and states may vary over time.

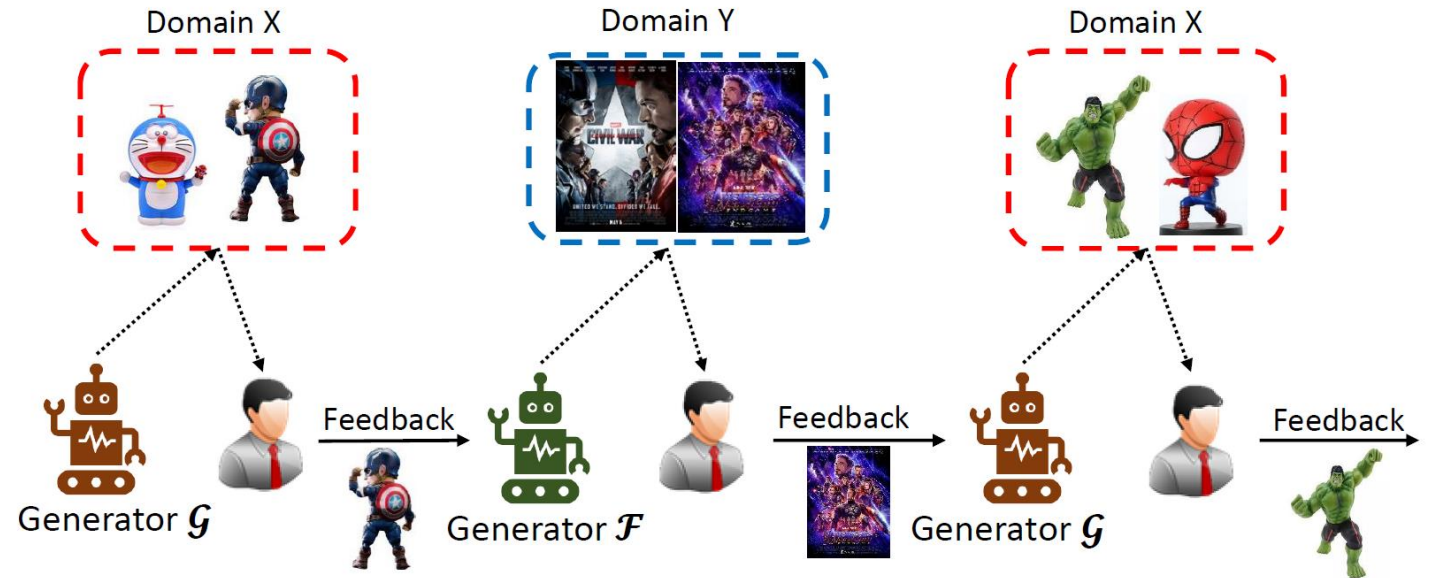
➤ Users usually interact with items in multiple domains.



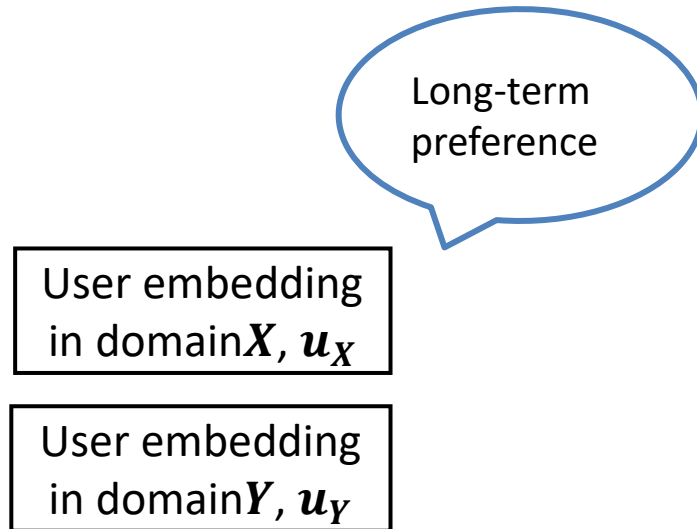
CoNet: Collaborative Cross Networks for Cross-Domain Recommendation, CIKM'18

# Problem Formulation

- In this work, we aim to exploit a user's behavior data in one domain to generate her item recommendation for **the same time period** in another domain.
- We proposed Cycle Generation Networks (CGN).

