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.
INFORMATION OVERLOAD
# Recommender Systems

<table>
<thead>
<tr>
<th>Collaborative Filtering</th>
<th>Content-based Filtering</th>
</tr>
</thead>
</table>

**Introduction**

- Our Approach
- Experiments
- Results
- Conclusion
Recommender Systems

Collaborative Filtering

<table>
<thead>
<tr>
<th>Users</th>
<th>Items</th>
<th>New Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 1 4</td>
<td>? ?</td>
</tr>
<tr>
<td>2</td>
<td>5 4 ?</td>
<td>? ?</td>
</tr>
<tr>
<td>3</td>
<td>1 ? 5</td>
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<tr>
<td>4</td>
<td>? 5 ?</td>
<td>? ?</td>
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<tr>
<td>5</td>
<td>1 ? 4</td>
<td>? ?</td>
</tr>
</tbody>
</table>

Content-based Filtering
Recommender Systems

Collaborative Filtering

<table>
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<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th></th>
<th>4</th>
<th>5</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>4</td>
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<td>1</td>
<td>4</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
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<td>2</td>
<td>3</td>
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<td>?</td>
<td>4</td>
<td>?</td>
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COLD START PROBLEM

Solution #1: Wait for ratings to come in.
Solution #2: Use content-based filtering.
# Recommender Systems

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<tr>
<td>• Recommends items based on similar content.</td>
<td>• <strong>Con:</strong> Lack of diversified recommendations. (e.g., genres, textual descriptions)</td>
</tr>
<tr>
<td>Example: a user who has downloaded a weather app will receive weather-related app-recommendations.</td>
<td></td>
</tr>
</tbody>
</table>
Meanwhile...
“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.
We made two observations:

1. Apps contain references to their Twitter accounts.
Introduction

Our Approach

Experiments

Results

Conclusion
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.
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Follow @angrybirds on Twitter
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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1. Apps contain references to their Twitter accounts.

2. Early signals about apps can be present in social networks, even before ratings are received.

By May 2012, Evernote’s Twitter account already had 120,000 followers and 1,300 tweets.
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.

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 $a$.”

\[
p(+ | a, u)
\]

“like” \quad app \quad user
We want to estimate the probability that “a target user $u$ will like an app $a$.”

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

“Pseudo-documents” & “Pseudo-words”

“like”  app  user

Twitter-follower

Uniform distribution over the various Twitter-followers ($t$) following app $a$. 
Introduction › Our Approach › Experiments › Results › Conclusion

User u downloads twitter.com/angrybirds

twitterID_31230
twitterID_2289
twitterID_999
twitterID_50401
...
twitterID_2
twitterID_3142439
twitterID_111031
Introduction › Our Approach › Experiments › Results › Conclusion

User u downloads

twitter.com/angrybirds

followers

twitterID_31230
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...
Our Approach

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  - twitterID_31230
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User u

twitterID_31230

twitterID_2289

twitterID_999

twitterID_50401

......

twitterID_2

twitterID_3142439

twitterID_111031
User u

- Disliked
  - App a
    - Followed by:
      - twitterID_{10}
      - twitterID_{12}

- Liked
  - App b
    - Followed by:
      - twitterID_{10}
      - twitterID_{12}
      - twitterID_{29}

  - App c
    - Followed by:
      - twitterID_{29}
      - twitterID_{31}

Twitter-follower ID

- Preference indicator
  - (twitterID_{10}, DISLIKED)
  - (twitterID_{12}, DISLIKED)
  - (twitterID_{10}, LIKED)
  - (twitterID_{12}, LIKED)
  - (twitterID_{29}, LIKED)
  - (twitterID_{29}, LIKED)
  - (twitterID_{31}, LIKED)

Pseudo-document u
The concept of “pseudo-documents” and “pseudo-words” *does not* apply exclusively to Twitter followers.
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Pseudo-document u
Constructing Latent Groups

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Pseudo-document u
Constructing Latent Groups

Pseudo-documents

LDA

Per-document topic distribution

Per-topic word distribution
Constructing Latent Groups

\[
p(+ | t, u) = \sum_{z \in Z} p( +, t | z) p( z | u)
\]
Constructing Latent Groups

Pseudo-documents

LDA

Per-document topic distribution

Per-topic word distribution

\[ p( + \mid t, u) = \sum_{z \in Z} p( +, t \mid z) p( z \mid u) \]
Constructing Latent Groups

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p(+ | t, u) = \sum_{z \in Z} p( +, t | z) p( z | u)
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Probability that the presence of Twitter-follower \( t \) indicates that it is “liked” by user \( u \).
Our Approach

\[ p( + | t, u) \]
We want to estimate the probability that “a target user $u$ will like an app $a$.”

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

- 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 $a$.

