DynFluid: Predicting Time-Evolving Rating in Recommendation Systems via Fluid Dynamics

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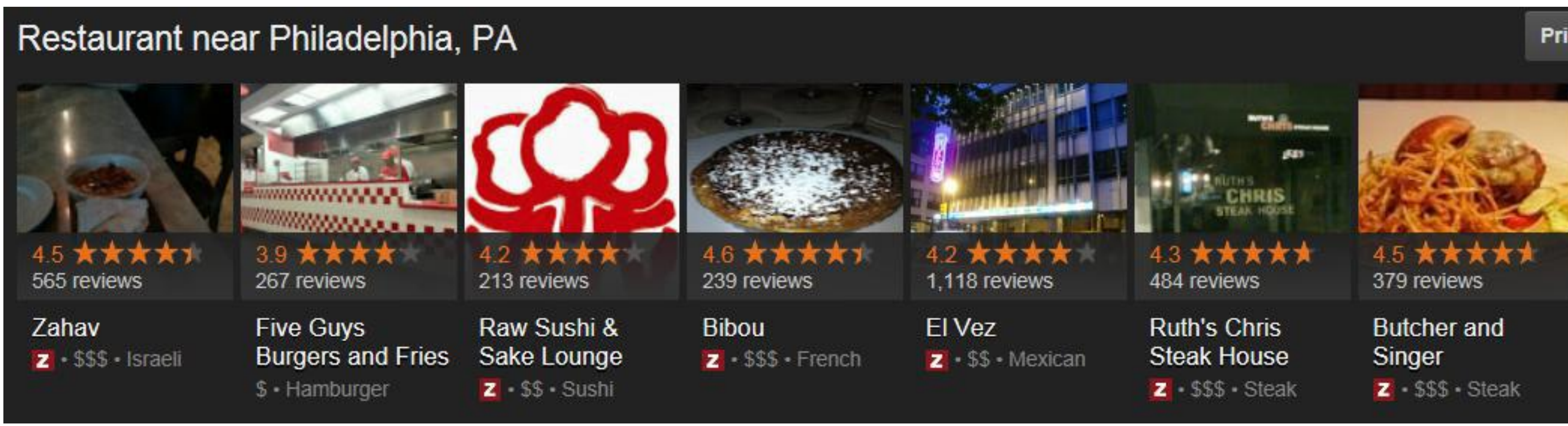
1. Personalized Recommendation

Too many choices in daily life:

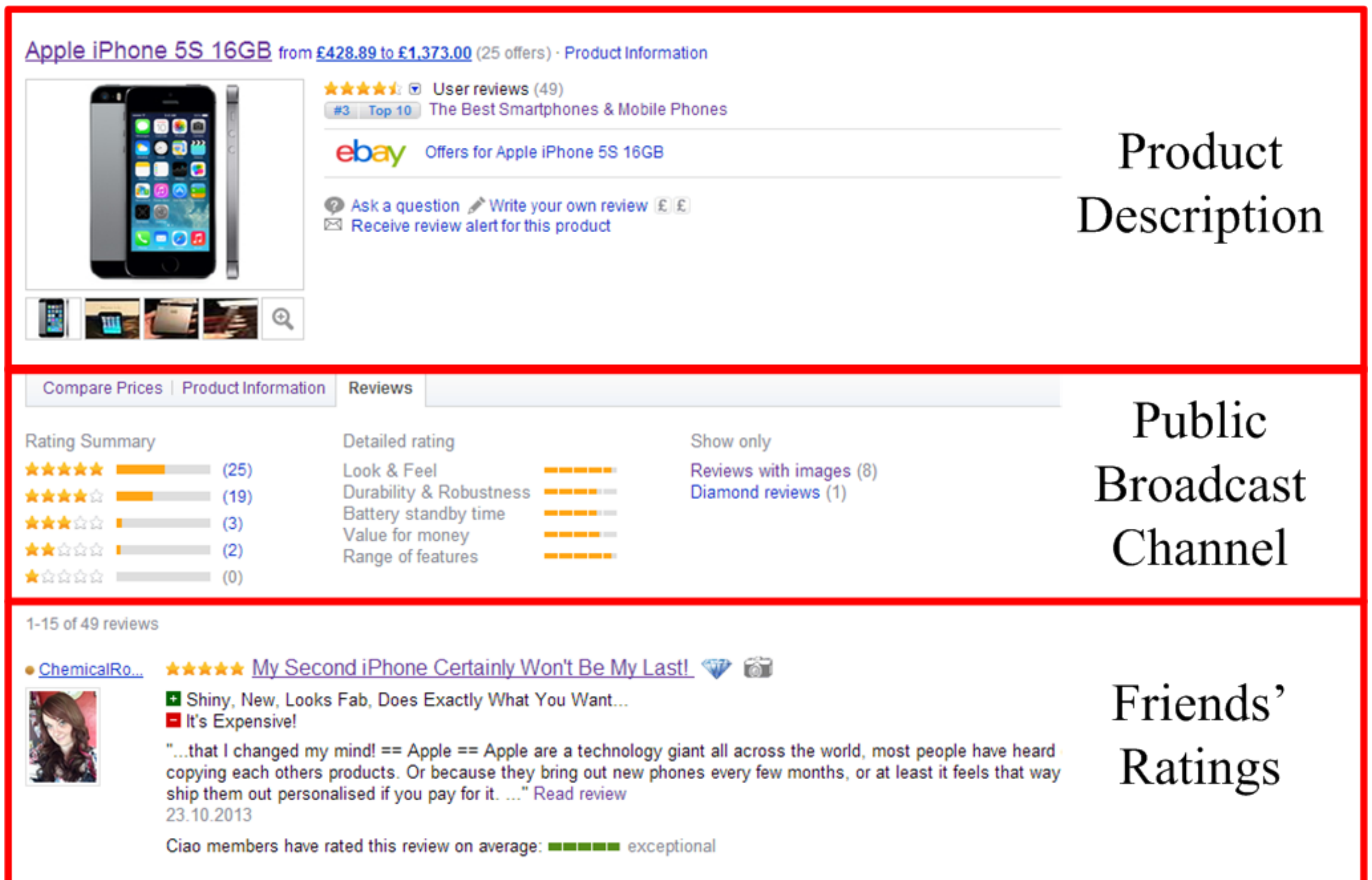
- which restaurant for dinner,
- which movie to watch,
- which product to purchase….



