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# Designing Social Media Tools for Emergency Response

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UNIVERSITY OF CALGARY

Designing Social Media Tools for Emergency Response

by

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A THESIS

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## **Abstract**

With the ubiquity of smartphones and the use of social media, people can share information with a population once reserved to traditional media (e.g. print, television, or radio). This combination has empowered citizens to use social media to share and disseminate information during emergencies, like the 2013 Southern Alberta floods and Bermuda Shorts Day 2014.

Social media's increased use during emergencies presents an interesting challenge for emergency operations centre personnel who need to filter and assess information before deciding if, how, and when to act, often in parallel with handling information from other sources. Though commercial tools exist, they are not designed with emergency management personnel in mind.

This thesis presents Piu, a Twitter-based social media tool supporting both emergency planning and emergency response phases of emergency management. Piu was designed, built, and subsequently evaluated through a series interviews with emergency operations, campus security, and crisis communication experts.

## Acknowledgements

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I dedicate this thesis to my wife, Crystal, and my daughters, Jaya and Priya, who have put up with me and my back-to-school schedule which included many late nights. Your love and support, smiles and laughter are what pushed me through the tougher times.

I love you all!

## Publications from This Thesis

Portions of the materials and ideas presented in this thesis may have appeared previously in the following peer reviewed publications:

- *ePlan Multi-Surface: A Multi-Surface Environment for Emergency Response Planning Exercises*. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Interactive Tabletops and Surfaces 2014, (ITS2014), Dresden, Germany, 2014.
- *Gesture Design and Feasibility in Emergency Response Environments*. Francisco Marinho Rodrigues, Teddy Seyed, Apoorve Chokshi, Frank Maurer. In Proceedings of the Workshop on Gesture-based Interaction Design: Communication and Cognition, (CHI2014), Toronto, Canada, 2014.
- *Managing Peripheral Interaction in Emergency Response Environments*. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Workshop on Peripheral Interaction: Shaping the Research and Design Space, (CHI2014), Toronto, Canada, 2014.

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## List of Acronyms

Acronym	Full description
API	Application Programming Interface
ASE	Agile Surface Engineering
BSD	Bermuda Shorts Day
CanVOST	Canadian Virtual Operations Support Team
CEMA	Calgary Emergency Management Agency
COP	Common Operating Picture
CSCW	Computer Supported Collaborative Work
EMS	Emergency Medical Services
EOC	Emergency Operations Centre
EOG	Emergency Operations Group
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GUI	Graphical User Interface
ICS	Incident Command System
ICT	Information and Communication Technology
ISIS	Islamic State of Iraq and Syria
JSON	JavaScript Object Notation
MVC	Model-View-Controller
RDBMS	Relational Database Management System

Acronym	Full description
SA	Situational Awareness
TOS	Terms of Service
UI	User Interface

## Chapter One: **Introduction**

Recurring major natural disasters and events such as the 2013 floods in southern Alberta have resulted in significant efforts by authorities worldwide to investigate how information and communication technologies (ICT) can further facilitate and improve upon existing emergency planning and response capabilities. This effort is imperative because large-scale emergencies and disasters highlight the vulnerability of modern infrastructure crucial to daily life (e.g. roads, phone service, and electricity). The investment in ICT by authorities worldwide can be primarily found in emergency operations centres (EOC), where trained personnel make decisions in situations that can be both stressful and highly volatile and where information is both uncertain and incomplete. Supporting the development of new or enhanced ICT in EOCs can help save life and property.

During the 2013 floods, the City of Calgary continually communicated with its citizens through different media: television and radio stations, newspapers, city website ([calgary.ca](http://calgary.ca)), and social media. By many estimates, the City of Calgary did an excellent job communicating during the flood, frequently updating residents about what action the city was taking to respond to the crisis and to mitigate further damage [15,20,48,72]. However, at one point in the four-day ordeal, citizens flocked to local grocery stores seeking bottled water (Figure 1.1, Figure 1.2) because of a false rumour about the safety of the city's drinking water [18,26]. Even with their successful use of social media, the city still saw rumours about the drinking water spread.



**Figure 1.1 – Messages about drinking water from Twitter June 21, 2013**

In spite of Calgary's sound management of its Twitter<sup>1</sup> accounts during the floods, miscommunication occurred and rumours spread. This incident provides an opening to investigate what ICT tools can be developed and used to help EOCs work more effectively with social media (e.g. Twitter). Furthermore, the crisis in Calgary raised the following questions,

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<sup>1</sup> <http://www.twitter.com>

which need to be addressed to better understand if or how ICT can help: What do citizens communicate through Twitter during emergency events? How did the emergency management personnel manage the city's Twitter account during the flood, and do they see an opportunity to improve? If so, can a tool be developed to help manage information arriving via this medium into the EOC?



**Figure 1.2 – Messages about drinking water from Twitter June 22, 2013**

The research discussed in this thesis explores how personnel managing social media accounts, but more specifically Twitter, can more efficiently analyze, assess, and filter tweets. By doing so, I hope that personnel making decisions in an EOC can receive more timely and accurate information to support their decision-making processes, which may counteract the public's circulating and acting on false information.

This chapter provides an introduction to the thesis with Section 1.1 providing the motivation for the thesis. The research questions behind this thesis are then discussed in 1.2

and serve as the basis for the research goals in Section 1.3, which is followed by an overview of the remaining structure of this thesis in Section 1.4.

## **1.1 Motivation**

The June 2013 flood was the largest flood in the City of Calgary's history [22], forcing thousands of people to be evacuated from their homes and businesses and causing hundreds of millions of dollars in damage [71]. During the flood, the city's newly built EOC [40] was the home base for key city personnel (the mayor, members of the crisis communication team), representatives from external agencies (utility companies, provincial health agency), police, fire, and emergency medical services [19], and it was the hub for information-gathering and dissemination.

Calgary's EOC, run by the Calgary Emergency Management Agency (CEMA), is staffed by twenty-five full-time employees; however, that number increases during a crisis event, such as a flood [19,40]. Within the EOC, there are offices for full-time staff, meeting rooms, and a centrally-located room ("Ops") that houses multiple workstations labeled and reserved for external and internal partners working in the EOC during an emergency (Figure 1.4).



**Figure 1.3 – CEMA’s EOC (Courtesy City of Calgary)**



**Figure 1.4 – CEMA’s EOC (Courtesy Darren Krause/Metro)**

In the centre of “ops” (Figure 1.3) is a series of three large screens on which the city’s complex geographic information system (GIS) runs. The GIS includes maps displaying layers of information about flood plains, critical infrastructure (schools, cell towers), social media

(Twitter, Instagram<sup>2</sup>), and live feeds from traffic and police cameras [19]. This map system enables personnel in “ops” to monitor a number of different things while providing space to the agencies to work on their own plans at their respective workstations.

The city’s crisis communication team was one team brought in to work at the EOC, and they were based in one of the rooms adjoining “ops”. Tasks performed by the crisis communication team included reading, assessing, and responding to messages for the city’s Twitter account, thereby providing another communication channel for the public. Perhaps better than any other channel, Twitter epitomizes the principal challenge faced by EOC personnel in a crisis: the volume of information and amount of data that need to be analyzed and continually monitored during an emergency. As Van de Walle notes, “accurate and timely information is as crucial as is rapid and coherent coordination among the responding organizations. [70]” But in the age of social media, how could the EOC be sure it was receiving and disseminating accurate, timely information?

## **1.2 Research Questions**

The aim of this thesis is to understand how emergency response personnel work with social media, using Twitter as the case-study. This background informed the design of ICT that facilitates assessing, filtering, and sharing information that supports decision-making in time-sensitive emergency response work. Furthering knowledge on this front means increasing the response capabilities of emergency responders.

Accordingly, the research questions in this thesis include:

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<sup>2</sup> <http://www.instagram.com>

- What features do emergency response personnel desire when handling information from social media, using Twitter as a case study?
- How should social media management tools be designed and created to support emergency response work?

### **1.3 Research Goals**

This thesis has two primary research goals. The primary goal of the thesis is to provide a set of features for a real-time social media analysis tool informed through discussions with emergency operations experts. The secondary goal, which is symbiotic with the first, is to understand the use-cases for which emergency operations personnel see this tool might be applied.

### **1.4 Thesis Structure**

This introductory chapter presents the motivation, research questions and research goals for the thesis. The remaining chapters for this thesis are organized as follows:

- *Chapter Two: Background & Related Work*

In the next chapter, I will provide an overview of research related to the use of social media in emergency response. Throughout the chapter, I will also highlight available commercial social media monitoring tools.

- *Chapter Three: ePlan Multi-Surface*

This chapter details work from an early EOC planning prototype developed in conjunction with a Calgary-based company. Multiple components of this prototype were retrofitted to

elicit requirements for Piu, the real-time social media tool that was built and evaluated for this thesis, as well as provide initial exploratory context for the work in this thesis.

- *Chapter Four: Tweets from Bermuda Shorts Day 2014*

Here, I provide an analysis of tweets collected from an annual, springtime, campus-wide celebration: Bermuda Shorts Day (BSD) at the University of Calgary in 2014. This chapter also provides insights on how tweets from BSD 2014 informed the design of Piu.

- *Chapter Five: Requirements for Piu*

In this chapter, I detail how I elicited requirements for Piu from a set of emergency response experts through a set of in-person interviews that were facilitated by a retrofitted prototype of ePlan's wall display.

- *Chapter Six: Piu*

After detailing the requirements elicitation process in the previous chapter, this chapter unveils Piu and the components to this multi-tiered application.

- *Chapter Seven: Evaluation of Piu*

The penultimate chapter outlines that Piu was evaluated with a different set of emergency response personnel than the group who provided the requirements. The conducted study and feedback provided are described herein.

- *Chapter Eight: Conclusion & Future Work*

This chapter wraps up the work on the thesis and provides direction for future work in this area.

## Chapter Two: **Background & Related Work**

Emergency management comprises many important tasks, including detecting and monitoring the emergency, deploying resources, and managing communication [12,31] for either public or private organizations. Critical information about an emergency can arrive from numerous sources (e.g. first responders, reporters, or online sources) and information processing and analysis are typically done in parallel with the primary emergency response activity [7] frequently with interruptions [23]. Several aspects on emergency management, social media, and previous research by others will be described in the remaining sections of this chapter.

Throughout this thesis, I will use the terms “emergencies” or “emergency event” interchangeably to mean an event that would require the Director of CEMA to open the EOC. Similarly, at the University of Calgary, these terms would refer to a Level 2 or Level 3 [68] emergency response level necessitating the activation of the Emergency Operations Group (EOG).

### **2.1 Emergency Management**

According to Public Safety Canada<sup>3</sup>, the Canadian government department that helps to protect Canadians from emergencies and disasters, the ultimate purpose of emergency management is to “save lives, preserve the environment, and protect property and the economy”. Emergency management comprises four interdependent components: prevention and mitigation, preparedness (planning), response, and recovery. In the subsequent section, I

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<sup>3</sup> <http://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/index-eng.aspx>

will talk more about these areas, but I will start with the two components (prevention and mitigation & recovery) that are not instances where Piu is likely to be used.

### **2.1.1 Prevention and Mitigation**

Prevention and mitigation are activities that reduce the risk that an emergency will result in losses to property or the economy. Some recent examples of prevention and mitigation work include the Red River Floodway<sup>4</sup>, built between 1962 and 1968, which protects the City of Winnipeg from flooding from the Red River. According to the government of Manitoba, since 2011, the floodway has prevented more than \$40 billion in potential flood damage to Winnipeg.

### **2.1.2 Recovery**

The recovery component to emergency management is usually the longest-lasting phase, as an emergency event that occurs over just seconds, minutes, hours, or days can deteriorate or wash away infrastructure that requires months or years to repair. A year after the southern Alberta 2013 floods, for example, some pedestrian bridges that spanned the Elbow and Bow Rivers finally re-opened, and further infrastructure was still not fully restored in Calgary. The length of the recovery period is also exaggerated as communities and cities that are rebuilding after an emergency event focus on rebuilding in such a way to prevent another event from inflicting the same damage, not simply restoring buildings and roads to their original conditions.

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<sup>4</sup> <http://www.gov.mb.ca/flooding/fighting/floodway.html>

### **2.1.3 Planning**

It is not possible to know exactly when, where, and how emergencies will occur, and depending upon the area affected, emergencies can create complex organizational and coordination issues. In some emergencies, power, cellular networks and water supplies can be affected, making daily activities difficult.

Activities in the planning phase focus on ensuring that the primary actors understand what roles they will play during an emergency and what responsibilities those roles carry. In the abstract, I mentioned that Piu was built to support a training mode. The training mode ensures that personnel operating the tool during emergencies have seen and used the tool assessing and filtering simulated Twitter data during emergency planning exercises. There are two common methods to execute such emergency planning exercises: tabletop exercises and live exercises.

#### **2.1.3.1 Tabletop Exercises**

Tabletop exercises are based on the simulation of a realistic scenario and are either real-time or on accelerated time. They can be run in a single room or in a series of linked rooms that could simulate the division between responders who need to communicate and be coordinated. People involved in these exercises are expected to know the plan, and they are invited to test how the plan works as the scenario unfolds. This type of exercise is particularly useful for validation purposes, particularly for exploring weaknesses in procedures [28].

#### **2.1.3.2 Live Exercises**

These exercises are a live rehearsal for implementing a plan, and they can be particularly useful for testing logistics, communications, and physical capabilities. They are a

useful training tool to help build experiential learning by having participants develop confidence in their skills and witness how a plan's procedures would unfold in a real event [28].

#### **2.1.4 Response**

Emergency response is the time during which the emergency is unfolding and different personnel trained through planning exercises work in a highly intensive, highly ambiguous environment. These actors may have previously worked with one another or, more likely, there is a combination of emergency veterans and newcomers. This was the situation at CEMA's EOC during the 2013 Southern Alberta floods. Ultimately, however, they all share a common goal: to minimize loss.

Piu was built to support real-time social media analysis during emergency response to assess and filter tweets, thereby contributing to emergency responders' situational awareness and to building a common operating picture.

#### **2.1.5 Situational Awareness**

Situational awareness (SA), like common operating picture, is important for effective decision-making in emergency management. Though originally used in the field of aviation, SA has been adopted in other situations such as emergency management. Endsley [24] has been widely cited for her definition of SA as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future". To understand how this definition applies to emergency, the sentence above can be deconstructed. Firstly, "the perception of the elements in the environment within a volume of time and space" can be taken to mean how people interpret the events around them. Then, "the comprehension of their meaning" indicates that someone

must take those events and understand that meaning. Finally, “the projection of their status in the near future” means that it is important to not only grasp what is happening now but also to anticipate how events taking place may affect or determine the future.

For instance, understanding that water bottles are sold out at stores across a city could reasonably mean that other people going to the store to purchase them would not be happy if these stores ran out. Furthermore, if this phenomenon is replicated at other stores across the city, the citizens might begin to worry, given the absence of water for purchase that their water is unsafe to drink.

#### **2.1.6 Common Operating Picture**

It is also vital that *emergency personnel have the most current information to form a common operating picture (COP) – a "continuously updated overview of an incident compiled throughout an incident's life cycle from data shared between integrated systems for communication, information management, and intelligence and information sharing."*<sup>5</sup> COP coupled with SA would help ensure that all personnel would have the same picture about what is happening, what possible outcomes may result from the current situation, and, thus, what action to take to mitigate the potential loss to property or people. Piu was designed and built to create, maintain, and support both SA and COP by ensuring that social media information sources are being widely shared amongst those operating in an EOC and making decisions affecting property and people.

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<sup>5</sup> FEMA- <https://www.fema.gov/pdf/emergency/nrf/nrf-glossary.pdf>

## 2.2 Emergency Operations Centres

An EOC can be a stand-alone facility or room where people from multiple organizations (Figure 2.1) gather during emergency planning exercises, during emergency response, or during the recovery phase of an emergency. EOCs are found in both public and private enterprises that need either to conduct planning exercises or to support personnel during an emergency response [51]. During these events, multidisciplinary teams of experts collaborate to define how they should respond to various scenarios [63].



**Figure 2.1 – Nassau County Office of Emergency Management  
(Courtesy FEMA/Howard Greenblatt)**

In both emergency planning and real emergency situations, the EOCs plays a key liaison role between municipal officials, external resources, and policy-makers. To help EOC staff coordinate an emergency response with other key stakeholders and personnel, clearly defined

principles are used, typically called the Incident Command System (ICS) [21], inspired by the military.

Responders [e.g. police, EMS, and hazardous materials (HAZMAT)] communicate with people both inside and outside the room, and it is vital that personnel have the most current information to form a COP. Developing a COP helps to support decision-making and to ensure that personnel in the field are working with current information. Technology has long played a role in helping people manage emergencies, with the first systems designed to “focus on the group communication process and how humans gather, contribute, and utilize data in a time-urgent manner” [64], and this is no different today with the types of tools available to CEMA EOCs described in Chapter 1.

We can apply learnings from research on ICT in other control room settings, those that are staffed around-the clock in places like airports, road traffic control centres, and subway control centres. Heath *et al.* [30] contribute to this field of computer-supported collaborative work (CSCW) through their documentation of the London Underground, where they shared that the communication between operators is not done solely through explicit communication and actions. Rather, the parties implicitly communicate with one another based on their proximity and other non-verbal cues. These non-verbal cues are powerful ways to communicate information when working in a busy, noisy environment. Pettersson [52] suggests that we can use ambient displays in an unobtrusive way in emergency service centres to visualize information not central to personnel’s main tasks, supporting the type of implicit communication described by Heath.

## **2.3 Emergency Management and the Role of Social Media**

Citizens are increasingly using social media in their daily lives, and this use extends to emergency situations. In fact, there is a wealth of research that has been performed in this field [33] outlining how social media has been used during disasters along with technologies that have been developed or deployed to help manage the inflow of information. EOCs are motivated to integrate ICT technologies to support information gathering and dissemination when they think it will save lives and property.

In Chapter 1, I mentioned how CEMA's EOC includes a GIS that displays information from a number of sources, one of which is images from Twitter and Instagram that have been geo-located. In the subsequent sections, I will delve into what is social media and outline details on how it has been used during emergencies.

### **2.3.1 What is social media?**

Kaplan *et al.* [37] define social media as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content." In that same paper, Kaplan *et al.* [37] describe the six different social media categories as: 1.) collaborative projects, 2.) blogs and microblogs, 3.) content communities, 4.) social networking sites, 5.) virtual game-worlds, and 6.) virtual social worlds. Twitter is a representative form of blogs and microblogs, bridging a gap between traditional media (e.g. newspapers, television, or radio) and the user by providing a real-time channel that is instantaneously updated by millions of users worldwide [65].

Social media is increasingly becoming important in times of crisis, as people are continuously connected via their smartphones to their friends and acquaintances. And, with

individuals placing more trust in social media in times of crisis [6], it is important for entities such as the City of Calgary to receive and share information via social media. Thus, more investigation needs to be done on how emergency personnel are using (or would like to use) this medium to gather, assess and filter information before sharing it with both their colleagues making decisions in an EOC, but the public as well.

Researchers have studied how a variety of social media platforms have been used during emergencies, including the incident at Virginia Tech [50] where researchers looked at a number of different platforms including Facebook<sup>6</sup>. These studies examine how citizens seek and share information [49] to help coordinate response efforts after the 2010 Haiti earthquake [58,60]. Beyond coordination and information sharing, Twitter has also been used in some contexts [69] to enhance situational awareness. Further, though first responders have tried to direct citizens to 911 or other conventional sources, citizens are turning to Twitter, among other social media platforms, to communicate during emergencies [32]. Social media photo-sharing sites (i.e. Flickr<sup>7</sup> and Instagram) can also provide photographic evidence of damage during emergencies as another valuable information source [46].

#### 2.3.1.1 What is Twitter?

Twitter is a global social media platform used by 284 million monthly users who are sending 500 million messages every day, mostly through their smartphones or other mobile devices [65]. Twitter allows users to create custom news feeds by choosing other Twitter users

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<sup>6</sup> <http://www.facebook.com>

<sup>7</sup> <http://www.flickr.com>

to “follow”. A person can own one or more accounts, and accounts can also be held by news organizations, sports teams, and university departments. By following one or more users, a Twitter user can, without posting their own content, receive updates from the users they are following.

