

# Revisit Behavior in Social Media: The Phoenix-R Model and Discoveries

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# How should we account and model information popularity online?



A screenshot of a YouTube video player showing the official trailer for X-Men: Days of Future Past. The video is at 0:33 / 2:41. The video content shows several characters in a dark, industrial setting. Below the video player, the title is "X-Men: Days of Future Past | Official Trailer 3 [HD] | 20th Centur...". The channel is "X-Men Movies" with 166 videos. The video has 14,429,124 views, 45,306 likes, and 2,134 dislikes. A red "Subscribe" button is visible with 142,424 subscribers.

X-Men: Days of Future Past | Official Trailer 3 [HD] | 20th Centur...

X-MEN  
MOVIES

X-Men Movies ✓ - 166 videos

14,429,124 views

45,306 2,134

Subscribe 142,424

# How should we account and model information popularity online?



The image shows a YouTube video player interface. The video is titled "X-Men: Days of Future Past | Official Trailer [HD] | 20th Century...". The video player shows a scene from the movie with several characters in a dark, industrial setting. The video progress bar is at 0:33 / 2:41. Below the video player, the channel name "X-Men Movies" is visible with a checkmark and "166 videos". A red "Subscribe" button is present with "142,424" subscribers. The view count is "14,429,124 views" with a thumbs up icon for "45,306" likes and a thumbs down icon for "2,134" dislikes. A green callout arrow points from the text "Over 14 million views" to the view count.

Over 14 million views

X-Men: Days of Future Past | Official Trailer [HD] | 20th Century...

X-MEN  
MOVIES

X-Men Movies ✓ - 166 videos

Subscribe 142,424

14,429,124 views

45,306 2,134

# Audience: Unique users



X-Men Movies

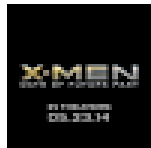


via Google+ 4 weeks ago

The final X-Men trailer is here! How many times have you watched it?

Reply · 845  

# Audience vs Visits

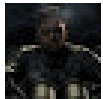


X-Men Movies

via Google+ 4 weeks ago

The final X-Men trailer is here! How many times have you watched it?

Reply - 845



Tristan Nicoll 4 weeks ago  
about 13 times lol

Reply - 18



Charlie Davis 4 weeks ago  
27 times

Reply - 10



methazza 4 weeks ago  
56 times.... im pathetic  
Translate

Reply - 16



OutOfRegs 4 weeks ago  
over 9000 times

Reply - 19



# Measuring both visits and audience (unique users) have their benefits

- How many users watched my ad?
  - Exposure
  - Revenue
- How many times was my ad watched?
  - Caching
  - Sharding and content provisioning
- However...
  - Understanding and modeling both effects is still an open issue

# Our Study

- **Understanding and modeling** revisit behavior in social media
- **Understanding**
  - Characterization of millions of user activities
  - User played/watched/visited a social media object at a certain time
- **Modeling**
  - The **Phoenix-R** model for popularity time series

# Datasets

- User Activity
  - User, Object (song/tweet/video), Time stamp
- All of the datasets range from months to years

Dataset	User Activities	Description
<b>MMTweet (Million Musical Tweets)</b>	Little over 1 million	Tweets declaring songs which users listen to
<b>Twitter</b>	576 million	Hashtags
<b>LastFM</b>	19 million	Plays on artists and songs
<b>YouTube</b>	-	3 million daily time series



# Discoveries

# Discoveries

- Relationships between audience (unique users) and revisits

Dataset	Median $\frac{\#Revisits}{\#Audience}$	Median $\frac{\#Revisits}{\#Total\ Visits}$	% of cases $\#Revisits > \#Audience$
MMTtweet	0.68	0.40	33%
Twitter	1.70	<b>0.62</b>	<b>66%</b>
LastFM	<b>25.39</b>	<b>0.96</b>	<b>100%</b>