1. Personalized Recommendation

Two types of trust-based recommendations

friend advices and public channel



2. Motivation

Existing trust-based recommendation methods

- Calculate at the current time
- Take direct friends, and friends of friends, equally
- Assume adoption of all influences

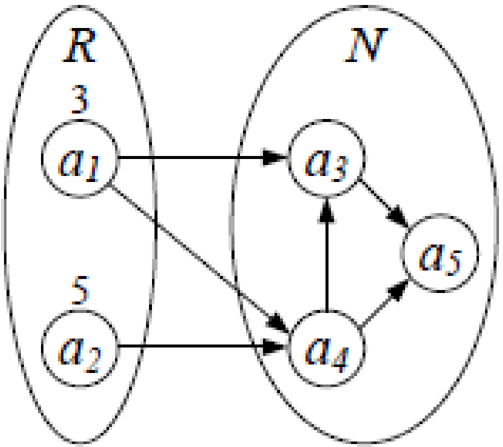
In real life

- Time-evolving system
- Closer friends have more impact
- Users have different features

3. System Setting

Nodes

- Raters, R
- Non-raters, N

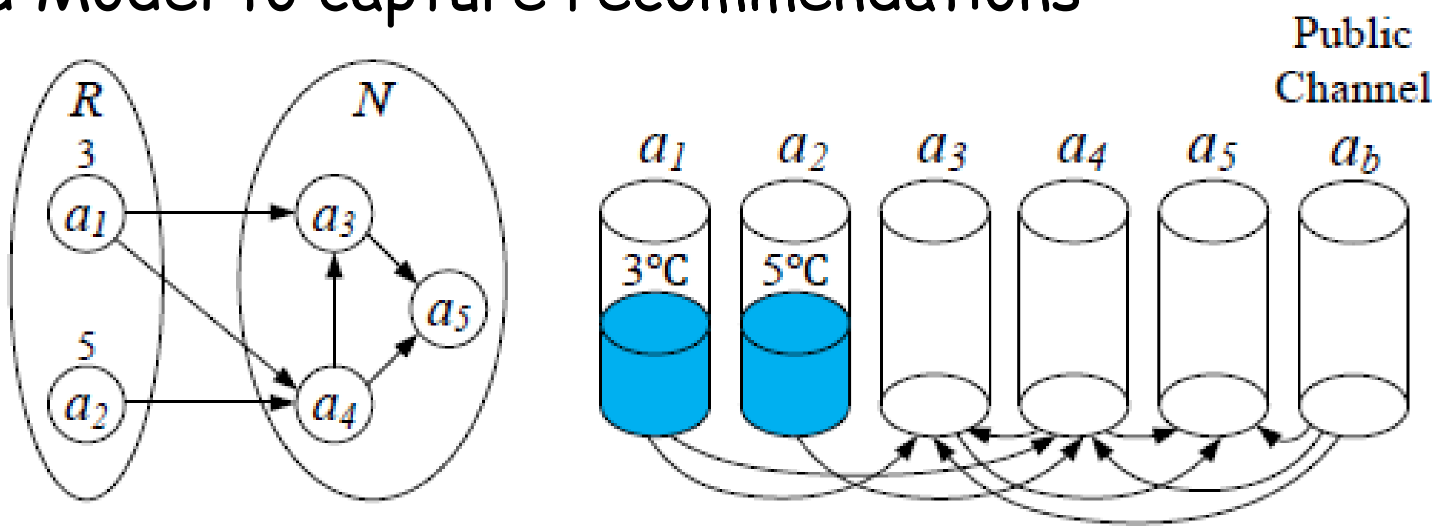


Influence Relationships

- Converted from trust relations
- Among raters and non-raters
- Each relationship is weighted

4. Model

Fluid Model to capture recommendations



Containers -> Users

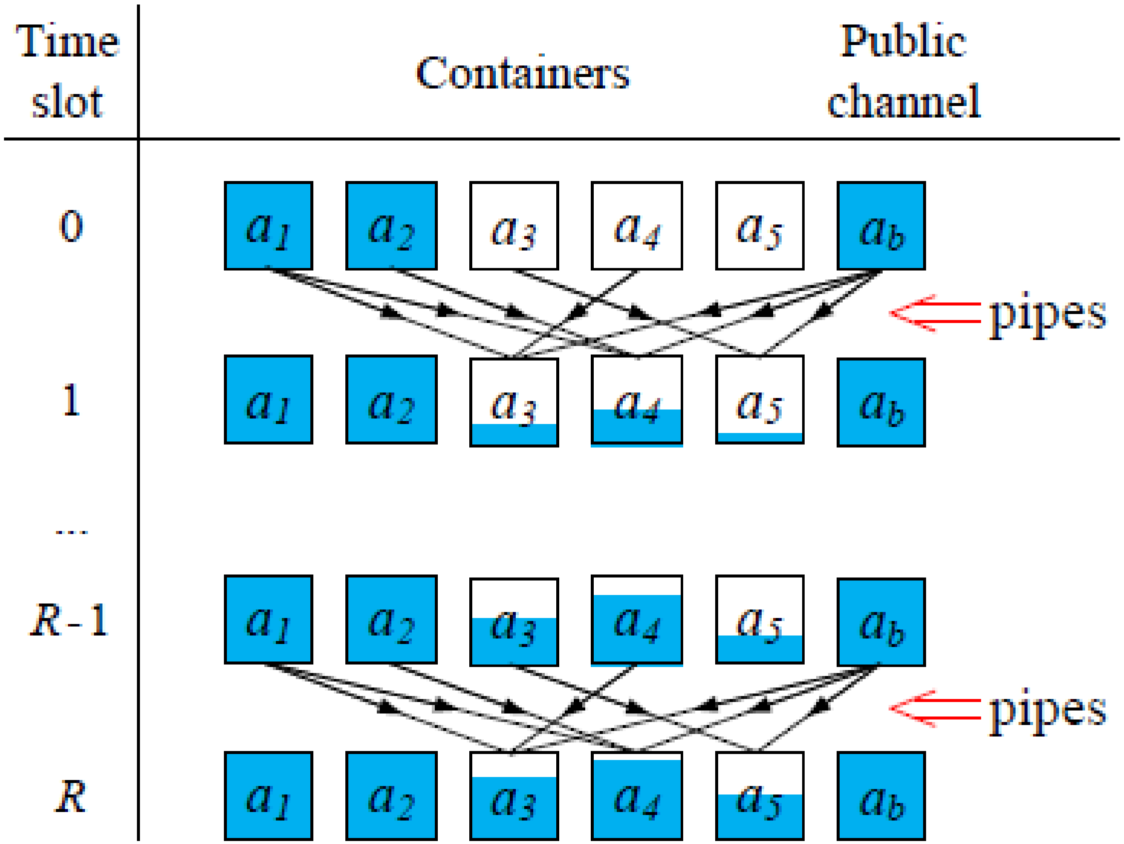
Container fluid height -> User persistency

