

UNIVERSITY OF ARKANSAS AT LITTLE ROCK

DOCTORAL THESIS

**A Framework for Collecting, Extracting
and Managing Event Identity
Information from Short Social Media
Text**

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*A thesis submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy*

in

Integrated Computing
Information Quality Track
Department of Information Science

April 2015

Declaration of Authorship

I, Debanjan Mahata, declare that this thesis titled, 'A Framework for Collecting, Extracting and Managing Event Identity Information from Short Social Media Text' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

“Torture the data, and it will confess to anything.”

Ronald Coase, Economics, Nobel Prize Laureate

Abstract

With the popularity of social media platforms like Facebook, Twitter, Google Plus, etc, there has been voluminous growth in the digital footprints of real-life events in the Internet. The user generated colloquial and concise textual content related to different types of real-life events, produced in these websites, acts as a hotbed for researchers and organizations for extracting valuable and meaningful information. There has been significant improvement in natural language processing techniques for mining formal and long textual content often found in blogs and newspaper articles. But, it is still a challenging task to mine textual information from the social media channels producing terse, informal and noisy text with an unusual structure. For an event of interest it is necessary to detect and store event-specific signals from the noisy social media channels that allows to distinctively identify that event among all others and characterizes it for drawing actionable insights. These event-specific cues also forms its identity in the unstructured domain of social media. This identity information when mined and analyzed in a timely manner has tremendous applications in the areas of real-life event analysis, opinion mining, reference tracking, recommendation engines, cyber security, event management, among others. Thus, there is a need of a generic framework that can collect short textual content related to real-life events, extract information from them and maintain the information persistently for performing data analytics tasks, and tracking newly produced content as an event evolves. The patent pending work presented in this thesis establishes the design and implementation of an extendable framework enabling collecting, extracting and persistently managing identity information of real-life events from short textual content produced in social media. Towards this objective a pipeline of data processing components going through repeated processing cycles - *Event Identity Information Management Life Cycle* (EIIM) is proposed. A novel persistent graph data structure - *EventIdentityInfoGraph* representing the identity information structure of an event is implemented that forms the core component of the EIIM cycle. Mutually reinforcing relationships between event-specific social media posts, hashtags, text units, URLs and users, forming the vertices of the graph and denoting *event identity information units*, are defined and quantified. An iterative and scalable algorithm - *EventIdentityInfoRank* is proposed that processes the vertices of the graph and ranks them in terms of event-specific informativeness by leveraging the mutually reinforcing relationships. The ranked *event identity information units* are further used in tracking new event related content and extracting valuable event-specific information. Different components of the framework are tested and validated for real-time event related content generated in social media. The work is concluded by discussing about its novel contributions, practical applications in various other domains and envisaging future directions.

Acknowledgements

I would like to express the deepest appreciation to my committee chair Dr. John R. Talburt, who has shown the attitude and the substance of a genius. He continuously and persuasively conveyed a spirit of adventure in regard to research and scholarship, and an excitement in regard to directing innovation towards practical problems. Without his supervision and constant support this dissertation would not have been possible.