# Discoveries on Smaller time Scales

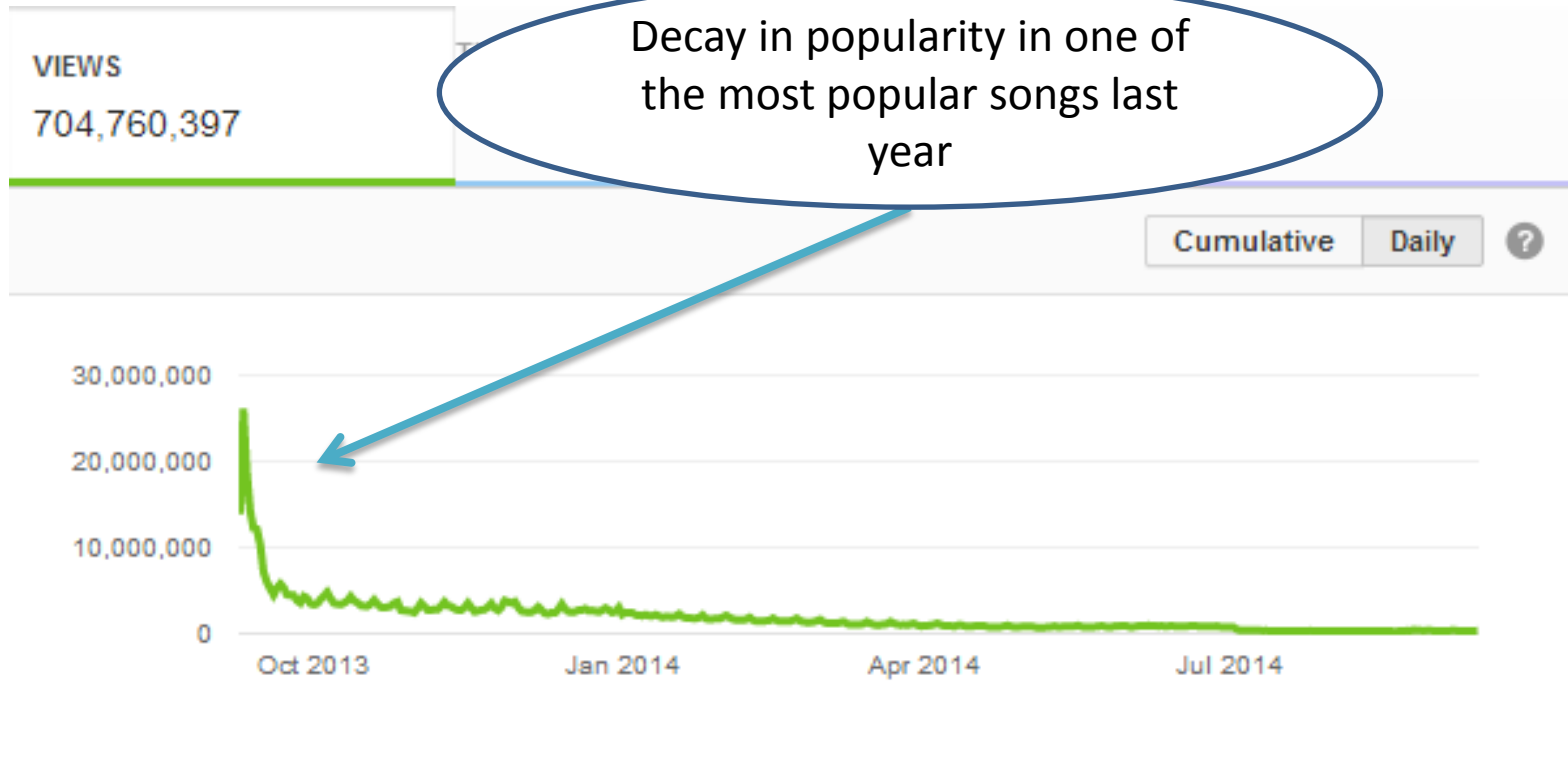
- Isolate the effect of users coming back to the datasets after long periods
- Daily Time Windows

Dataset	$\frac{\text{Median } \#Revisits}{\#Audience}$
MMTweet	0.83
Twitter	2.50
LastFM	<b>28.0</b>

