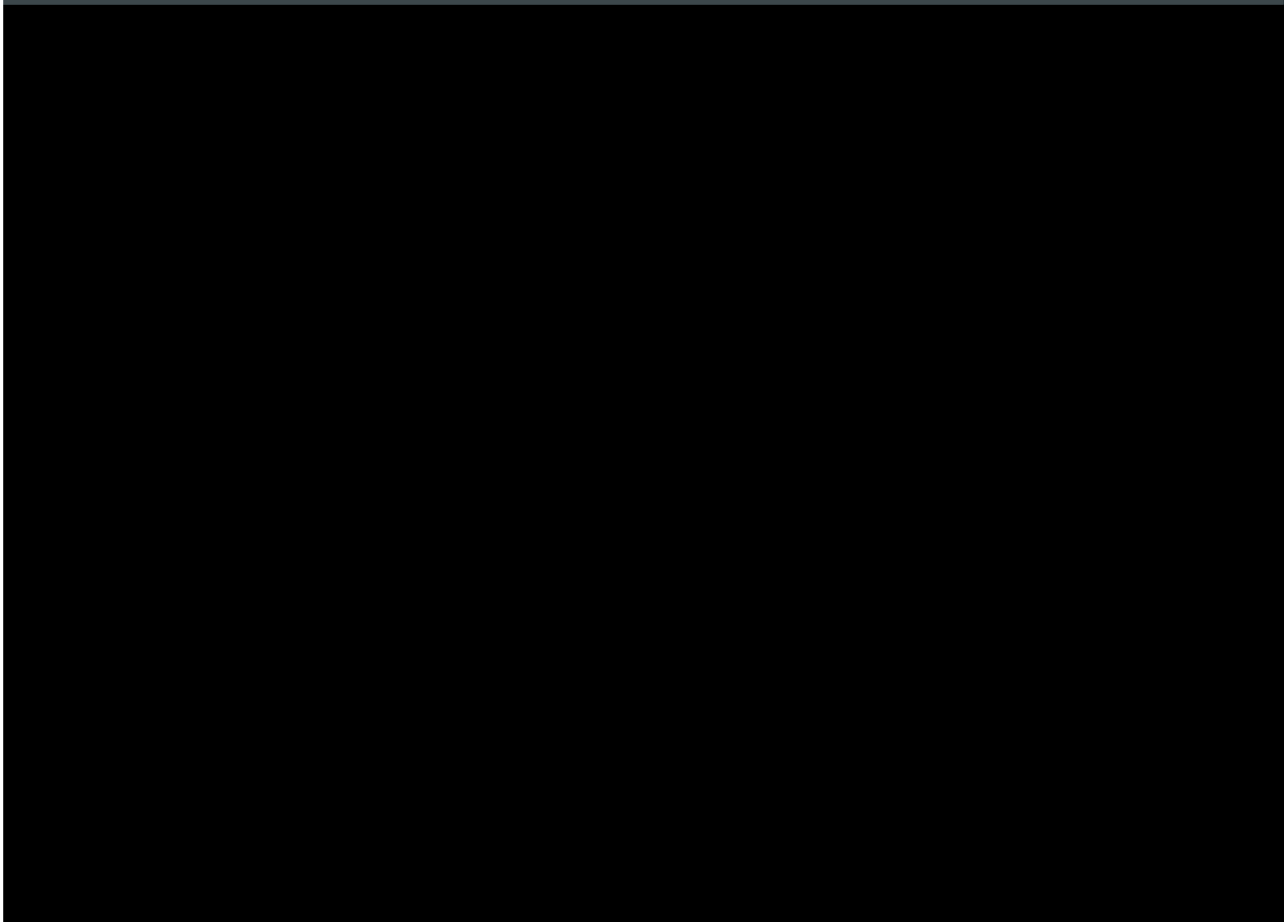
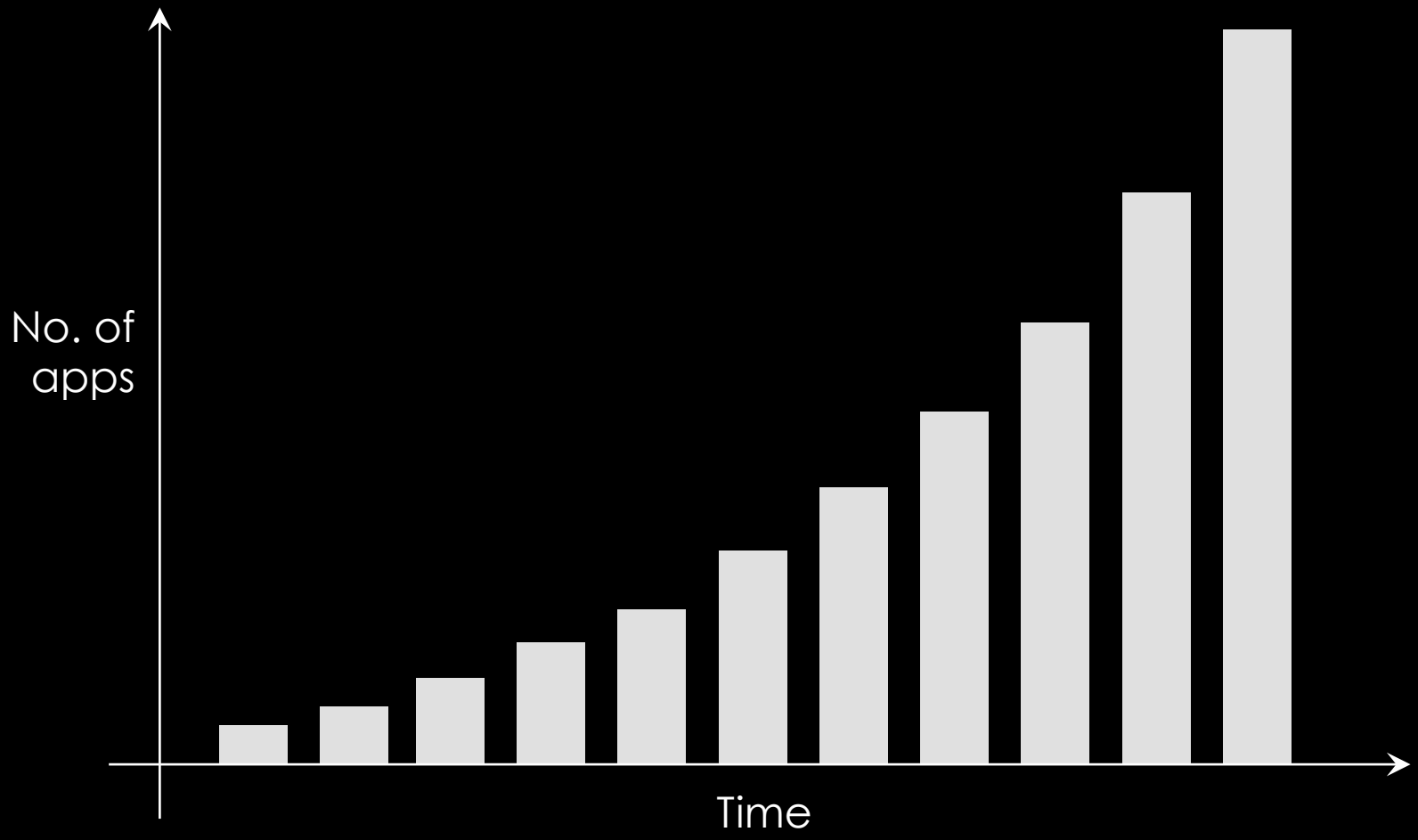

# Addressing Cold-Start in App Recommendations: Latent User Models Constructed from Twitter Followers

Jovian Lin / Kazunari Sugiyama / Min-Yen Kan / Tat-Seng Chua
National University of Singapore



# Many, many apps.

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Pageonce
Poll Tracker
nyc weather
SGN Golf
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Air Mouse
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tvChatter
Things
Stocks
Things
LiveView
Yahoo!
colorendar
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!
INFORMATION
OVERLOAD

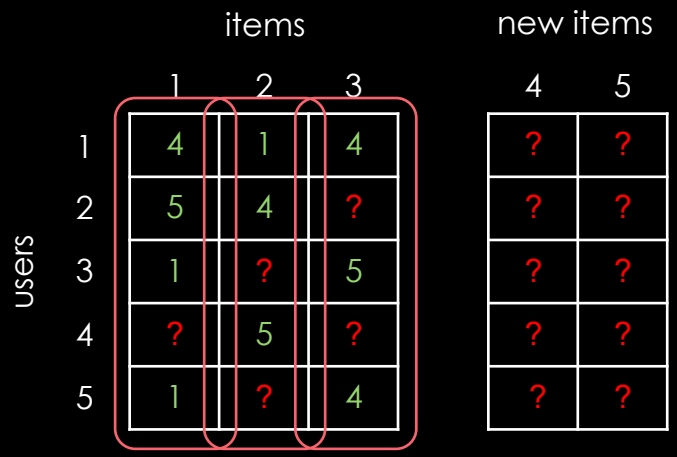
# Recommender Systems

Collaborative Filtering

Content-based Filtering

# Recommender Systems

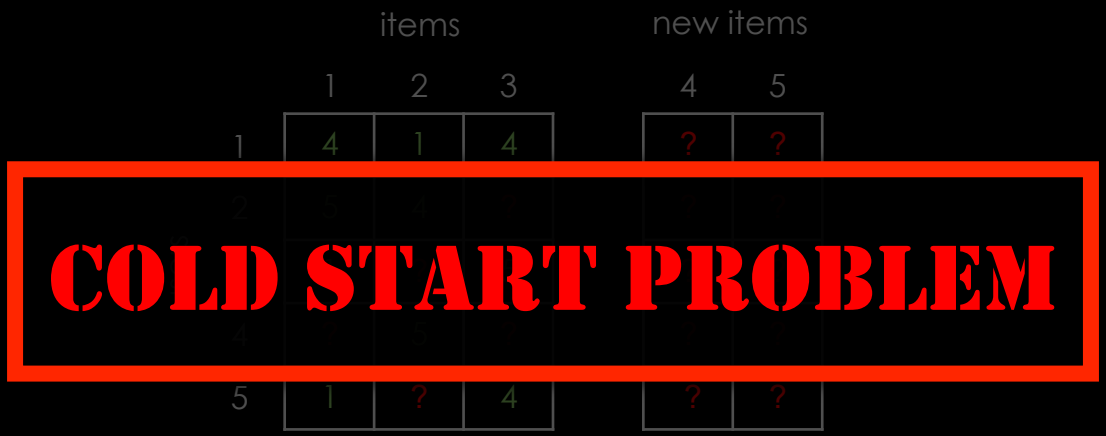
## Collaborative Filtering




## Content-based Filtering

# Recommender Systems

## Collaborative Filtering




**COLD START PROBLEM**

Solution #1: Wait for ratings to come in.

Solution #2: Use content-based filtering.

## Content-based Filtering

# Recommender Systems

## Collaborative Filtering

## Content-based Filtering

- Recommends items based on similar content.
- Con: Lack of diversified recommendations. (e.g., genres, textual descriptions)

  Example: a user who has downloaded a weather app will receive weather-related app-recommendations.

# Meanwhile…


SOCIAL MEDIA


LinkedIn
skype
foursquare
LIVEJOURNA
vimeo
Insta
YouTube
facebook
Blogger
twitter
flickr
tumblr.
yelp
Like

"Can we merge information mined from social networks to enhance (app) recommendations?"

"Can we address the cold-start in recommender systems by using nascent signals in social networks?"


YES, WE CAN.

We made two observations:

1. Apps contain references to their Twitter accounts.
2. Early signals about apps can be present in social networks, even before ratings are received.