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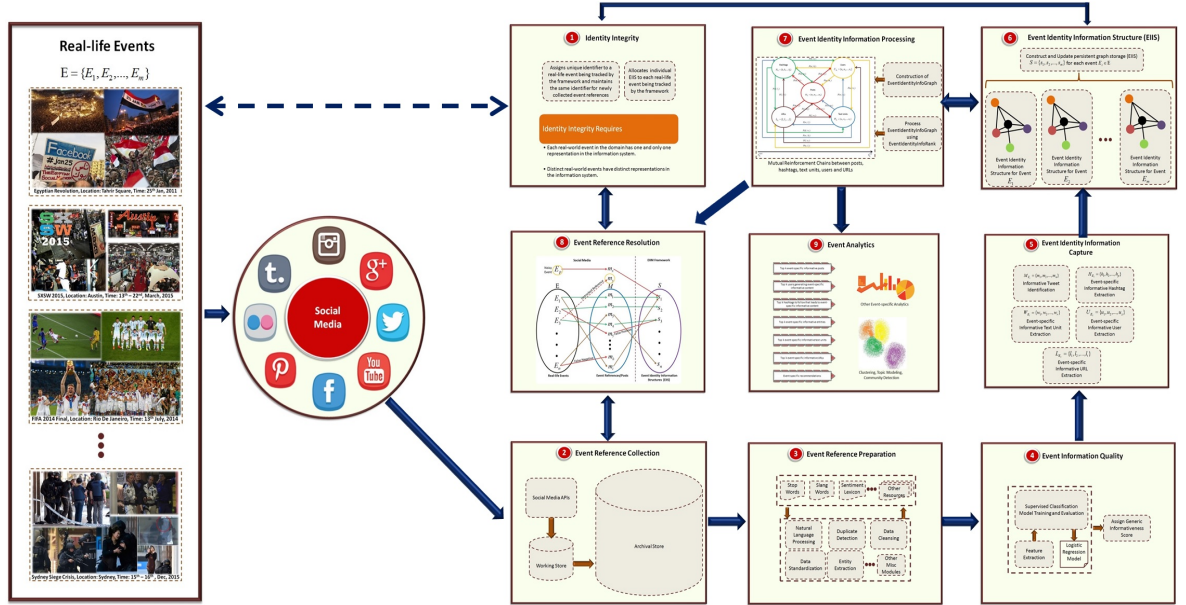
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*Dedicated to my parents, wife and my entire family for their
endless love, support and encouragement.*

Dissertation Overview

FIGURE 1: Event Identity Information Management (EIIM) Life Cycle for user generated short textual content in social media



Related Filed Patent

- A System for Collecting, Ranking and Managing Entity Identity Information from Social Media (US 62135258). Inventors: **Debanjan Mahata** and John R. Talburt, Assignee: The Board Of Trustees Of The University Of Arkansas.

Related Publications

- **Debanjan Mahata**, John R. Talburt and Vivek Kumar Singh; *Identifying and Ranking of Event-specific Entity-centric Informative Content from Twitter*. 20th International Conference On Applications Of Natural Language To Information Systems (NLDB 2015), Passau, Germany. 17th – 19th June, 2015.
- **Debanjan Mahata** and John R. Talburt; *A Framework for Collecting and Managing Entity Identity Information from Social Media*. 19th International Conference on Information Quality, Xi'An, China.
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- **Debanjan Mahata**, John R. Talburt, Vivek Kumar Singh and Rajesh Piryani; *Chatter that Matter: A Framework for Identifying and Ranking Event-specific Informative Tweets*. 18th International Conference on Text, Speech and Dialogue, Plzen, Czech Republic (Notification Due: May 10, 2015)
- **Debanjan Mahata**, John R. Talburt and Vivek Kumar Singh; *A Framework for Collecting, Extracting and Managing Event Identity Information from Twitter*. 20th International Conference on Information Quality, M.I.T, Boston (Notification Due: April 30, 2015)

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Chapter 1

Introduction

1.1 Social Media and Real-life Events

1.2 Challenges and Opportunities

1.3 Research Questions

1.4 Research Methodology

1.5 Research Contributions

1.6 Structure of the Thesis

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Literature Review

2.1 Event Identification in News Text

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2.5 Reference Tracking and Entity Resolution

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Defining Events

3.1 Topic Detection and Tracking

3.2 Automatic Content Extraction

3.3 Multimedia Event Detection

3.4 Events in Social Media

Chapter 4

Event Identity Information Management Life Cycle

4.1 Identity Integrity

FIGURE 4.1: Identity Integrity component of the EIIM life cycle.