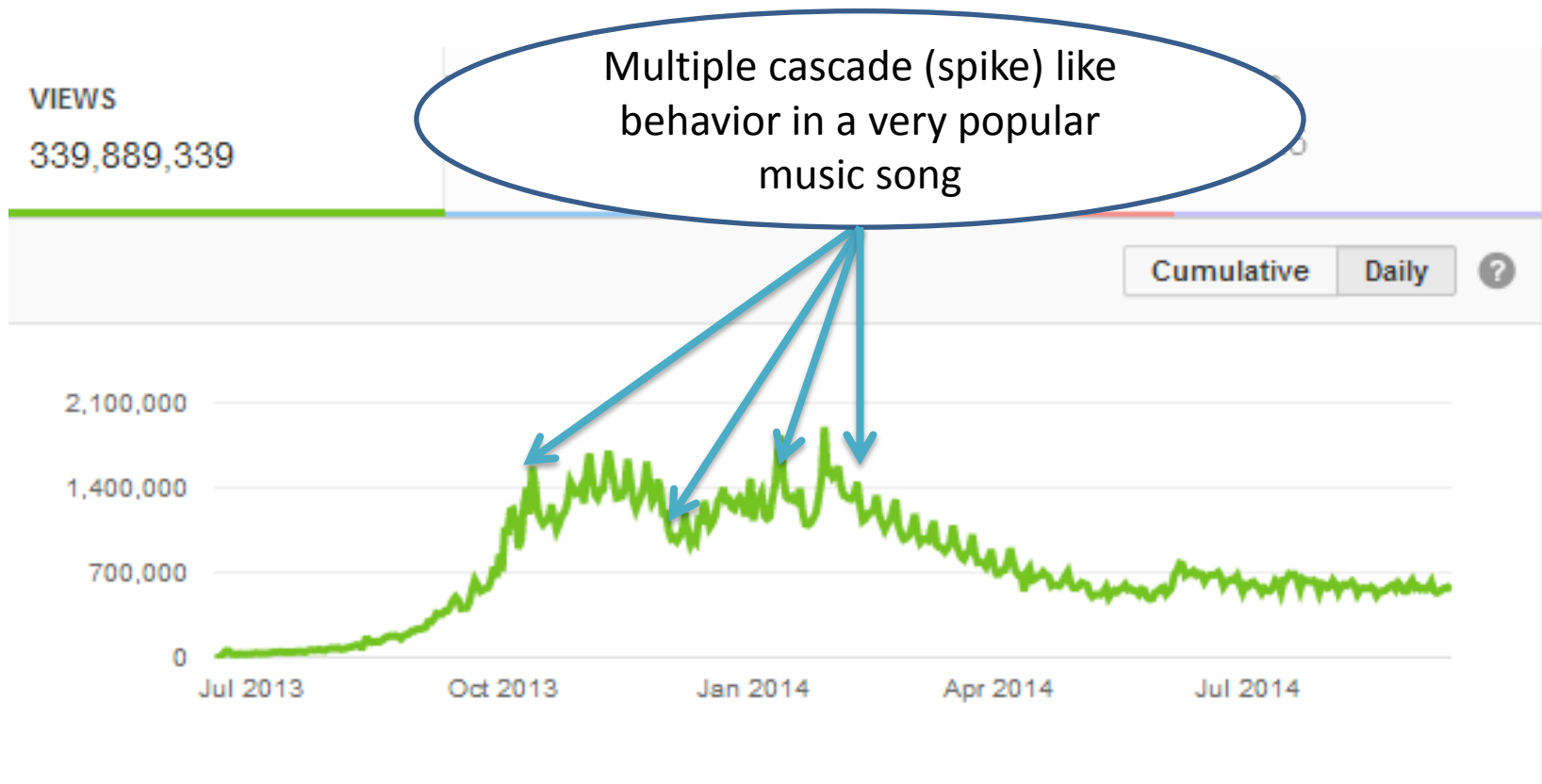
# What we know so far

- Users revisit the same object
  - On some datasets (LastFM and Twitter) most of visits are returning users
- Revisits are common on small time scales
  - Above results hold
  - Complements [Anderson2014]
- Users abandon content but it may take a long time
  - Preying behavior from [Ribeiro2014]

# Users eventually stop visiting



# Some objects behave like a sum of multiple cascades



**How de we model these time series?**

# The Phoenix-R Model!

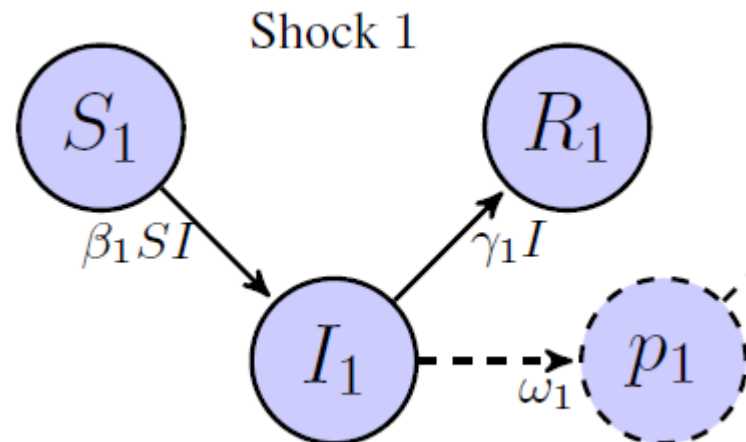
Table 1: Comparison of PHOENIX-R with other approaches

	Revisits	Non-Linear	Forecasting	Multi Cascade
SI [12]		✓		
SpikeM [18]		✓	✓	
TemporalDynamics [21]			✓	
PHOENIX-R	✓	✓	✓	✓