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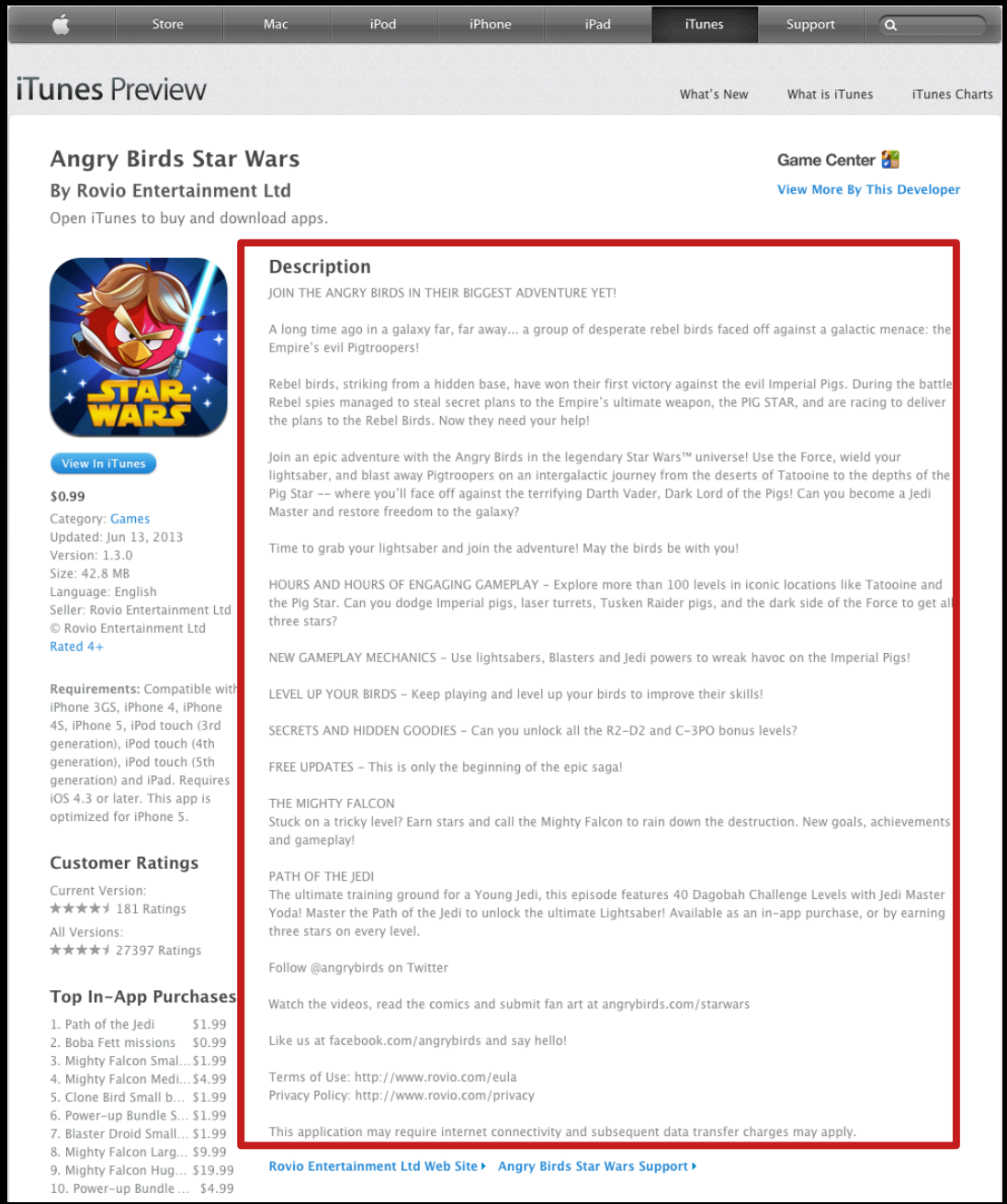
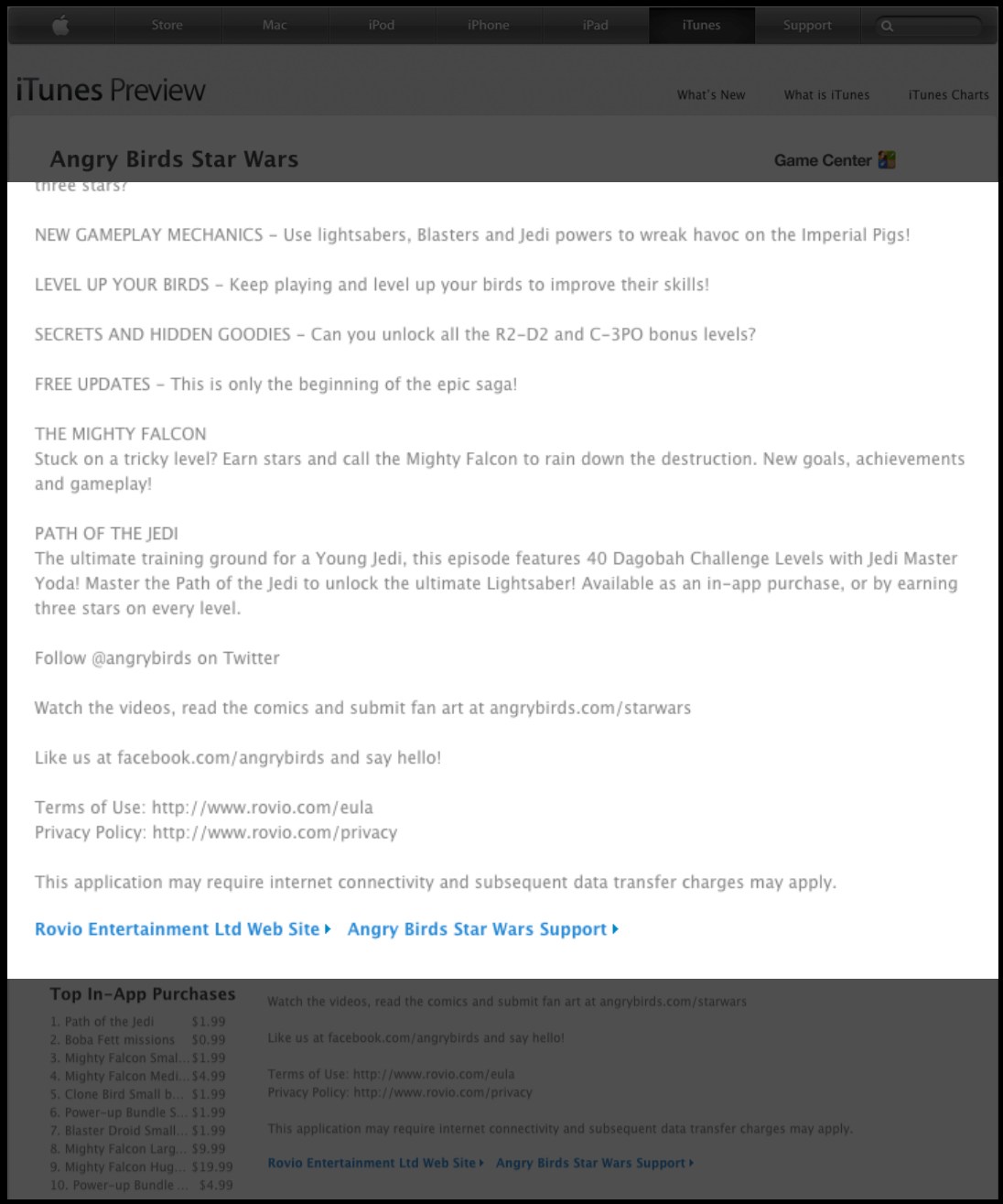

Store
Mac
iPod
iPhone
iPad
iTunes
Support
iTunes Preview
What's New
What is iTunes
iTunes Charts
Angry Birds Star Wars
By Rovio Entertainment Ltd
Open iTunes to buy and download apps.
Game Center
View More By This Developer
View In iTunes
$0.99
Category: Games
Updated: Jun 13, 2013
Version: 1.3.0
Size: 42.8 MB
Language: English
Seller: Rovio Entertainment Ltd
© Rovio Entertainment Ltd
Rated 4+
Requirements: Compatible with iPhone 3GS, iPhone 4, iPhone 4S, iPhone 5, iPod touch (3rd generation), iPod touch (4th generation), iPod touch (5th generation) and iPad. Requires iOS 4.3 or later. This app is optimized for iPhone 5.
Customer Ratings
Current Version:
181 Ratings
All Versions:
27397 Ratings
Top In-App Purchases
1. Path of the Jedi $1.99
2. Boba Fett missions $0.99
3. Mighty Falcon Smal... $1.99
4. Mighty Falcon Medi... $4.99
5. Clone Bird Small b... $1.99
6. Power-up Bundle S... $1.99
7. Blaster Droid Small... $1.99
8. Mighty Falcon Larg... $9.99
9. Mighty Falcon Hug... $19.99
10. Power-up Bundle ... $4.99
Description
JOIN THE ANGRY BIRDS IN THEIR BIGGEST ADVENTURE YET!
A long time ago in a galaxy far, far away... a group of desperate rebel birds faced off against a galactic menace: the Empire's evil Pigtroopers!
Rebel birds, striking from a hidden base, have won their first victory against the evil Imperial Pigs. During the battle Rebel spies managed to steal secret plans to the Empire's ultimate weapon, the PIG STAR, and are racing to deliver the plans to the Rebel Birds. Now they need your help!
Join an epic adventure with the Angry Birds in the legendary Star Wars™ universe! Use the Force, wield your lightsaber, and blast away Pigtroopers on an intergalactic journey from the deserts of Tatooine to the depths of the Pig Star -- where you'll face off against the terrifying Darth Vader, Dark Lord of the Pigs! Can you become a Jedi Master and restore freedom to the galaxy?
Time to grab your lightsaber and join the adventure! May the birds be with you!
HOURS AND HOURS OF ENGAGING GAMEPLAY - Explore more than 100 levels in iconic locations like Tatooine and the Pig Star. Can you dodge Imperial pigs, laser turrets, Tusken Raider pigs, and the dark side of the Force to get all three stars?
NEW GAMEPLAY MECHANICS - Use lightsabers, Blasters and Jedi powers to wreak havoc on the Imperial Pigs!
LEVEL UP YOUR BIRDS - Keep playing and level up your birds to improve their skills!
SECRETS AND HIDDEN GOODIES - Can you unlock all the R2-D2 and C-3PO bonus levels?
FREE UPDATES - This is only the beginning of the epic saga!
THE MIGHTY FALCON
Stuck on a tricky level? Earn stars and call the Mighty Falcon to rain down the destruction. New goals, achievements and gameplay!
PATH OF THE JEDI
The ultimate training ground for a Young Jedi, this episode features 40 Dagobah Challenge Levels with Jedi Master Yoda! Master the Path of the Jedi to unlock the ultimate Lightsaber! Available as an in-app purchase, or by earning three stars on every level.
Follow @angrybirds on Twitter
Watch the videos, read the comics and submit fan art at angrybirds.com/starwars
Like us at facebook.com/angrybirds and say hello!
Terms of Use: http://www.rovio.com/eula
Privacy Policy: http://www.rovio.com/privacy
This application may require internet connectivity and subsequent data transfer charges may apply.
Rovio Entertainment Ltd Web Site
Angry Birds Star Wars Support