Fluid temperature -> User Rating Score

Public channel -> A special public container

4. Model

Discrete approach to compute fluid update



4. Model

Container fluid volume update rule:

$$s_a(i+1) = s_a(i) - \sum_{a' \in N_a^+} s_{aa'}(i) + \sum_{a' \in N_a^-} s_{a'a}(i)$$

Container fluid temperature update rule:

$$t_a(i+1) = \frac{\left[s_a(i) - \sum_{a' \in N_a^+} s_{aa'}(i)\right] \cdot t_a(i) + \sum_{a' \in N_a^-} \left[s_{a'a}(i) \cdot t_{a'a}(i)\right]}{s_a(i+1)}$$

5. Theorem and Property

Theorem 1: If we use a constant value (denoted by h) to initialize the fluid heights of all the raters and the public channel, then the fluid heights of all the non-raters will always be no larger than h, during the fluid updating process.

Theorem 2: If we use a constant value (denoted by h) to initialize the fluid heights of all the raters and the public channel, then, after a time period that is sufficiently long, the fluid heights of all the non-raters will be h.

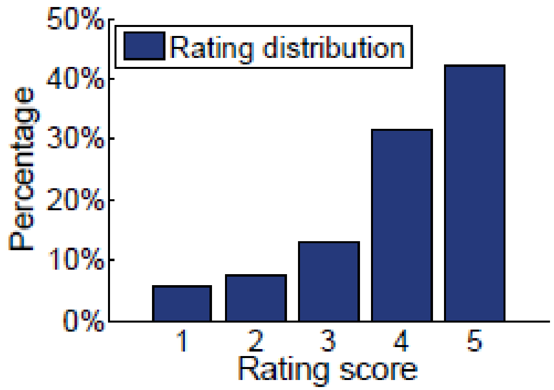
5. Theorem and Property

Property 1: In DynFluid, the opinion influence from a user, a, to another user, a′, decays monotonously with respect to the hop-count distance from a to a′.

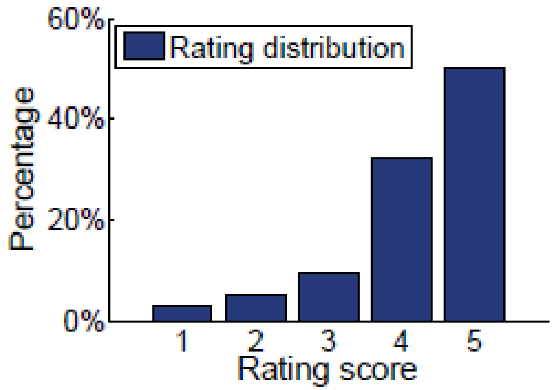
Property 2: In DynFluid, the certainty of the rating prediction for a non-rater can be measured by the fluid height (or persistency) of that non-rater.

6. Experiments

- Epinions dataset consists of 49,290 users who rated a total of 139,738 different products. The total number of issued trust relationships is 487,181.
- The Ciao dataset consists of 2,248 users who rated a total of 16,861 different products. The total number of issued trust relationships is 57,544



(a) Rating scores in Epinions.



(b) Rating scores in Ciao.

6. Experiments

Performance metric

- Root mean squared error (RMSE)
- F-score (harmonic mean of precision and recall)