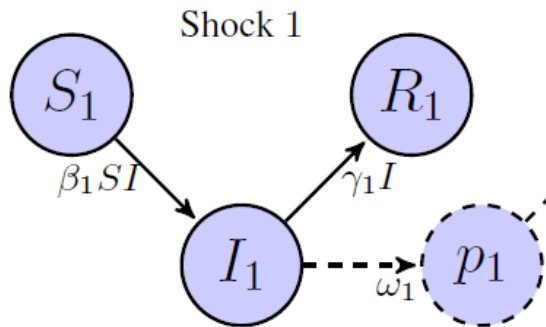


# Phoenix-R Explained

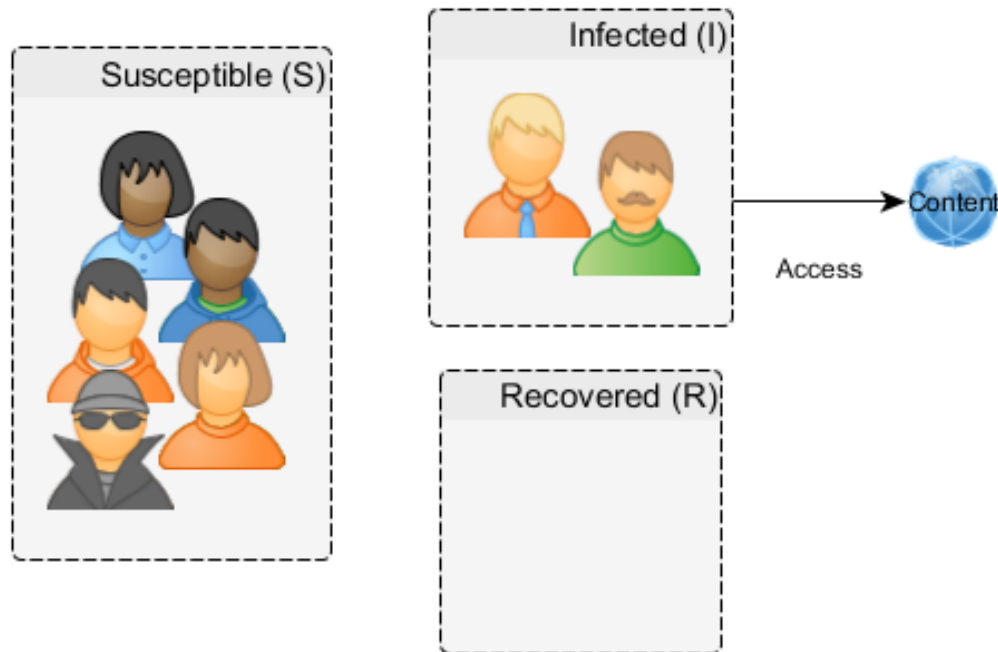
- Single shock (cascade) model
- Epidemiology model



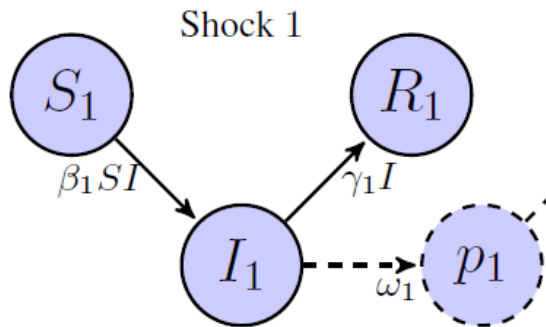
# Single Shock



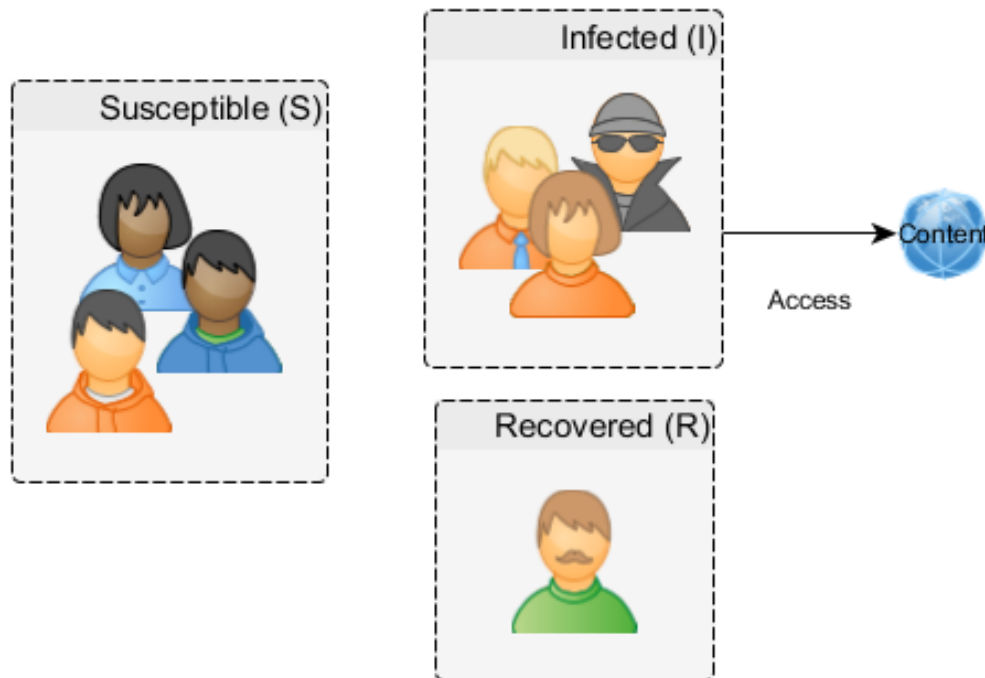
- Starting with some Susceptible and Infected Individuals
- The Infected access the content