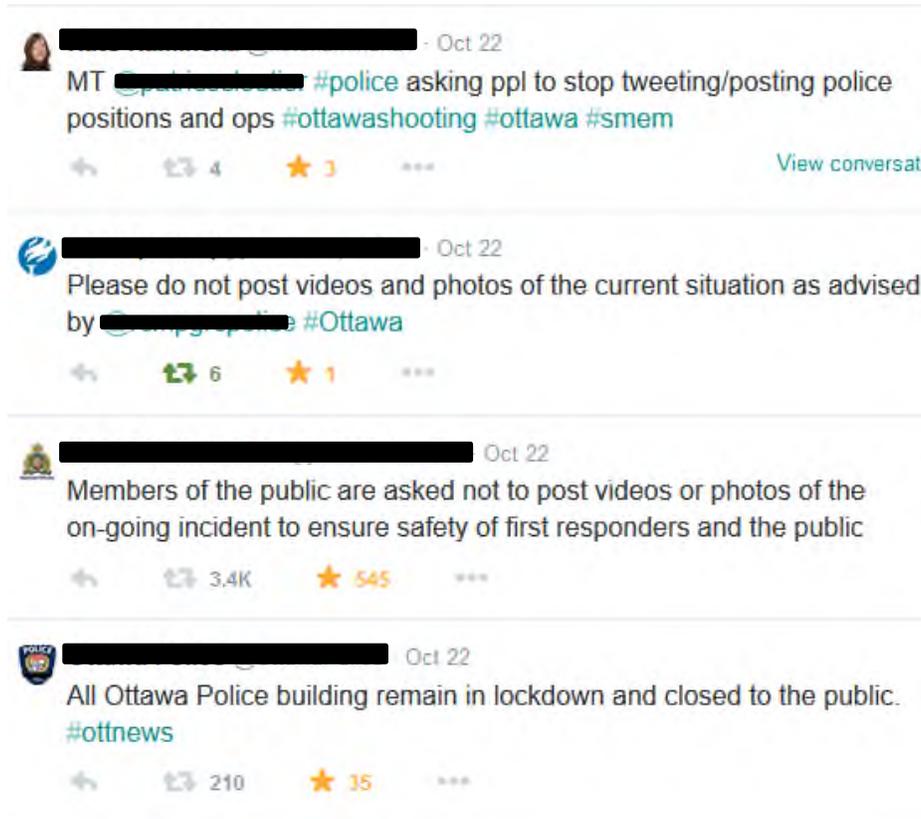
Unlike Facebook, a Twitter account is public by default, which enables other Twitter users to follow the account (“followers”) and which makes the user’s messages (“tweets”) public, one reason why Twitter was the chosen platform for Piu. If a user decides to create a private account, then they control their followers, and thus who sees the tweets they make. Tweets from private accounts are non-public and unsearchable; most Twitter users, however, avoid this option.

When posting content on Twitter, users are limited to tweets of 140 characters or less, which may include photos and the user’s location. The ease with which tweets can be posted has made Twitter a place where news events are likely to break first. For example, according to Brooks [13], “the first reports of Osama bin Laden’s death and the crash of US Airways Flight 1549 were made through Twitter”.

#### 2.3.1.2 Twitter During Emergencies

From the time of Twitter’s launch in 2006, people have used the service to tweet about catastrophic events such as disease outbreaks, police incidents, and natural disasters. The earliest of these uses came from the 2009 H1N1 flu pandemic [16], and the trend has continued through the years with the revolution and toppling of the Mubarak regime in Egypt in 2011 [17] and the Southern Alberta floods in 2013 (Figure 1.1, Figure 1.2). Most recently, we have seen

Twitter used by Islamic State of Iraq and Syria (ISIS) as a propaganda tool [9,45], and by both the police and citizens during the 2014 shootings on Parliament Hill, in Ottawa, Canada (Figure 2.2).



**Figure 2.2 – RCMP and Ottawa Police tweets from October 22, 2014**

Some research on social media use in emergency management response have focused on the best practices of using social media [39], including how people can format tweets [61] to enable both the sharing and extracting of information from tweets. When it comes to social media analytics for Twitter, a popular focus has been to perform sentiment analysis [3,16]. These are both interesting avenues to explore, however automated approaches to assessing tweets fail to adjust when the context of an emergency changes. How can we build a tool that

can support a human process and assess tweets as emergency events unfold so that they may communicate with their EOC colleagues better? These is a questions that this thesis attempts to address.

## **2.4 Twitter Analytic Tools**

There are a number of tools that organizations use to monitor and analyse tweets, such as Hootsuite<sup>8</sup>. Hootsuite is a web-based tool supporting users through features such as scheduling tweets to be published, tracking how tweets are retweeted, and the ability to track other users and their tweets. A number of these features help companies and organization measure the effectiveness of marketing campaigns, measure brand value, and understand the virality of their tweets. Hootsuite also provides a dashboard that allows its users to monitor accounts from other social media accounts, including LinkedIn<sup>9</sup>, Instagram, and Facebook. While there is a fee-free version of the tool, the tool's more advanced features are available in a paid version of the tool. Hootsuite was one tool used by the City of Calgary during the 2013 floods.

Another popular product to manage Twitter accounts is Tweetdeck<sup>10</sup>, a tool that provides many of the same features as Hootsuite. However, Tweetdeck if fee-free and as a Twitter-owed tool they do not provide the ability to integrate with third-party sites like Facebook and Instagram. Both these tools require users to setup dashboards, campaigns, or

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<sup>8</sup> <http://www.hootsuite.com>

<sup>9</sup> <http://www.linkedin.com>

<sup>10</sup> <http://www.tweetdeck.com>

follow users before that information becomes available to the organizations, however not all organizations, cities, or towns have the staff necessary to setup and monitor these tools.

#### **2.4.1 Twitter Analytics for Emergencies**

A growing phenomena to monitor social media during emergencies, where the city or town does not have the capacity, is the mobilization and use of a Virtual Operations Support Team (VOST). In Canada, the Canadian Virtual Operations Support Team (CanVOST) is a group of volunteers that “will support emergency management agencies and other organizations by monitoring social media (or conducting active social listening) to gather operational information and assess the situation and needs of communities/citizens affected by incidents/emergencies” [53]. During the 2013 Southern Alberta floods, the Canadian Red Cross engaged CanVOST for a limited time to support its operations [36]. Through the use of a VOST, there needs to be a mechanism, either through the VOST or in conjunction with the city or town, to understand the rules of engagement so that incorrect information is not shared on social media channels.

#### **2.4.2 Real-Time Twitter Analytics for Emergencies**

Different real-time systems have been proposed to both detect disasters and notify citizens. Sakaki *et al.* [57] proposed a way to detect earthquakes and to estimate the earthquake epicentre in Japan. The Australian Government Crisis Coordination Centre developed Emergency Situation Awareness – Automated Web Text Mining (ESA- AWTM) to create situational awareness among those affected by an emergency incident by collecting Australian tweets [14]. Twitcident [1] is a framework and web-enabled system for filtering, searching and analysing real-world incidents or crisis by integrating with the national emergency broadcasting service in the Netherlands.

Ushahidi<sup>11</sup> is a crowd-based system originally based on the collaboration of citizen-journalists in Kenya during crisis. Originally Ushahidi mapped incidents of violence and peace efforts throughout the country based on reports submitted via the web and mobile phones. TweetTracker was designed to focus on features useful to humanitarian aid and disaster relief organizations for monitoring and analyzing pertinent tweets from different perspectives [41]. CrisisTracker [56] is a real-time online system that automatically tracks Twitter keywords and constructs stories by automatically clustering related tweets with the expectation of capturing distributed situation awareness reports during emergencies. CrisisTracker notably mentions the evaluation of the tool with experts, however they fail to provide information on the experts' profiles. Artificial Intelligence for Disaster Response (AIDR) [35] is designed to perform automatic classification of crisis-related tweets using natural language processing techniques, and then attempts to use crowdsourcing in real-time.

## **2.5 Conclusion**

The systems and research cited in this chapter have focused on both real-time and post-mortem analysis of social media and Twitter data. However, there is a gap in research where emergency experts are engaged in the design of these real-time social media analytic tools, and few studies have been run that evaluate the implementation with intended end-users. In this thesis, I examine the design of a real-time social media tool informed through discussions with emergency experts, and I then evaluate the tool by a diverse set of emergency response personnel.

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<sup>11</sup> <http://www.usahidi.com>

## Chapter Three: ePlan Multi-Surface

As mentioned in earlier chapters, emergency response planning is a multi-stakeholder process that aims to prepare people to deal with real emergencies when there are numerous input sources including social media, police and traffic cameras, and personnel in the field. Communication with these groups takes place concurrently, and may involve different channels to exchange information artefacts.

ePlan Multi-Surface is a prototype for emergency response planning exercises that uses multi-surface environments to support communication and collaboration. The prototype was built through a partnership between the Agile Surface Engineering (ASE) group at the University of Calgary and C4i Consultants Inc.<sup>12</sup> (C4i), a military and emergency response simulation software company also based in Calgary, Alberta, Canada. I was a member of the team working on this prototype when the 2013 Southern Alberta floods hit Calgary and surrounding areas.

Though social media formed a small, passive component of the ePlan prototype, the use of social media during the floods provided me the opportunity to explore how the active assessing and filtering of social media could be explored in my thesis. Eventually, a modified ePlan, detailed in this chapter, served as the prototype to elicit requirements from a group of emergency management experts. While more information on the requirements elicitation process is detailed in Chapter 5, the remainder of this chapter delves into the technical components of ePlan shown to the experts.

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<sup>12</sup> C4i - <http://www.c4ic.com/>

### **3.1 ePlan Multi-Surface**

ePlan Multi-Surface comprises five components: C4i's ePlan desktop simulation engine, which drives the simulation; a tablet application that provides users a private area in which to work; a tabletop application that provides users a semi-private area to work and collaborate; Microsoft Kinect and server; and a wall display application that acts as an information radiator for creating and maintaining situational awareness.

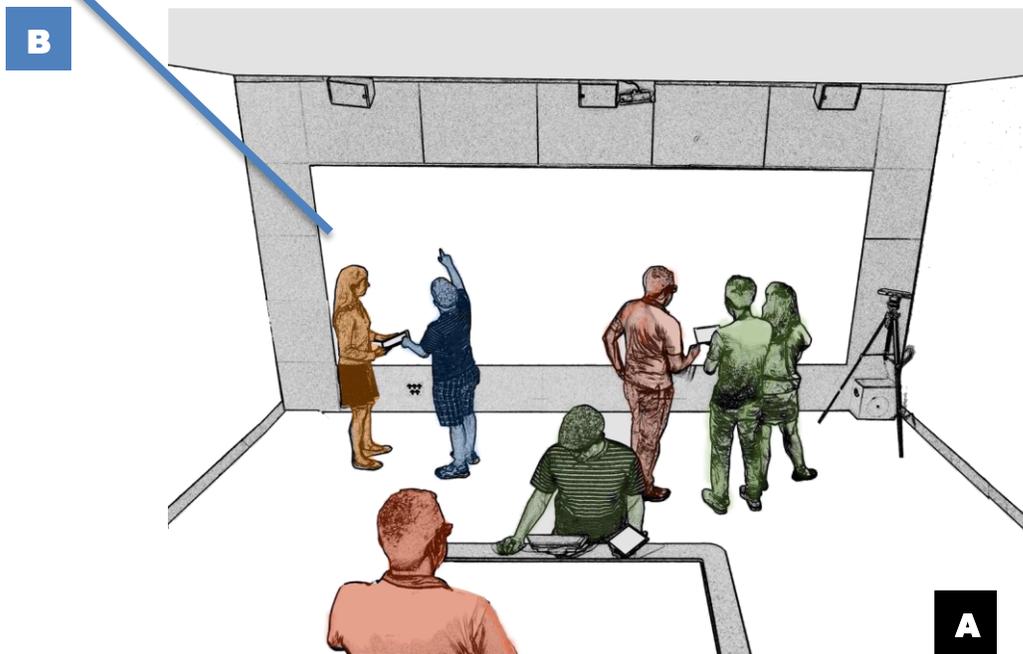
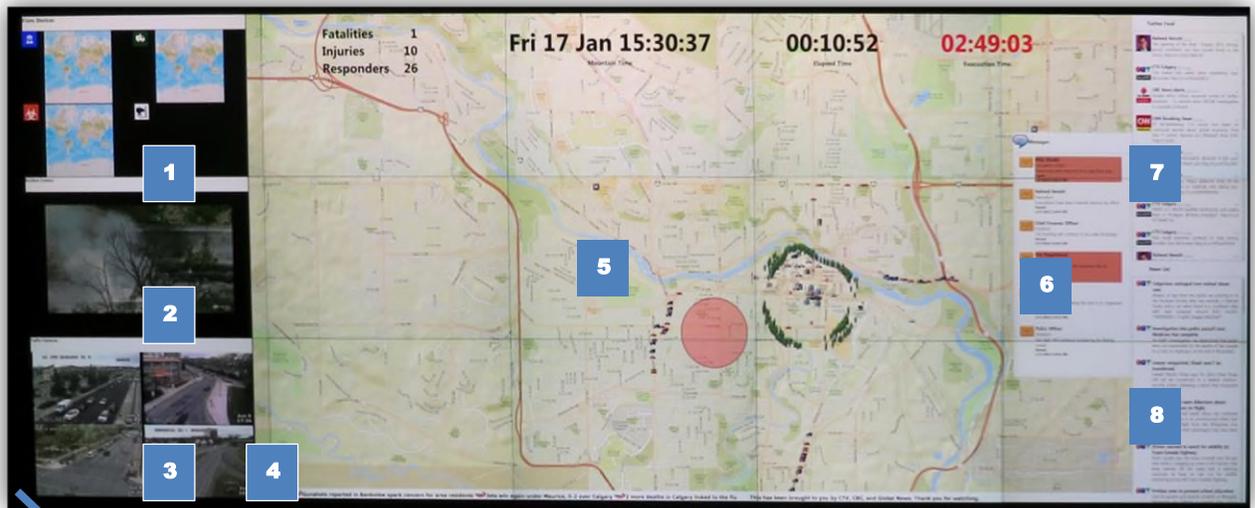
### **3.2 Wall Display Application**

This application consolidates information from eight different sources on a high-resolution wall display, and it was inspired by CEMA's EOC (Figure 1.3, Figure 1.4,). In CEMA's EOC, there are three large screens at the front of the room that display multiple sources of information (cameras, GIS, social media, desktop computer sharing). Given the information displayed, their location, and prominence, the screens can assist in creating or maintain a COP.

Figure 3.1A shows how a room could be configured with *ePlan Multi-Surface*, and

Figure 3.1B shows eight information sources for the wall display application:

1. Shows the areas under review by the three iPad applications;
2. Represents a camera showing a live-feed from the incident zone;
3. Represents the area where traffic cameras are live-streaming into the EOC;
4. A ticker showing news headlines from the area;
5. The map overview showing the entities (people, buildings, vehicles, etc.) from C4i's software along with annotations and other information shared from the tabletop and/or iPad applications;
6. Shows messages that have been received by the EOC



**Figure 3.1 – An overview of ePlan MultiSurface**

- 7. Shows a Twitter feed from people or organizations followed by the organization; and,
- 8. Detailed information about news items that are scrolling through in (4).

The wall display is used as an information radiator to share factual information about the situation, and the agreed upon plan to assist the creation and maintenance of the COP. I envisioned a wall display application as a central component to any proposed solution for assessing and filtering tweets, however I sought to ground this theory through conversations with EOC experts.

### ***3.2.1 Twitter Feed in Wall Display Application***

The situation described in Chapter 1 had the crisis communication team operating in a side-room to “ops”, and my envisioned system was a multi-display system which could have supported the work of the city’s crisis communication team. This system would therefore require two components: 1.) A primary interface supporting the analyst monitoring Twitter (or other social media streams) to filter and assess tweets, and 2.) A second interface that resides in “ops” which would support decision-makers by rendering the analyst’s filtered and assessed tweets.

### **3.3 Summary**

This chapter illustrated how ePlan’s wall display was modified to support the eliciting of requirements from emergency management personnel, some of whom who had not used Twitter during an emergency event. This modified prototype was run during the elicitation process using real tweets collected from the University of Calgary’s Bermuda Shorts Day 2014 (BSD).

## Chapter Four: Tweets from Bermuda Shorts Day 2014

Bermuda Shorts Day is an event which began in 1960 and is held annually on the University of Calgary campus. This end-of-term celebration marks the end of classes and is only open to students at the University of Calgary. In 2014, the campus concert had a capacity for 4400 people (Figure 4.1) [62]. This event involves the re-routing of buses and other traffic on-campus since the event occupies a prominent location on campus. The campus' risk and security group, the people who handle emergency operations on-campus, in-conversation indicated that this is their largest event, and holds potential as an event that they would monitor and analyze on Twitter, though they had yet to do this.



**Figure 4.1 – Bermuda Shorts Day (Courtesy University of Calgary)**

## **4.1 Bermuda Shorts Day 2014 (BSD 2014)**

BSD 2014 took place on Monday, April 14, 2014, and based on the interest shown by the campus' risk and security group, I collected tweets from April 8, 2014 until May 5, 2014. These tweets were collected looking for the keywords #bsd, #uofc, #yyc, #calgary, #ucalgary. During the collection period, there were multiple instances where the network connection or power was lost on the server running the tweet collection software. The tweet collection process by will be described in more detail in Chapter 4.

On Tuesday, April 15, 2014, citizens across the country awoke to the news that five university-aged students were killed in one of the worst murders in the City of Calgary's history [16, 18, 20, 29, 32, 45]. I was interested in understanding when and who was the first to report the crime, and to uncover any other details through Twitter that might help the risk and security group use Twitter for future events.

## **4.2 Twitter Analysis**

As I was prepared to meet the risk and security group to present results from the tweet collection, I analysed the tweets through the use of SQL operations and natural language processing tasks on the data, to understand what insights could be gained from a longer look at the tweets. From the timeline outlined above, I collected 1857 tweets using the custom-built tweet-collector.

### **4.2.1 BSD – Part 1**

For the initial tweet analysis, 1857 tweets were returned when I looked for the following combination of hashtags (#bsd OR #uofc OR #yyc OR #calgary OR #ucalgary) in the database, with only 310 (16.7%) tweets containing embedded media (video, pictures). Within those 1857

tweets, there were only 1546 unique tweets (approximately 300 tweets were retweets), and only 88 (4.8%) tweets were geo-tagged. Though the number of geo-tagged tweets seems low, this is actually higher than the “approximately 1% of all Tweets published on Twitter are geo-located [42]”. When analysing these tweets, it became obvious that #bsd captured many tweets not related to the campus event at the University of Calgary, but rather Berkeley Software Distribution<sup>13</sup>, a special term in the field of computer science. Therefore, I realized that data analysis needed to be adjusted.

#### **4.2.2 BSD – Part 2**

With the second pass through the tweets, I looked for tweets that matched the following criteria (#bsd AND (#uofc OR #yyc OR #calgary OR #ucalgary)), where the keyword #bsd was paired with one of #uofc, #yyc, #calgary, or #ucalgary. This criteria retrieved 371 tweets, with a higher percentage of tweets containing media, 73 tweets (19.7%). However, within the 371 tweets, a smaller percentage of tweets were geo-tagged ( $8/371 = 2.2\%$ ). As indicated above, this number is still higher than the Twitter average.

With the large number of tweets, an effective means of visualization was needed to quickly examine textual information. Word clouds are an example of textual visualization, representing the frequency a word appears relative to other words. Words in larger a font will have appeared more often than a different word appearing in a smaller font. I was interested in seeing what information would percolate from creating a word cloud of the top 10 words and

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<sup>13</sup> <http://www.bsd.org/>  
[http://en.wikipedia.org/wiki/Berkeley\\_Software\\_Distribution](http://en.wikipedia.org/wiki/Berkeley_Software_Distribution)

hashtags amongst the tweets. As shown in Figure 4.2, which highlights the top words from the tweets, without knowing the crime, it would be difficult to understand what precipitated the inclusion of words: 'families', and what incident pushed 'police' into the Twitter stream during BSD. While this is not a new revelation, it helped to create discussions with the group with whom I met at the University of Calgary, and will be described in more detail in Chapter 4.