Store
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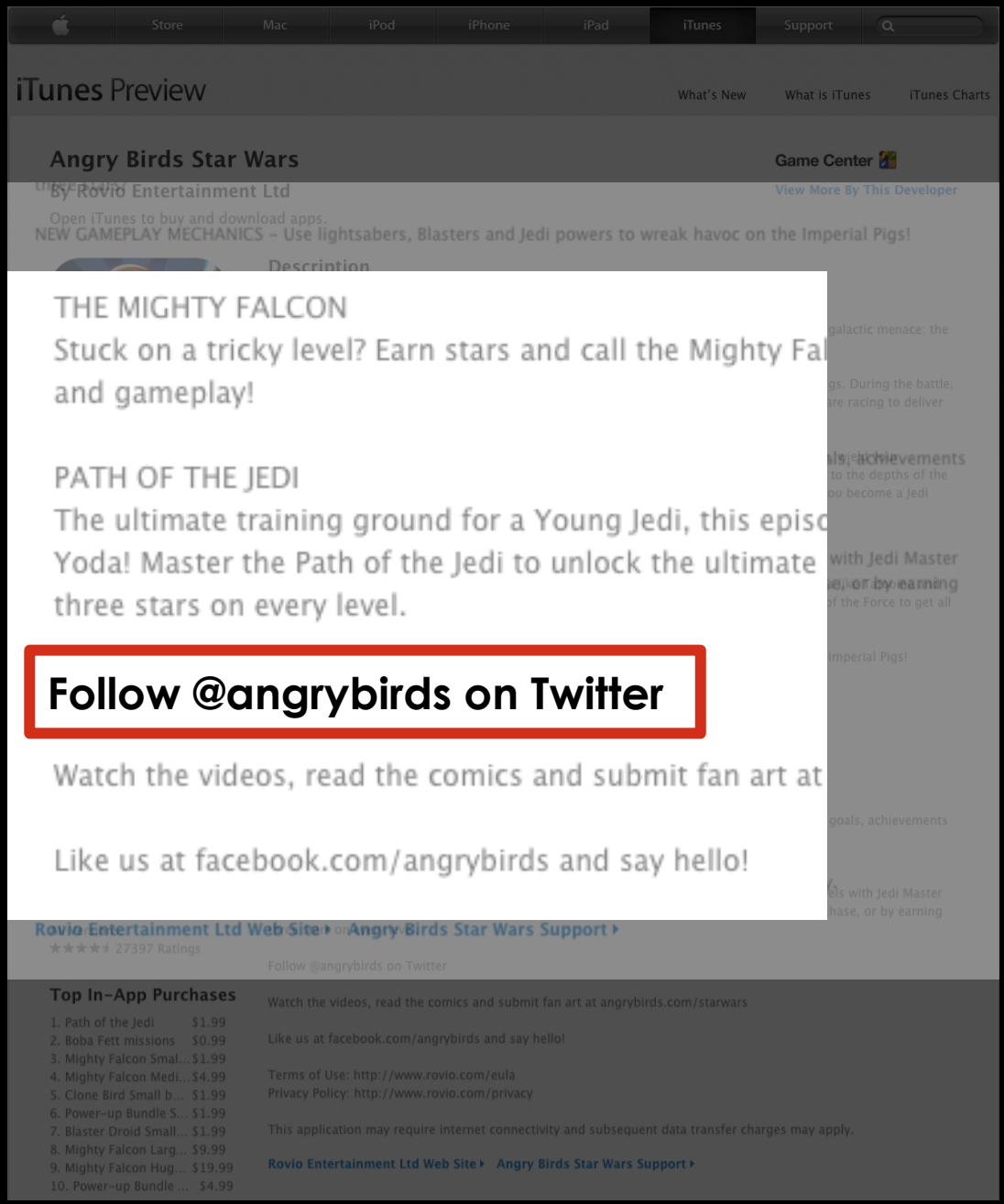
Store
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View More By This Developer
Open iTunes to buy and download apps.
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**David Icke** @davidicke
Followed by Tom Kirk and others
Follow

**Don Metzler** @metzlerd
Follow

Popular accounts · Find friends

Singapore Trends · Change

#ReplaceSongTitlesWithHaze
#3words
#913BRIDGITMEndlerBreakfastChat


47,265 TWEETS | 9,050 FOLLOWING | 584,621 FOLLOWERS | Follow

## Tweets All / No replies

**Mari Taibi** @MariTaibi 7h
@AngryBirds Twin Beaks
Retweeted by Angry Birds
Expand

**Angry Birds** @AngryBirds 3h
Lovely Stella #AngryBirdsArt by Fonora! rov.io/17j0ZBN twitpic.com/cxw73c
View photo

**Ignacio BravoPeralta** @IgnacioZippy 4h
A shout out to my mom @fresiamaria who after 8 months finally completed and 3-starred all @AngryBirds (Original) levels :3
Retweeted by Angry Birds
from Chile

**Steph Nutterfield** @SNutterfield 7h
@AngryBirds Squawkward #BirdTV @MTVAwkward
Retweeted by Angry Birds
Expand

**RS Gray** @utgardsloki 18 Jun
@AngryBirds I just realized yellow bird and I have the same profile picture! pic.twitter.com/8RVvfoeiu4
Retweeted by Angry Birds
View photo

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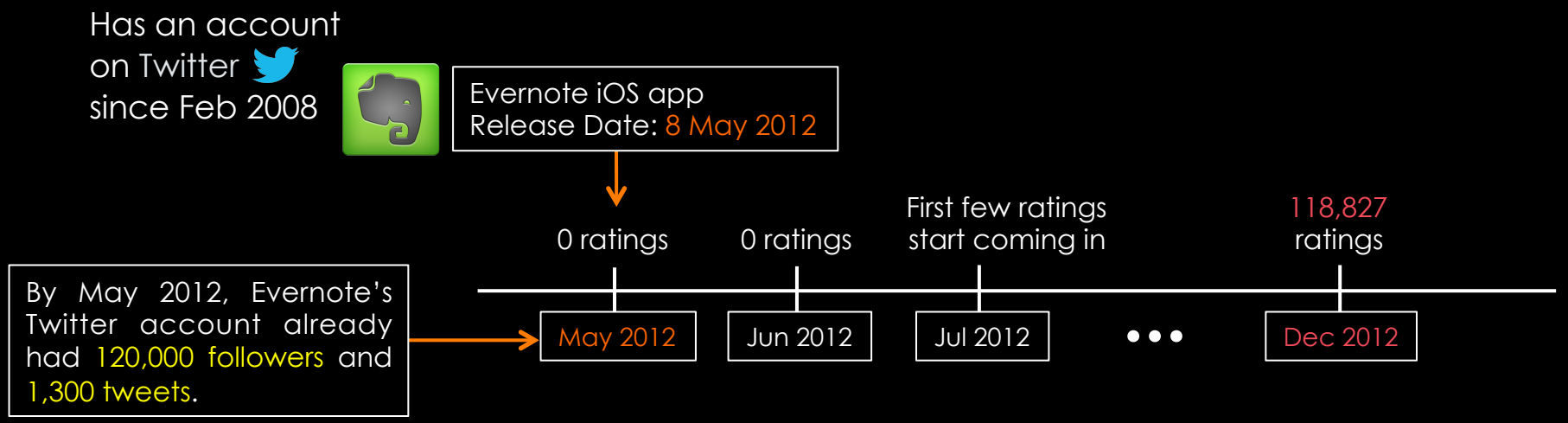

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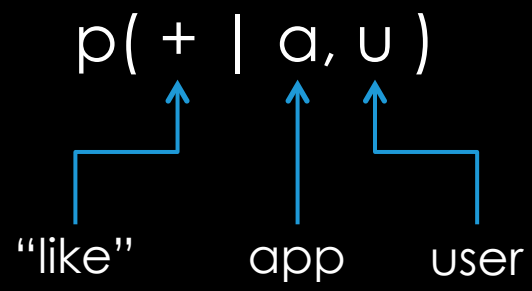
We *CAN* address the cold-start in recommender systems by using nascent signals in social networks.

We want to estimate the probability that "a target user *u* will like an app *a*."



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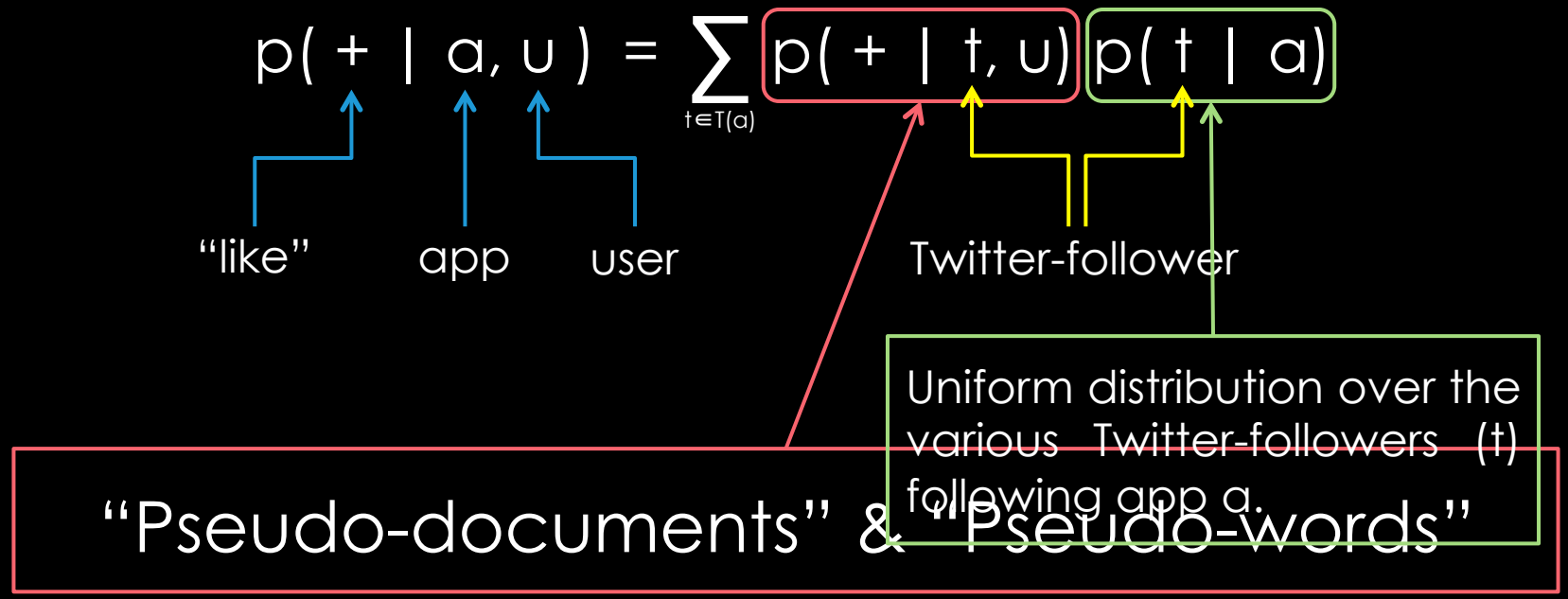