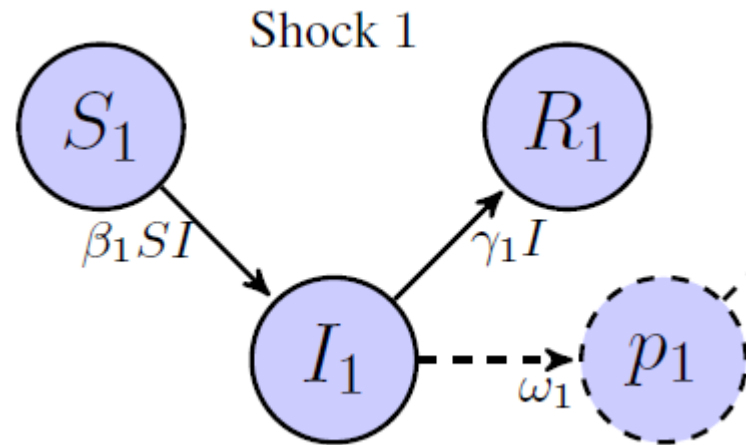
# Single Shock



- At the next time tick some Infected recover
- Some Susceptible are infected by the previous infected
- We now expect more visits (more infected)



# Single Shock Equations



$$S(t) = S(t - 1) - \beta S(t - 1)I(t - 1)$$

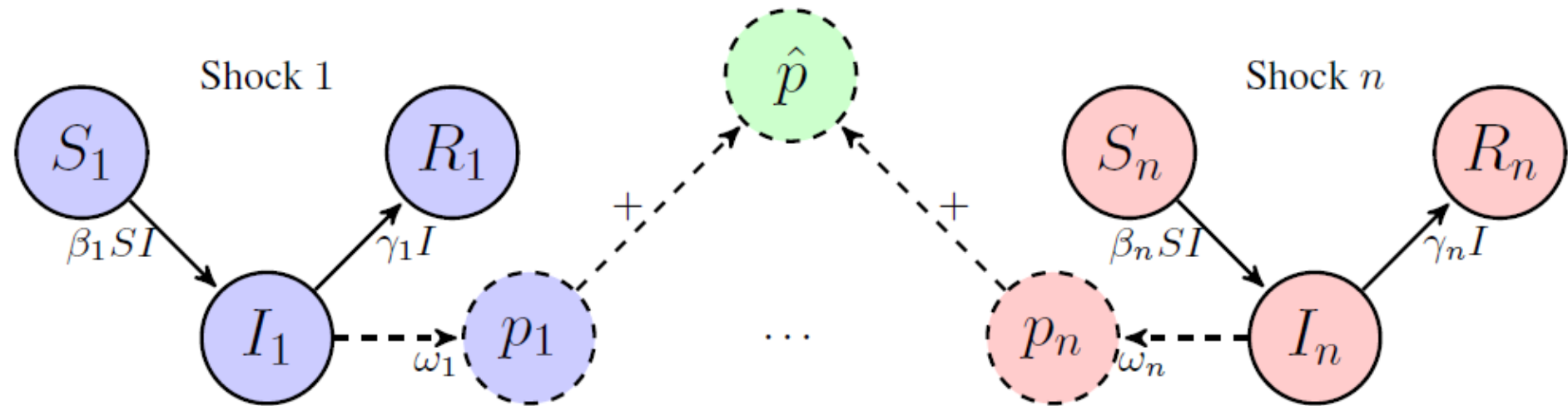
$$I(t) = I(t - 1) + \beta S(t - 1)I(t - 1) - \gamma I(t - 1)$$

$$R(t) = R(t - 1) + \gamma I(t - 1)$$

$$p(t) = \omega I(t).$$

# Multiple Shocks

- Simplifying assumption that each shock is a new population (set of users)



$$\hat{p}(t) = \sum_{i, s_i \in \mathcal{S}} p_i(t - s_i) \mathbb{1}[t > s_i]$$

# How many shocks to add?

- A perfect model (zero error) can be created by
  - Letting each access be a single user which immediately recovers
  - However, lot's of parameters (cost)
- Using Minimum Description Length (MDL)

$$Cost(\mathbf{t}; \mathcal{P}) = \log^* n + Cost(\mathcal{P}) + Cost(\mathbf{t} | \mathcal{P})$$