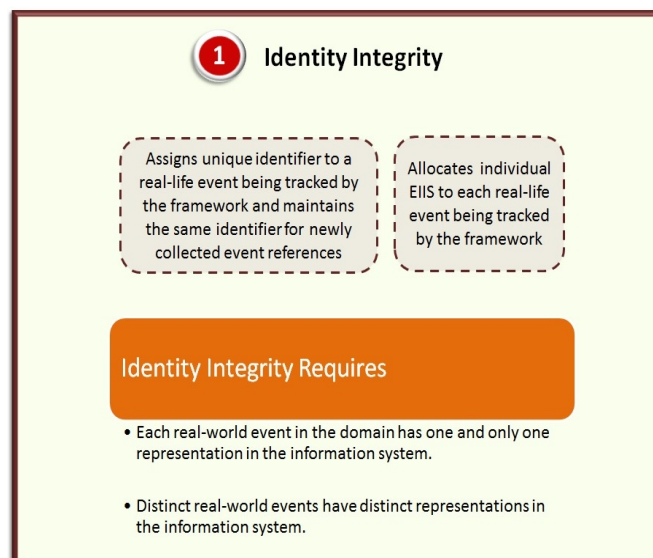


FIGURE 4.2: Event Reference Collection component of the EIIM life cycle.

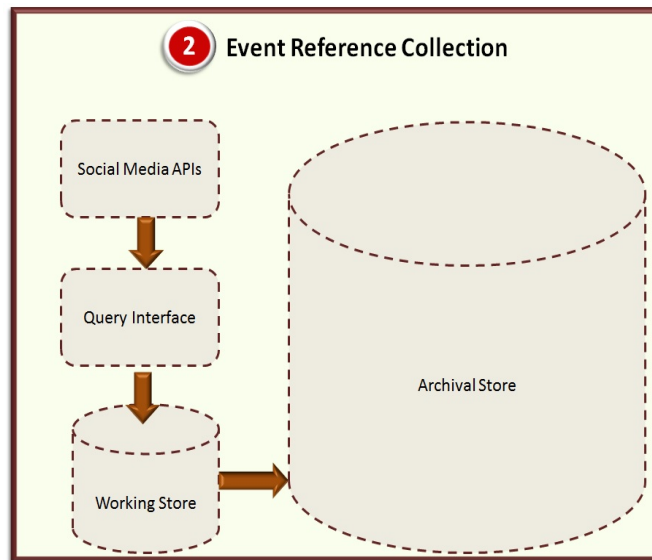


FIGURE 4.3: Event Reference Preparation component of the EIIM life cycle.

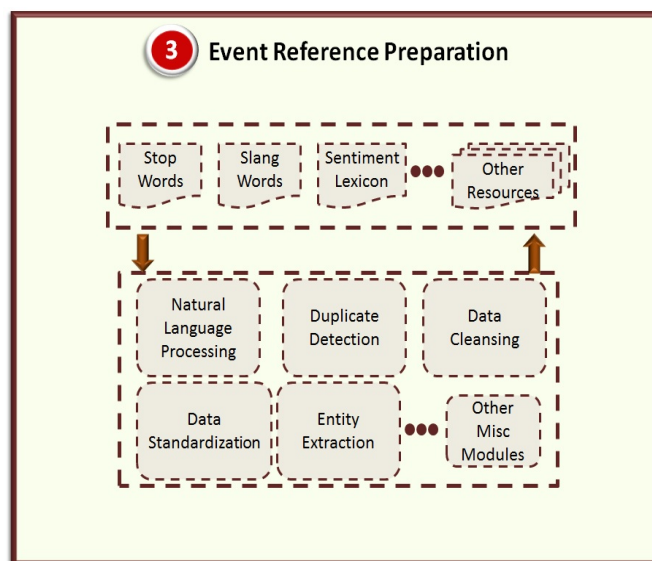


FIGURE 4.4: Event Information Quality component of the EIIM life cycle.