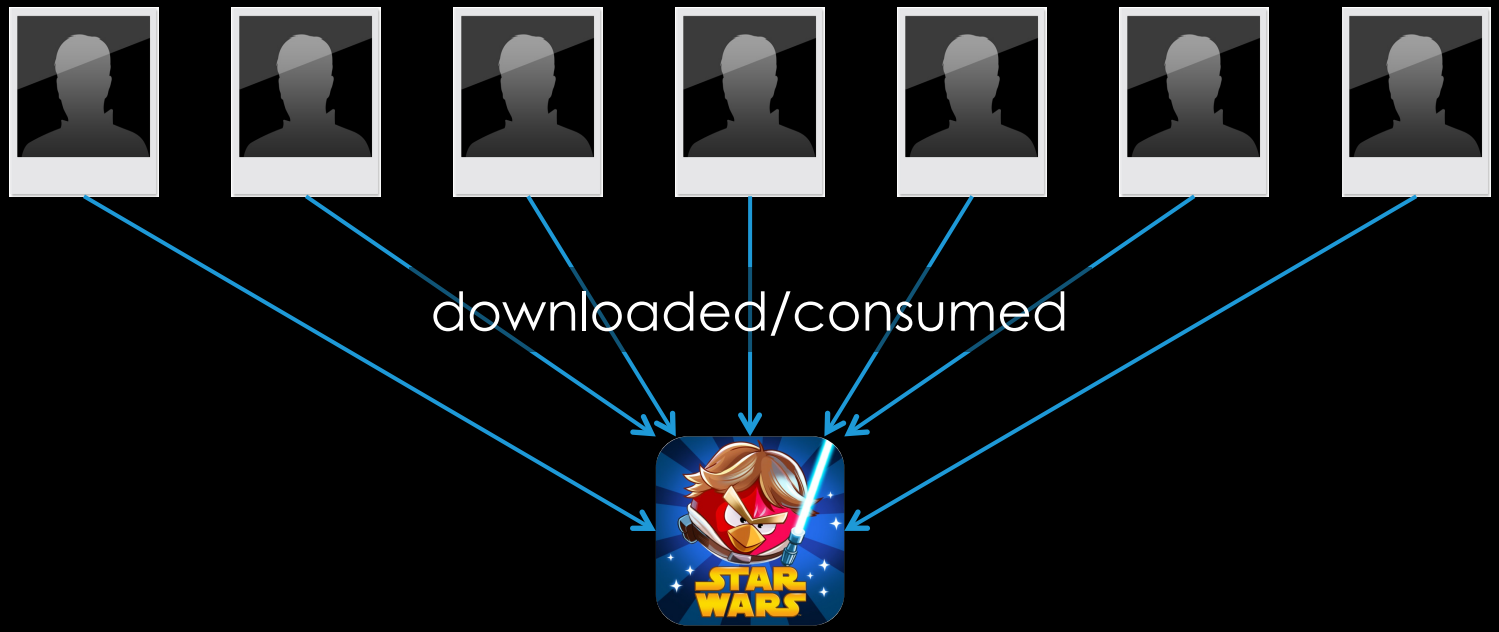
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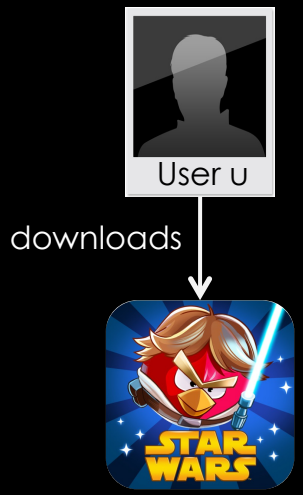
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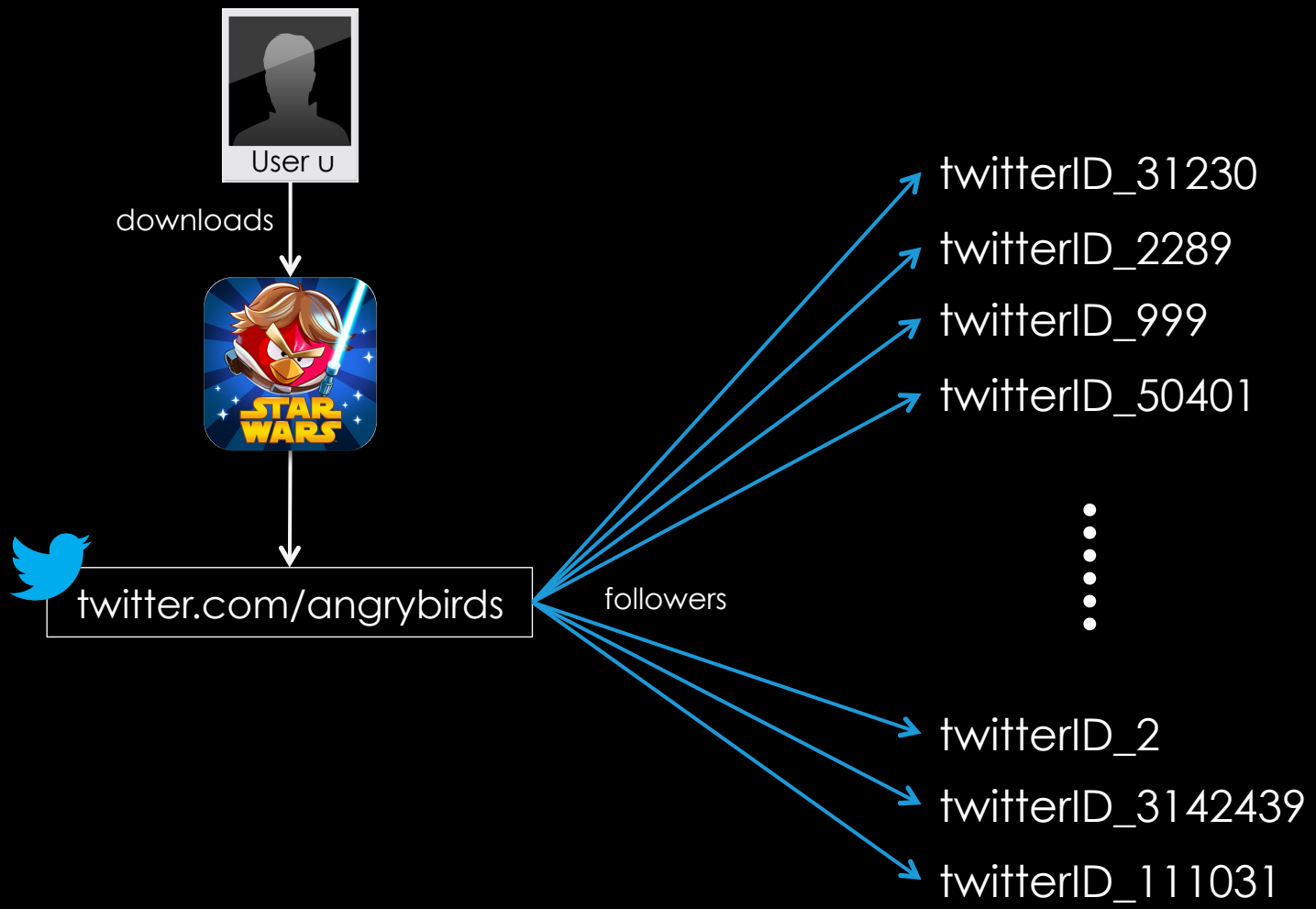
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David Icke @davidicke
Followed by Tom Kirk and others
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#ReplaceSongTitlesWithHaze
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Angry Birds
@AngryBirds
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Helsinki, Finland · angrybirds.com/starwars