# How do we fit a time series?

- Step 1:
  - Identify Peaks using Wavelets
  - Intuitively, each peak is a candidate shock (cascade)
  - Linear
- Step 2:
  - Add each peak sorted by height to the model
  - If the MDL decreases, accept peak
- Step 3:
  - Stop when the MDL stops decreasing

# Linear runtime (time series length) and parameter free algorithm

**Algorithm 1** Fitting the PHOENIX-R model. Only the time series is required as input.

```
1: function FITPHOENIXR(t)
2:    $\epsilon = 0.05$ 
3:    $s \leftarrow \{\}$ 
4:    $p, s' \leftarrow FindPeaks(t)$ 
5:    $s[1] = 0$ 
6:    $s \leftarrow append(s')$ 
7:    $\mathcal{P} \leftarrow \{\}$ 
8:    $min\_cost \leftarrow \infty$ 
9:   for  $i \leftarrow 1$  to  $|s|$  do
10:     $\mathcal{F} \leftarrow LM(t, s(:i))$ 
11:     $m \leftarrow PhoenixR(\mathcal{F})$ 
12:     $mdl\_cost \leftarrow Cost(m, t, \mathcal{F})$ 
13:    if  $mdl\_cost < min\_cost$  then
14:       $min\_cost \leftarrow mdl\_cost$ 
15:       $\mathcal{P} \leftarrow \mathcal{F}$ 
16:    end if
17:    if  $mdl\_cost > min\_cost * (1 + \epsilon)$  then
18:      break
19:    end if
20:  end for
21:  return  $\mathcal{P}$ 
22: end function
```

Find Peaks

Adding shocks

Exit



# How good is Phoenix-R?

- Comparing Phoenix-R with two state of the art alternatives
  - RMSE (smaller is better)

	PHOENIX-R vs. TemporalDynamics (daily series)		PHOENIX-R vs. SpikeM (hourly series)	
	RMSE PHOENIX-R	RMSE TemporalDynamics	RMSE PHOENIX-R	RMSE SpikeM
MMTweet	<b>2.93</b> ( $\pm 0.23$ )	4.18 ( $\pm 0.49$ )	-	-
LastFM	<b>7.09</b> ( $\pm 0.23$ )	8.31 ( $\pm 0.32$ )	-	-
Twitter	<b>72.05</b> ( $\pm 6.08$ )	194.79 ( $\pm 20.49$ )	<b>10.83</b> ( $\pm 1.61$ )	<b>9.77</b> ( $\pm 2.24$ )
YouTube	<b>280.58</b> ( $\pm 29.29$ )	3429.19 ( $\pm 577.76$ )	-	-

- Phoenix-R is always better or just as good

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- Phoenix-R is always better or just as good

# Phoenix-R is also good at forecasting

- RMSE (smaller is better)
- 1, 7 or 30 days ahead forecasting
- Ties on very linear time series