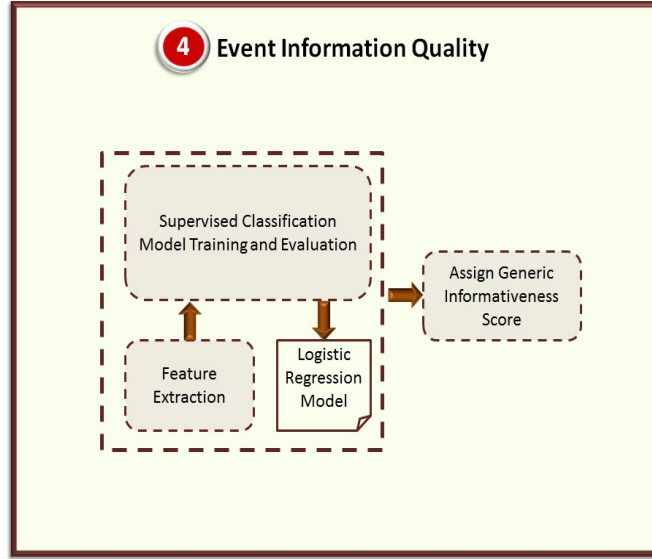
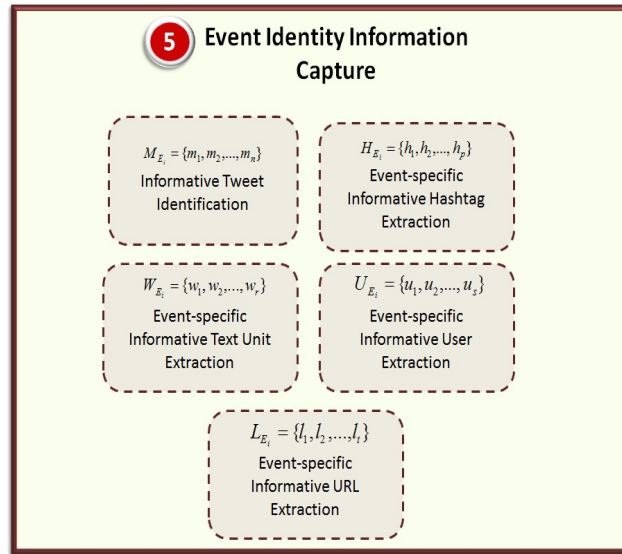


FIGURE 4.5: Event Identity Information Capture component of the EIIM life cycle.



4.2 Event Reference Collection

4.3 Event Reference Preparation

4.4 Event Information Quality

4.5 Event Identity Information Capture

4.6 Event Identity Information Structure

4.7 Event Identity Information Processing

4.8 Event Reference Resolution

FIGURE 4.6: Event Identity Information Structure component of the EIIM life cycle.

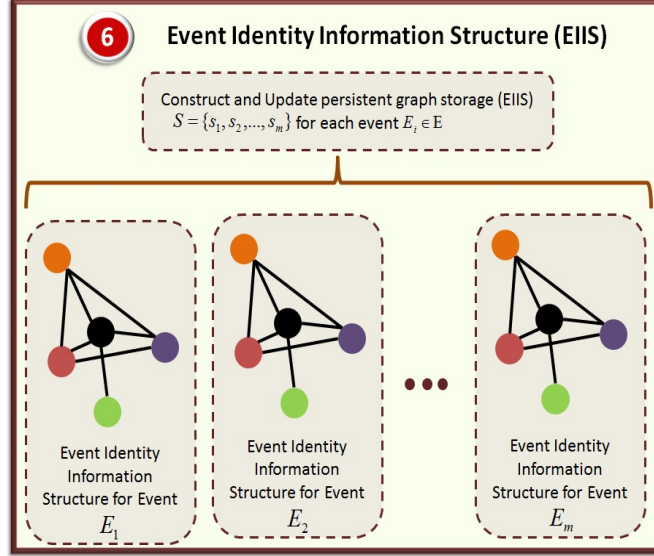


FIGURE 4.7: Event Identity Information Processing component of the EIIM life cycle.