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Tweets All / No replies

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Expand

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View photo

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RS Gray @utgardsloki 18 Jun
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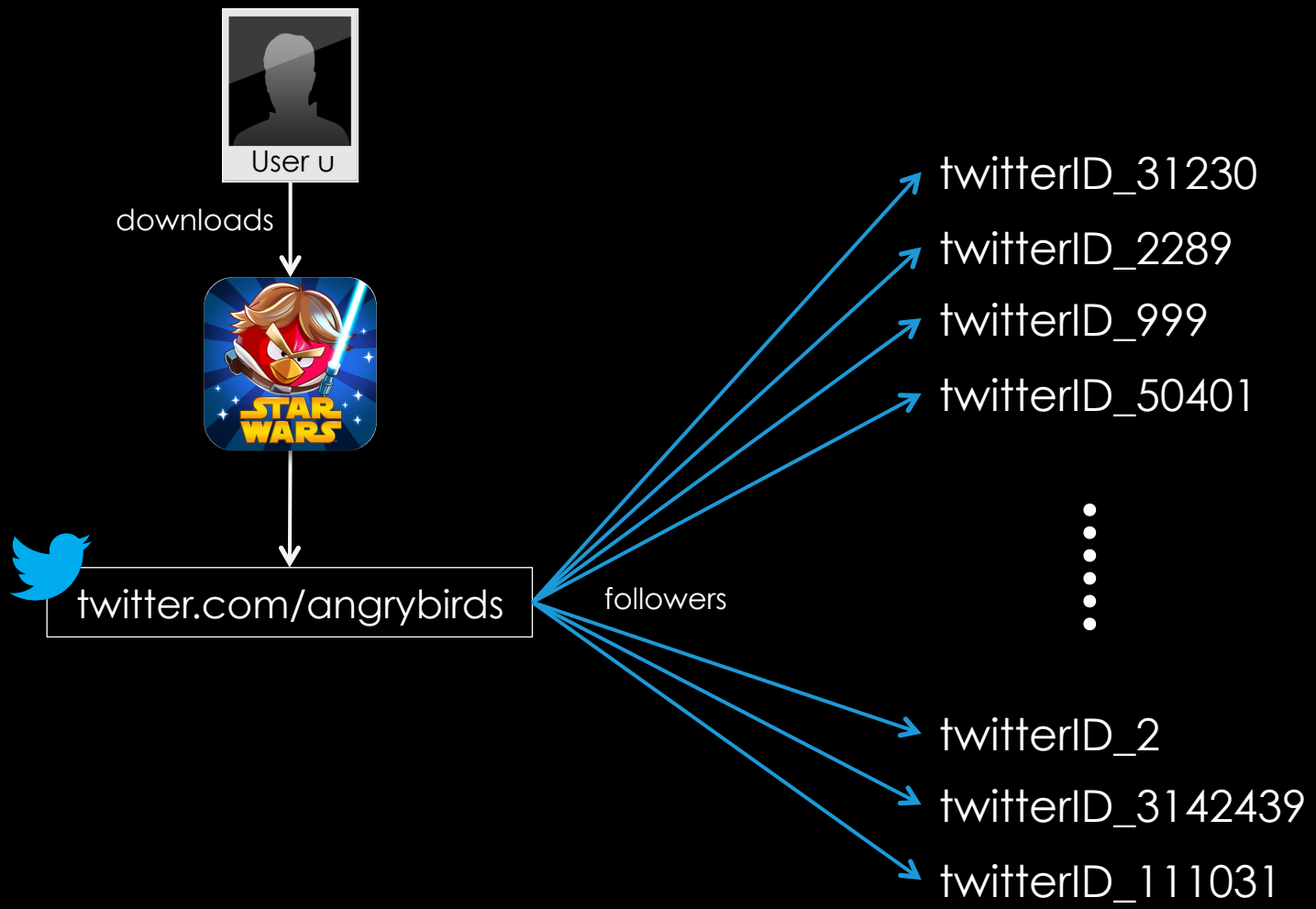
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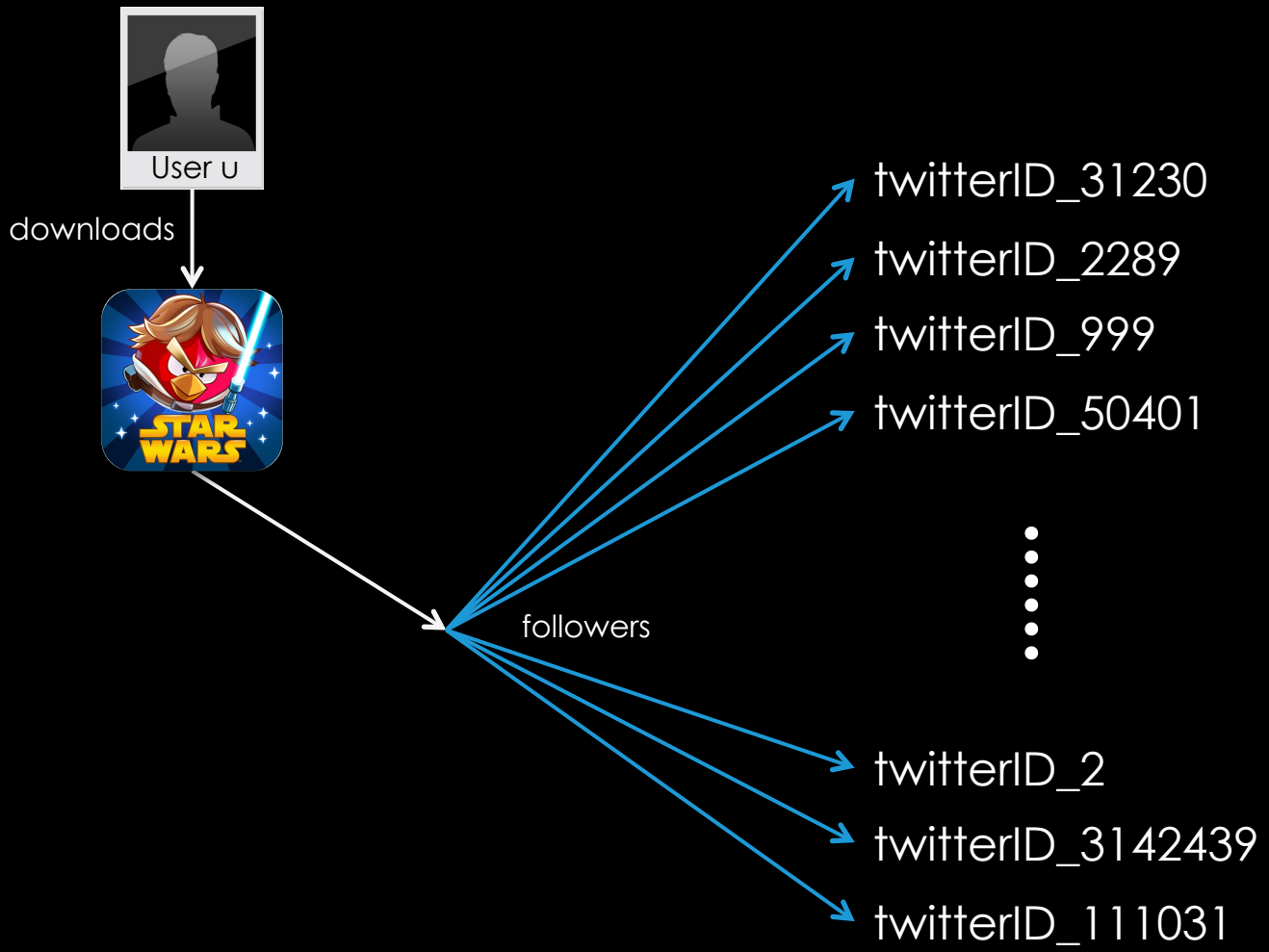
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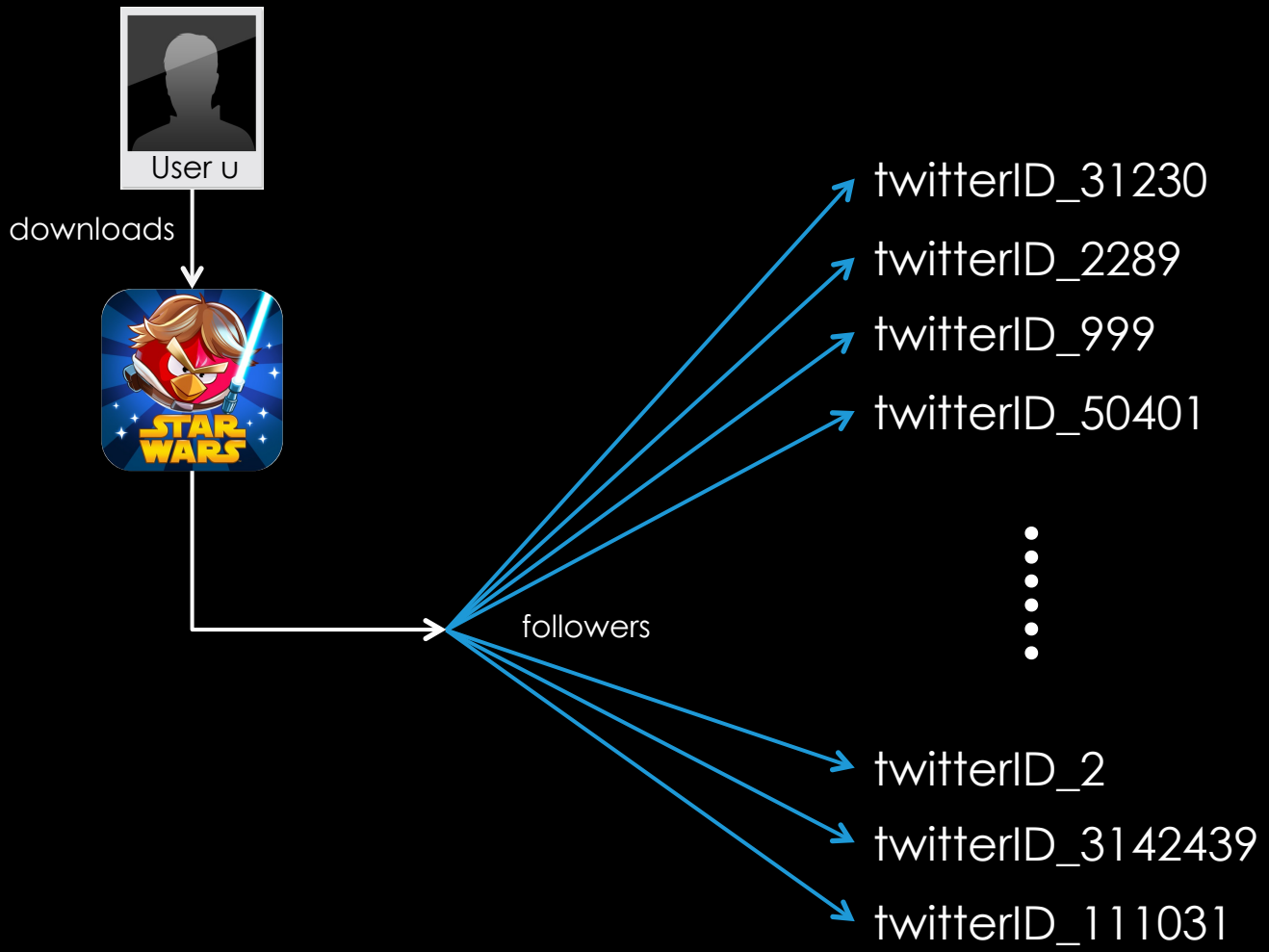
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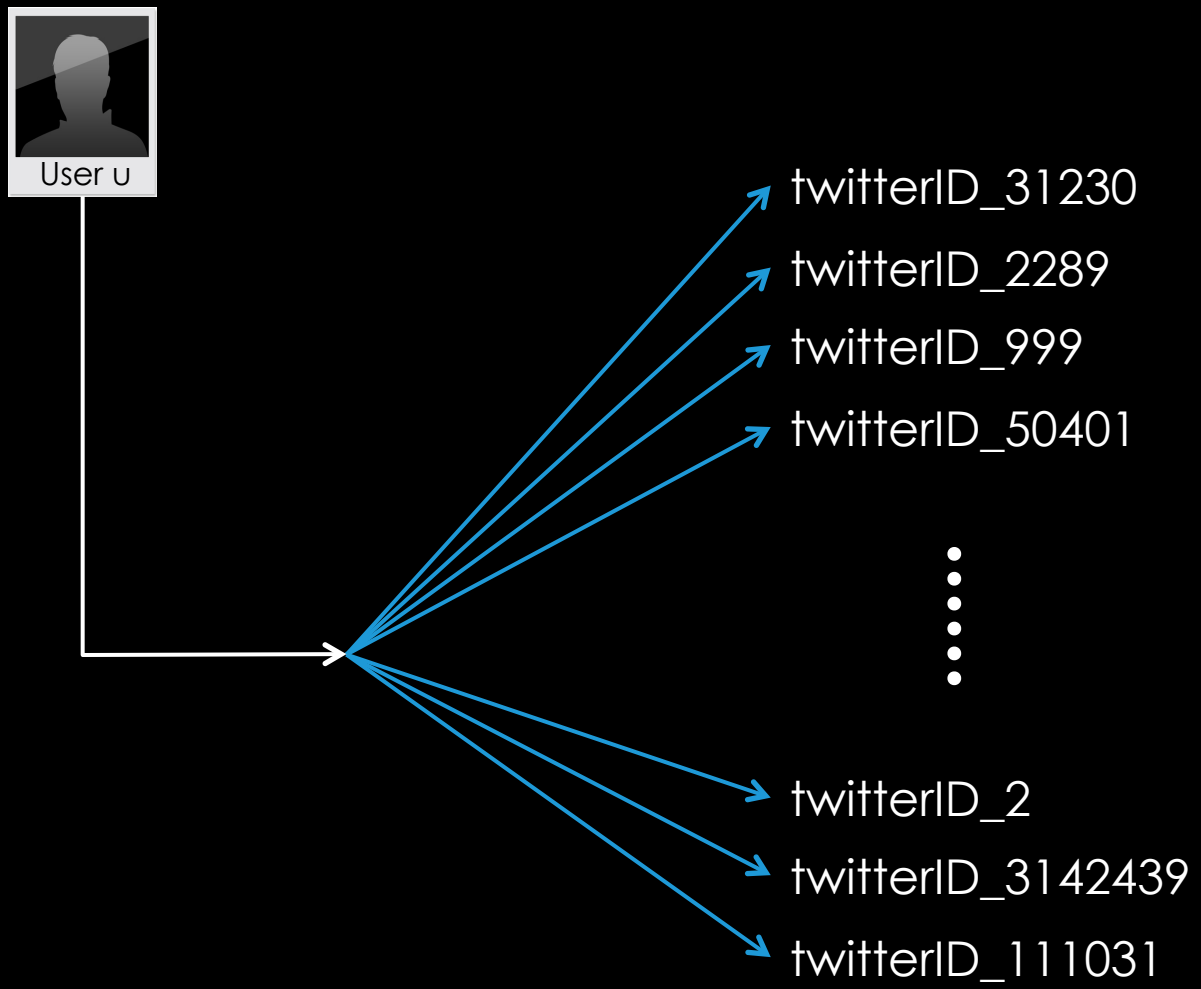
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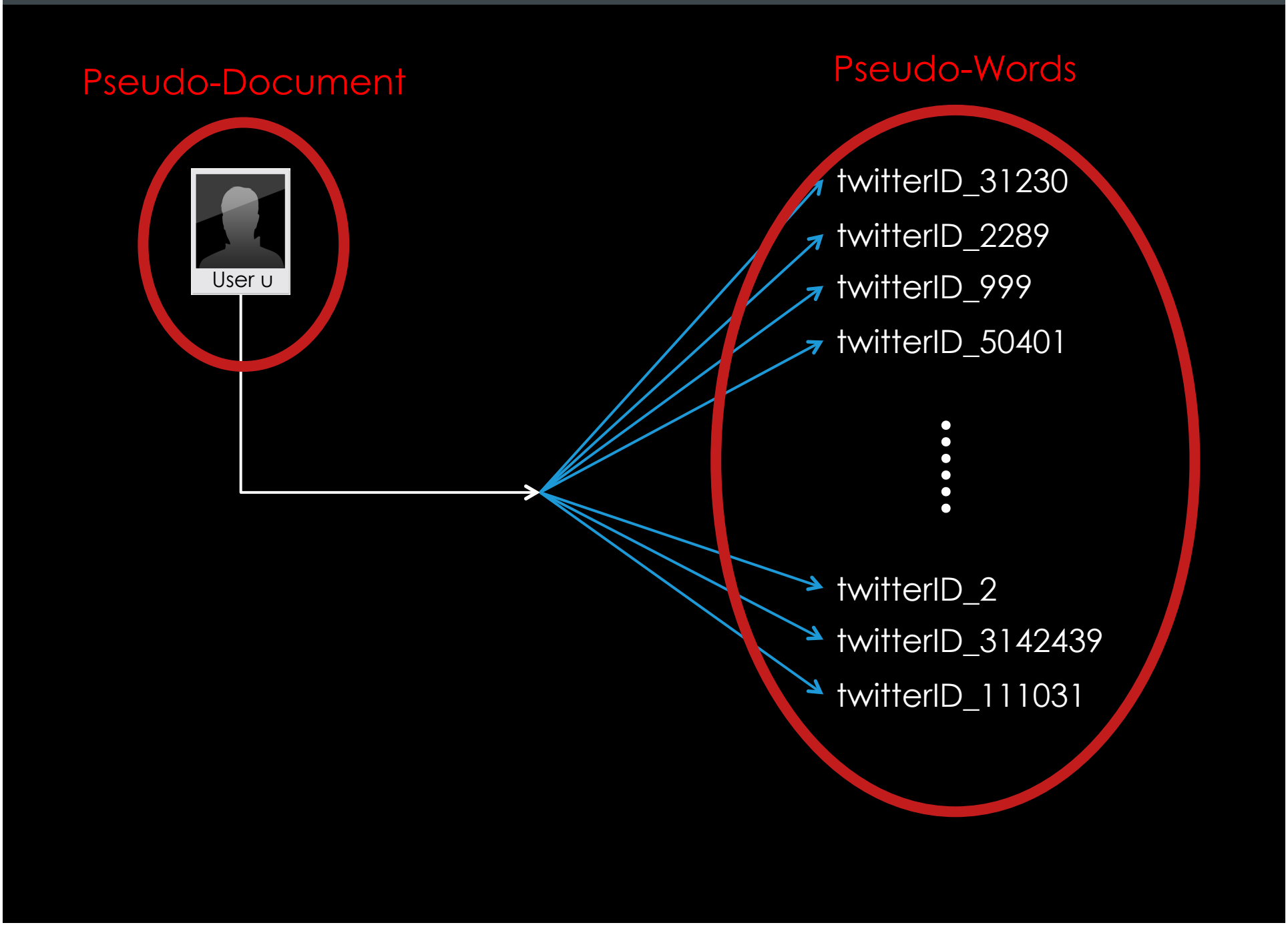
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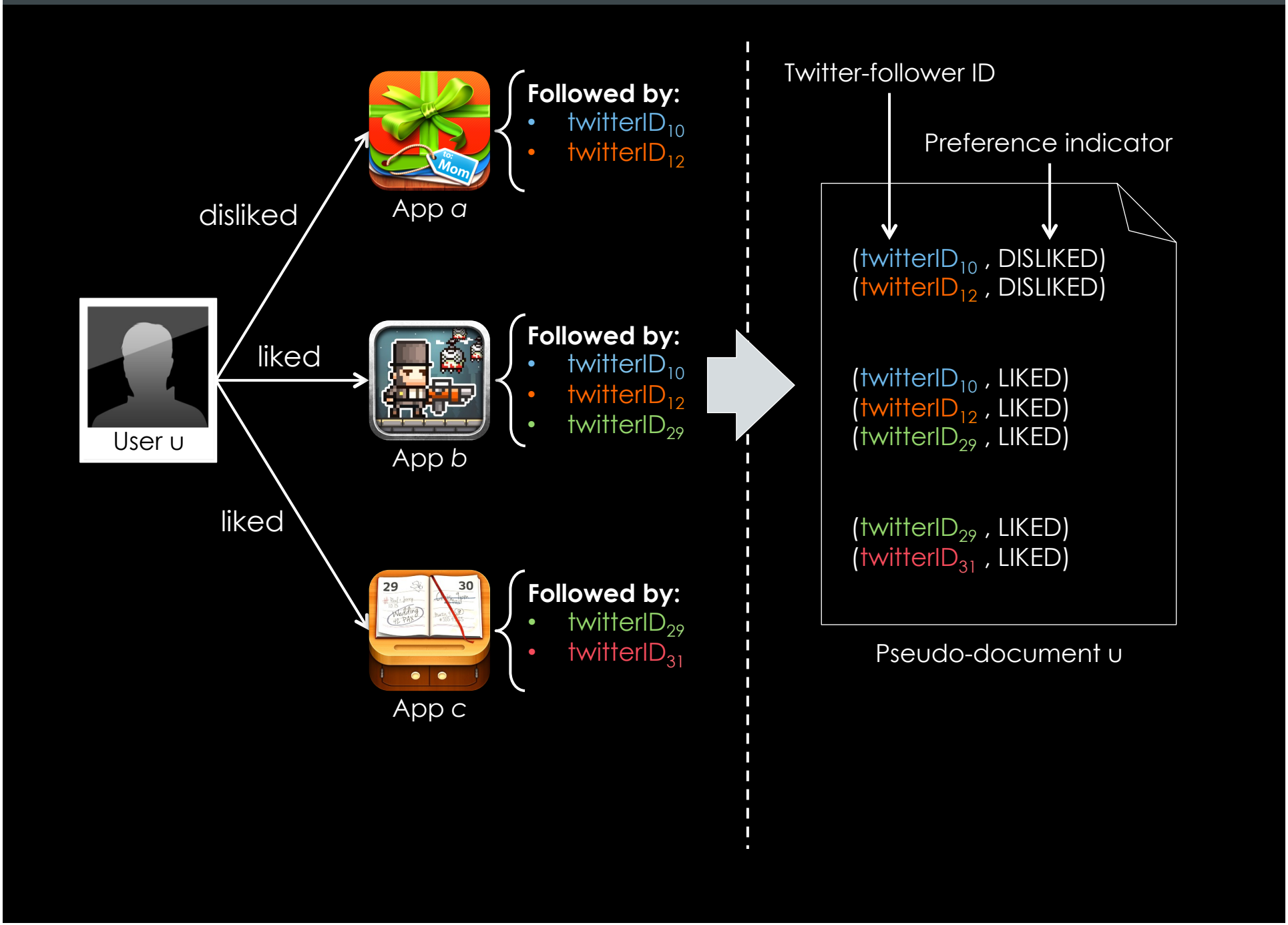
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• twitterID12
Followed by:
• twitterID10
• twitterID12
• twitterID29
Followed by:
• twitterID29
• twitterID31
Twitter-follower ID
Preference indicator
(twitterID10 , DISLIKED)
(twitterID12 , DISLIKED)
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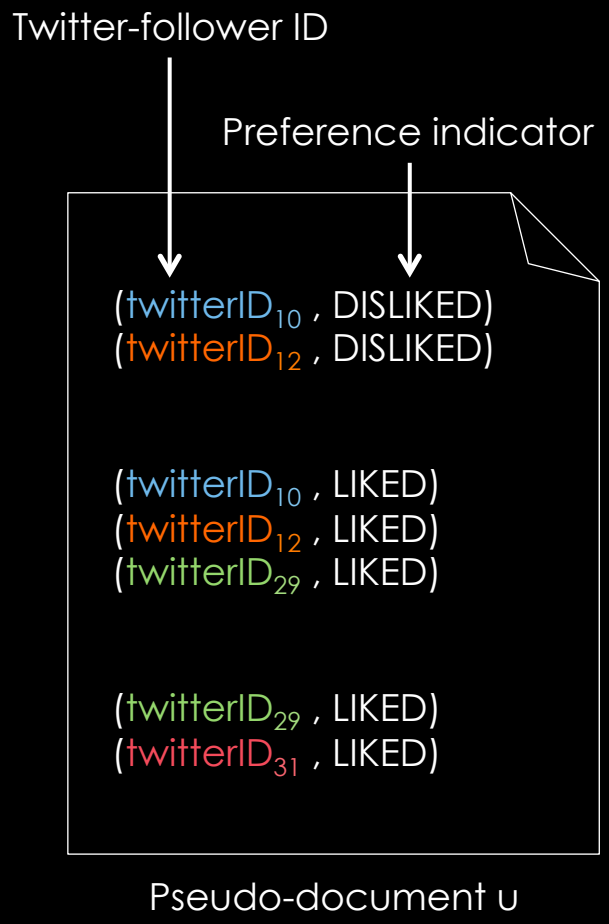
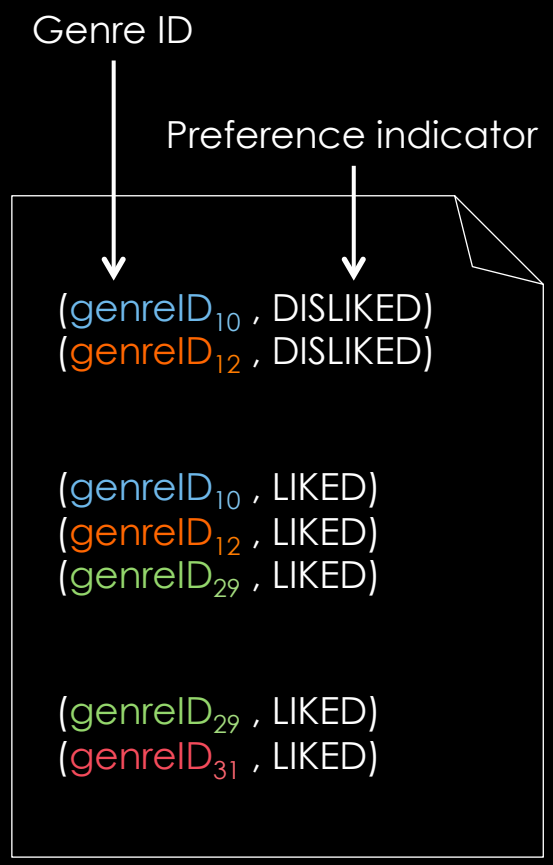