**Figure 4.2 – Word cloud from top 10 words from BSD tweets**

In some ways, looking at a word cloud of the top 10 hashtags (Figure 4.3 ) was more interesting than the previous word cloud, which shows the top words from the tweets. Once again, without some context of the event, a newcomer to campus might not know that BSD has turned into one of the larger organized days of service (#dayofservice, #ucalgarycares), where

students volunteer their time to outside groups or agencies. Also, this word cloud shows the effectiveness of a campus campaign to promote sexual consent at this large gathering of university students (#consent). However, even though these two previous groups of hashtags might be known prior to the event, and thus a user could listen for them, the evolution of the event from a day of celebration to a time of mourning was not known beforehand, it evolved. The hashtag #brentwood was related to the off-campus neighbourhood in which the crime took place, and #rip and #wearealldinos were hashtags used as part of the grieving shared through Twitter. Clearly, the feelings of the campus community were not focused on an end-of-term celebration, but something more complex.



Figure 4.3 – Word cloud from top 10 hashtags from BSD tweets

### 4.3 Evolution of BSD Tweets

Based on the analysis above, I was motivated to understand how sentiments and opinions were shared through Twitter during the event. By manually reading through the 357 tweets, I found that I had retweets amongst my sample, and by removing them, I was reduced to 286 tweets to further understand. The general theme of these tweets could be categorized into seven groups: tweets expressing anticipation for the event, celebration of the event, the topic of sexual consent, mourning the lives lost, the topic of ending BSD, reminiscing about past BSDs and a neutral category that was a catch-all for those tweets which could not fit into the previous categories (Table 4.1).

While these seven categories are not perfect, and analysis by others may end up with a different category set, they serve the purpose to illustrate that people used Twitter to express a range of emotions during the build-up to the event, during the event, and then during the letdown from the event. To get a slightly better understanding of what the tweets looked like, please see samples in Table 4.1 below:

Emotion	Sample tweet
Anticipation	Gearing up for #BSD !! 🍷🍷 #party #drinks #ucalgary #unilife <a href="http://t.co/71Je6pL5La">http://t.co/71Je6pL5La</a>
Celebration	happy day-where-everyone-wishes-they-went-to-UofC #bsd
Consent	If you like it then you should ask permission for it. #ucalgary #BSD2014 #BSD
Mourning	U of C students - if you need to talk, support services are being offered at school #uofc #yyc #BSD <a href="http://t.co/MKadi4nMgh">http://t.co/MKadi4nMgh</a>

Emotion	Sample tweet
End BSD	Cancel BSD the increased sexual assaults, violence, binge drinking and public intoxication is enough. People over profits. #UCalgary #ableg
Reminisce	Third successful #BSD in a row 🙌❤️ #bsd2014 #beergardens #uofc #university <a href="http://t.co/4pCNMCDN8J">http://t.co/4pCNMCDN8J</a>
Neutral	████████ awesome pic! We are fortunate to have great #ucalgary volunteers like you! also #ucalgarycares #bsd #dayofservice

**Table 4.1 – Tweet categories with sample tweets**

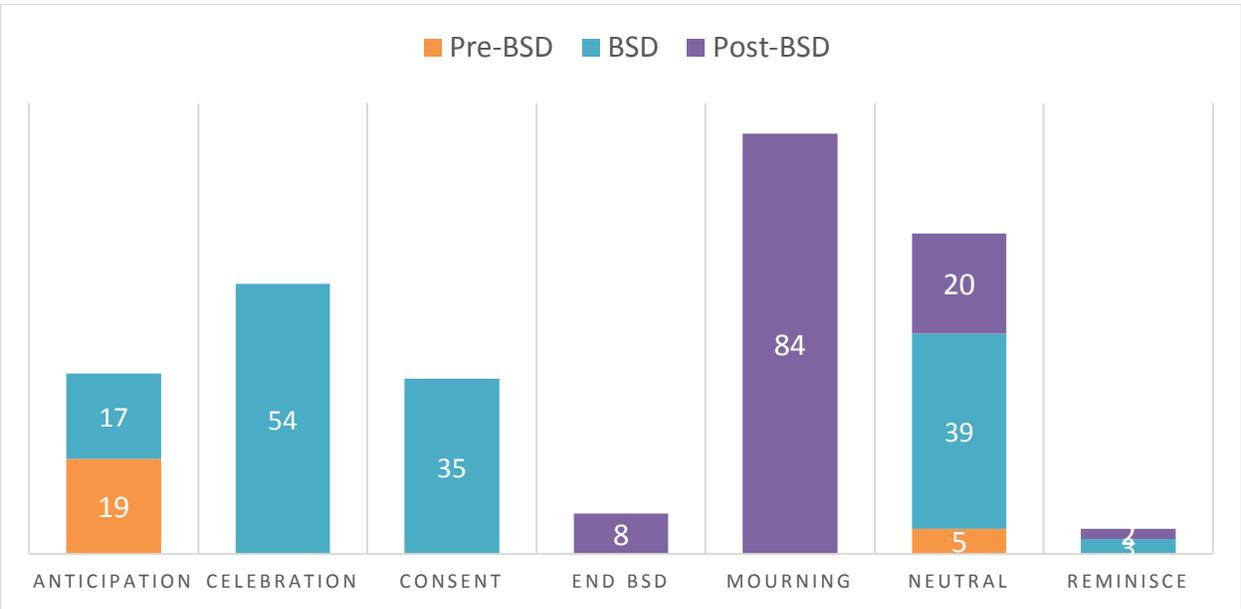
Unsurprisingly, a large portion of the tweets were related to people mourning and grieving the loss of life (29.4%), while the same is true for anticipation and celebration (31.5%). Prior to looking at the data, I was unaware of the active campaign on consent, nor that there were more people talking about ending the BSD event. This led me to further examine how the type of tweets evolved over the three periods of the event.

Emotion	# Tweets	Percentage
Anticipation	36	12.6%
Celebration	54	18.9%
Consent	35	12.2%
Mourning	84	29.4%
End BSD	8	2.8%
Reminisce	5	1.7%
Neutral	64	22.4%

**Table 4.2 – Overall categorization of BSD tweets**

Emotion	Pre-BSD		During BSD		Post-BSD	
	# Tweets	Percentage	# Tweets	Percentage	# Tweets	Percentage
Anticipation	19	79.2%	17	11.5%	-	-
Celebration	-	-	54	36.5%	-	-
Consent	-	-	35	23.6%	-	-
Mourning	-	-	-	-	84	73.7%
End BSD	-	-	-	-	8	7.0%
Reminisce	-	-	3	3 %	2	1.8%
Neutral	5	20.8%	39	26.4%	20	17.5%

**Table 4.3 –BSD categorization of tweets**



**Figure 4.4 - Evolution of BSD Tweets**

**4.4 Summary**

Without having access to 100% of the tweets during BSD, it is difficult to determine whether Table 4.3 and Figure 4.4 are representative of how people were sharing their feelings about BSD. As mentioned earlier, the seven categories may not be representative of how others

would categorize the tweets. However, even with these limitations, it was extremely useful to understand that no BSD tweets contained operational information of benefit to campus security, nor did Twitter break information about the murders as the first tweet collected was linked to a CBC News article (Figure 4.5). The analysis of these tweets supported the feedback collected during requirements elicitation, and through discussions during the evaluation that analysts using Twitter during emergency events are interested in sharing the mood or feelings of the population with the decision-makers.



**Figure 4.5 – First collected tweet related to BSD crime<sup>14</sup>**

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<sup>14</sup> <http://pbs.twimg.com/media/BIQ8BZRIMAAcIXC.jpg>

## Chapter Five: Requirements for Piu

*“If I had asked people what they wanted, they would have said faster horses.”*

*Henry Ford*

*“It’s really hard to design products by focus groups. A lot of times, people don’t know what they want until you show it to them.”*

*Steve Jobs*

As the quotes above suggest, getting ideas from users or potential users is not always possible or easy. One challenge I faced during my decade working in the private sector was to move beyond receiving simple, incremental features or ideas when engaging clients. I queried my clients to share their aspirations for the software, rather than convey features and functions that I could determine were technically possible. The client’s aspirations could then be used to feed the software development process when trying to determine whether a feature would meet the client’s current or future goals for their solution, thereby building a richer solution.

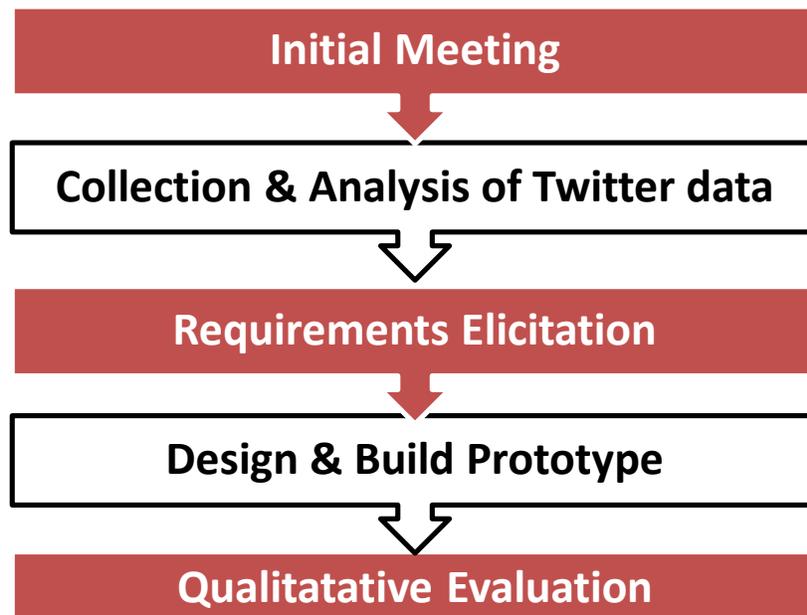
Placing users of the software at the centre of the software or design process is central to both the Agile software development process [8] and User-Centered Design [2], and users also play a central role in the more recent Lean Startup [55] model where features are assessed and iterated upon based on their utility to the user. Piu’s software development model was inspired by the three methodologies above, and can be seen in the simplified model in Figure 5.1.

When applying the methodologies above to software development, the users (clients) are either paying for the software development, or in the case of Airbnb<sup>15</sup>, who applied the Lean Startup model, there is a virtual unlimited pool of potential clients who could evaluate the

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<sup>15</sup> <https://www.airbnb.com/>

software. However, when developing Piu, a tool for emergency management personnel in an academic environment, user-involvement was voluntary and the pool of users limited. My first meeting, with CEMA took over a year to coordinate, whereas the first meeting with the University of Calgary took multiple months to coordinate. Secondary, follow-up meetings with both groups took multiple weeks / months to coordinate, and on more than one occasion meetings were cancelled due to conflicts with the client's paid work – emergency management is a volatile field where it is not easy to predict when and where the next event will take place.



**Figure 5.1 - Piu's Simplified Development Process**

The development model in Figure 5.1 represents the simplified process I followed to develop Piu. While it may look like a waterfall software development model as outlined by Lethbridge *et al.* [43], the Piu development process involved loops between the various stages. For instance, meetings with the end-users took place concurrently while Twitter data was being collected and analysed, and development was taking place while I was eliciting requirements

from users. In the development model in Figure 5.1, steps with white text involved the emergency management users whereas steps with black text did not involve the emergency management-users.

This remainder of this chapter describes a set of features for Piu, a real-time social media tool that supports an analyst filtering and assessing tweets in a two-interface system. The first interface is used by the analyst, and the second interface acts as a passive display and it resides with the decision-makers who may be operating in a separate location from the analyst. This thesis focuses on manual features that would empower an analyst to filter and assess tweets, rather than the automated features described in the tools in Chapter 2.

## **5.1 Development Process**

In this and subsequent chapters, I will detail the steps I followed while developing Piu. After my initial meetings with both groups, I altered the ePlan Multi-Surface wall display application, described in Chapter 3, to elicit Twitter-related analytic features for Piu. Each feature was broken into smaller tasks which I then assigned to myself or another developer. Through the requirements elicitation process, I determined whether to assign a high, medium, or low priority rating, and then based on my development experience I assigned a high, medium, or low implementation difficulty rating, and implementation effort rating to help with the both organizing and assigning the tasks. Then, after the features were implemented, Piu was evaluated through a pilot study with non-emergency management personnel, and a laboratory study by emergency management personnel.

**5.2 Initial Discussions**

After attending a public talk about the city’s experience during Southern Alberta floods, I reached out to the speaker to have a 1-on-1 interview. Instead, I was given a tour of CEMA’s EOC, and he proceeded to explain the details on how the city managed their social media communication during the flood. My supervisor reached out to members of the risk and security group on campus to understand if they would be interested in participating in my research work, and to understand their use of social media in their day-to-day work. Both discussions focused on what the user’s job responsibilities, how they dealt with past events, how they would deal with future events, any software they used to manage social media, along with any general thoughts.

**5.2.1 Expert profiles**

As the Table 5.1 highlights, the experts had, on average, twenty-two years of experience either working or training in emergency events. Furthermore, these users held a variety of positions in an emergency operations hierarchy, none were new hires, and thus were well-suited to discuss the operations of their groups or departments.

User	Years worked or trained in emergency events
User 1	18 years
User 2	25 years
User 3	35 years
User 4	30 years
<b>Average years of experience</b>	<b>22 years</b>

**Table 5.1 – Requirements elicitation users’ experience profile**

### **5.2.2 City of Calgary**

During discussions with the City of Calgary, I was told that future EOC software needed to be easy to learn and use, and I was offered as evidence that during the 2013 floods, personnel who did not normally work from the EOC were working there. Due to the nature of the emergency, there was little time to train people who do not normally work in the EOC on the complexities of their software. Emergencies are not the place to train people how to use software, however the lens of an emergency provides a mechanism to evaluate whether a system can be learnt through “shoulder surfing” whereby the pupil glances over their partner’s shoulder to understand the systems’ core features. *The ability to learn how to operate Piu through “shoulder surfing” became a primary core goal in developing Piu.*

Furthermore, the city representatives commented that the personnel managing the social media feed were not present in “ops” during the 2013 floods. Rather, the city’s crisis communication team worked in an adjacent room to “ops”, the area highlighted in Figure 5.2. With decision-makers working in “ops” and social media management taking place in a secondary room, the second core goal emerged to *create a system that would not require both the social media monitors and decision-makers working in the same room.*

This necessitates a client-server architecture where multiple clients, located in multiple locales would connect to a server that would distribute information to the clients. This feature was corroborated with the social media monitor from the University of Calgary, who shared during the evaluation study, that she monitored Twitter remotely from a friend’s house during the floods, and she would copy, paste, and email relevant tweets to the university’s senior

management. A client-server architecture would have enabled her to just select relevant tweets for sharing, and they would then be available to the university's decision-makers in real-time.



**Figure 5.2 – CEMA EOC (Courtesy CEMA/City of Calgary)**

### **5.2.3 University of Calgary**

During my discussions with the group from the U of C, they shared their interest in how students and the public would use Twitter for the upcoming on-campus event *Bermuda Shorts Day* (BSD). This served as the motivation to collect and analyze tweets from BSD which were discussed in the previous chapter.

None of these experts were active Twitter users, however through our discussions, it emerged that they would be interested in seeing a tool that could help them with analysing an incident or emergency after the situation arose. The post-mortem analysis of events allows the group to learn what they did right, what they did wrong, and what areas they could improve the next time if they are faced with a similar situation. *The third core goal for Piu is to create a*

*tool that supports the post-mortem analysis by collecting tweets so that the content can be analysed and replayed if necessary during a post-mortem.*

#### **5.2.4 Summary**

Through the initial discussions with the city and the U of C, three goals emerged through the conversations on how Piu should be built:

1. Piu interface should be learnable through “shoulder surfing”;
2. Piu should not require both the social media monitors and decision-makers working in the same room (separate interfaces for the two different user groups);
3. Piu should support post-mortem analysis.

#### **5.3 Requirements Elicitation**

Prior to meeting the groups for requirements elicitation, I modified the wall display application to ePlan Multi-Surface, which was introduced in Chapter 1. This prototype acted as a technological probe [34] to familiarize the users on possible features and functionality that could be implemented in Piu. As I was alluding to at the beginning of the chapter, the prototype served to open the users’ imagination on possible features for Piu.

##### **5.3.1 Alterations to ePlan Multi-Surface**

I made four minor modifications to the wall display application shown in Chapter 1 to aid in gathering requirements for a Twitter-based social media monitoring and assessing tool (Figure 5.3):

1. News headline ticker was removed;
2. List of messages received by the EOC was removed;
3. Detailed information about the news headlines was removed; and,

4. Live Twitter feed was expanded to the fit the full right-side of the application.

Finally, the wall display's Twitter component was programmed to display tweets collected from BSD 2014 (April 7 to April 18, 2014) to ensure that all participants experienced the same prototype simulating tweets collected during BSD 2014.

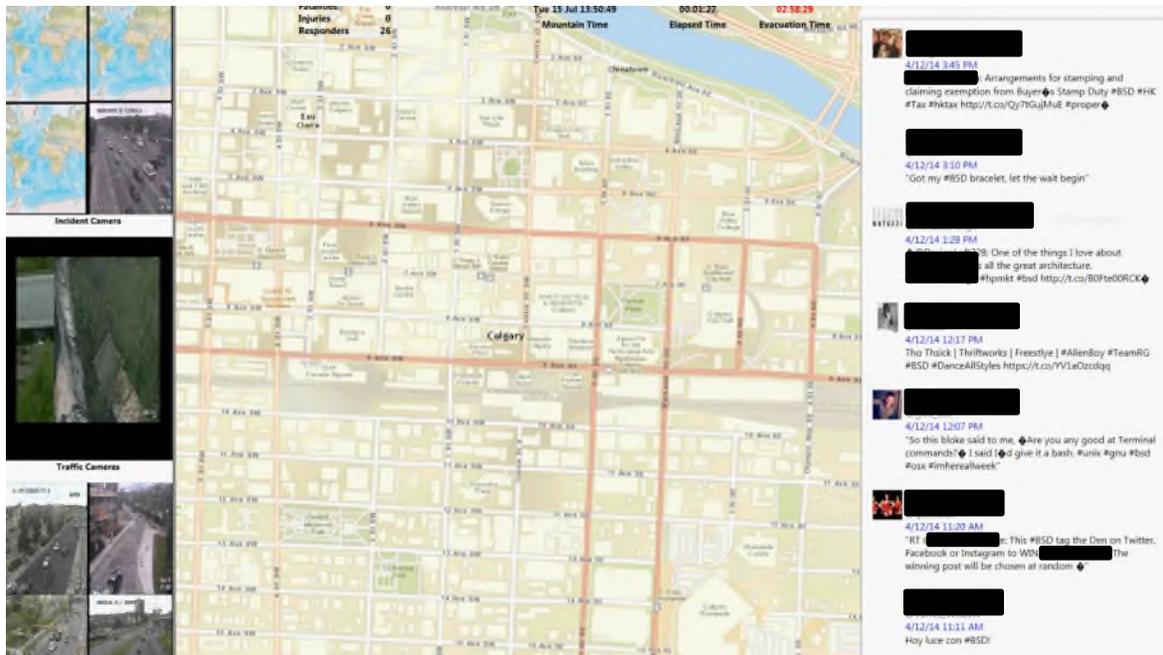
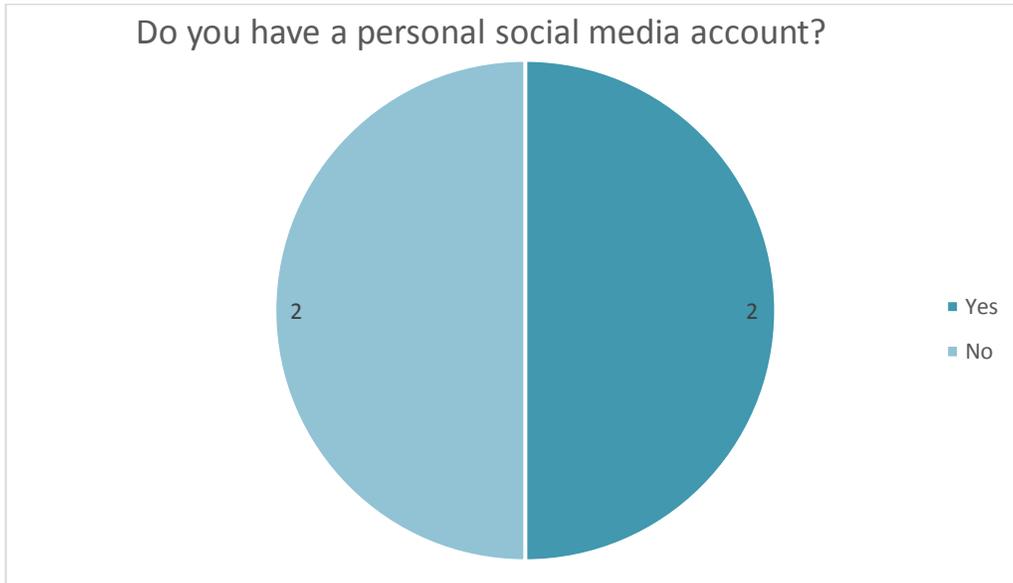