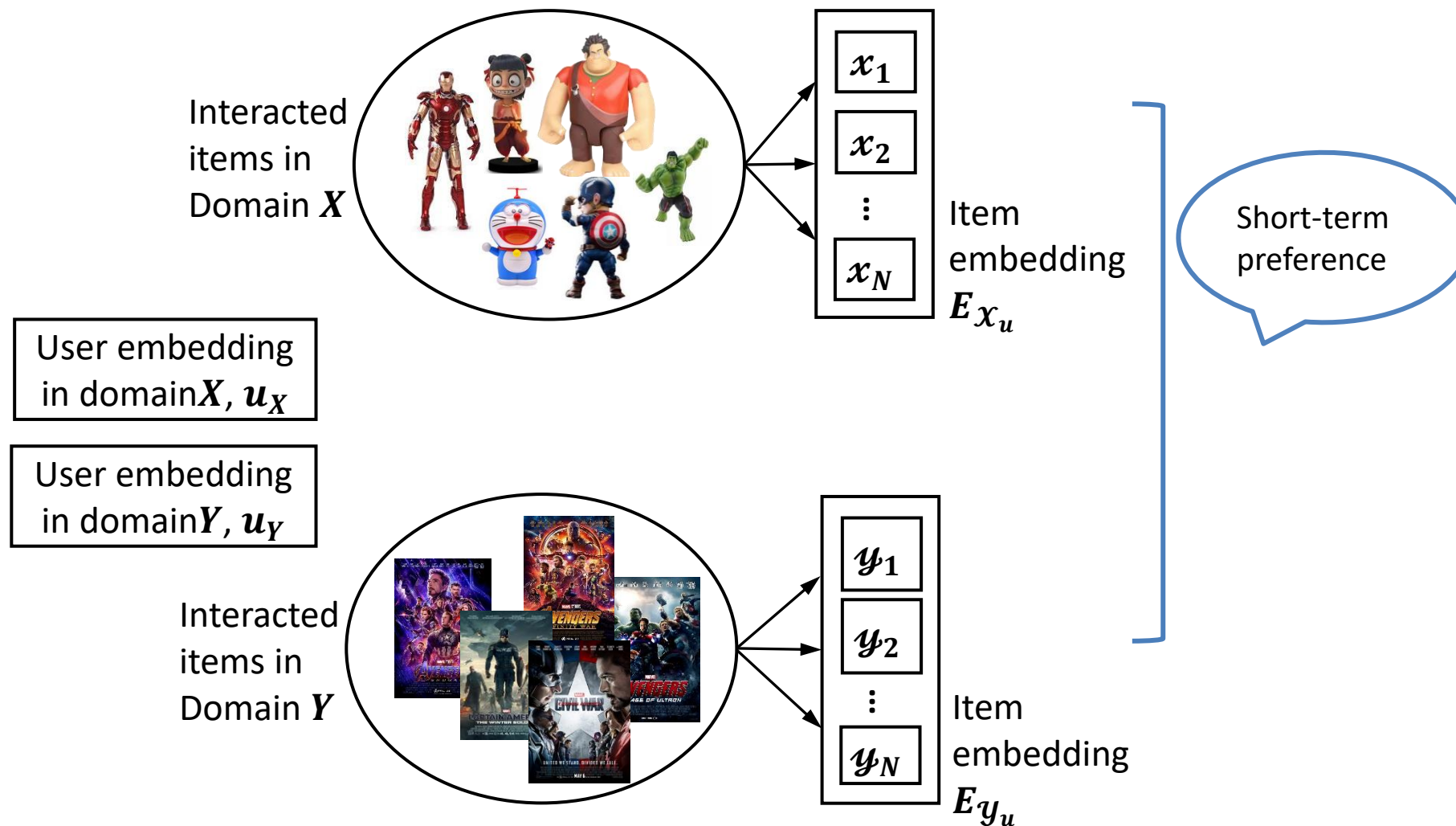


# Cycle Generation Networks

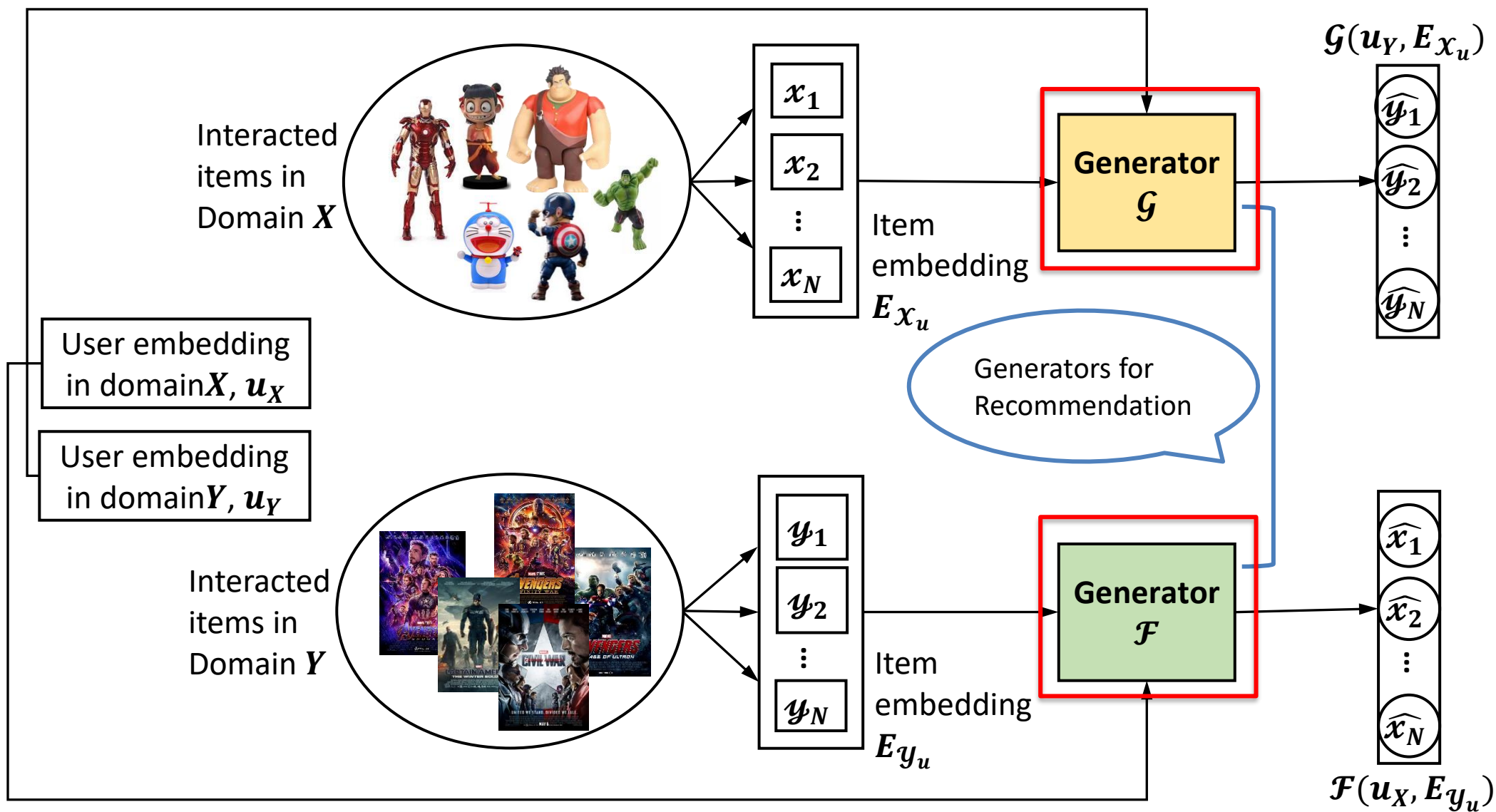




# Cycle Generation Networks



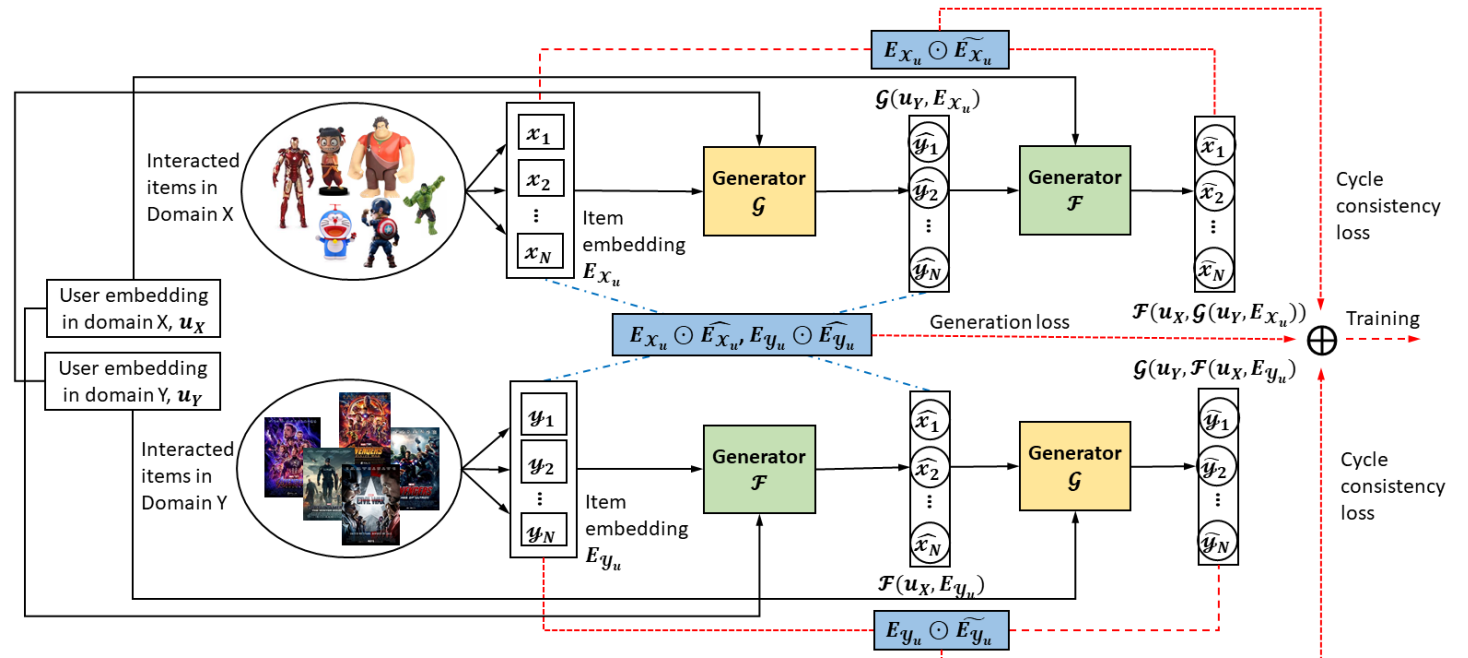
# Cycle Generation Networks



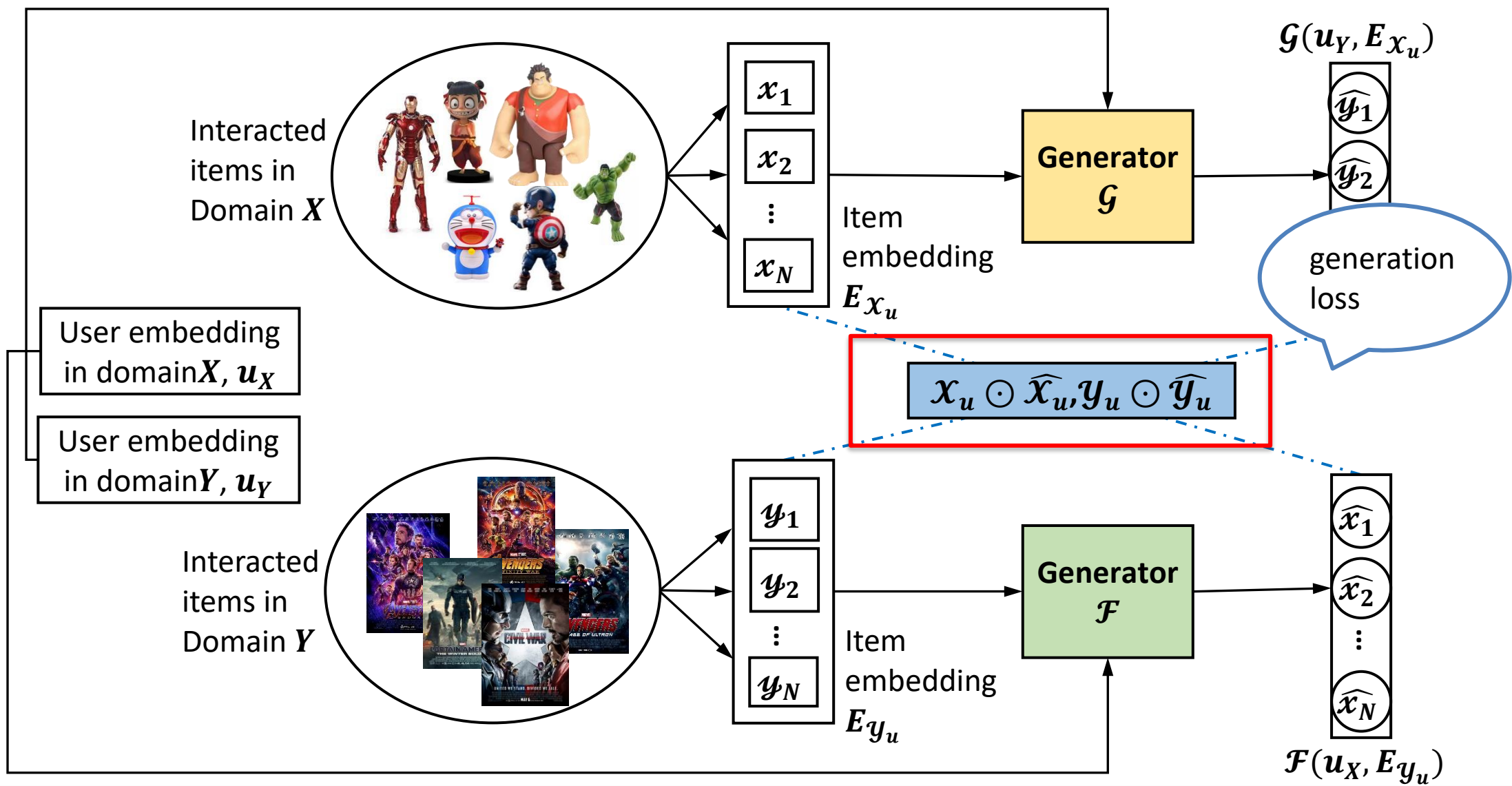


# Cycle Generation Networks

- Loss Functions
  - generation loss
  - cycle consistency loss