Stated earlier in Slide 13/32
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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<table>
<thead>
<tr>
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<th>R@100</th>
</tr>
</thead>
<tbody>
<tr>
<td>All features (TGDW)</td>
<td>* 0.513</td>
</tr>
<tr>
<td>All, excluding Twitter-followers (GDW)</td>
<td>0.452</td>
</tr>
<tr>
<td>All, excluding Genres (TDW)</td>
<td>0.491</td>
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<tr>
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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?
RQ2: How does our method compare with other techniques?

![Graph showing comparison of different techniques with increased recall as the number of recommended apps increases.]
RQ3: Do the latent groups make any sense? What can we learn from them?

<table>
<thead>
<tr>
<th>Latent Group 1</th>
<th>Latent Group 2</th>
<th>Latent Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top genres:</strong></td>
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<td><strong>Top genres:</strong></td>
</tr>
<tr>
<td>Books (45%)</td>
<td>Music (92%)</td>
<td>Games (77%)</td>
</tr>
<tr>
<td>Education (33%)</td>
<td>AmpKit+ (Music)</td>
<td>Photo &amp; Video (12%)</td>
</tr>
<tr>
<td>Games (13%)</td>
<td>GuitarStudio (Music)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Everyday Looper (Music)</td>
<td></td>
</tr>
<tr>
<td>Example apps:</td>
<td>Mixr DJ (Music)</td>
<td></td>
</tr>
<tr>
<td>The Cat in the Hat (Books)</td>
<td>KORG iPOLY6 (Music)</td>
<td></td>
</tr>
<tr>
<td>Christmas Cutie (Books)</td>
<td>KORG iDEECTRIPE (Music)</td>
<td></td>
</tr>
<tr>
<td>Happy Earth Day, Dear Planet (Books)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friendly Shapes (Education)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There’s No Place Like Space! (Education)</td>
<td></td>
<td></td>
</tr>
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<td>Pro Metronome (Music)</td>
<td></td>
</tr>
<tr>
<td>Gingerbread Dress (Games)</td>
<td>Chord Detector (Music)</td>
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**Nosy Crow Apps** (twitter.com/nosycrowapps)
Nosy Crow creates children's books and apps. You may know our 3-D Fairytale apps, The Three Little Pigs & Cinderella too.

**The iMums** (twitter.com/TheiMums)
Four mums dedicated to reviewing apps and technology products for children to help educate their parents about the variety available. Loads of giveaways too!

**Mums with Apps** (twitter.com/mumswithapps)
Supporting family-friendly developers seeking to promote quality apps for kids and families.

**Charly James** (twitter.com/CharlyJames2)
Div. Mom of 2 w/varying SN & medical d/x, dandelion moms; A4 Free Apps @CharlyJames4; Ellie’s Games; Fernandez Design.

**Next is Great** (twitter.com/nextisgreat)
We create and develop brain teasing educational iOS apps for kids and teenagers. Check out Pirate Trio Academy and Geek Kids.

**Derek Jones** (twitter.com/MusicInclusive)
Indie music publishing label, studio & brand. Blues&Rock, Progressive&Funk, Jazz&Fusion, Alternate&Christian, Classical, Education & a lot in-between too!

**Chip Boaz** (twitter.com/iomusicandyou)
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

**Dave Gibson** (twitter.com/MicroTrackDB)
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

**Ashley Elsdon** (twitter.com/IamAshleyElsdon)
Everything from Mobile Music Creation, geekery, tech, art and Doctor Who! http://www.ashleyelsdon.com

**Andrew Wardell** (twitter.com/andrewwardell)
Nostalgic futurist, amateur photographer, sax-playing synthesist, musical mountain-biking metacomic. More than just a bag of salty water...

**Sarah Thomson** (twitter.com/SarahLuvzVGames)
Video games warrior, lover of life, eternal student of the universe, drinker of kombucha, Baroness of PlayStation Mobile.

**JasonLeeNester** (twitter.com/JasonNester)
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.

**Agalag iOS Games** (twitter.com/AgalagGames)
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.

**Samadhi Games** (twitter.com/SamadhiGames)
Hi! Samadhi Games LLC is an Indie Developer of iOS, Android and Desktop Apps. Arizona · http://www.samadhigames.com

**Finger Arts: App Dev** (twitter.com/fingerartsgames)
We develop cool & innovative iPhone, iPod Touch & iPad Games. Rocking the charts in iTunes: Sudoku 2, Hangman RSS, 4 in a Row & now Solitaire :)
### RQ3: Do the latent groups make any sense? What can we learn from them?

#### Latent Group 1

<table>
<thead>
<tr>
<th>Top genres:</th>
<th>Books (45%)</th>
<th>Education (33%)</th>
<th>Games (13%)</th>
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Supporting family-friendly developers seeking to promote quality apps for kids and toddlers.

**Charly James** [twitter.com/CharlyJames2](twitter.com/CharlyJames2)

Div. Mom of 2 w/ varying SN & medical dx. dandelion moms; A4 Free Apps @CharlyJames4; Ellie’s Games; Fernandez Design.