Figure 5.3 – Prototype Used During Requirements Elicitation

### 5.3.2 Expert social media profile

It is important to understand the social media knowledge and experience of the participants to provide context on the requirements they provided. While half (2/4) participants held personal social media accounts, they were all aware which social media accounts their companies held, this differs from the users who evaluated the system-profiled in Chapter 5. The city has numerous Twitter accounts for the police department, roads department, and from 311, and the university has numerous Twitter accounts at both the departmental and faculty levels. Each of these accounts may have an audience slightly different than others, and it might

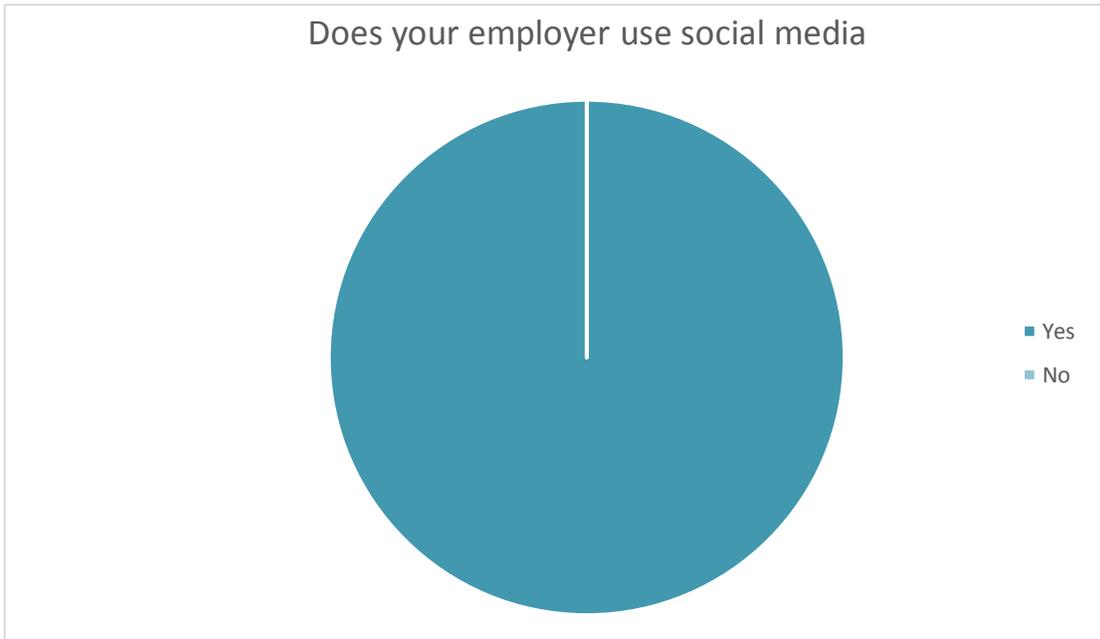
have been helpful to ask the participants if they knew more information about their company's accounts.



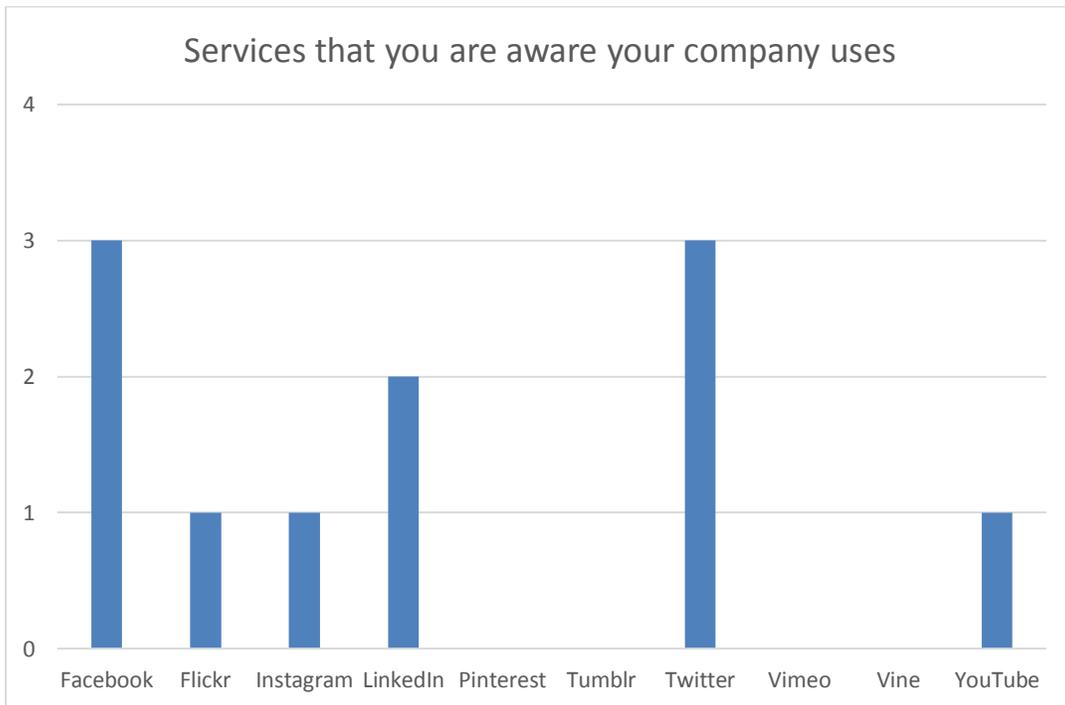
**Figure 5.4 – Personal social media accounts held by experts from the U of C and the city**



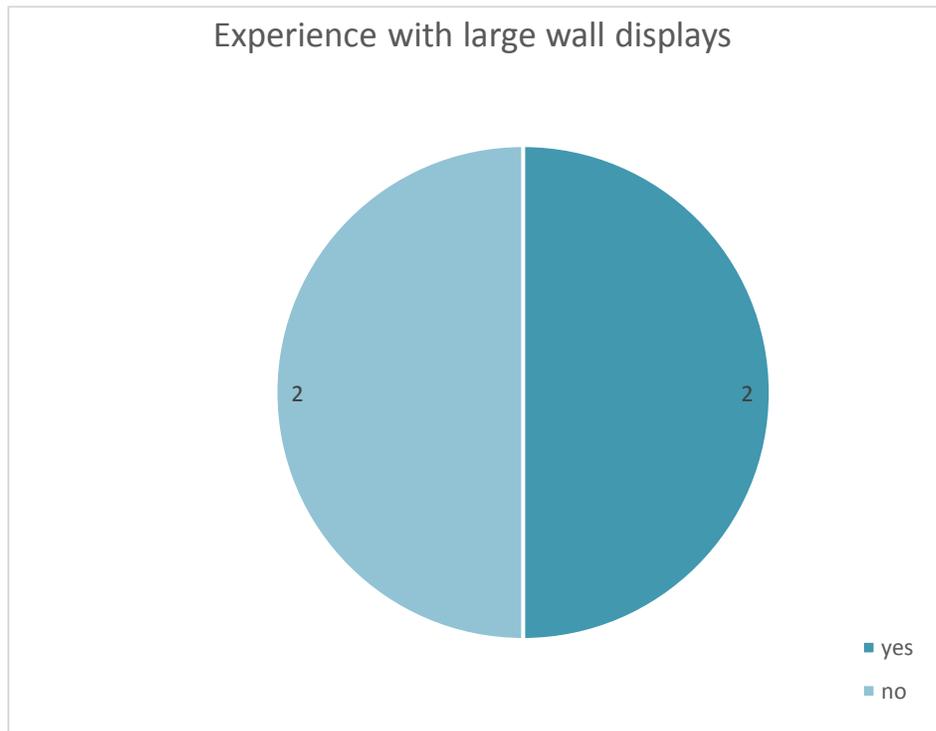
**Figure 5.5 – Personal social media use by experts from the U of C and the city**



**Figure 5.6 – Corporate social media use at the U of C and the city**



**Figure 5.7 – Corporate social media accounts at the U of C and the city**



**Figure 5.8 – Past experience with wall displays by users at the U of C and the city**

## **5.4 Feature List**

The following section describes features along with justifications provided by the participants. To aid with the implementation work – which may have included both server-side and client-side code, the features have been grouped into general areas.

### **5.4.1 General**

#### **5.4.1.1 System should be available in a training mode**

As mentioned in Chapter 1, live exercises and tabletop exercises are common for people working in an EOC to help them prepare for emergencies. And, the users felt that a tool should have an offline / training mode to ensure people had an opportunity to learn the tool and its features outside of an emergency event.

## **5.4.2 Twitter Trends**

### 5.4.2.1 Show 'top 3' trending word from Twitter stream

The users could not agree on the number of trending words to display, however they all agreed that it was valuable to see the words people were tweeting to better understand how and whether to update the Twitter keywords to track. This feature would aggregate word counts from all tweets, and should support adjusting when to reset the word counts.

### 5.4.2.2 Show word cloud of words mentioned in Twitter stream

Though the users agreed that there was limited value to a word cloud, there was general consensus that corporate executives enjoy seeing word clouds. Reasons given for this 'accessible analytics' is that, at a quick glance, someone can get an idea about the hot topics that people are discussing since the size of the word represents a proxy on the frequency that word was tweeted.

## **5.4.3 Map-related features**

### 5.4.3.1 When a tweet has been geo-located, display the location on a map

Though the majority of tweets do not include the location from where the person tweeted (geocoded), users wanted tweets that did include this information to be displayed on a map. The participants hoped that as more tweets were geocoded that it would be possible to see emergent behavior on hotspots around the city or campus.

### 5.4.3.2 Map should be visible along with tweets

In CEMA's EOC, the map is a central part of their GIS system, and maps are central part of emergency planning and response activities whether they are physical or digital. All parties mentioned the importance of maps, and that this tool should have a map as part of the system.

Participants from the U of C suggested that buildings on campus be listed and that the floor maps for these campus buildings be queryable.

#### 5.4.3.3 Analyze tweet text for street location

Though the majority of tweets are not geo-located, users sometimes include their location within the tweet. For instance, during Bermuda Shorts Day 2014 (BSD '14), a number of people tweeted about what they saw, and where they saw it. In Figure 5.9, a well-known landmark on the U of C campus is mentioned by its nickname – “Mac Hall”. The participants envisioned that the tool could decipher and place a pin on the map on Mac Ewan Hall (Mac Hall) at the U of C.



Figure 5.9 – Tweet containing geographic location<sup>16</sup>

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<sup>16</sup> <https://twitter.com/SpeakersBooth/status/454704621999509504>

#### **5.4.4 Twitter Timeline**

##### 5.4.4.1 Twitter keyword search terms should be updateable

When the tool is operating in live-mode, the user can track one or more keywords (e.g. #yyc, #nhl, #flames). In the instance where the user uncovers new words that they should track, this feature would allow them to alter “#yyc, “#nhl, #flames” to “#nhl, #isles”.

##### 5.4.4.2 Save or archive tweets

Tweets during an emergency, like BSD 2014, can arrive quickly, thereby making it difficult for a user to read all tweets as they arrive. After an emergency, personnel complete a post-mortem that includes details on the actions they took to understand what went well and what could be improved. Therefore, our participants wanted to ensure that Piu could save tweets to a database as they arrived. Furthermore, since Twitter allows users to delete tweets, this feature would permit the maintenance of an independent record when Twitter’s public record had erased them.

##### 5.4.4.3 Capture and store media while scroll is active

As seen in Figure 5.9, the user embedded a picture within their Tweet, but sometimes images are posted with secondary services, like Instagram – a photo sharing social media site – where the image cannot be displayed with the message; rather, the public sees a hyperlink they need to follow to see the image. As mentioned in 5.4.4.2, since users can delete tweets, images that were included with a tweet can be removed as well. Thus, the users wanted Piu to save images to a server – whether the image originated from Twitter, Instagram, Vine, or media-sharing website so that they could follow-up later, or to ensure their archive was not incomplete.

#### 5.4.4.4 Communicate directly with a user

If a Twitter user posted content of interest, the participants wanted to communicate with that user without having to rely on external tools or websites. This feature was already supported by Twitter through a feature called 'direct messages' where two Twitter users can have a private conversation. However, direct messages requires that both users are followers of each other.

#### 5.4.4.5 Track or follow Twitter users

As discussed in Chapter 1, Twitter users can follow one or more accounts to create a curated news feed, however during an emergency, where the user is receiving tweets by following keywords, the Twitter stream may uncover users that are not being followed. Thus, the participants wanted the tool to support the ability to follow or unfollow users so that all tweets coming from that user – even those that do not match the keywords – would arrive in the Twitter stream.

#### 5.4.4.6 Mute or unmute tweets from a specific user

Similar to email SPAM, Twitter has users who post content undesirable to others, and though the tweets match the keywords that the user wants to see, the content might be undesirable. Thus, the ability to mute a user temporarily (e.g. muting for 30-minutes, 1-hour) would make other tweets more visible to the user who is assessing and filtering tweets for the larger EOC audience.

#### 5.4.4.7 Remove tweets from a specific user

This feature is related to the one above, however with this feature, not only would be user be muted such that future tweets would not be seen, but also the tweet the user made would disappear from the main Twitter timeline.

#### 5.4.4.8 Save tweets for follow-up

In contrast to 5.4.4.2, this feature would allow the user to save a tweet while tweets are scrolling so the system's user would be able to see that tweet at a later time, possibly to take further action.

#### 5.4.4.9 Display icon if tweet is from a verified Twitter account

Twitter classifies some accounts, like those from celebrities, the mayor of Calgary, and others as verified indicating that the person (or organization) is who they say they are with the presence of an icon. This icon (●) would be displayed alongside the user's profile picture.

#### 5.4.4.10 Display image if the tweet contains one

When tweeting, users are able to embed photos with their tweets which are visible to users connecting to Twitter via a web client or smartphone application. This feature would permit Piu to render the same images onto the Twitter timeline if an image was included with the tweet.

### 5.5 Conclusion

This chapter opens with an overview of the development process used to develop Piu. The remaining sections describe the features and ideas shared by emergency experts through the "Initial Meeting" and "Requirements Elicitation" stages of the development process. However, before these features are enumerated, I established the qualifications of the

emergency management domain experts participating in these two stages. Three goals established by the experts which framed the feature list were:

- Piu's interface should be learnable through "shoulder surfing"
- Piu's two users (social media analyst and the EOC team) require separate interfaces
- Piu should support post-mortem analysis

Lastly, I enumerated the features requested for Piu along with their rationale.

## Chapter Six: Piu

In Chapter 2, I discussed prior work on the use of social media in emergency management along with some commercial social media monitoring tools companies and organizations are using today. In the last chapter, I described the development process I used when developing Piu along with the requirements elicited for Piu from emergency response experts at the University of Calgary and the City of Calgary.

This chapter outlines how Piu was built beginning with a description of the users whom Piu seeks to support. In subsequent sections, I discuss a possible usage scenarios outlined by the experts during the requirements elicitation process, where the scenario is supported through screenshots of Piu.

### 6.1 Piu User Interfaces

The first of Piu's three UIs was built for the analyst, the person performing the monitoring, filtering, and assessing – *Piu Monitors* (Figure 6.1). This UI could be used by crisis communications staff, social media employees working for the organization, or volunteer-based groups like CanVOST that may remotely monitor and assess social media during emergency events. The other two UIs, called *Piu Observers* and *Piu Word Cloud* (Figure 6.2), were built to support the EOC team who are not co-located with the analyst using Piu Monitors. The people using Piu Observers and Piu Word Cloud may include people working in a formal or informal emergency operations centre where these UIs update as the analyst filters and assesses tweets through the Piu Monitors interface.

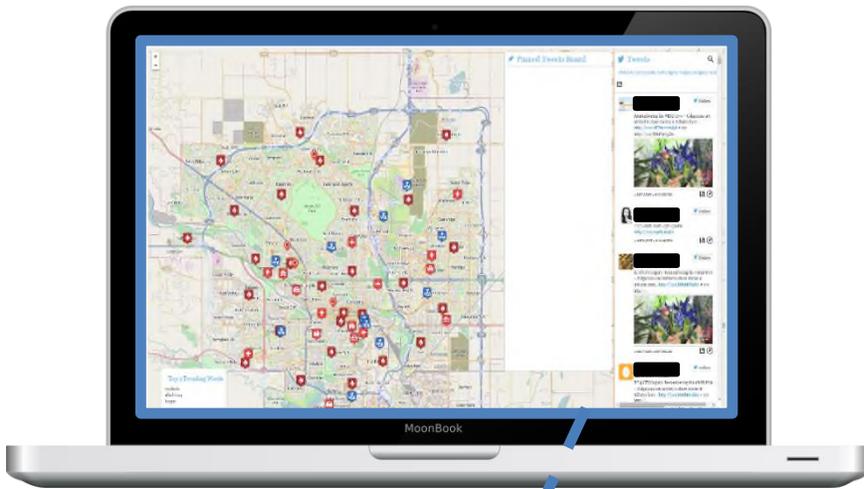


Figure 6.1 –Piu Monitors

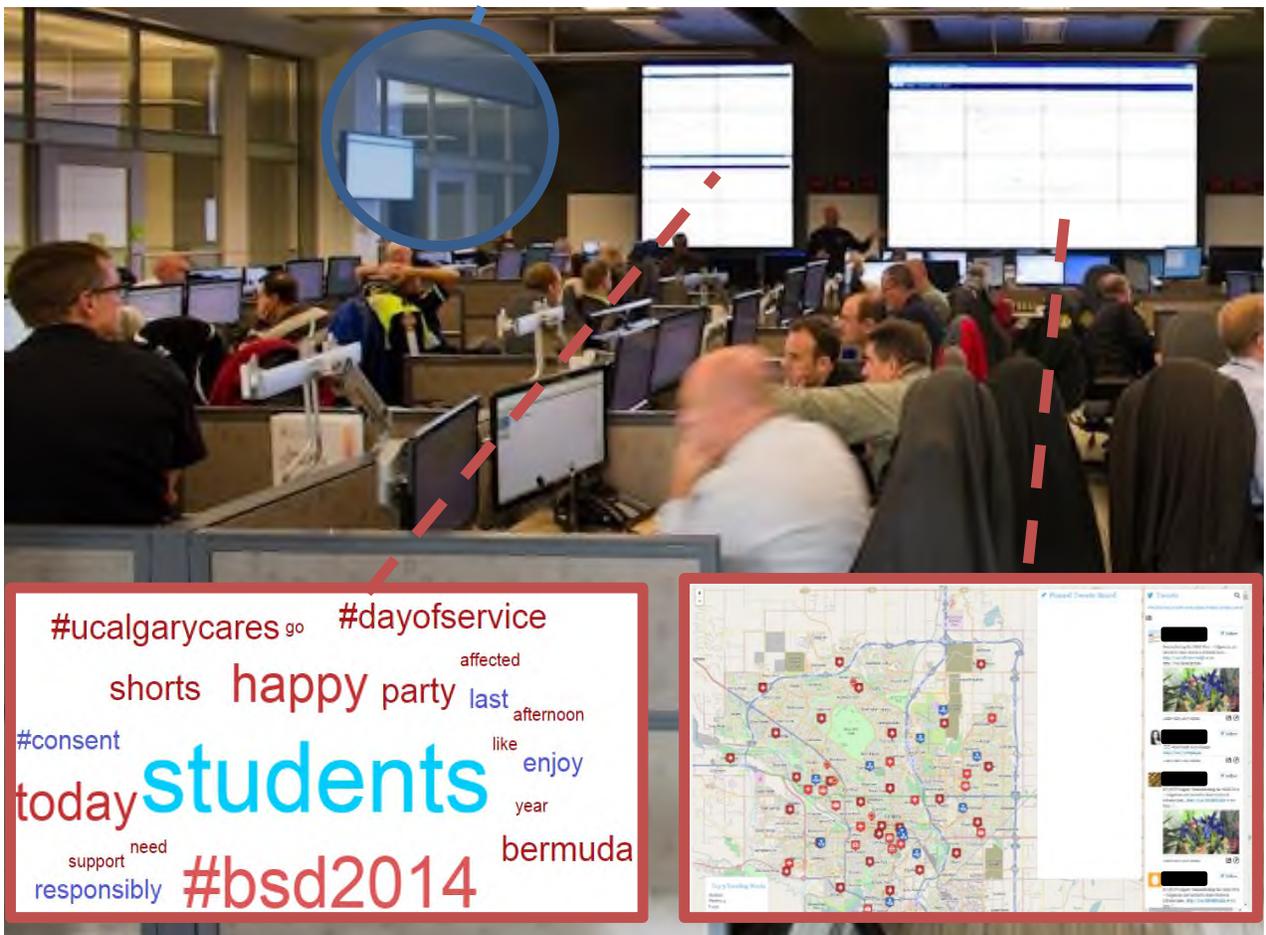


Figure 6.2 – CEMA mock up with Piu Observer and Piu Word Cloud

### **6.1.1 Feature difference**

Piu Monitors was designed to support behaviours initiated by the social media analyst. They are provided with the ability to control both what information is coming into Piu, through the maintenance of tracked keywords or training scenario. Once these tweets arrive into the system, the analyst is then able to determine how these tweets will be rendered on the two complimentary interfaces residing with the EOC team (Piu Observers and Piu Word Cloud). In comparison, Piu Observers and Piu Word Cloud reside with the EOC team who may not be able to dedicate their full attention to these interfaces as they deal with other information sources.