The concept of "pseudo-documents" and "pseudo-words"
*does not* apply exclusively to Twitter followers.

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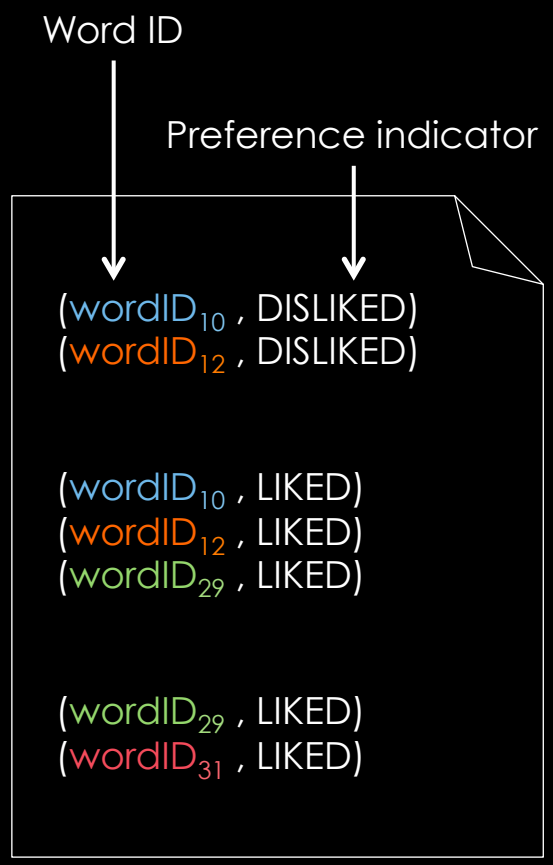


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Pseudo-document u

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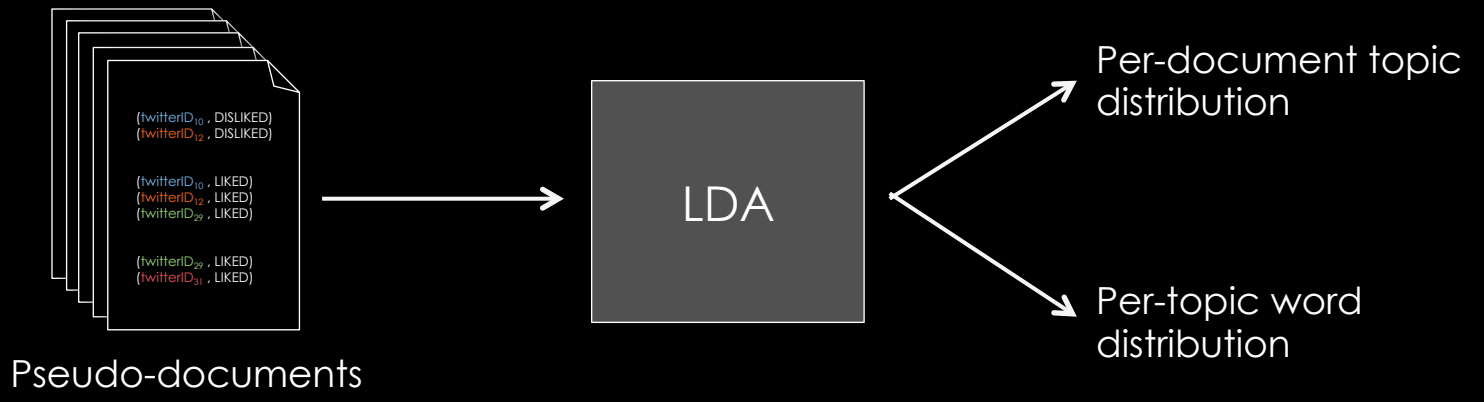