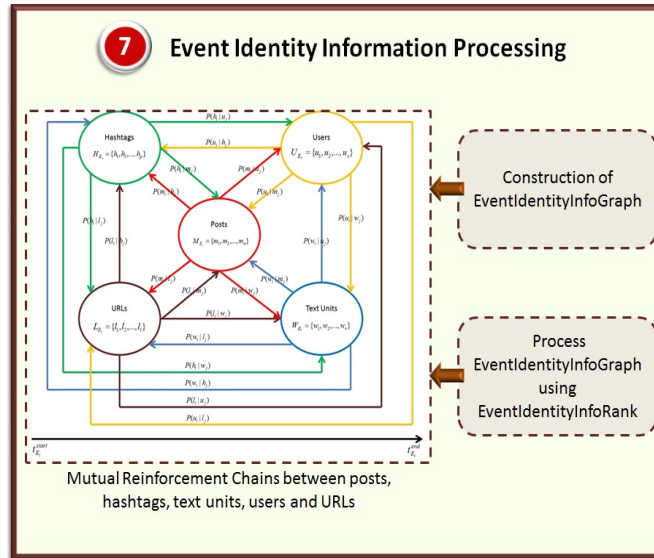


FIGURE 4.8: Event Reference Resolution component of the EIIM life cycle.

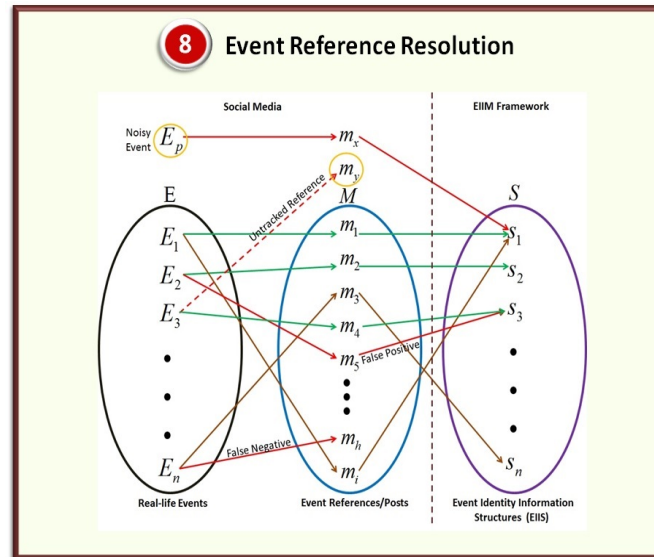


FIGURE 4.9: Event Analytics component of the EIIM life cycle.



Chapter 5

Discovering Event-specific Informative Content from Twitter

5.1 Twitter and Event Related Content

5.2 Analysis of Informative and Non-informative Content in Tweets

5.3 EventIdentityInfoGraph

5.4 EventIdentityInfoRank

5.5 Experiments

5.5.1 Data Collection

5.5.2 Data Preparation

5.5.3 Baselines

5.5.4 Evaluation

5.5.5 Sample Results

Chapter 6

Potential Applications of the EIIM Framework

6.1 Event Monitoring and Analysis

References related to real-life events are extremely abundant in social media. Right from natural disasters such as the ‘Haiti Earthquake’ [1] to international sporting events like the ‘Winter Olympics’ [2] to socio-political [3] and socio-economical [4] events that shook the world such as presidential elections [5], ‘Egyptian Revolution’ [6], and recessions were covered, analyzed, extrapolated and informed by social media. This prolific event-specific content in social media makes it a promising ground for performing event analytics. Platforms like Geofeedia¹, TwitterStand², Twitris³, Truthy⁴, and TweetTracker⁵ have developed techniques to provide analytics related to different local and global real-life events.