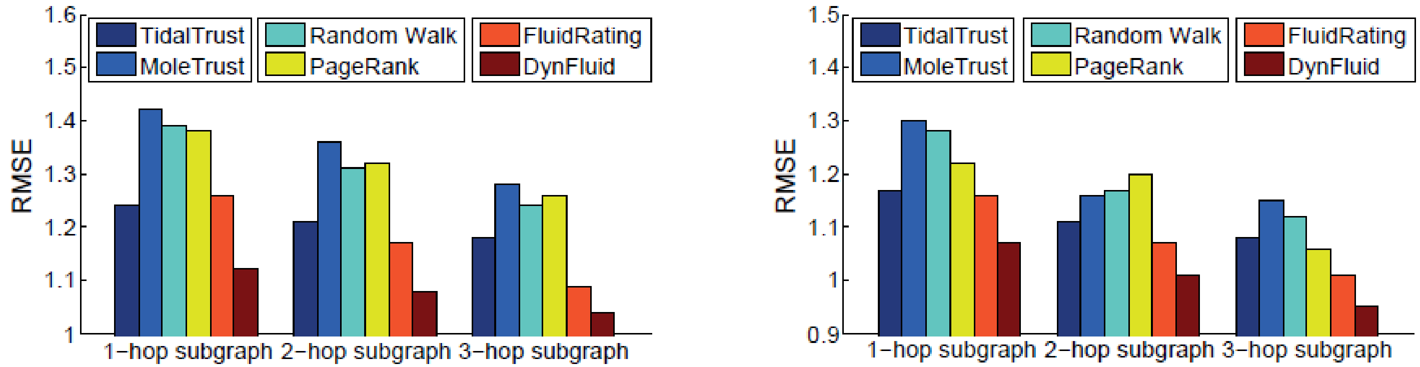
Default parameters

- Time slot length is 0.1
- Rounds of update is 10
- Cross-sectional areas of all the containers are 1
- Initial temperature of the public channel is the average score of all the raters.

Comparison algorithms: TidalTrust, MoleTrust, Random Walk, PageRank, and FluidRating

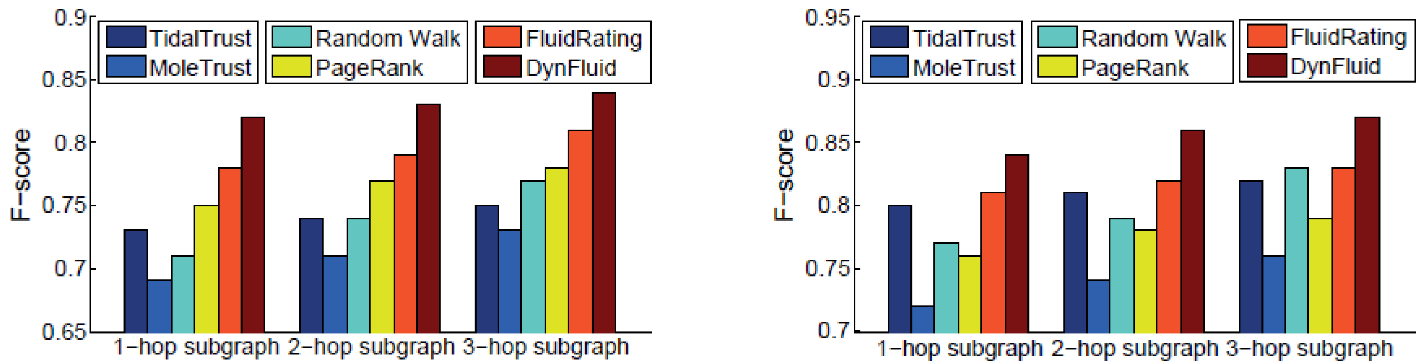
6. Experiments

Epinions and Ciao result (RMSE and F-score):



(a) The RMSE in the Epinions dataset. (b) The RMSE in the Ciao dataset.

Fig. 6. Compare DynFluid with the other methods, in terms of the RMSE metric.