Piu Observer and Piu Word Cloud reflect the updates carried through on Piu Monitor by the analyst who may have determined relevant tweets upon which the EOC team should act. This is a key difference when reading through the scenario below as the EOC team needs mechanisms to understand what is happening at a macro level while the analyst is assessing the situation unfolding at the micro level. Thus, the features to see pinned tweets and word clouds of twitter words provides some information to the EOC team on what the public is sharing.

### **6.1.2 Usage scenario**

When a situation arises, the analyst launches *Piu Monitors* (Figure 6.3) and selects “Live” from the five options presented (Figure 6.4) from “Choose a scenario” (Figure 6.3A).

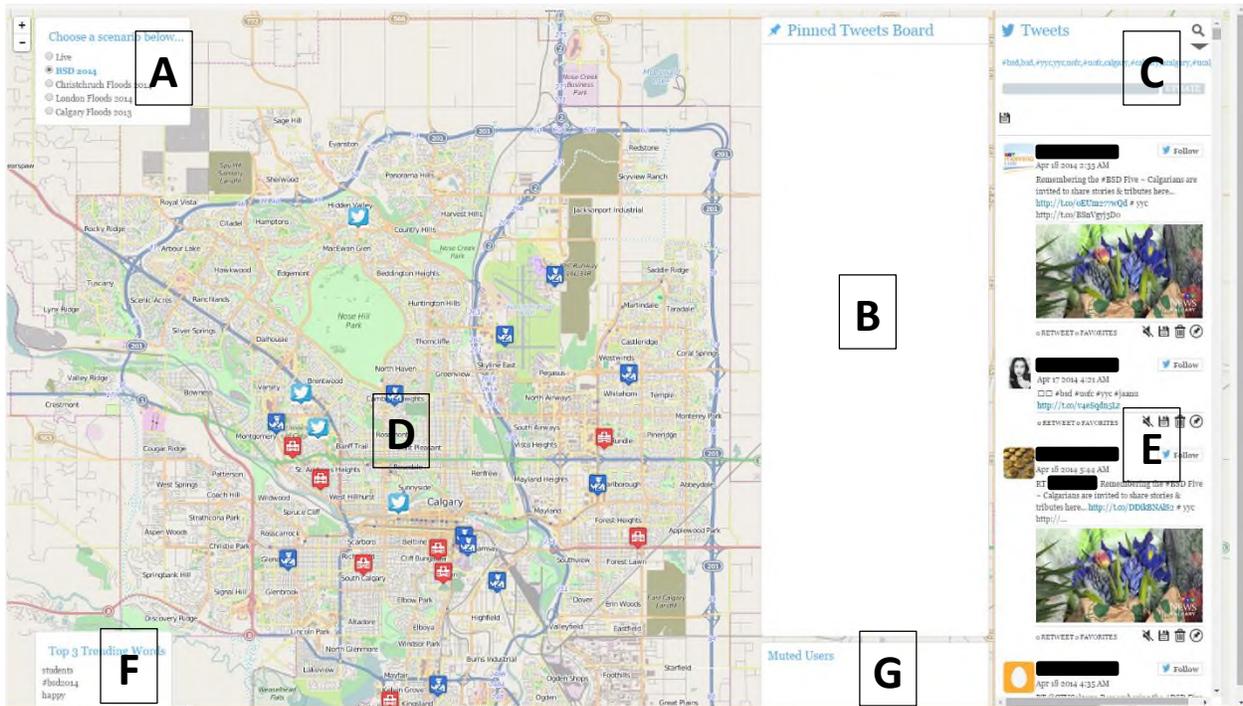


Figure 6.3 – Piu Monitors

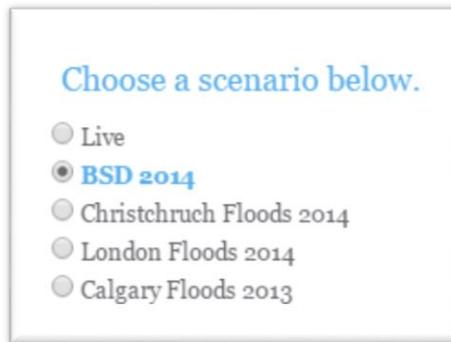


Figure 6.4 – Piu Monitors – “Choose a scenario”

Subsequently, the social media analyst enters one or more Twitter keywords to track in Figure 6.5B, and once the keywords have been received by the server, the list of active tracking keywords will update Figure 6.5A. Tweets begin to arrive simultaneously in *Piu Monitors* (Figure 6.3E) and *Piu Observers* (**Error! Reference source not found.B**). In some situations, like when tweets are arriving quickly, the social media analyst chooses to save all tweets to the database

by enabling the “record all” button (Figure 6.5C). While running in live-mode, the analyst may be tracking generic keywords like #yyc, however when an event like the 2013 Calgary floods occurred, new hashtags emerged, #yycflood being one. To facilitate this possibility, Piu empowers the analyst to update the tracked keywords by entering the new keywords in Figure 6.5B.



Figure 6.5 – Piu Monitors – Enter Tracking Keywords

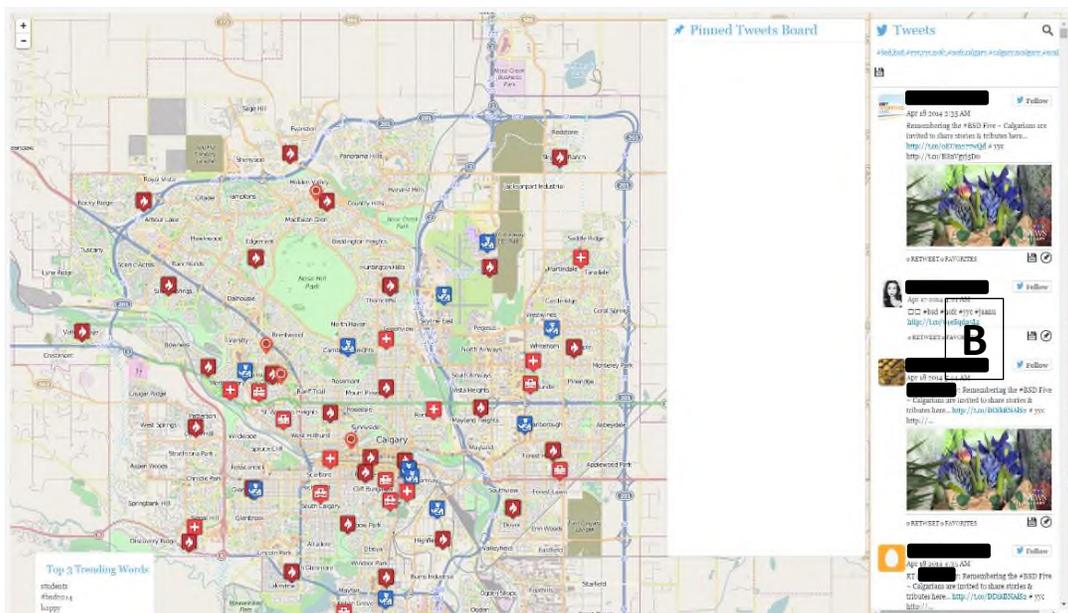
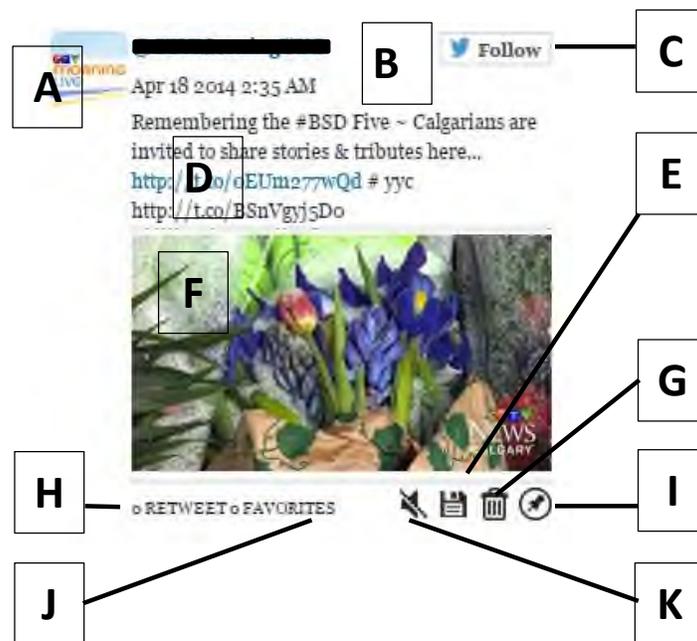


Figure 6.6 – Piu Observers



**Figure 6.7 – Tweet panel in Piu Monitors**

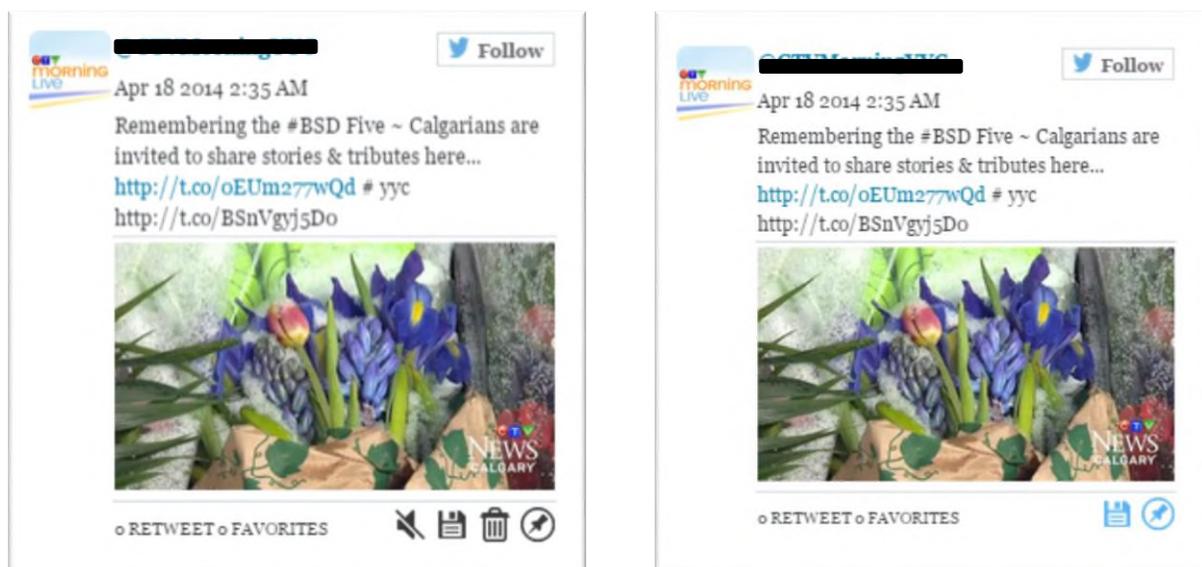
The Piu Observer interface cannot initiate filtering, thus the features are limited compared to Piu Monitors. As tweets arrive, they are displayed concurrently in *Piu Monitor* in *Piu Observer*, however the tweet panel in *Piu Monitors* displays buttons which can initiate actions (Figure 6.7) by the analyst.

### **6.1.3 Tweet Elements**

- A. The user's profile picture, and if the account has been verified by Twitter, the icon (●) appears below this image;
- B. The Twitter user's username;
- C. A button permitting the monitor to follow a user not being followed, or which permits the monitor to unfollow a user being followed;
- D. The tweet text;
- E. A button permitting the user to save the tweet to the database;

- F. The image the user may have included in the their tweet;
- G. A button permitting the user to remove the tweet from the timeline in Piu Monitors or Piu Observers;
- H. Text displaying how many times this tweet has been retweeted by others;
- I. A button permitting the user to save the tweet for follow-up;
- J. Text displaying how many times other users have marked this tweet as a favorite;
- K. A button permitting the user to mute any future tweets arriving from this user

As mentioned earlier, all buttons on *Piu Monitor* are clickable to support filtering and assessing, while the buttons in *Piu Observer* reflect actions taken through Piu Monitors. Figure 6.8 shows how *Piu Observer* (right) updates after someone clicks the button to pin and save a tweet in *Piu Monitor* (left). Secondly, since *Piu Observers'* tweet panel is not interactive, two buttons are not present in *Piu Observers* (Figure 6.7G, Figure 6.7K) .



**Figure 6.8 – Tweet Panels in Piu Monitor (right) and Piu Observer (left)**

As tweets continue to arrive, the “Top 3 Trending Words” area of Figure 6.3F in *Piu Monitors* change concurrently with the same area in *Piu Observers* as the server sends updates (Figure 6.9).



**Figure 6.9 – Piu – “Top 3 Trending Words”**

#### **6.1.4 Muting Users**

Some Twitter users post SPAM and include keywords that are being tracked. In those instances, the analyst using *Piu Monitors* can mute the user by clicking the button highlighted in Figure 6.10 to ensure that no further tweets from this person appear in the Twitter feed of both interfaces. If a user is muted, their Twitter username will appear in the area highlighted in Figure 6.11, and future tweets from this user will only re-appear once the monitor clicks on the username in Figure 6.11 to unmute the user.



Figure 6.10 – Tweet panel mute button highlighted

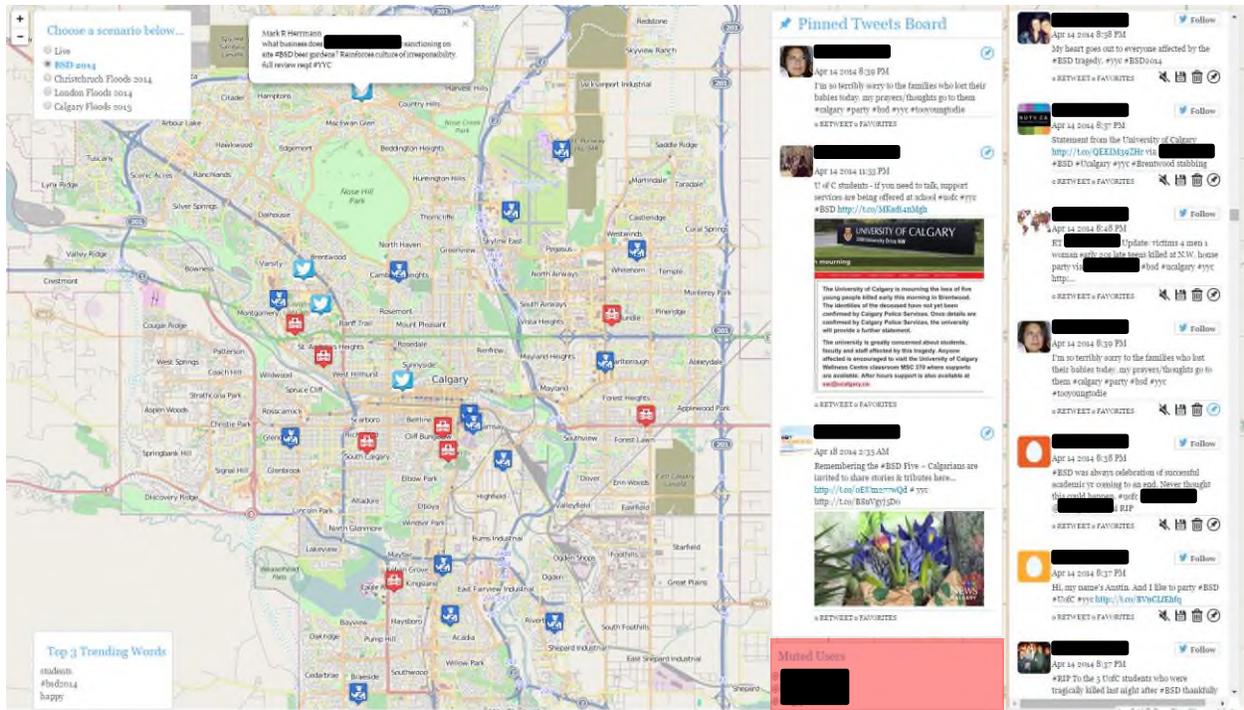


Figure 6.11 – List of muted users

### 6.1.5 Save Tweet to Database

Sometimes the analyst monitoring Twitter through *Piu Monitor* would like to save a tweet of interest to the database, or they may want to take a second look at the tweet when they have more time. *Piu* supports this behaviour through the “save to database” button highlighted in Figure 6.12. Once the button has been selected, both UIs update (Figure 6.13), thereby communicating to the EOC team watching Piu Observer that someone has initiated an action through Piu Monitor.



Figure 6.12 – Tweet panel from Piu Monitor with save to database highlighted



**Figure 6.13 – Tweet panel from Piu Observers with save to database activated**

#### **6.1.6 Delete Tweet from Twitter Feed**

Similar to the use-case described above to mute users, in order to remove a tweet from the Twitter timeline, the analyst using *Piu Monitors* clicks the button highlighted in Figure 6.14. During requirements elicitation, when describing this feature, the users indicated that this feature would both remove the tweet from the timeline and mute the user posting the tweet. As with muting users, in order to see future tweets from the user whose tweet was deleted, the monitor clicks the username to unmute the user. The deleted tweet will not re-appear if a muted user is unmuted.



Figure 6.14 – Tweet panel with delete tweet button highlighted

### 6.1.7 Pinning Tweets



Figure 6.15 – Button to activate tweet pinning

For every tweet that comes into *Piu Monitors*, the analyst can select tweets to “pin” (Figure 6.15). Once the tweet is pinned, both interfaces will populate a separate “pinned tweets” area (Figure 6.16) so that these tweets are not lost by newly arriving tweets. The pinned tweets area will display the last pinned tweet at the top with the older pinned tweets

appearing below it. When actions are taken on tweets, all relevant interfaces update so that users watching these interfaces can infer information about those tweets. For example, Figure 6.16 highlights a state of Piu Observer indicating that the highlighted tweet was pinned using Piu Monitor before the two tweets above it. Furthermore, this highlighted tweet is the latest one of interest since it appears at the top of the Twitter timeline.