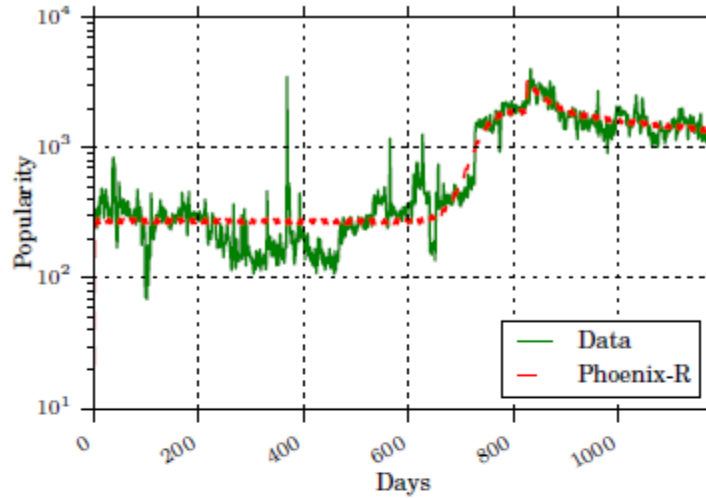
		5%			25%			50%		
		1	7	30	1	7	30	1	7	30
MMTweet	PhoenixR	<b>11.61</b>	<b>12.78</b>	<b>15.15</b>	<b>8.67</b>	<b>6.74</b>	<b>8.82</b>	<b>4.08</b>	<b>6.87</b>	<b>13.58</b>
	TempDynamics	17.07	17.41	16.52	9.63	10.78	14.46	25.19	23.08	30.39
Twitter	PhoenixR	<b>53.68</b>	<b>60.78</b>	<b>215.76</b>	<b>132.21</b>	<b>135.15</b>	<b>210.30</b>	<b>75.58</b>	<b>229.59</b>	<b>254.93</b>
	TempDynamics	104.45	129.36	255.69	643.39	643.83	786.50	420.74	587.86	598.75
LastFM	PhoenixR	<b>2.37</b>	<b>3.97</b>	<b>5.71</b>	<b>8.60</b>	<b>12.06</b>	<b>14.66</b>	<b>11.34</b>	<b>15.03</b>	<b>15.43</b>
	TempDynamics	6.47	7.03	8.00	11.15	14.62	17.86	14.91	18.15	18.80
YouTube	PhoenixR	<b>91.62</b>	<b>106.38</b>	<b>138.88</b>	<b>83.76</b>	<b>113.14</b>	<b>147.04</b>	<b>127.53</b>	<b>97.97</b>	<b>115.97</b>
	TempDynamics	3560.65	3631.09	3661.81	5091.82	5107.82	5143.70	4136.14	4139.73	4169.26

# Phoenix-R is also good at forecasting

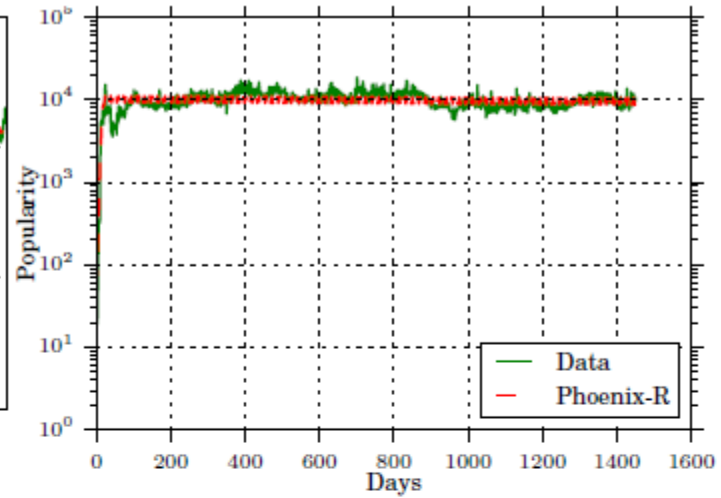
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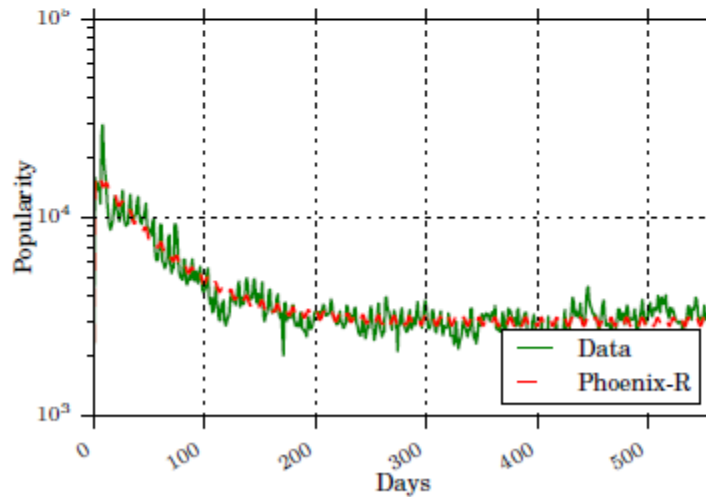
# Examples of Phoenix-R at work



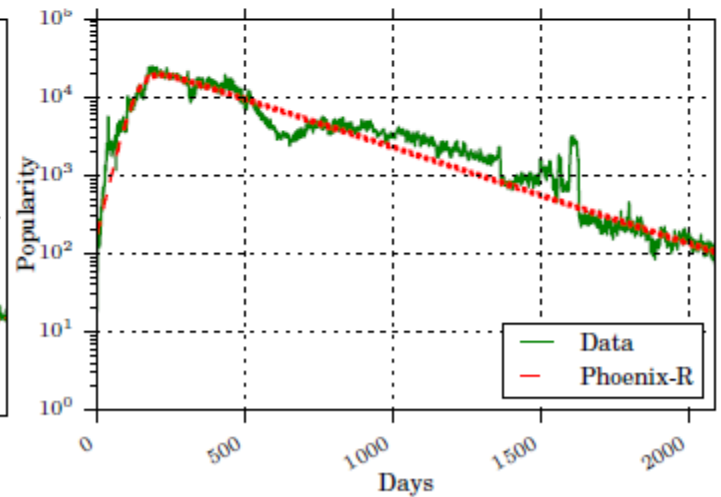
(a) Rock Song (growth in popularity)