**Next is Great** [twitter.com/nextisgreat](twitter.com/nextisgreat)

We create and develop brain teasing educational iOS apps for kids and teenagers. Check out Pirate Trio Academy and Geek Kids.

#### Latent Group 2

<table>
<thead>
<tr>
<th>Top genres:</th>
<th>Music (92%)</th>
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<tbody>
<tr>
<td>Example apps:</td>
<td>BeatStudio (Music)</td>
</tr>
<tr>
<td></td>
<td>AmpKit+ (Music)</td>
</tr>
<tr>
<td></td>
<td>GuitarStudio (Music)</td>
</tr>
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<td></td>
<td>Everyday Looper (Music)</td>
</tr>
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#### Latent Group 3

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  - Games (13%)
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  - *The Cat in the Hat* (Books)
  - *Christmas Cutie* (Books)
  - *Happy Earth Day, Dear Planet* (Books)
  - *Friendly Shapes* (Education)
  - *There’s No Place Like Space!* (Education)
  - *Pasta Crazy Chef* (Games)
  - *Gingerbread Dress* (Games)

**Latent Group 2**
- **Top genres:**
  - Music (92%)
- **Example apps:**
  - *BeatStudio* (Music)
  - *AmpKit+* (Music)
  - *GuitarStudio* (Music)
  - *Everyday Looper* (Music)
  - *Mixr DJ* (Music)
  - *KORG iElectribe* (Music)
  - *KORG iPolysix* (Music)
  - *Pro Metronome* (Music)
  - *Chord Detector* (Music)

**Latent Group 3**
- **Top genres:**
  - Games (77%)
  - Photo & Video (12%)
- **Example apps:**
  - *Another World 20th Anniversary* (Games)
  - *Paper Monsters* (Games)
  - *Stickman Cliff Diving* (Games)
  - *Lilli* (Games)
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Latent Group 1

Top genres:
- Books (45%)
- Education (33%)
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Example apps:
- The Cat in the Hat (Books)
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- Happy Earth Day, Dear Planet (Books)
- Friendly Shapes (Education)
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Supporting family-friendly developers seeking to promote quality apps for kids and families.

Next is Great (twitter.com/nexthisgreat)
We create and develop brain teasing educational iOS apps for kids and teenagers. Check out Pirate Trio Academy and Geek Kids.
RQ3: Do the latent groups make any sense? What can we learn from them?

**Latent Group 1**

**Top genres:**
- Books (45%)
- Education (33%)
- Games (13%)

**Example apps:**
- The Cat in the Hat (Books)
- Christmas Cutie (Books)
- Happy Earth Day, Dear Planet (Books)
- Friendly Shapes (Education)
- There’s No Place Like Space! (Education)
- Pasta Crazy Chef (Games)
- Gingerbread Dress (Games)

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**Charly James** ([twitter.com/CharlyJames2](twitter.com/CharlyJames2))
Div. Mom of 2 w/ varying SN & medical d/x; dandelion moms; A4 Free Apps @CharlyJames4; Ellie’s Games; Fernandez Design.

**Next is Great** ([twitter.com/nextisgreat](twitter.com/nextisgreat))
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"Books" / "Education" / "Games"

"Pasta Crazy Chef" (Games)
"Gingerbread Dress" (Games)

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

Latent Group 2

Top genres:
- Music (92%)

Example apps:
- BeatStudio
- AmpKit+
- GuitarStudio
- Everyday Looper
- Mixr DJ
- KORG iELECTRIBE
- KORG iPolysix
- Pro Metronome
- Chord Detector

Derek Jones (twitter.com/MusicInclusive)
Indie music publishing label, studio & brand. Blues&Rock, Progressive&Funk, Jazz&Fusion, Alternate&Christian, Classical, Education & a lot in-between too!

Chip Boaz (twitter.com/iosmusicandyou)
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

Dave Gibson (twitter.com/MicroTrackdB)

Ashley Elsdon (twitter.com/IamAshleyElsdon)
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“Music”

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

**Latent Group 2**

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**Top 5 Twitter Profiles in Latent Group 2.**

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“Music”


**Dave Gibson**

Creator of MicroTrack dB, a music making app for iOS and Samsung bada. Musician, writer, audio engineer and synth nerd.

---

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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)
- InstaBooth+ (Photo & Video)
- ArtStudio for iPad (Photo & Video)

“Games”, “Photo & Video”

“Paper Monsters”, “Stickman Cliff Diving”, “Lili”, “Snoopy’s Street Fair”, “Gizmonauts”, etc.

Sarah Thomson (twitter.com/SarahLuusVGames)
Video games warrior, lover of life, eternal student of the universe, drinker of kombucha, Baroness of PlayStation Mobile.

JasonLeeNester (twitter.com/JasonNester)
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.

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• 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.