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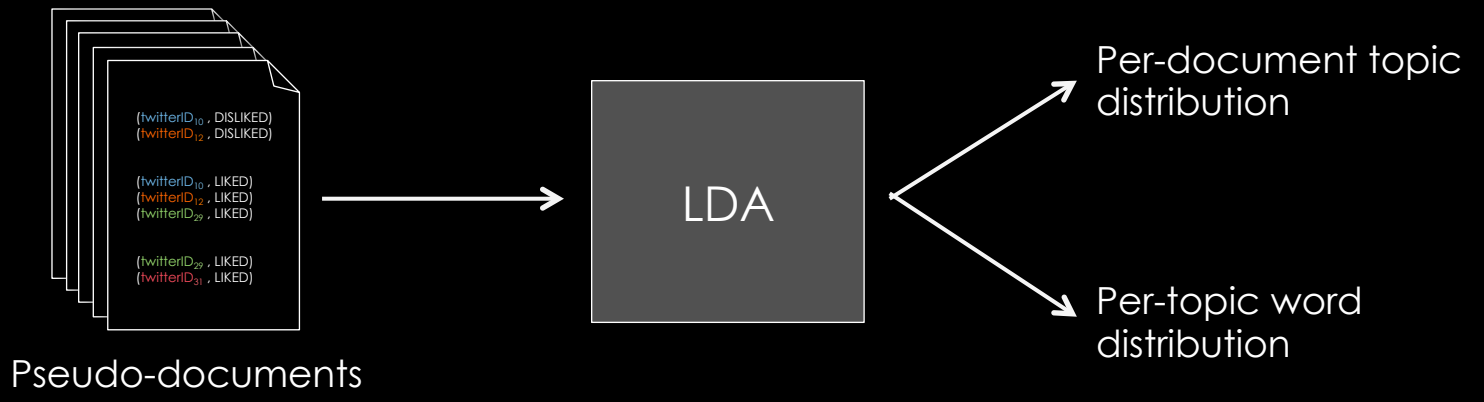


$$p(+ \mid t, u) = \sum_{z \in Z} p(+, t \mid z)\, p(z \mid u)$$

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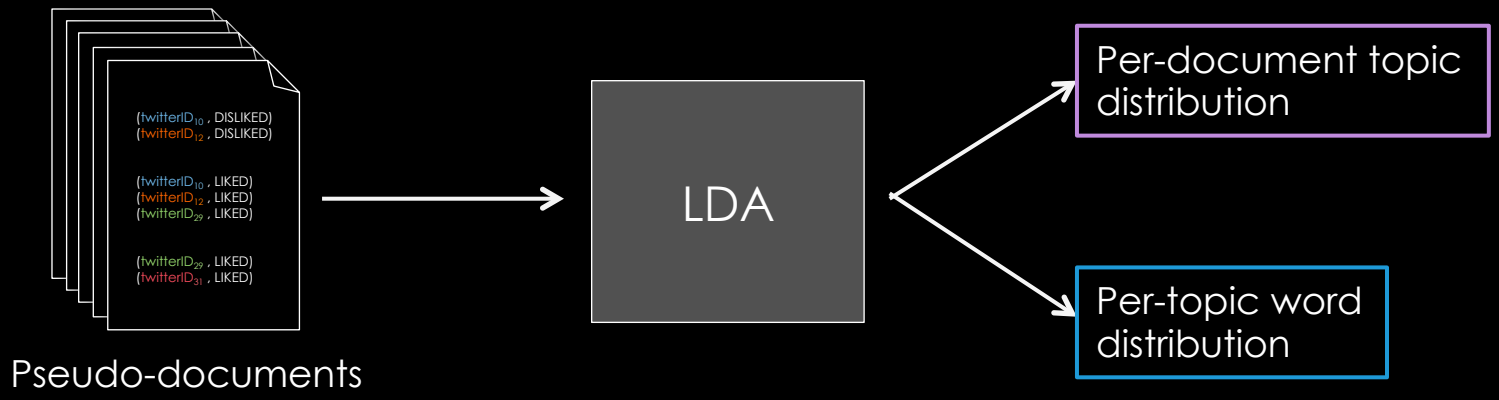


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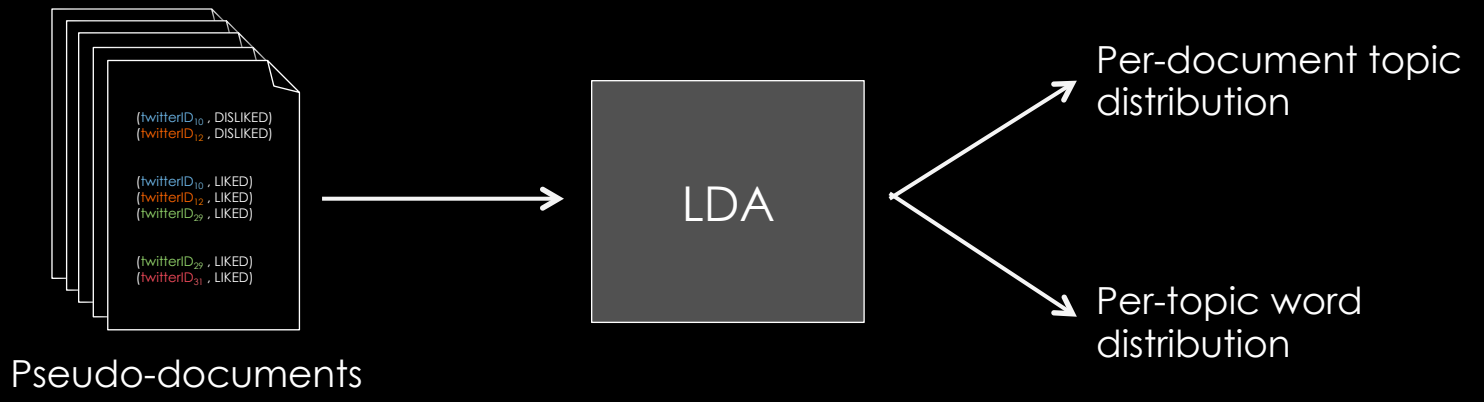
Per-topic word distribution

Per-document topic distribution

# Constructing Latent Groups




$$p(+ \mid t, u) = \sum_{z \in Z} p(+, t \mid z)\, p(z \mid u)$$

Probability that the presence of Twitter-follower *t* indicates that it is "liked" by user *u*.

$p( + \mid t, u)$

Stated earlier in Slide 13/32

We want to estimate the probability that "a target user *u* will like an app *a*."

$$p(+ \mid a, u) = \sum_{t \in T(a)} p(+ \mid t, u)\, p(t \mid a)$$

"like" app user

Probability that the presence of Twitter-follower *t* indicates that it is "liked" by user *u*.

Derived from Pseudo-Documents and Pseudo-Words.

Uniform distribution over the various Twitter-followers (t) following app a.

# Dataset

- We collected data from the Apple iTunes Store and Twitter during September to December 2012.
- Stats:
  - 1,289,668 ratings
  - 7,116 apps (with Twitter accounts)
  - 10,133 users.
- Restrictions:
  - Each user must give at least 10 ratings for apps.
  - Each Twitter ID is related to at least 5 apps.

# Simulating Cold-Start

- 10-fold cross validation.
- Selected 10% of the apps to be the held out set for all users.
- Each user has the same within-fold apps.
- Guarantee that none of these apps are in the training set of any user.

# Evaluation Metric

- Our system outputs *M* apps for each user, sorted by their probability of liking the apps.
- Recall@M
- *Zero ratings* are uncertain – it is difficult to accurately compute *precision*.
- Since the ratings are *true positives*, *recall* is a more pertinent measure – it only considers the positively rated apps.

# 3 Research Questions (RQ)

RQ1: How does the performance of Twitter-followers feature compare with other features?

RQ2: How does our method compare with other techniques?

RQ3: Do the latent groups make any sense? What can we learn from them?

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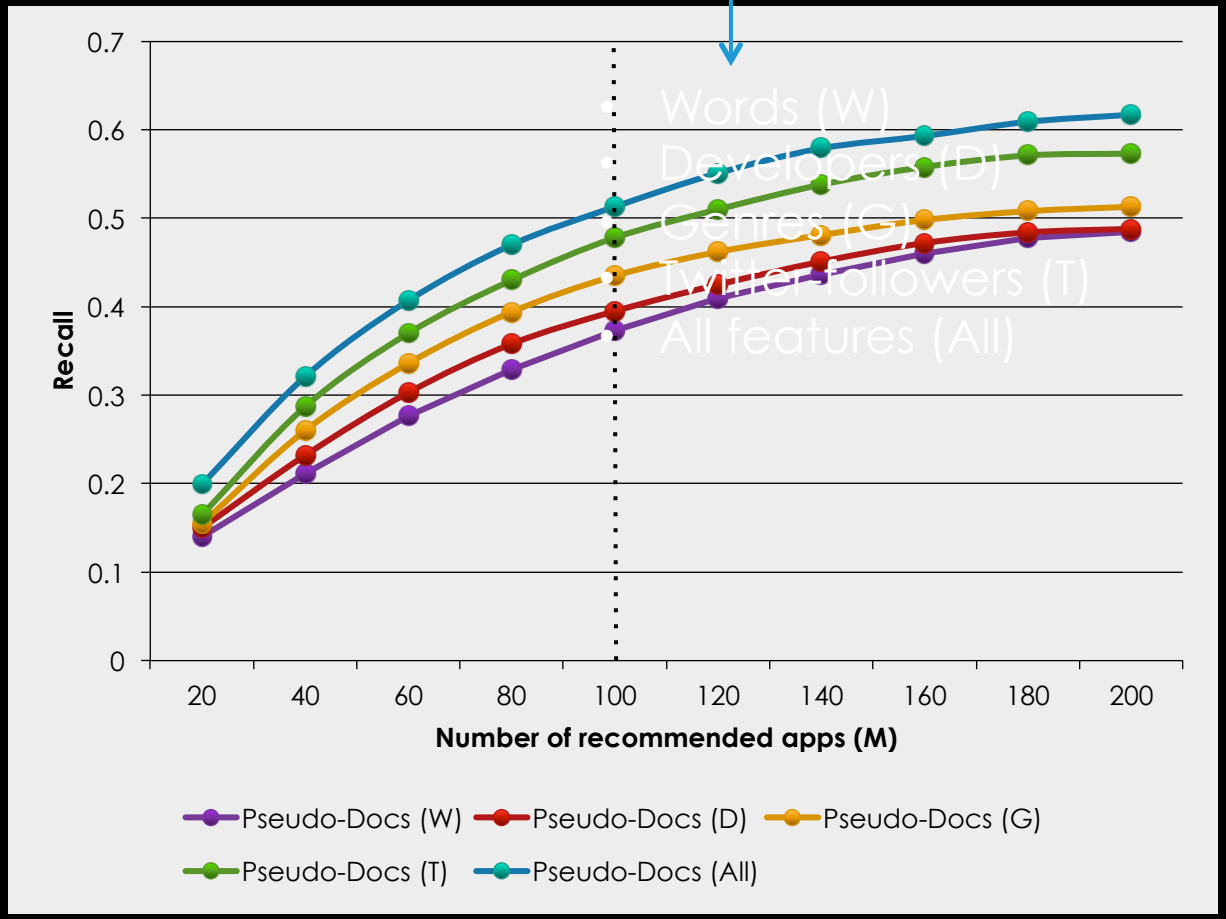


All = All features
T = Twitter-followers
G = Genres
D = Developers
W = Words

# RQ1: How does the performance of Twitter-followers feature compare with other features?

| Feature | R@100 |
|---|---|
| All features (TGDW) | * 0.513 |
| All, excluding Twitter-followers (GDW) | 0.452 |
| All, excluding Genres (TDW) | 0.491 |
| All, excluding Developers (TGW) | 0.498 |
| All, excluding Words (TGD) | 0.507 |
| Twitter-followers (T) | 0.478 |
| Genres (G) | 0.435 |
| Developers (D) | 0.395 |
| Words (W) | 0.373 |

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**Description**

*** EDITORS' CHOICE FOR USA, AUSTRALIA, MEXICO, SPAIN, BRAZIL, ARGENTINA, CANADA AND MORE – WHOA! ***

***Press Quotes***

"Time Surfer is blazing fast" -- Indie Games

"Time Surfer is a glorious mess of bright colors, pixel art and the most upbeat of chiptunes." -- TouchArcade (4.5 stars)

"...leaving you with a wide, faraway grin on your space battered face." -- PocketGamer (8/10)

"The Time Surfer soundtrack is more than just a single piece of music—it's a journey." -- Kotaku