Monitoring social media has become one of the essential activities of national security agencies for predicting potential threats and mass protests [7]. Social media is being used for tracking terrorism activities [8], collective actions [9], and countering cyber-attack threats⁶. One of the main components of each of these applications is tracking references related to the events. The proposed EIIM model could be an essential component of such systems. It would help in identifying, tracking and analyzing events and its related references in an organized manner over time.

¹<http://geofeedia.com/>

²<http://twitterstand.umiacs.umd.edu/>

³<http://twitris.knoesis.org/>

⁴<http://truthy.indiana.edu/>

⁵<http://tweettracker.fulton.asu.edu/>

⁶<https://www.recordedfuture.com/>

6.2 Event Information Retrieval

Retrieving informative content related to real-life events shared in social media and presenting them in an organized way to the interested users has led to web based services like Seen⁷. It allows users to follow live updates of the events and also aids in witnessing and re-living the events at a later stage from the archives. Showing useful and interesting content to users by filtering out the pointless babbles from social media streams is an important component of such services. Additionally, such systems could get immensely benefitted by identification of event-specific informative hashtags, text units, users and URLs over time as the event proceeds. This would further enable efficient indexing of event-specific terms and hashtags that leads to high quality information, and effective processing of information. It would enhance the user experience, allowing better consumption and summarization of information related to the events, and positively impact triggering of event-specific recommendations. Thus, the proposed EIIM model in this thesis can act as the core component of information retrieval systems retrieving and organizing information related to real-life events from social media.

6.3 Opinion and Review Mining

Every day millions of people express their opinions in social media about products and companies they like and dislike. Their communications often include thoughts about good and bad experiences with the products and services. This provides a great opportunity for companies to understand its customers and to get unbiased valuable feedback from them about their product offerings without asking them to fill out time consuming outdated surveys. The EIIM framework when used for monitoring references of products/services from social media during product launch events could be useful in mining insightful and informative opinionated content. Combined with sentiment analysis, the invention could be a powerful tool for review analysis. One of the important contributions of the system could be to identify the sources having high chances of containing insightful information and filter them out for further processing. This would make a review mining system more efficient and increase its overall quality. Mining opinions related to entities related to an event could be used in many other contexts like political campaigns, socio-political studies, market behavior analysis, e-commerce applications, etc. Steps are being taken for adding this capability to the EIIM framework. On considering a mix of named entities and unigram opinionated words as text units in the *EventIdentityInfoGraph* we obtained some preliminary encouraging results. A glimpse

⁷<http://seen.co>

of the results obtained for a basketball game "Miami Heats VS Cleveland Cavaliers", played on 25th December, 2014 is as follows:

Top 10 insightful and opinionated tweets for an hour related to the game

1. Good win for the Heat tonight against Cavs and Lebron. Great game for Wade and Deng. Just imagine if Bosh were healthy. #HeatvsCavs
2. Good work Dwayne Wade. Good work Miami Heat. LeBron is embarrassed. It's all over his face. #NBA #heatvscavs
3. Great game on Christmas Heat Showed up and spoiled Lebron Return to MIA! #Wade County #HeatvsCavs #NBAChristmas
4. Lebron leaves Miami high and dry and they cheer his return. Some even cheering cavs. Embarrassing bandwagon fan base. #heatv...
5. I totally understand LBJ move to Cleveland and like it. But if I'm a #Miami fan, I would boo LeBron like crazy today. #heatvscavs #CLEvsMIA
6. Stay classy #Miami. Good game vs. Lebron and; Cavs. #NBA #MIAvsCLE #HeatvsCavs #Heat #HeatNation
7. Loul Deng playing both ends of the floor. He's playing good D to LBJ #heatvscavs
8. Heat fans ; Cavs fans. Class vs no class. No burning a jersey in Miami #heatvscavs #HeatNation
9. WE FUCKING WON!!!!!! LETS GO HEAT #HEATgame #HeatNation #HeatvsCavs Wade with 31 points 5 assist 5 rebounds! Good shit MIAMI
10. Kevin Love is overrated. Big fish, small pond in MN and injury prone. #HeatvsCavs #NBAXmas

The above tweets point to the reactions of the viewers on the game as well as the players participating in the event.