# Cycle Generation Networks



# Cycle Generation Networks

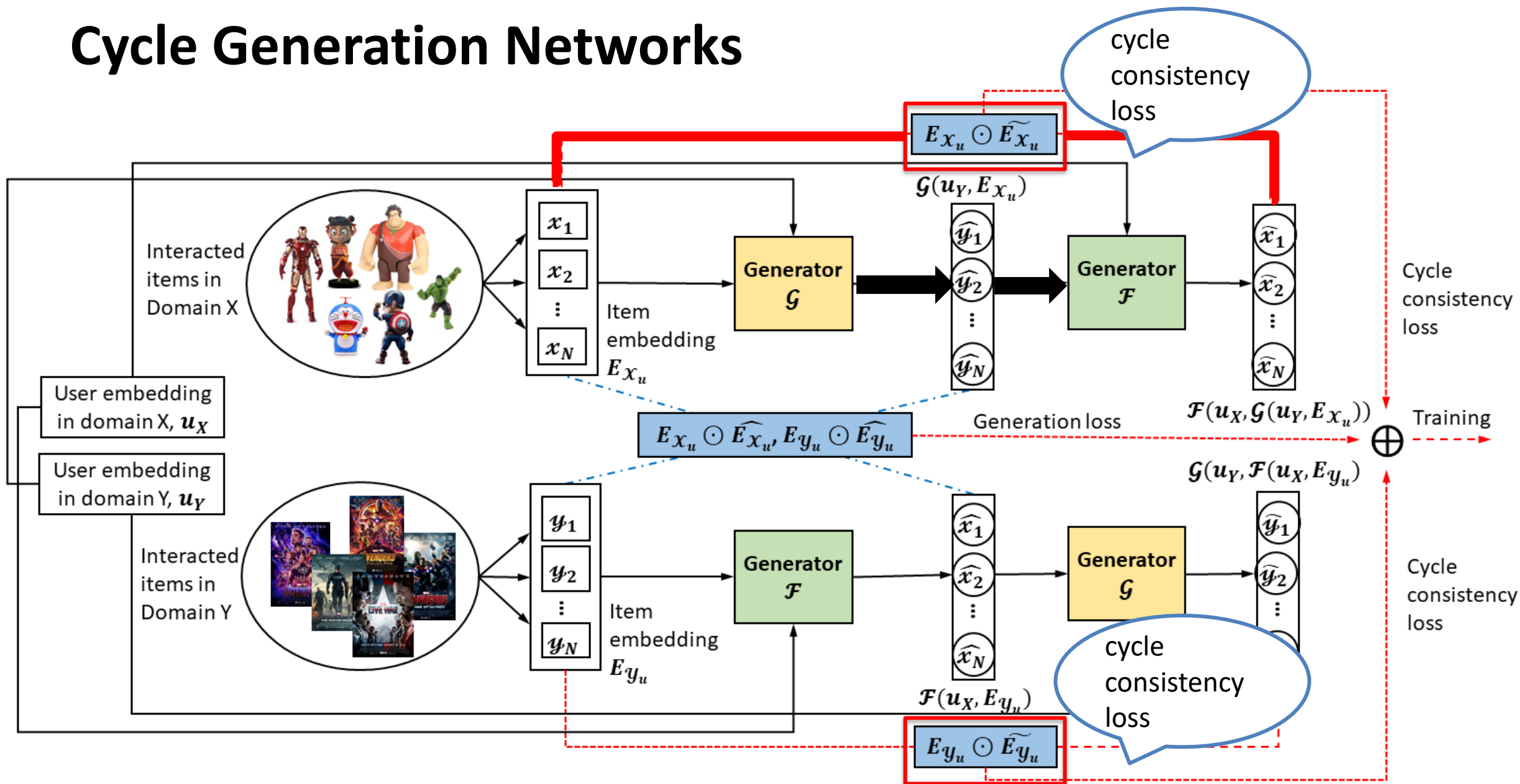
- generation loss
  - maximum mean discrepancy (MMD)

$$\begin{aligned} MMD(M, E) = & \frac{1}{m^2} \sum_i^m \sum_{i'}^m k(M_i, M_{i'}) \\ & + \frac{1}{n^2} \sum_j^n \sum_{j'}^n k(E_j, E_{j'}) - \frac{2}{mn} \sum_i^m \sum_j^n k(M_i, E_j), \quad (1) \end{aligned}$$

- generation loss

$$\begin{aligned} \ell_{gen}(u_X, u_Y, \mathcal{X}_u, \mathcal{Y}_u) = & MMD\left(\mathcal{G}(u_Y, E_{\mathcal{X}_u}), E_{\mathcal{Y}_u}\right) \\ & + MMD\left(\mathcal{F}(u_X, E_{\mathcal{Y}_u}), E_{\mathcal{X}_u}\right). \quad (2) \end{aligned}$$

# Cycle Generation Networks



# Cycle Generation Networks

- cycle consistency loss
  - cycle consistency pattern

$$\mathcal{G}(u_Y, \hat{E}_{\mathcal{X}_u}) \rightarrow \mathcal{F}(u_X, \mathcal{G}(u_Y, \hat{E}_{\mathcal{X}_u})) \approx \hat{E}_{\mathcal{X}_u}$$

$$\mathcal{F}(u_X, \hat{E}_{\mathcal{Y}_u}) \rightarrow \mathcal{G}(u_Y, \mathcal{F}(u_X, \hat{E}_{\mathcal{Y}_u})) \approx \hat{E}_{\mathcal{Y}_u}$$