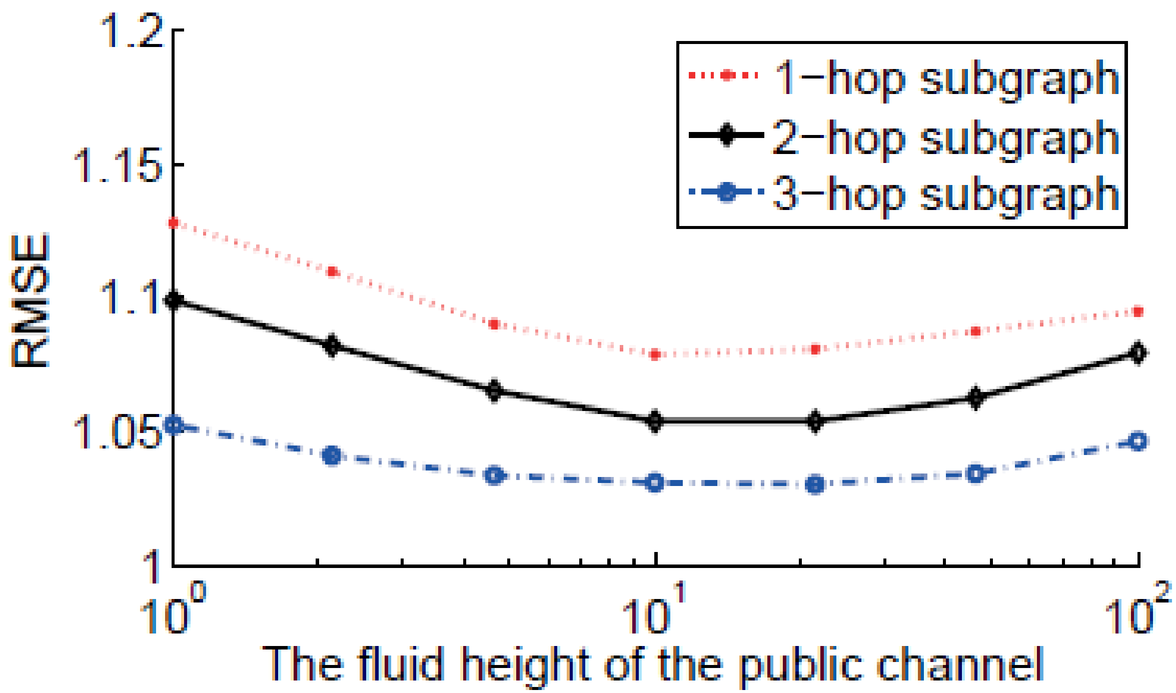


(a) The F-score in the Epinions dataset. (b) The F-score in the Ciao dataset.

Fig. 7. Compare DynFluid with the other methods, in terms of the F-score metric.

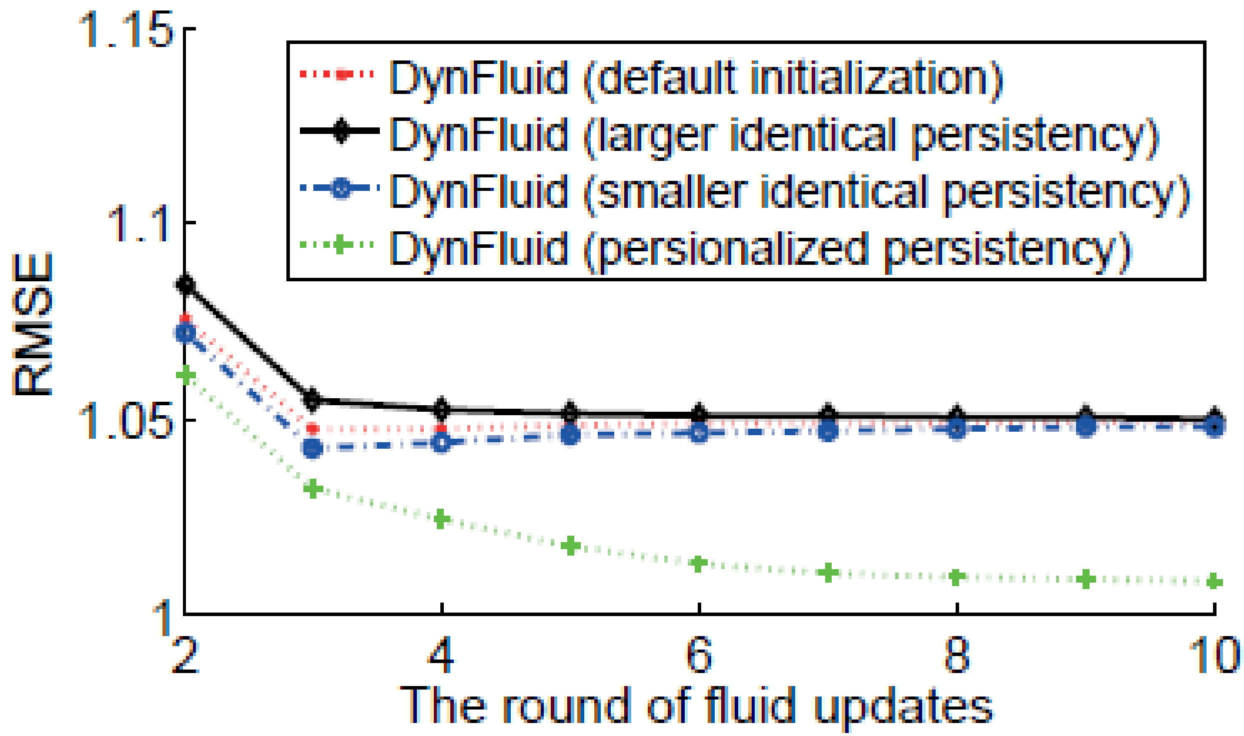
6. Experiments

Impact of the public channel (Epinions):



6. Experiments

Impact of the user persistency (Epinions):



7. Conclusion

Conclusion:

- Our model can reflect the time-evolving feature
- Differentiate direct and indirect influence
- Public Channel is very effective
- Reflect the user personality feature (persistency)

Future Work

- Update the discrete computation model
- Capture more user features

8. End

Q & A