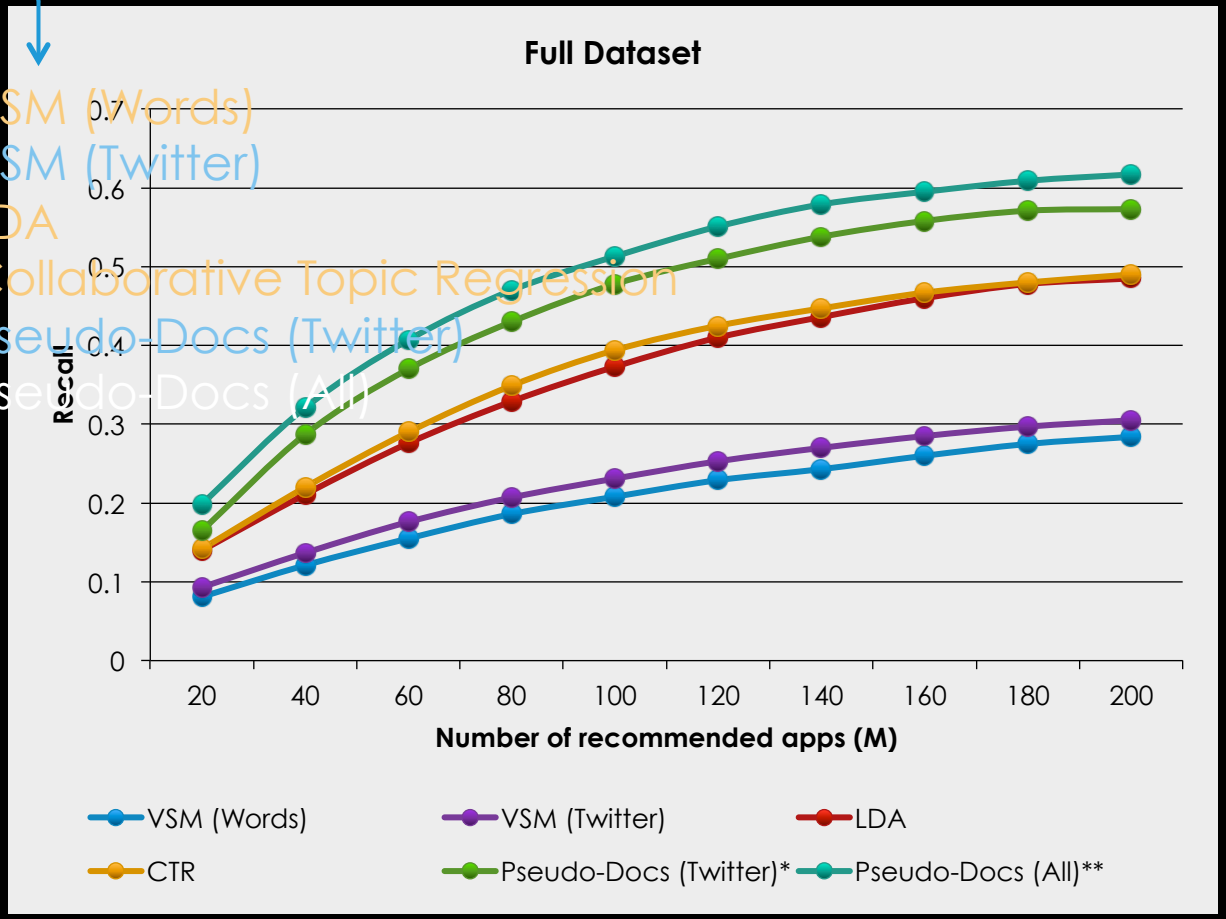
"The most promising runner I've seen in a long while." -- IGN

"From the old school visuals to the thrilling gameplay, you need this title in your life." -- GameTrailers.com

"A great example of how a fun idea can be iterated upon." -- 148 Apps (4 stars)

# RQ2: How does our method compare with other techniques?

- VSM (Words)
- VSM (Twitter)
- LDA
- Collaborative Topic Regression
- Pseudo-Docs (Twitter)
- Pseudo-Docs (All)

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CTR
LDA

VSM (Twitter)
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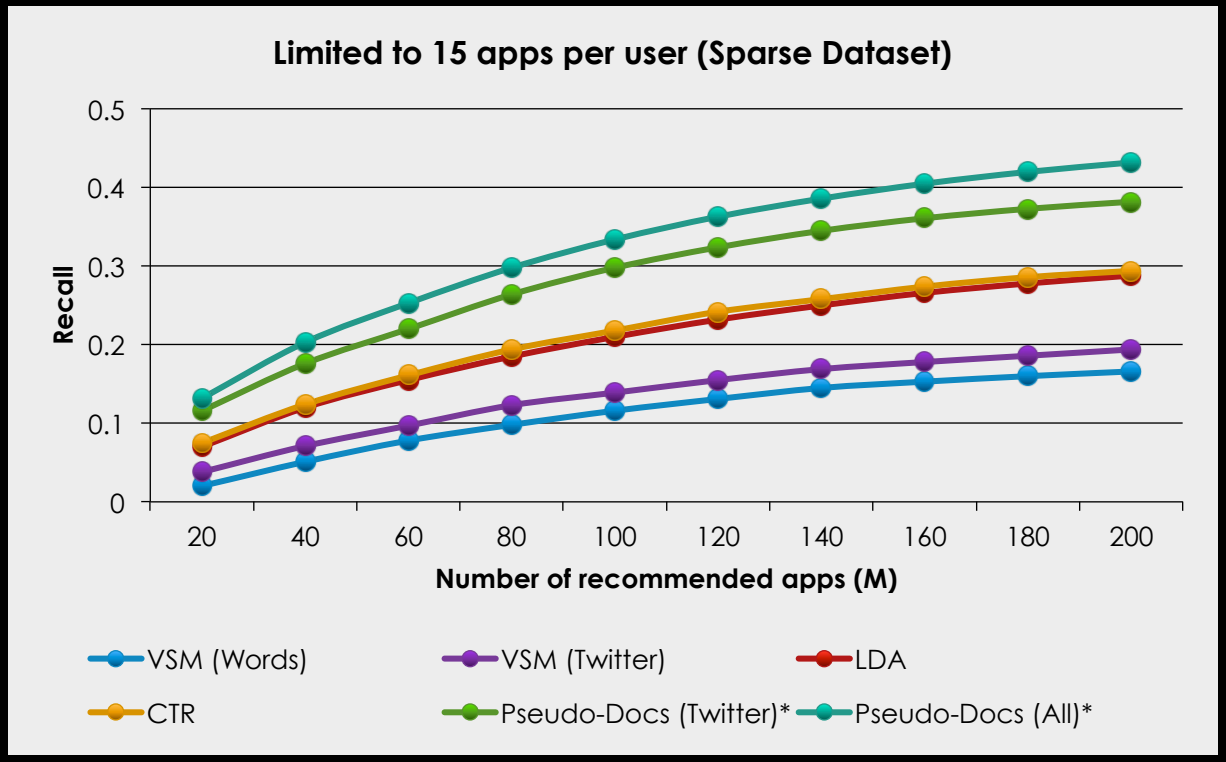


Pseudo-Docs (All)
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CTR
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**Latent Group 2**

**Top genres:**

- Music (92%)

**Example apps:**

- BeatStudio (Music)
- AmpKit+ (Music)
- GuitarStudio (Music)
- Everyday Looper (Music)
- Mixr DJ (Music)
- KORG iELECTRIBE (Music)
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**Latent Group 3**

**Top genres:**

- Games (77%)
- Photo & Video (12%)

**Example apps:**

- Another World 20th Anniversary (Games)
- Paper Monsters (Games)
- Stickman Cliff Diving (Games)
- Lili (Games)
- Snoopy's Street Fair (Games)
- Gizmonauts (Games)
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We develop cool & innovative iPhone, iPod Touch & iPad Games. Rocking the charts in iTunes: Sudoku 2, Hangman RSS, 4 in a Row & now Solitaire :)

"Games", "Photo & Video"

"Paper Monsters", "Stickman Cliff Diving", "Lili", "Snoopy's Street Fair", "Gizmonauts", etc.

"Video games warrior, lover of life, eternal student of the universe…"

"I'm a Multimedia developer working at Kent State Uni! I also do art services for the game industry…"

"Agalog Games is an independent iOS game studio…"

"Hi! Samadhi Games LLC is an Indie Developer of iOS, Android, etc"

# RQ3: Do the latent groups make any sense? What can we learn from them?

| Latent Group 1 | Latent Group 2 | Latent Group 3 |
|---|---|---|
| **Top genres:**<br>• Books (45%)<br>• Education (33%)<br>• Games (13%)<br>**Example apps:**<br>• The Cat in the Hat (Books)<br>• Christmas Cutie (Books)<br>• Happy Earth Day, Dear Planet (Books)<br>• Friendly Shapes (Education)<br>• There's No Place Like Space! (Education)<br>• Pasta Crazy Chef (Games)<br>• Gingerbread Dress (Games) | **Top genres:**<br>• Music (92%)<br>**Example apps:**<br>• BeatStudio (Music)<br>• AmpKit+ (Music)<br>• GuitarStudio (Music)<br>• Everyday Looper (Music)<br>• Mixr DJ (Music)<br>• KORG iELECTRIBE (Music)<br>• KORG iPolysix (Music)<br>• Pro Metronome (Music)<br>• Chord Detector (Music) | **Top genres:**<br>• Games (77%)<br>• Photo & Video (12%)<br>**Example apps:**<br>• Another World 20th Anniversary (Games)<br>• Paper Monsters (Games)<br>• Stickman Cliff Diving (Games)<br>• Lili (Games)<br>• Snoopy's Street Fair (Games)<br>• Gizmonauts (Games)<br>• InstaBooth+ (Photo & Video)<br>• ArtStudio for iPad (Photo & Video) |
| **Nosy Crow Apps (twitter.com/nosycrowapps)**<br>Nosy Crow creates children's books and apps. You may know our 3-D Fairytale apps, The Three Little Pigs & Cinderella. | **Derek Jones (twitter.com/MusicInclusive)**<br>Indie music publishing label, studio & brand. Blues&Rock, Progressive&Funk, Jazz&Fusion, Alternate&Christian, Classical, Education & a lot in-between too! | **Sarah Thomson (twitter.com/SarahLuvsVGames)**<br>Video games warrior, lover of life, eternal student of the universe, drinker of Kombucha, Baroness of PlayStation Mobile. |
| **The iMums (twitter.com/TheiMums)**<br>Four mums dedicated to reviewing apps and technology products for children to help educate their parents about the variety available. Loads of giveaways too! | **Chip Boaz (twitter.com/iosmusicandyou)**<br>I'm a musician based in the San Francisco Bay Area with an interest in using my iPad, iPhone, & iPod to make music. Follow my iOS adventures @ iOS Music And You | **JasonLeeNester (twitter.com/JasonNester)**<br>I am a Multimedia developer working at Kent State University! I also do art services for the game industry as well as run a small indie game company, True Media. |
| **Mums with Apps (twitter.com/momswithapps)**<br>Supporting family-friendly developers seeking to promote quality apps for kids and families. | **Dave Gibson (twitter.com/MicroTrackdB)**<br>Creator of MicroTrack dB, a music making app for iOS and Samsung bada. Musician, writer, audio engineer and synth nerd. http://www.facebook.com/microtrackdb | **Agalag iOS Games (twitter.com/AgalagGames)**<br>Agalag Games is an independent iOS game studio. Our aim is to create fun innovative and casual iPhone games which we really like and want to play. Publisher. |
| **Charly James (twitter.com/CharlyJames2)**<br>Div. Mom of 2 w/varying SN & medical d/x. dandelion moms; A4 Free Apps @CharlyJames4; Ellie's Games; Fernandez Design. | **Ashley Elsdon (twitter.com/IamAshleyElsdon)**<br>Everything from Mobile Music Creation, geekery, tech, art and Doctor Who! http://www.ashleyelsdon.com | **Samadhi Games (twitter.com/SamadhiGames)**<br>Hi! Samadhi Games LLC is an Indie Developer of iOS, Android and Desktop Apps.<br>Arizona · http://www.samadhigames.com |
| **Next is Great (twitter.com/nextisgreat)**<br>We create and develop brain teasing educational iOS apps for kids and teenagers. Check out Pirate Trio Academy and Geek Kids. | **Andrew Wardell (twitter.com/andrewwardell)**<br>Nostalgic futurist, amateur photographer, sax-playing synthesist, musical mountain-biking metacomic. More than just a bag of salty water... | **Finger Arts: App Dev (twitter.com/fingerartsgames)**<br>We develop cool & innovative iPhone, iPod Touch & iPad Games. Rocking the charts in iTunes: Sudoku 2, Hangman RSS, 4 in a Row & now Solitaire :) |

- Alleviate the cold-start in app-recommendation by using Twitter profiles of apps + Twitter followers.

- By using the feature of Twitter-followers to generate latent groups, our method works well – especially in a domain with unreliable textual features.

- Allows us to map users from the App Store to users in Twitter.

- Future work:
  - Explore second-degree relationships on Twitter.
  - Explore the use of our approach in other domains, such as music-recommendation.

Thank you 

- Ratings lag behind Twitter followers.

- Because it takes more effort to post a rating/review than to follow a Twitter account.

- Monitored a few new apps:
  - Average # of new ratings/reviews in a week: 4.2
  - Average # of new Twitter followers in a week: 21.4

- We want to recommend ASAP – even if it's 1 day faster.