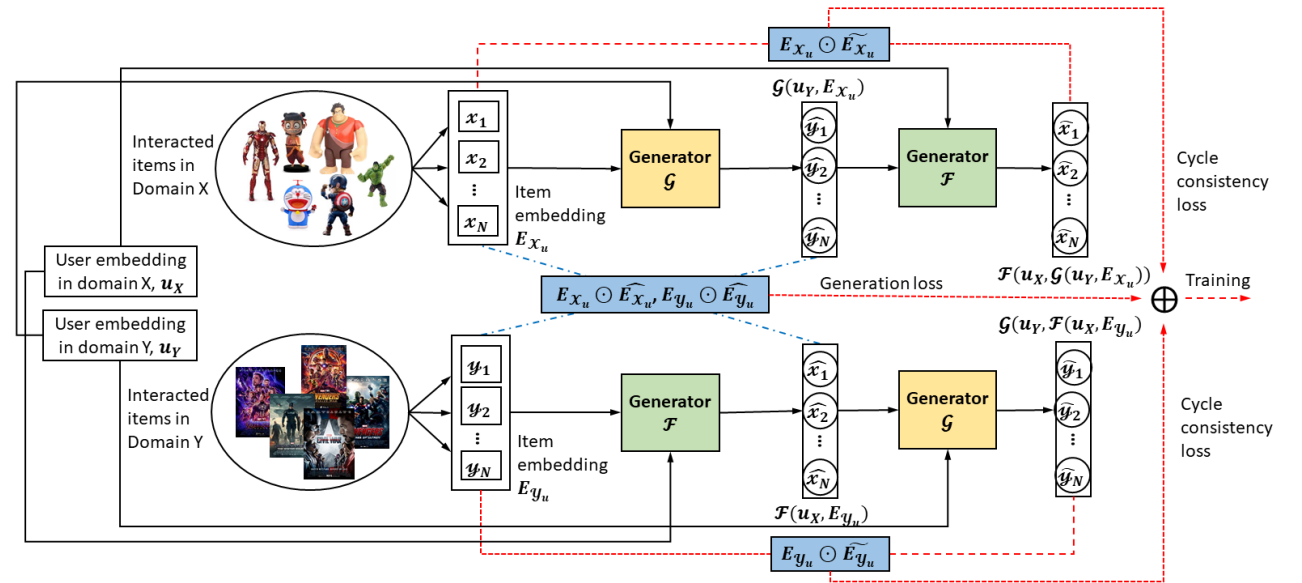
- cycle consistency loss

$$\begin{aligned} \ell_{cyc}(u_X, u_Y, \mathcal{X}_u, \mathcal{Y}_u) = & \left\| \mathcal{F}(u_X, \mathcal{G}(u_Y, E_{\mathcal{X}_u})) - E_{\mathcal{X}_u} \right\|_F^2 \\ & + \left\| \mathcal{G}(u_Y, \mathcal{F}(u_X, E_{\mathcal{Y}_u})) - E_{\mathcal{Y}_u} \right\|_F^2, \quad (3) \end{aligned}$$