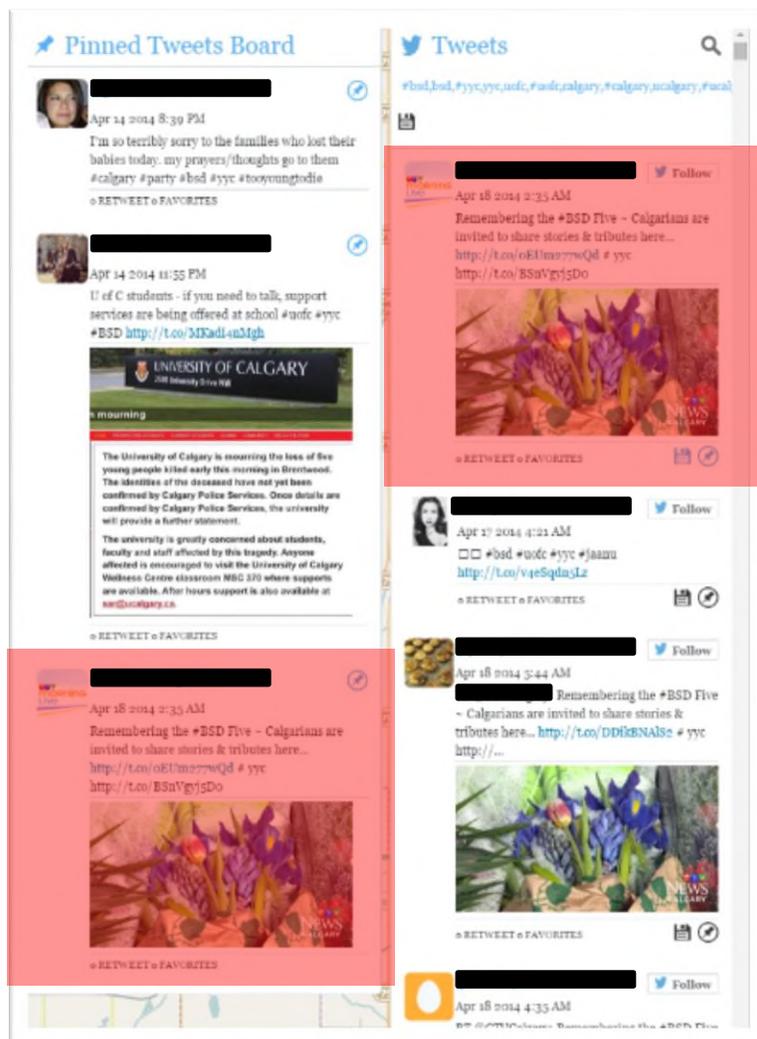


Figure 6.16 – Pinned tweets in Piu Observer

### 6.1.8 Geo-located Tweets

At times, tweeters include their current location when creating tweets, and Piu supports rendering the latitude and longitude of this location on the map (Figure 6.17), and by clicking the button, the user can see the tweet.

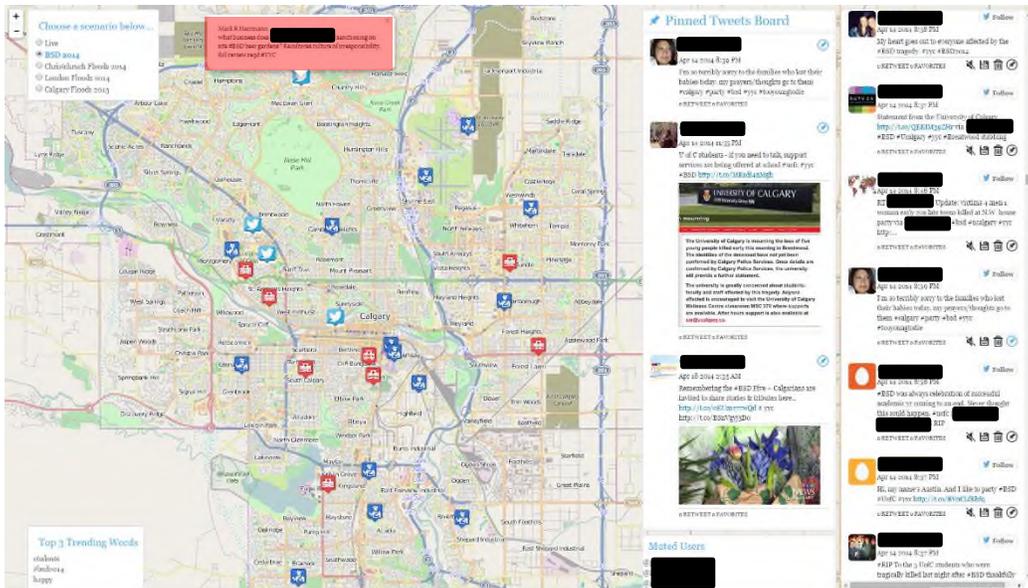


Figure 6.17 – Geo-located tweet in Piu Monitor

### 6.1.9 Piu Word Cloud

Similar in behaviour to “Top 3 Trending Words” (Figure 6.9), Piu Word Cloud (Figure 6.18) is a separate interface from Piu Monitor and Piu Observer that displays the top 20 words used in the tweets. The larger the font, the more frequent that word has appeared relative to other words in the cloud, with the word counting initiated from the time the scenario was selected by the user. Some users questioned the added value of a word cloud during the requirements elicitation, but they generally agreed that it is something that people with limited

time could observe and gain some insight. The analysis performed by the server excludes prepositions, pronouns, and conjunctions to focus on nouns, verbs, and hashtags.



Figure 6.18 – Word cloud from BSD 2014 training mode

## 6.2 List of functional and non-functional requirements

The last chapter’s requirements from city experts and U of C experts are summarized as a list of functional or non-functional requirements below. Functional requirements have been described by Lethbridge *et al.* [43] as “what the system should do ... they describe the services provided for the users and for other systems”, whereas non-functional requirements are “constraints that must be imposed on the design of the system”.

Before undertaking any development, the priority of each development task was determined through the requirements elicitation process while I determined the risk and complexity for each requirement based on my decade of development experience in the private sector. Each dimension ranked either low, medium, or high.

ID	Requirement Descriptions	Risk	Complexity	Priority
NFR1	The system should be learnable through shoulder surfing	Low	High	High
NFR2	The system should be operational remotely (accessible from another room, location, or city)	Low	High	High
NFR3	The system should support post-mortems (after-action) reports	Low	Low	High

**Table 6.1 – Non-Functional Requirements**

ID	Requirement Descriptions	Risk	Complexity	Priority
FR1	System should be available in a training mode	High	High	High
FR2	Show 'top 3' trending words from Twitter stream (live or training)	Medium	High	High
FR3	Show word cloud of words mentioned in Twitter stream (live or training)	Medium	High	High
FR4	When a tweet has been geo-located, display the location on a map (live or training)	Low	Low	High
FR5	Map should be visible along with tweets (live or training)	Low	Low	High
FR6	Analyse tweet text for street location (live or training)	Low	High	Medium
FR7	Twitter keyword search terms should be updateable (live only)	High	High	High
FR8	Save or archive tweets (live or training)	Low	Medium	High
FR9	Capture and store media while stream is active (live or training)	High	High	Low
FR10	Communicate directly with a user (live-only)	Low	High	Medium
FR11	Track or follow Twitter users	Low	High	High

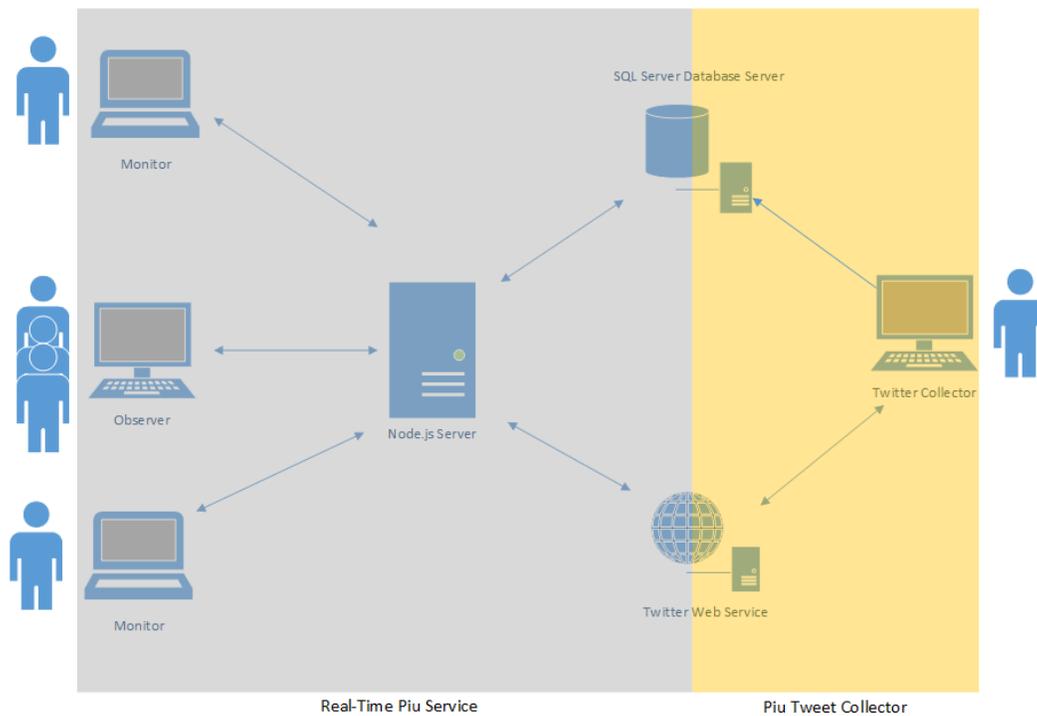
ID	Requirement Descriptions	Risk	Complexity	Priority
FR12	Mute or unmute tweets from a specific user	Medium	Medium	High
FR13	Remove tweets from a specific user	Medium	Medium	High
FR14	Save tweets for follow-up	Low	Low	Medium
FR15	Display an icon if the tweet is coming from a verified Twitter account	Low	Low	High
FR16	Display image if the tweet contains one	Low	Low	High

**Table 6.2 – Functional Requirements**

**6.3 System Architecture**

A couple of different options were considered when designing how the system was going to be developed, each of which had their own pros and cons. To support NFR2, I explored the idea of creating device-specific applications for different physical forms from a computer tablet versus desktop computer to support mobility, however coupled with this decision came the choice of platform (e.g. iOS, Android, Blackberry). However, with the limited availability of my experts, and the desire to gather feedback from the users as quickly as possible, I chose to implement the tool as a browser-based system that would be computer & platform agnostic.

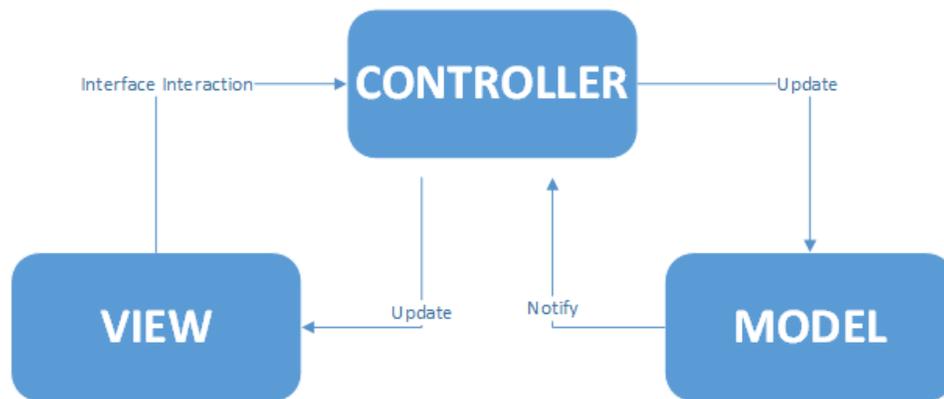
There are a number of different components to the system to support both real-time (FR7) and training modes (FR1). In Figure 6.19 below, the right-hand side of the application diagram shows the tweet collector which interacts with both the Twitter application programming interface (API) and the SQL Server database server. On the left-side of Figure 6.19, the real-time Piu service shows how multiple clients connect to one server that will retrieve information from both the Twitter API and the SQL Server database.



**Figure 6.19 – Piu tiered application diagram**

### **6.3.1 Model-View-Controller (MVC)**

The MVC architectural pattern was followed while building the system to separate the user interface from the other components of the system. This pattern helped with development and eventually maintenance of the system as the functionality of the different components listed above were separated into modules that were written independently. In an MVC design pattern (Figure 6.20), the users interact with the view, and it contains information on how the content should be rendered. The controller acts as a proxy between the view and the mode, transforming commands initiated by the user into calls to the model. Finally, the model receives requests from the controller, and then replies to those requests from the controller.



**Figure 6.20 – MVC diagram inspired by Apple (source [5])**

For instance, when the user clicks on the ‘save tweet database’ button, a command is sent to the server indicating which tweet is to be saved. Then, the server processes the request, and sends a command to the database server, where the tweet is saved. Once the tweet has been saved, a message is sent back to the webpage where the UI is updated to indicate which tweet was saved through a change in icon from an inactive state to an active state.

In subsequent sections, I will provide details on how the model, view, and controller were built to support feature development. Further, since I had help implementing the interfaces for Piu Monitor and Piu Observer, I will refer to work in those sections being performed by “we”.

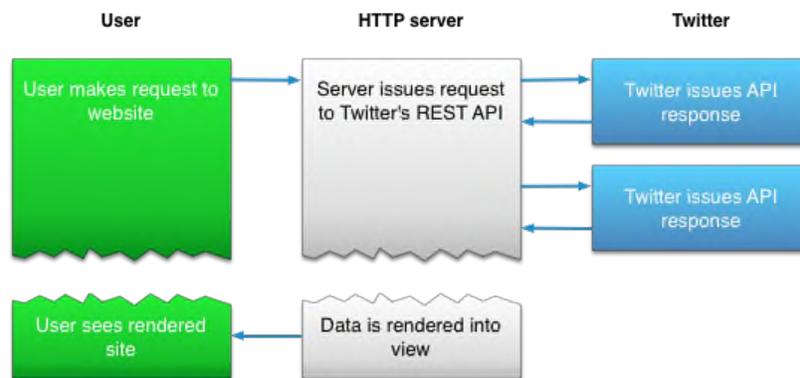
### **6.3.2 Twitter REST API**

Twitter provides two independent sets of APIs to access their data, a REST API<sup>17</sup> allowing users to search for tweets from the recent past, and where tweets are returned by the service as JavaScript Object Notation<sup>18</sup> (JSON), a text-based data format. When I sought tweets from BSD 2014, I set search parameters as “#bsd, #ucalgary, #yyc, #calgary”. As shown in Figure 6.21

<sup>17</sup> <https://dev.twitter.com/rest/public>

<sup>18</sup> <http://www.json.org/>

from Twitter [66], the user sets a series of search parameters, sends the request to Twitter HTTP server, and then Twitter will return a series of tweets in JSON that match the search criteria. For the Piu tweet collector, once this JSON data was returned, I processed them before saving it into a Microsoft SQL Server database (more information on the tweet collector will be found in section 6.4).



**Figure 6.21 – Twitter REST API diagram (source: [66])**

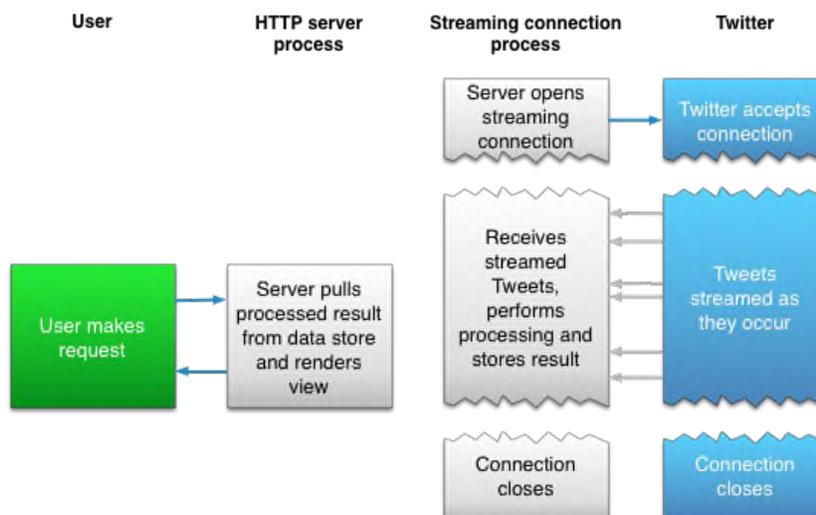
### 6.3.3 Twitter streaming API

Twitter also provides a streaming API<sup>19</sup> that allows users to set keywords that they would like to monitor, and then a tweet is returned by the service if and only if people create tweets that match those keywords. When looking at Figure 6.21 above, and Figure 6.22 below, the persistent connection that is present in Figure 6.21 does not exist in Figure 6.22. Compared to the REST API, tweets from the streaming API are returned as single JSON, and it is difficult to predict when Twitter will return tweets as the monitoring is taking place in real-time. Thus, when Twitter returns a tweet to my code in JSON format, I would save the data as files, and

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<sup>19</sup> <https://dev.twitter.com/streaming/overview>

after some processing it would be saved into a Microsoft SQL Server database (which will be described in more detail in the subsequent section).



**Figure 6.22 – Twitter streaming API diagram (source: [66])**

#### 6.4 Piu tweet collector

This prototype made heavy use of Twitter’s two APIs described above to retrieve tweets from four major events that took place recently – the 2013 floods in Calgary, Canada, the 2014 floods in Christchurch, New Zealand, the 2014 floods in London, England, and BSD 2014 in Calgary, Canada. Since this collector was not whitelisted by Twitter like the tweet collector at the University of Colorado’s Project EPIC (Empowering the Public with Information in Crisis) [4], as others have noted [38,67], we were limited in the number of tweets we could access by the Twitter terms of service (TOS).

Therefore, the process that follows cannot be assured to have received all tweets from an event; rather, I can only assert that I received tweets that were in compliance with Twitter’s rate limit policy, a policy that governs how many requests can be made to Twitter’s API within a

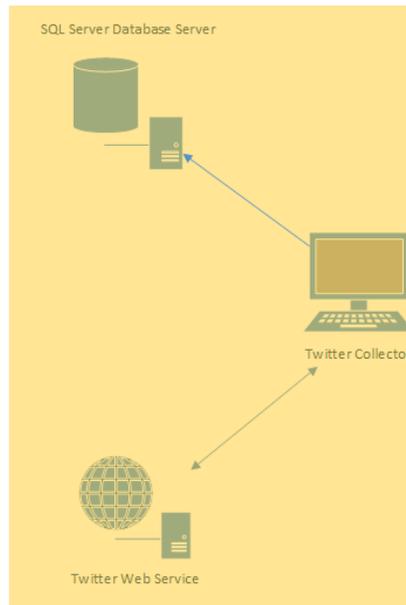
given period of time. As mentioned in Chapter 3, prior to the initial requirements elicitation meeting with the U of C and the city, I collected and analysed tweets from BSD 2014. To support this analysis, I built Piu tweet collector, a standalone application that could retrieve tweets through either Twitter's streaming or REST API.

The Piu tweet collector (Figure 6.23) is a Java-based desktop tool designed to retrieve tweets from both current and past events to build a picture of the tweets for an event. I used Twitter 4J<sup>20</sup>, a third-party Java-based library API for Twitter that has been around since 2007 to facilitate the connection to both Twitter's streaming and REST APIs. Using a third-party library APIs reduces the development effort since it provides more convenient ways to authenticate with Twitter, to setup search keywords, and to insulate the developer from changes to the underlying Twitter API. Twitter lists other library APIs online to aid development in other programming languages:<sup>21</sup> (e.g. ASP, C#, JavaScript, Objective C, and Python).

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<sup>20</sup> <http://twitter4j.org/en/>

<sup>21</sup> <https://dev.twitter.com/overview/api/twitter-libraries>



**Figure 6.23 – Piu tweet collector**

Since the Twitter streaming API and the Twitter REST API are independent, I was able to run the Piu tweet collector in parallel for events in Christchurch, London, and BSD, and this was facilitated by enabling the application to be run in either mode with two different set of parameters (see Appendix C for more details).

### **6.5 Database (model)**

As I begin discussion on the model, remember that the previous section outlined that the tweet collector was not whitelisted by Twitter, and as a consequence the database did not need to handle large, daily volume of tweets. Then, based on my prior experience and familiarity with the software, along with its availability in the ASE laboratory, I decided to use Microsoft SQL Server<sup>22</sup>. In assessing this choice, it should be noted that the tweet collector at Project

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<sup>22</sup> <http://www.microsoft.com/en-us/server-cloud/products/sql-server/>

EPIC, mentioned in section 6.4 was initially built using MySQL , another RDBMS (relational database management system), and only recently moved to Cassandra, a NoSQL database due to the 2 billion disaster-related messages they have collected since 2009, and also due to other operational decisions in running a highly-accessible system [59]; these features were not relevant for the Piu tweet collector.