(b) Flashdance (80's movie) clip (revisits)

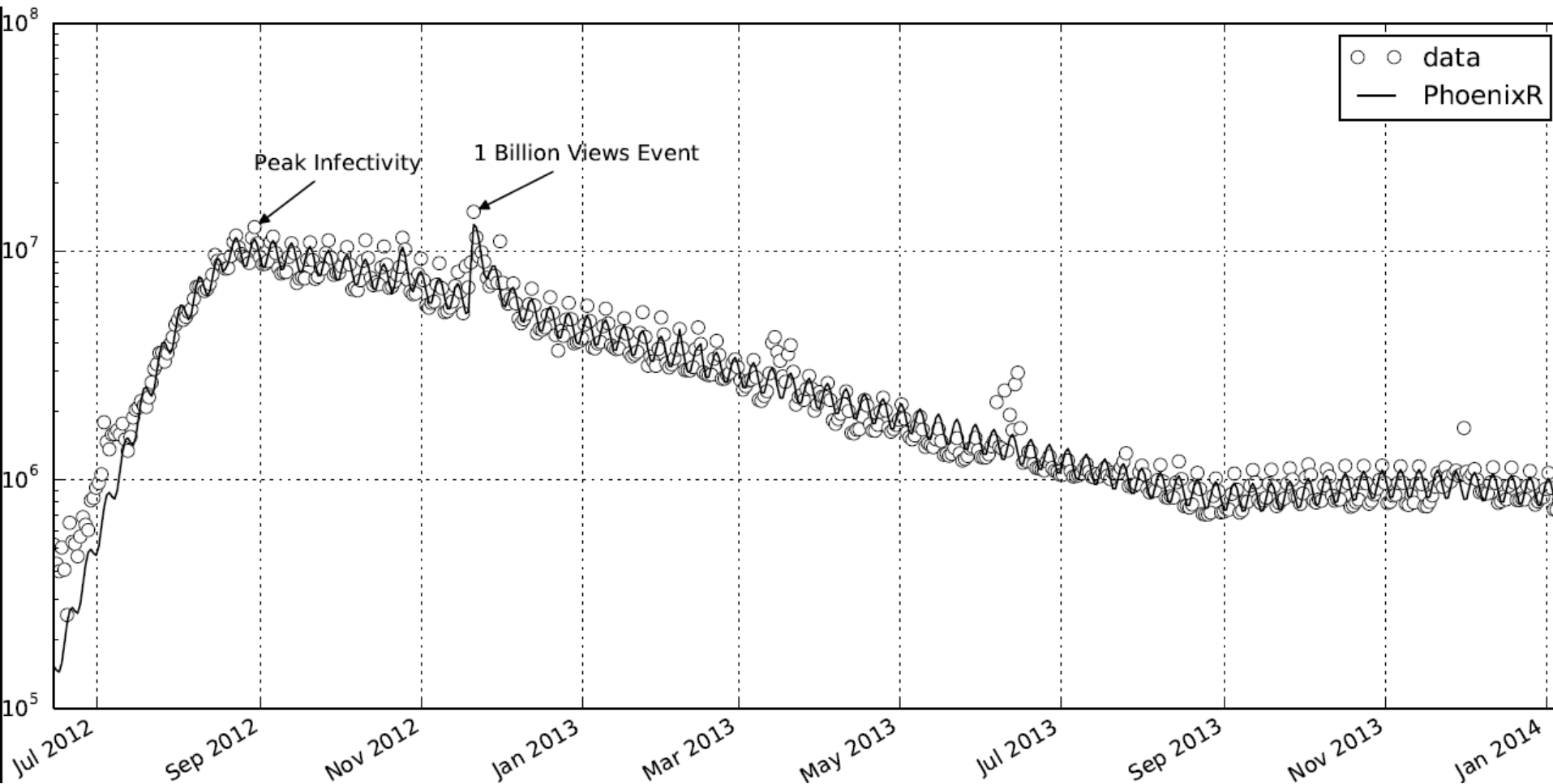


(c) Korean Music Video (single cascade)



(d) User Dancing Video (single cascade)

# Examples of Phoenix-R at work



# Conclusions

- Phoenix-R model for revisits and multiple cascades
- Based on discoveries from real data
- Scalable linear fitting algorithm
  - On time series length
- Useful for predictions