# Cycle Generation Networks

- Final loss function

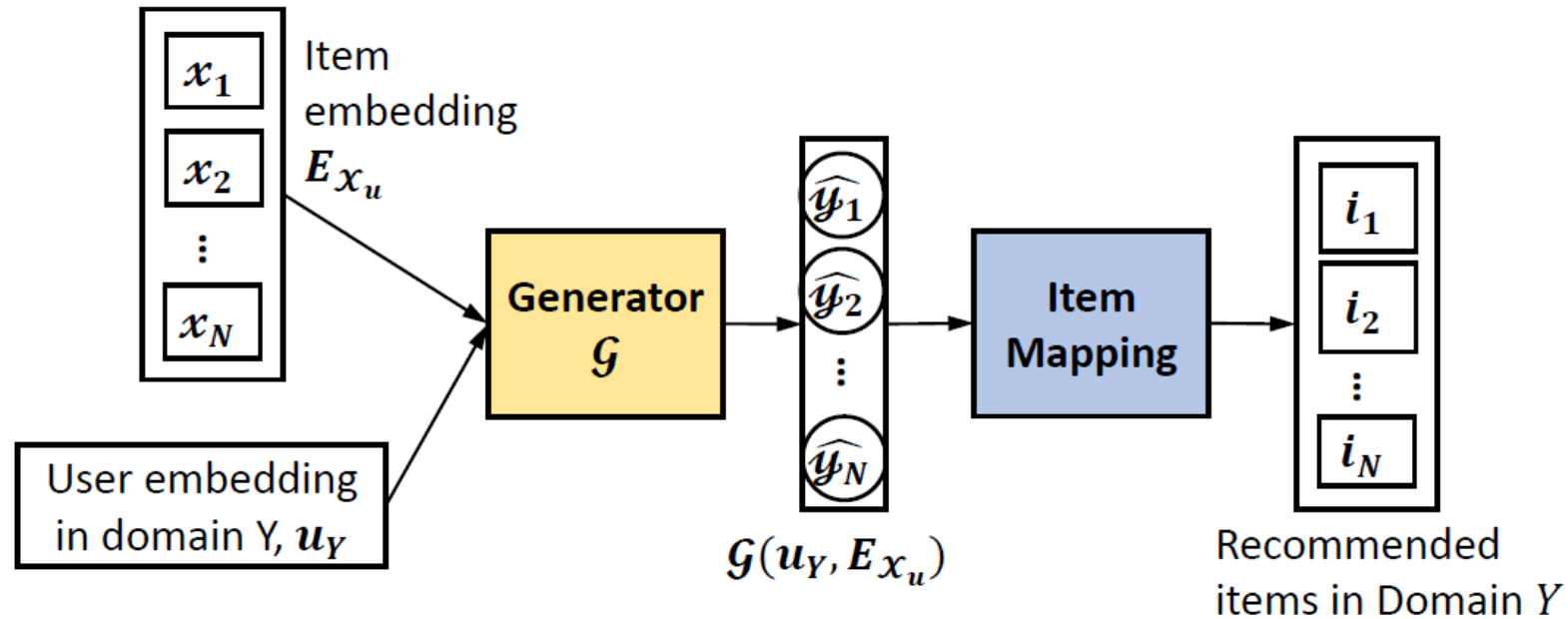
$$\ell_{gen}(\mathbf{u}_X, \mathbf{u}_Y, \mathcal{X}_u, \mathcal{Y}_u) + \lambda \ell_{cyc}(\mathbf{u}_X, \mathbf{u}_Y, \mathcal{X}_u, \mathcal{Y}_u).$$





# Cycle Generation Networks

- Recommendation Process



# Experimental Settings

- Experimental datasets

Datasets	#Initial Users	#Initial Items	#Valid Users	#Valid Items	#Valid Inter.
Home	2,512 K	410 K	206	4,793	6,637
Clothing	3,117 K	1,136 K		6,159	6,525
Books	8,026 K	2,330 K	800	37,533	159,735
Movies	2,089 K	201 K		22,662	114,808

- Evaluation metrics
  - Hit Ratio (HR)
  - Precision
  - Recall

# Experimental Results

Datasets	Metrics	BPRMF	Caser	CMF	CoNet	CGN <sub>w/o UE</sub>	CGN <sub>w/o Cycle</sub>	CGN
Source Domain: Clothing; Target Domain: Home	HR@5	0.1582	<u>0.2260</u> *	0.0113*	0.0622*	0.1695	0.1582	<b>0.2316</b>
	HR@10	0.2316	<u>0.2486</u> *	0.0226*	0.0735*	0.2316	0.2316	<b>0.2700</b>
	HR@20	<b>0.3277</b>	0.2768*	0.0339*	0.1469*	0.2825	0.3107	<u>0.3220</u>
	Precision@5	0.0757	0.0678*	0.0023*	0.0147*	<u>0.1209</u>	<b>0.1232</b>	0.1100
	Precision@10	0.0723	0.0514*	0.0023*	0.0090*	0.1113	<u>0.1215</u>	<b>0.1249</b>
	Precision@20	0.0715	0.0412*	0.0017*	0.0102*	0.0760	<u>0.0783</u>	<b>0.0900</b>
	Recall@5	0.0312*	0.0301*	0.0021*	0.0070*	<b>0.0655</b>	<u>0.0651</u>	0.0612
	Recall@10	0.0613*	0.0418*	0.0068*	0.0091*	0.1141	<u>0.1203</u>	<b>0.1267</b>
	Recall@20	0.1194	0.0600*	0.0110*	0.0297*	0.1339	<u>0.1428</u>	<b>0.1606</b>
Source Domain: Movies; Target Domain: Books	HR@5	0.0405	0.0544	0.0038*	0.0139*	0.0126	<u>0.0708</u>	<b>0.0777</b>
	HR@10	0.0683	0.0822	0.0101*	0.0405*	0.0240	<u>0.0936</u>	<b>0.1113</b>
	HR@20	0.0910	<u>0.1113</u>	0.0177*	0.0797*	0.0202	0.0961	<b>0.1290</b>
	Precision@5	0.0162	0.0134	0.0008*	0.0038*	0.0028	<b>0.0245</b>	<u>0.0238</u>
	Precision@10	0.0182	0.0124*	0.0010*	0.0051*	0.0028	<u>0.0214</u>	<b>0.0230</b>
	Precision@20	<b>0.0197</b>	0.0104	0.0010*	0.0051*	0.0013	0.0130	<u>0.0181</u>
	Recall@5	0.0017	0.0042	0.0003*	0.0009*	0.0005	<u>0.0050</u>	<b>0.0064</b>
	Recall@10	0.0045*	0.0081	0.0007*	0.0037	0.0013	<u>0.0092</u>	<b>0.0140</b>
	Recall@20	0.0088	<u>0.0120</u> *	0.0018*	0.0079*	0.0025	0.0071	<b>0.0165</b>

- Overall, these results indicate that CGN usually achieves superior performance in terms of most evaluation metrics, comparing with all baselines.
- Both users' personalized preferences and the cycle consistency loss can help improve recommendation.