### **6.5.1 Stored procedures**

The tweet collector gathered tweets from Twitter that matched a series of keyword combinations either through the streaming API or the REST API, and then these tweets were saved to disk. To support the insertion of tweets into the database, I decided to use database stored procedures for a number of reasons:

- To support saving tweets to the database from both the Piu Tweet Collector and the client browser (FR8), this allowed me to maintain code in one location;
- To decrease the likelihood of SQL injection – which can compromise the safety of my database; and
- To increase speed and optimization as stored procedures are compiled code that resides on the SQL server.

In both the Java code and the Node.js code, calls to the stored procedure are parameterized such that *integers*, *strings*, and *dates* are identified before executing the stored

procedure. This helps to eliminate security-related bugs like SQL injections<sup>23</sup>. For more information on how this was achieved, please look at the Appendix D.

### **6.5.2 Database tables**

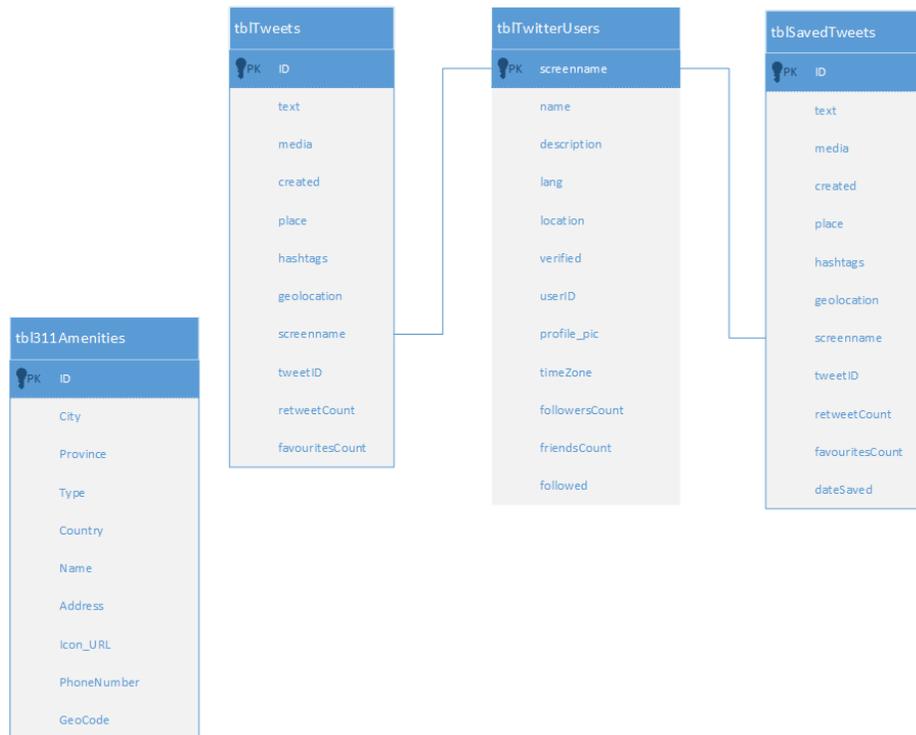
Based on the requirements for the tool, and the short development cycle, I kept the database structure simple with three main tables, and one ancillary table (Figure 6.24). Two main tables: *tblTweets* and *tblTwitterUsers* were populated through the use of stored procedures as outlined above, while the ancillary table *tblSavedTweets* is populated through the implementation of feature FR8.

The last main table, *tbl311Amenities*, supports the rendering of police stations, fire stations, hospitals, and emergency medical service (EMS) locations on the map. This table was populated for three cities: Calgary, Canada, Christchurch, New Zealand, and London, England, in two ways. For Calgary, the data was gathered from the City of Calgary's open data portal<sup>24</sup>, while Christchurch and London were populated through online searches for the emergency service locations above for the cities, and then the latitude and longitude for these cities was generated through Google maps.

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<sup>23</sup> [http://en.wikipedia.org/wiki/SQL\\_injection](http://en.wikipedia.org/wiki/SQL_injection)

<sup>24</sup> <https://data.calgary.ca/OpenData/Pages/DatasetListingAlphabetical.aspx>



**Figure 6.24 – Database diagram for Piu Emergency Operations Centre**

## 6.6 Client (view) & Server (controller)

The controller was written in JavaScript using three major third-party components to facilitate development: Node.js<sup>25</sup> as the base runtime supporting the creation of an event-driven, asynchronous application. On top of this base, we used Express<sup>26</sup> as a web-framework, and socket.io<sup>27</sup> to facilitate communication between the controller (server) and the view (browser client).

<sup>25</sup> <http://nodejs.org/>

<sup>26</sup> <http://expressjs.com/>

<sup>27</sup> <http://socket.io/>

The client was written using JavaScript and HTML using a number of JavaScript libraries: socket.io for communication with the server, Leaflet<sup>28</sup> for the embedded map, and jQCloud<sup>29</sup> for the word cloud.

Each functional requirement listed below (Table 6.3) has at least two parts – one related to the server (controller) and one related to the client (view). As shown in Figure 6.25, the client is connected to the server, and can initiate an action, like seeking the ‘top 3’ trending words from the server. The server which is already processing tweets from the Twitter web service processes the request from the client and performs computations, if necessary, before sending information back to the client. Finally, the client renders this information to the browser (and visible to the user).

ID	Requirement Descriptions
FR1	System should be available in a training mode
FR2	Show ‘top 3’ trending words from Twitter stream (live or training)
FR3	Show word cloud of words mentioned in Twitter stream (live or training)
FR4	When a tweet has been geo-located, display the location on a map (live or training)
FR5	Map should be visible along with tweets (live or training)
FR7	Twitter keyword search terms should be updateable (live only)
FR8	Save or archive tweets (live or training)
FR11	Track or follow Twitter users
FR12	Mute or unmute tweets from a specific user
FR13	Remove tweets from a specific user

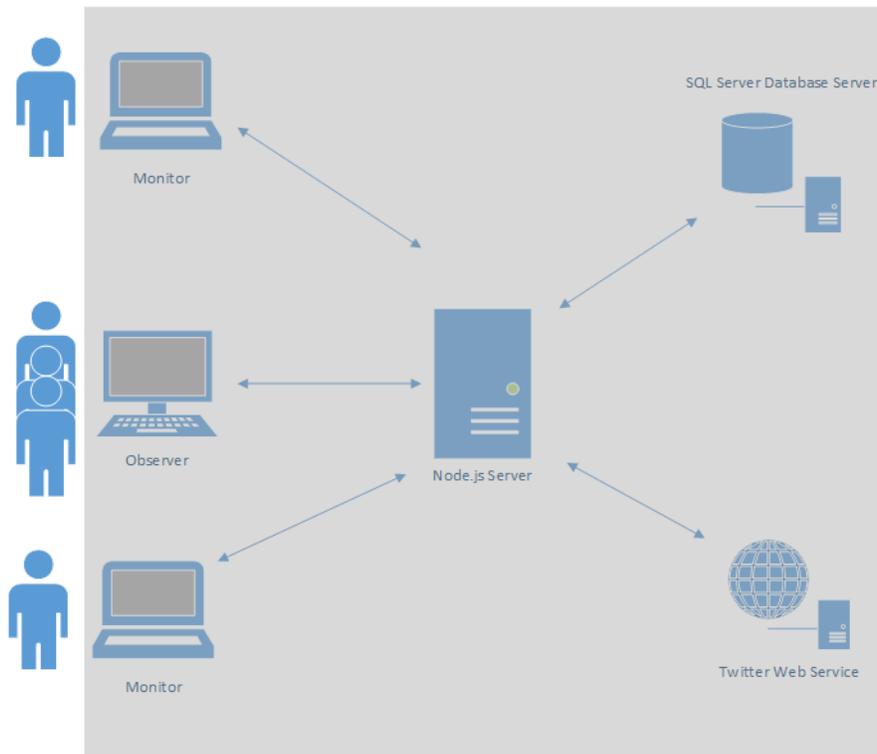
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<sup>28</sup> <http://leafletjs.com/>

<sup>29</sup> <https://github.com/lucaong/jQCloud>

ID	Requirement Descriptions
FR14	Save tweets for follow-up
FR15	Display an icon if the tweet is coming from a verified Twitter account
FR16	Display image if the tweet contains one

**Table 6.3 – Implemented functional requirements**



**Figure 6.25 – Real-Time Piu Service**

We were not able to implement every functional requirement elicited from the experts in the evaluated system due to time limitations and to ensure maximum stability for the prototype.

## 6.7 Conclusion

This chapter began by outlining the major difference between Piu's various interfaces, and this was followed by a description of the main use-case applied when developing Piu which helped ground the software development. I then moved into a description of the functional and

non-functional requirements in Piu. To support the multiple interface design of Piu, we used a mode-view-container system organization. The next chapter will outline how these tools were evaluated by a group of end-users.

## Chapter Seven: **Evaluation of Piu**

As outlined in the development process in Chapter 5, what follows next is the “Qualitative Evaluation” stage. A qualitative method was most appropriate for the type of tool we developed, for the tool’s development stage, for the data that was running through the prototype, and due to the study participants. There is no ‘right’ and ‘wrong’ way to evaluate how tweets are assessed and filtered as people will draw on their experience and roles to determine what they should share with others. Also, I was keenly aware that the twitter data was sensitive as it came from a public, national event where five university-aged students died [25,27,54].

First I performed a pilot study user evaluation of Piu, then incorporated changes from this study before conducting a laboratory study to evaluate Piu. The pilot study involved a group of non-emergency management personnel who provided general feedback on the look-and-feel of the tool, its learnability and they identified areas to be improved prior to the laboratory study. Remember, during discussions with the city it emerged that non-emergency management personnel were thrust into working in the EOC during the Southern Alberta 2013 floods. Thus, by performing a pilot study with non-emergency personnel, I gathered feedback from these potential users.

Once this feedback was incorporated, I conducted a laboratory evaluation of the tool with end-users from a variety of job responsibilities in the emergency management domain. This laboratory study sought to validate the design of the system, the prototype’s features, and

to plot the direction for future development. In both the pilot and laboratory studies, I used a similar setup to garner feedback on the prototype.

## **7.1 Study Goals**

In Chapter Five: Requirements for Piu, I discussed how I elicited features for Piu using interviews with emergency management experts, people with an average of 22 years of experience in the emergency management domain who either work daily in an EOC, or who would work in an EOC during emergencies.

During the 2013 Calgary floods, the city's crisis communication team operated in an adjacent room to "ops" within CEMA's EOC (Figure 7.1A) [Benjamin Morgan, personal communication, 2014] During both the 2013 Calgary floods and Bermuda Shorts Day (BSD) 2014 at the University of Calgary, the social media analysts for the U of C were not co-located with the emergency operations group (EOG) on-campus; rather they provided support while working remotely [Sarah McGinnis, personal communication, 2014]. The interface for Piu Monitor was designed to support an analyst assessing and filtering Twitter streams from one location (or room), while the companion interfaces, Piu Observer and Piu Word Cloud, were built to reside in emergency operations centres to support the EOC team; the interfaces were not designed to reside in the same room.



**Figure 7.1 – Location of crisis communication team during 2013 Calgary floods**

Furthermore, another of Piu’s design goals was to support learning by new users who could be thrust into supporting roles during emergencies, as was the case with City of Calgary crisis communication staff during the 2013 floods [Benjamin Morgan, personal communication, 2014]. Thus, a major design consideration for Piu was to support the research objective defined in Chapter 1.

*“Provide a set of “easy to learn” features for a real-time social media analysis tool from emergency operations experts.”*

Therefore, one of the study’s goal was to investigate the learnability of the interface from a diverse set of users. I sought evidence that Piu’s interface was easy-to-use through the participants’ hands-on experience with the tool. They were all given a short introduction on the tool’s major features, and they then assessed the prototype as tweets from the BSD 2014 training mode arrived onto Piu Monitor.

## **7.2 Pilot Study**

Pilot studies are normally performed before attempting a larger study so that poorly designed components are identified prior to engaging a larger audience in a study. A pilot study for Piu was especially important to validate its stability and performance under different conditions, and thus provide me confidence that Piu would run successfully throughout the study. The pre-pilot study was conducted after all features had been implemented and tested by the developers.

The primary aim for the pilot was to identify usability issues with the three interfaces (Piu Monitor, Piu Observer, and Piu Word Cloud) with four non-emergency management personnel. The secondary aim for this study was to gather feedback about the initial implementation.

These four individuals were asked to “click around” and explore the prototype, while providing their impressions while Piu was running in both live mode with the Twitter keywords “yc” and in the “BSD 2014” training mode for between ten and twenty minutes. They were setup in front of two monitors, with the main screen running Piu Monitors, and the other screen split between Piu Observer and Piu Word Cloud. They provided generally positive feedback on the look-and-feel, and its usability. They provided the following feedback, and where necessary their enhancements were addressed prior to conducting the main study:

### ***7.2.1 Clean look-and-feel***

All four users commented on the “clean” look-and-feel of the interface. Furthermore, they found the interface both intuitive and easy-to-remember. All users were enthusiastic about the word cloud. During BSD 2014, there are two spikes when tweets arrived quickly, and all users

commented that this spike made it difficult to keep pace reading tweets during those moments. During live mode, there were no comments on the tweet arrival speed.

### ***7.2.2 Number of words in Piu Word Cloud***

The initial design for Piu Word Cloud rendered all words that met a threshold onto the interface. However, the users commented that this made the interface busy, confusing, and unintelligible after the full run of the BSD 2014 training-mode dataset. A couple users mentioned that the word cloud, though pretty to see, would be easier to read with fewer words. After a series of conversations with the participants, I decided to set the maximum number of words to display to 20, and to make this a server-side configuration so that it could be easily adjusted.

### ***7.2.3 Synchronized UI controls***

Some buttons in Piu Monitor are also visible in Piu Observer – pin tweet, save tweet to the database, and follow or unfollow a user. The pilot users mentioned that they were confused that when they triggered a button on their interface, but they saw no change to the Piu Observer interface. To address this concern, button behaviours triggered on Piu Monitor were sent to the server so that all connected browsers using Piu Observer would see a change reflected in their UI.

### ***7.2.4 Live tweets during training mode***

One Piu feature is to follow or unfollow Twitter users. Prior to the pilot, any tweets arriving from followed Twitter users would be broadcast to both Piu Monitor and Piu Observer regardless of the mode (live or training). This behavior caused confusion for the pilot users who could not understand why they were seeing tweets from unconnected events – BSD 2014 and

tweets about current road conditions in Calgary. This behavior was removed from the training modes where the tweets came from the database, however the behaviour was kept for live mode where tweets were arriving through Twitter's streaming API. This means that Piu receives tweets on both Piu Monitor and Piu Observer from keywords being tracked along with people that Piu is following.

### **7.3 Main Study**

I primarily conducted the studies in a laboratory environment in which I held one-on-one evaluations of the tool, followed by an open-ended interview session. However, in a two instances, I performed a focus group to showcase the tool followed by an open-ended interview session, without direct hands-on evaluation by the participants.

In one instance, I performed the focus group at CEMA's EOC to a group of CEMA and city employees, whom I was unable to bring back for a one-on-one evaluation. In the second instance, I showcased the tool to two people from the U of C, however I was able to bring one person back to perform an individual tool assessment.

I investigated Piu's usability using a qualitative approach to address three questions:

- 1.) Did the participants find Piu easy-to-use?
- 2.) Did the participants find the features in Piu usable and understandable?
- 3.) Would the participants use Piu if it was made available to them in either their current role, or would they have used Piu if it were available during a past event?

There were two major goals of the study:

- I. Did Piu support how the users wanted to assess and filter tweets?
- II. What future features would they like to see supported by the tool, and why?

### 7.3.1 Study Participants

Ten participants (five university employees and five city employees) were recruited for this study through snowball sampling via email. These were domain-specific participants employed in a variety of positions at the city, CEMA, or in the Risk and Security group at the University of Calgary. Over the course of a month, I held four one-on-one tool evaluations and two focus group showcases with interviews. In the related work outlined in Chapter 2, I identified some weaknesses to the way tool evaluations, where performed, were conducted that I sought to avoid:

- Recruited participants were novices with minimal experience in the field;
- Recruited participants came from a shallow range of job functions; or,
- No emergency operations-related employees were recruited to evaluate the tool.

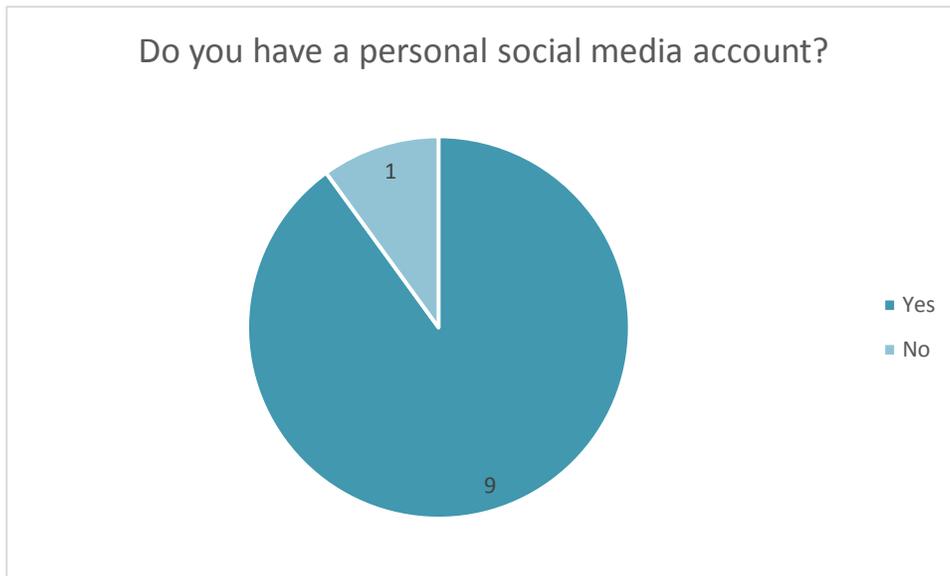
This was an early-stage assessment of Piu with a mixture of novice and expert-level users who have worked or trained in emergency events for an average of 8.5 years (Table 7.1) to address both the three usability questions and two goals identified earlier. Though all the requirements elicitation users were invited to participate in the tool evaluation, only one of these users could participate in this study due to scheduling conflicts (User 4).

User	Title	Years worked or trained in emergency events
User 4	Emergency Response Plan Coordinator	30 years
User 5	Emergency Volunteer Program Consultant	2 months

User	Title	Years worked or trained in emergency events
User 6	Communications Strategist	15 years
User 7	Media Relations Advisor	2 years
User 8	Admin Coordinator	2 years
User 9	Emergency Management Officer	15 years
User 10	Technical Writer	2 years
User 11	Emergency Management Manager / Business Continuity & Recovery Planner	6 years
User 12	Geospatial Fusion Specialist	3 years
User 13	Business Continuity & Recovery Planner	10 years
<b>Average user experience</b>		<b>8.5 years</b>

**Table 7.1 – System evaluation users’ experience profile**

With the large diversity with emergency event experience, from 2 months to 30 years in the job, it was important to understand whether these users have had experience with social media (Figure 7.2), and if so, what types of tools (Figure 7.3). Nearly all participants (9/10) had a social media account with two social networking sites, Facebook and LinkedIn at the top of the list. Half the participants had an account with Twitter, the photo-sharing site Instagram, or the video-sharing site YouTube. Thus it seems that despite the varied experience in the field of emergency events, they were social media aware with half of them (5/10) knowledgeable of Twitter, the model platform for Piu.