6.4 Recommender Systems

The EIIM framework can be used for developing event related recommender systems. The ranked list of event identity information can be used for giving useful recommendations. For example following is a refined tweet recommendation for an event obtained

from a snapshot of the *EventIdentityInfoGraph* created for the event: “BlackLivesMatter”: Protest movement against the killing of Eric Garner.

Original Tweet:

- #BREAKING #NEWS — New York City Mayor Says, #BlackLivesMatter <http://t.co/qYvp8L8gDh> — #BLACK HCP520

Recommended Tweets:

- New York: What’s the plan? Where are the protests happening tonight? #EricGarner #BlackLivesMatter #MichaelBrown #ICantBreathe
- Brooklyn District Attorney to Convene Grand Jury in Case of #AkaiGurley NBC New York <http://t.co/mLIYPy39Pa> #BlackLivesMatter
- New York Today! #ShutItDown #economicsshutdown #BlackLivesMatter #ICantBreathe #EricGarner #nojusticenoprofits <http://t.co/F0TrZtx2Y5>

Similarly an user can get other recommended users who are talking on the same topic. Hashtags and topics can also be recommended. It can further lead to clustering of similar content and discovery of communities around different topics related to the event. We wish to work on this in the future.

6.5 Event Management and Marketing

Social media is increasingly being used by event management practitioners while organizing conferences, seminars, music festivals, fashion shows, fundraisers and various other types of planned events. Tracking and producing useful and informative content before, during and after the events in social media from the perspective of event management has proved to be extremely beneficial⁸. Right from promoting the events, collecting RSVPs, creating communities around topics, announcing important information, getting real-time unbiased feedbacks, to marketing right content to the users creating buzz about the events, social media plays an important role. It also helps in building long term relationships with the communities of users interested in an event and track their related activities. In such a scenario the EIIM life cycle can constantly track and persistently store salient information related to events right from its inception. The *EventIdentityInfoGraph* can aid in identifying event-specific informative content and users producing

⁸<http://oursocialtimes.com/using-social-media-to-make-your-event-a-dazzling-success-infographic/>

them, which could further lead to effective targeting of user communities, generating event summaries, mining opinions, broadcasting interesting information, among other things related to an event.

6.6 Social Media Data Integration

Organizations have increasingly started integrating the data available in social media with the enterprise data⁹. Social media data is most powerful when it is combined with daily transactional data and the master data to give a comprehensive view of customers, products and business conditions. Customers often openly talk about the products in social media and build communities around hashtags [10] related to different topics. The EIIM framework could go a long way in collecting right information about the entities of concern maintained in the enterprise databases and integrate the collected information with the already existing ones. The entity resolution aspect would further help in managing the data quality issues related to data integration. In such conditions the EIIM model proposed could be used for integrating entity information from two distinct domains of enterprise system and social media in order to gain strategic intelligence related to business of an organization. This would further help an organization in marketing, corporate communications, public relations, customer support, product development, advertising, market research, product recommendations and gaining competitive intelligence.

⁹<http://www.altimetergroup.com/research/reports/social-data-intelligence>

Chapter 7

Conclusion and Future Work

7.1 Conclusion

7.2 Future Work

7.2.1 Summarizing Event Related Content

7.2.2 Identifying Insightful Opinionated Content Related to Events

7.2.3 Event Topic Modeling

7.2.4 Event-specific Recommendations

7.2.5 Distributed Processing of EventIdentityInfoGraph

7.2.6 Event Ontology for Social Media

Appendix A

Appendix Title Here

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