# Experimental Results

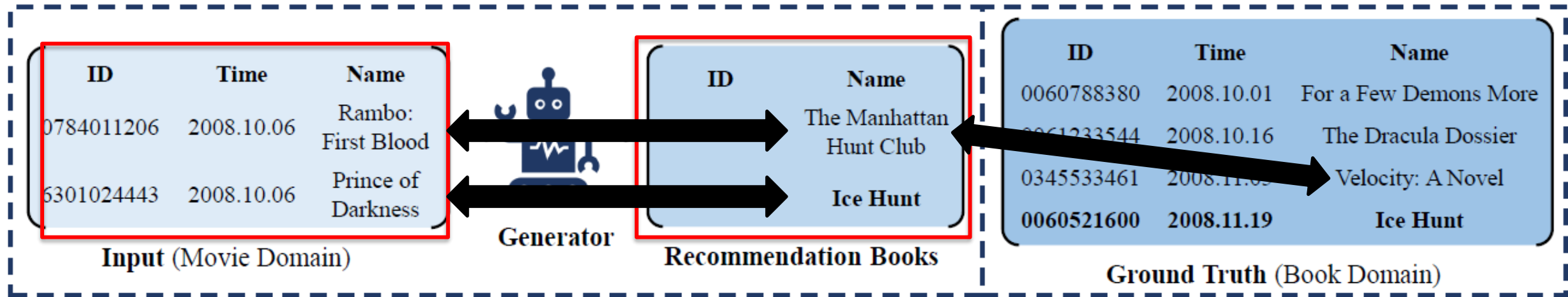


Figure 5: A case study of cross-domain recommendation showing the effectiveness of the proposed CGN model.

- Both “Rambo: First Blood” and “The Manhattan Hunt Club” talk about crime.
- Both “Prince of Darkness” and “Ice Hunt” are about the doomsday theme.

# Experimental Results

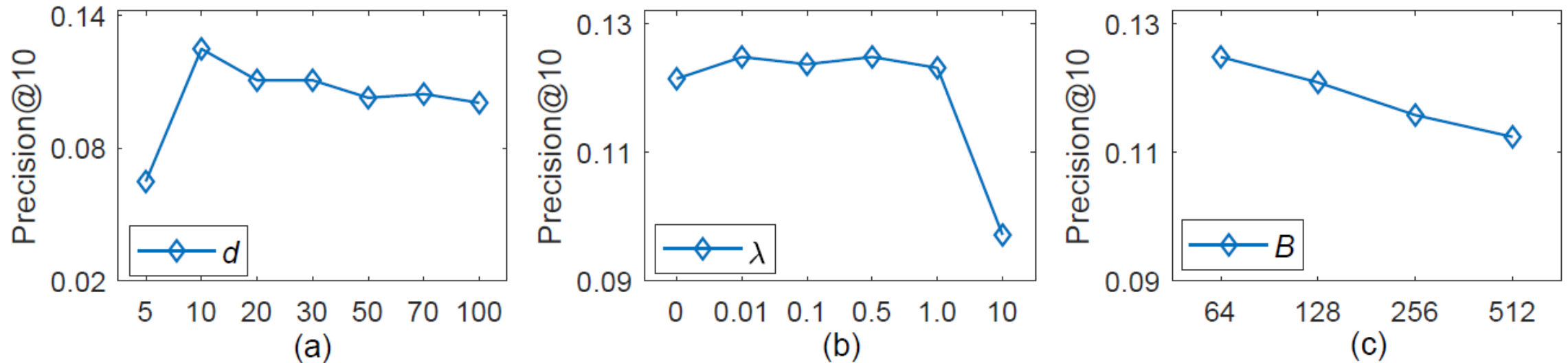


Figure 4: The recommendation accuracy of CGN with respect to different settings of  $d$ ,  $\lambda$ , and  $B$ , measured by Precision@10.

- The best performance is achieved when dimension  $d$  is set to 10.
- The recommendation accuracy can be improved by incorporating cycle consistency loss in training the generator networks.
- Better results can be usually achieved by using a smaller batch size (e.g.,  $B=64$ ).

# Conclusion

- ❑ We propose a novel cross-domain recommendation model(CGN), which learns a user's personalized mapping between her interaction itemsets in different domains at the same temporal period.
- ❑ We perform extensive experiments on four real-world datasets to demonstrate the effectiveness of CGN. CGN usually outperforms baseline methods in terms of all metrics.



Thank you!