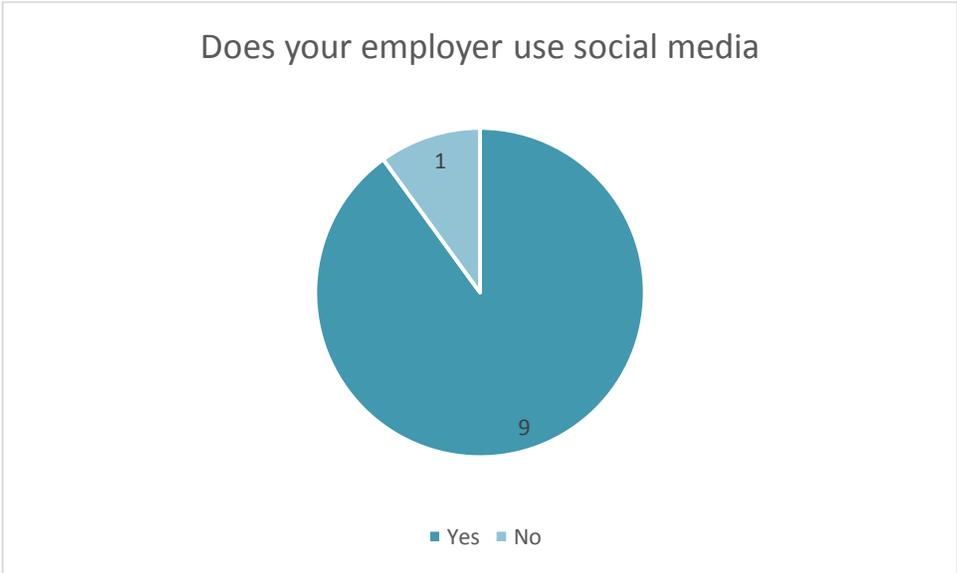
**Figure 7.2 – Study participants’ personal use of social media**



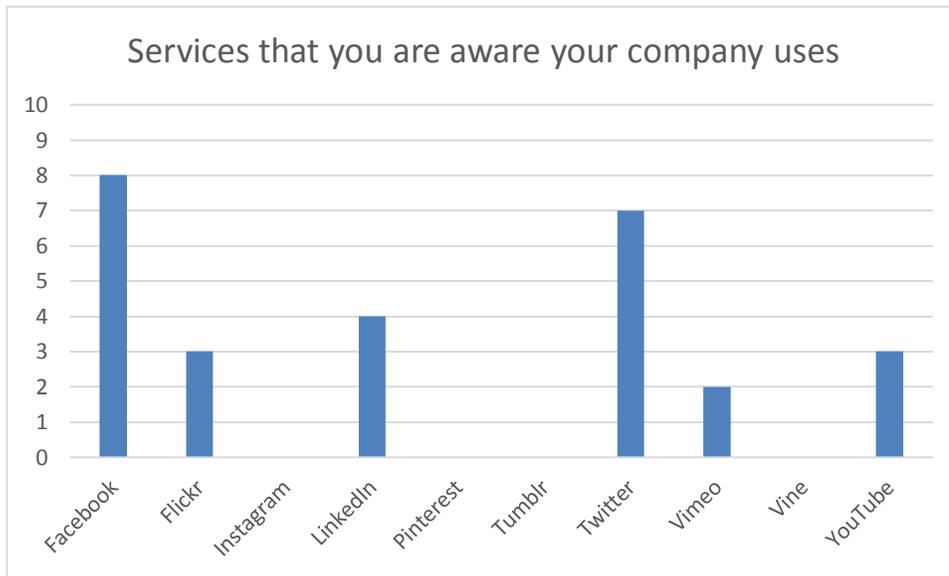
**Figure 7.3 – Study participants’ personal social media accounts**

Since Piu is built to filter and assess social media posts, I also wanted to understand what the users knew about the social media activity of their employers. Both the city and the U of C have official social media accounts for Facebook, LinkedIn, Twitter, and YouTube, while the

city also has an official Flickr account. In some instances, the employers have multiple social media accounts for the platforms listed above, each one serving a specific audience. At the U of C, this is manifested through Twitter accounts for departments, faculties, and affiliated groups (e.g. IT department, Faculty of Science, Graduate Students' Association), whereas the city has Twitter accounts for roads, 311, and parks.

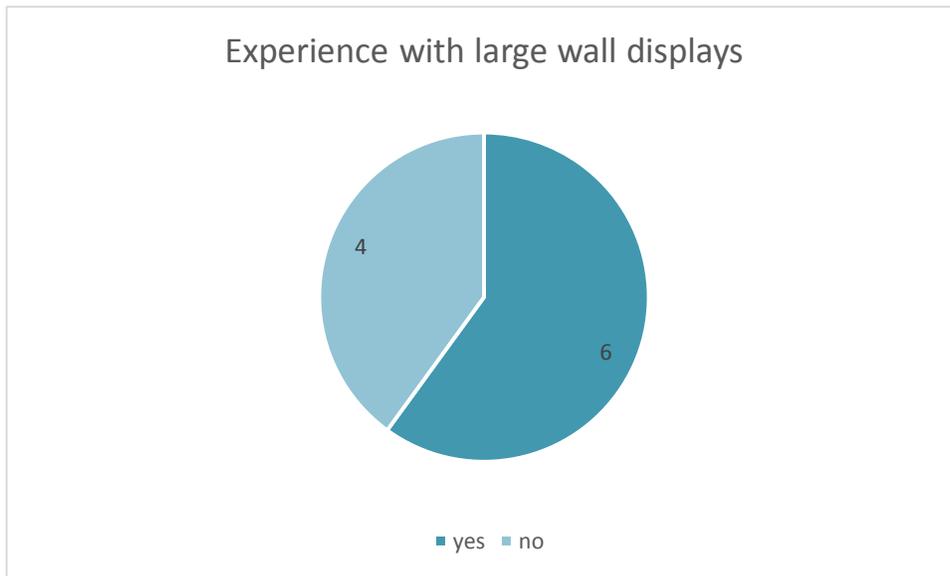


**Figure 7.4 – Study participants' employer's social media use**



**Figure 7.5– Study participants’ employer’s social media accounts**

With CEMA’s EOC setup (Figure 7.1) and my study setup (Figure 7.7), large wall displays were the target location for Piu Observer and Piu Word Cloud. As such, I wanted to understand whether the study’s users had experience with this type of display. I was surprised that only 6/10 users (Figure 7.6) had experience with large wall displays, and this might help explain the limited amount of feedback seen below on the Piu Observer and Piu Word Cloud interfaces.



**Figure 7.6 – Study participants’ experience with large wall displays**

### **7.3.2 Setup**

The study room was outfitted with one laptop, in front of which the subject sat, along with two large-screen displays at the front of the room (Figure 7.7). The laptop was connected to Piu Monitor and the two large screens at the front of room were connected to Piu Observer and Piu Word Cloud, simulating what decision-makers would see in ops. This setup provides the social media monitor with the ability to see how their assessing and filtering tasks manifest. A voice recorder was placed beside the laptop, and screen recording software was running on the laptop operated by the participant.

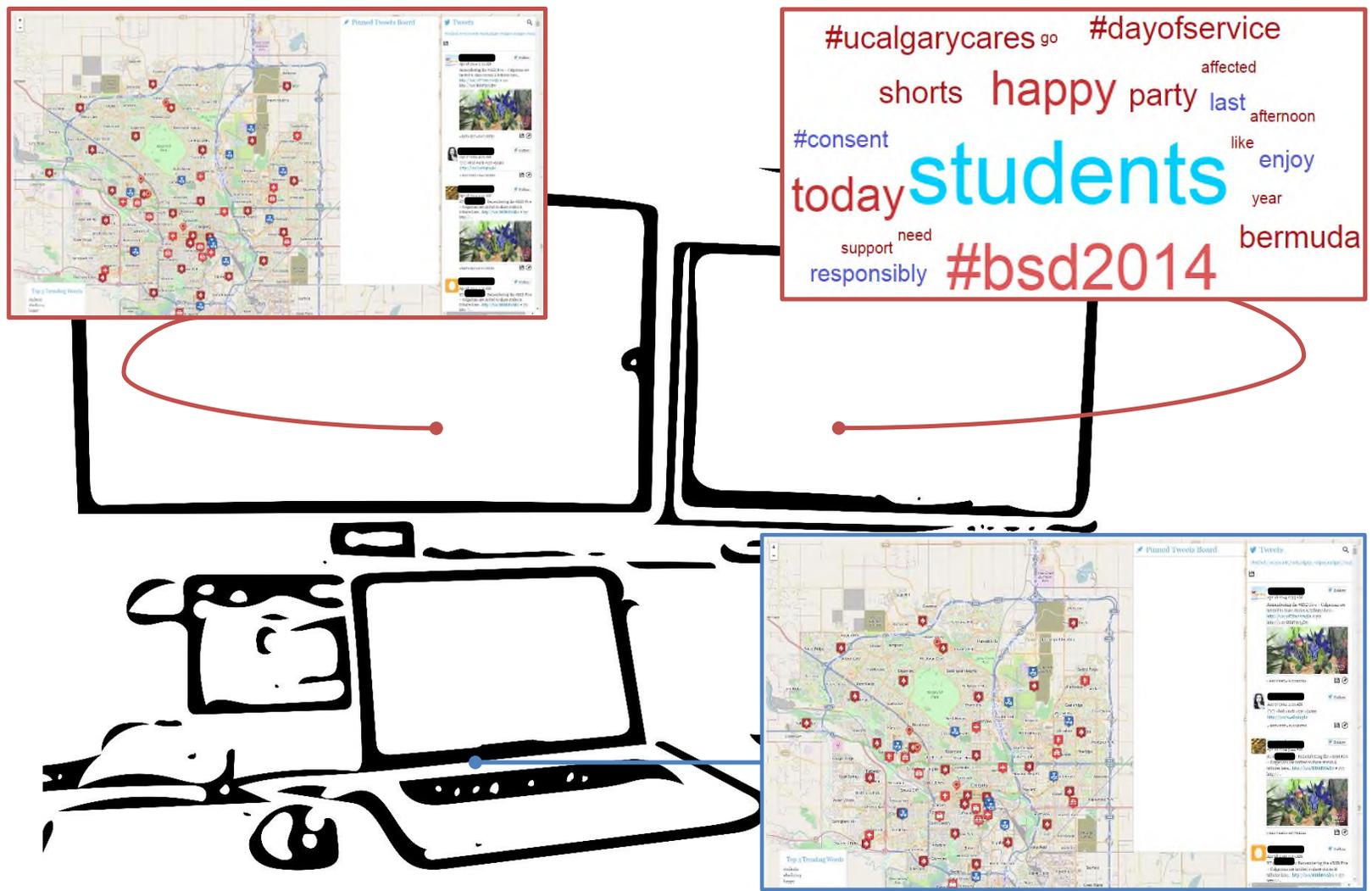


Figure 7.7 – Study room setup for PiU

### **7.3.3 Study procedure**

#### 7.3.3.1 Piu Introduction

This portion of the study took approximately 20 minutes, during which the participants were informed about the nature of the study, and that I would like to perform both a screen-recording and voice-recording of the study. Once they signed the consent form, they were provided with a pre-study questionnaire that helped me to understand their experience with emergency events and emergency training, their use of social media, their knowledge of their company's use of social media, and their experience with wall-displays. This was the same questionnaire used during requirements elicitation. Then, while the prototype was running in live mode, I explained that the features came through requirements elicitation from emergency management personnel, and lastly I provided a walkthrough of the prototype's features.

During the one-on-one study, the participants were told that were playing the role of a social media monitor, someone monitoring the social media feed during an emergency, and their goal was to identify tweets of interest using the prototype. Depending upon their actions, these tweets could appear on Piu Observer at the front of the room, they could disappear from their Twitter timeline, they could mute the user who is tweeting, or the tweet could be saved to the database. Further, the participants were notified that Piu Word Cloud would update automatically on a second large wall display at the front of the room. Throughout the three phases of the study, the participants were invited to ask questions, and to seek clarification on features that may have not been implemented in a manner consistent with their thinking.

#### 7.3.3.2 Using Piu Monitor

At this time, the participant was engaged with Piu Monitor in the BSD 2014 training mode, where data collected between April 8, 2014 and April 16, 2014 for BSD 2014 was programmed to arrive

within 10 minutes of initiating the scenario. Since this was a qualitative study, there was no quantitative data to analyse. Therefore, I asked the participants to apply the think-aloud protocol [11,44] where participants are asked to verbalize their thought process while selecting and analysing tweets. The study participants were not accustomed to this type of study, thus they had to be regularly prompted to talk while operating the prototype. While they operating the prototype, I was seated beside them where I observed, asked questions, and took notes. During the focus group showcases, I acted as the monitor clicking on buttons to show the users how the features worked, and then asking them about those features or the tweets.

#### 7.3.3.3 Post-study interview

Once the active portion of the study concluded, I asked a series of open-ended questions (Appendix B) on the participant's impressions on the prototype. I also solicited their feedback on unimplemented features, and other questions on the prototype's functionality. Given the users who participated, this was also a time when they would share insights into their jobs, how the tool could enhance their work, and finally I used snowball sampling [10] where I requested the names of other people whom I could contact to participate in the study.

#### **7.3.4 Data Collection**

Three data collection techniques were used during the study: think-aloud protocol with audio recorder; written notes during observations; and a screen-captured video. Beyond the questions listed in Appendix B, the closing interview often moved into a discussion about the participant's job and their experience during emergencies.

### **7.4 Results**

Using a qualitative approach, in addition to the benefits listed earlier, allowed me to spend more time on knowledge-sharing with the individuals on their jobs, what social media tools they used in their

jobs, and the type of modifications to Piu that would allow it to better support them in their jobs. As such, I found myself relying more heavily on both my field notes and the audio recordings to capture the participant's impressions of the tool.

#### **7.4.1 Usability feedback**

At the chapter's outset, I mentioned that the goal of this chapter was to study Piu to understand the answers to three questions:

1.) Did the participants find Piu easy-to-use?

*"Seems pretty easy"*

*"Feel for what's going on"*

*"Don't need to think"*

The overwhelming impression from the study participants was that I met my goals of creating an easy-to-use tool based on the feedback from the sample above. What was particularly encouraging was the feedback indicating that *"it's very simple"*.

2.) Did the participants find the features in Piu usable and understandable?

*"Really like the mute and recording"*

Once again, users thought that Piu's features were usable and understandable, including the muting feature that suppresses tweets from specific users along with the ability to record tweets as they come into the tool.

3.) Would the participants use Piu if it was made available to them in either their current role, or would they have used Piu if it were available during a past event?

*"Good straw poll"*

*"Can tweet from anywhere"*

*"Power is not necessary for Twitter"*

Generally speaking, the users found that the tool would have been useful to them either during a past event, or in their current role. One particularly noteworthy comment came from a U of C participant who commented that the tool would have saved them time if it was available during floods or BSD.

*During these events, I (and a colleague) would copy and paste relevant tweets into an email which would then be sent to members of the EOG. However, I had no idea when or if the EOG members read my emails. This tool would have saved me a lot of time from copying and pasting. Also, I could update the list of relevant tweets in real-time without having to send a second email.*

Another interesting use-case was shared from a user from CEMA who indicated that with their custom-built, in-house GIS system that incorporates geo-located photos from social media, they were unlikely to use this tool. However, they mentioned, they could see a strong case for this tool for smaller municipalities without the technical capacity of the city.

#### **7.4.2 Enhancements**

Earlier in this chapter, I noted that along with the usability questions addressed in the previous section, I sought answers to two other questions:

- I. Did Piu support how the users wanted to assess and filter tweets?
- II. What future features would they like to see supported by the tool, and why?

The answer to question (I) is yes and no. Yes, Piu supported the users when assessing and filtering tweets during the study. However, as Piu could not support all the features that the users wanted to both assess and filter tweets, the answer is also “no”. In the following sections, I have listed feature areas where the study users thought Piu could be reinforced, thereby answering question (II).

This study corroborated the requirements elicitation process in Chapter 5, however the users wanted more refined features in Piu Monitor and Piu Observer than what was available to them during the study. One possible explanation why I did not get more detailed feature requests during the elicitation process may be attributed to the fact that Piu Monitor was an interactive prototype, whereas *ePlan* was not. Also, the study's users are more likely to work with Piu Monitor than to work from the EOC where Piu Observer would be deployed.

After evaluation, new use-cases emerged highlighting where Piu could be deployed, and for each of these use-cases, a number of Piu feature areas require enhancement. In subsequent sections, I begin by summarizing general feature areas of Piu for improvement, and this is followed by features as requested by the study's users.

#### 7.4.2.1 Pinned Tweets Area

Unsurprisingly, this was a popular feature with the users, and it derived a number of enhancements to support two use-cases. The social media monitor for the U of C has previously sent emails to EOG members to make them aware of relevant tweets, and thus one feature that would help support the use of Piu to the replace copy & paste with email mechanism, is the ability to annotate pinned tweets. Additionally, this user also mentioned the benefit of being able to re-arrange the pinned tweets without having to pin and unpin a tweet, such that it moves to the top of the pinned-tweet list. With the ability to re-order, a user could ensure that certain tweets remain at the top of the list.

An additional use-case in this area, was the idea of Piu being used simultaneously by people in different job organizations, to the effect that pinned tweets that were relevant to one organization (e.g. the parks department) would appear in a different list or in a different color than those for another department (e.g. the roads department).

One feature that was not implemented from the initial requirements elicitation process was creating a geo-location for tweets that were not geo-located. Related to this idea, one user wanted the ability to drag-and-drop tweets that were not geo-located onto the map, thereby enabling other users to understand where the event was taking place. Feedback from the users included comments like:

*“Annotations on pinned tweets”*

*“Reorder pinned tweets”*

*“Multiple pinned tweet areas”*

*“Pin a tweet to a location”*

*“Pin users”*

*“Time when the tweet was pinned”*

*“Indication when the tweet was actioned”*

#### 7.4.2.2 Twitter Stream

Beyond the simple tweaks and defect identified at the bottom of this list, the other two features relate to filtering. For both training mode and live mode, the tweets that appear in the Twitter stream must have met a minimum keyword criteria. However, given the number of tweets arriving, the participants were interested in applying a secondary filter to these tweets so that particular tweets would “rise above the noise”.

Furthermore, some users felt that the Twitter stream in Piu Observer was too much information for EOC users, and that they would like to better control the information seen by them through completely eliminating the Twitter stream with its continuous updates; these users would only see tweets pinned by the monitor.

*“Search within streaming tweets”*

*“Remove Twitter feed on Piu Observer, it’s too busy and distracting”*

*"Tweet should display user's full name, not their handle"*

*"Defect: Time in live mode was in UTC, not local time"*

#### 7.4.2.3 Features from Commercial Tools

Other social media tools, like Hootsuite, allow the user to apply workflows and other tools to help manage the social media stream. While building the initial prototype, I focused on features that emergency management personnel wanted, and did not work with the assumption that features in commercial tools were the "right fit" for emergency-related personnel. However, future development of Piu should examine these features from other tools, and then present these features to emergency management personnel for ranking prior to implementation.

*"Add workflow"*

*"Saved geo fence"*

*"Create a sentiment analyzer"*

#### 7.4.2.4 Maps

Maps were an interesting area that may provide promising research avenues, however it also provided a number of challenges both for design and implementation. While a map would be helpful in a future tool, the study users did not find the Piu map materially important, with some feedback suggesting its removal. More interviews or conversations with Piu users is required to get a better sense for the direction to take on this feature area. Nonetheless, one interesting idea was to synchronize maps in the two interfaces to support the ability of a Piu Monitor user to highlight map areas that would be instantly visible on Piu Observer.

*"Place pins on a different map layer"*

*"Legend for map icons"*

*"Synchronization of maps on Piu Monitor and Piu Observer"*

*“Remove map as it is cluttered and confusing”*

#### 7.4.2.5 Dashboards for city councillors

While none of the study participants were city councillors, some people from the city saw value in using Piu to support city councillors. Through a dashboard, they described a system where tweets pinned by the councillor’s staff or by city-employed staff could highlight issues requiring their attention. However, similar to the map features, this area of future work will require more conversations with the affected parties.

#### 7.4.2.6 Situational Awareness

Situational awareness (SA) is a term that was seen in Chapter 2, and it is a topic brought up during the focus group with the city as it related to user-generated pictures during emergency events. They indicated that the city has moved away from Twitter as a source of social media pictures due to the low volume of geo-located media. In its place, they rely on Instagram which “makes it harder to turn off location reporting”, thus there are more geo-located photos. During the focus group, their issue with both photo-sharing sites is that geo-location is attributed to the place where the post was made; not where the photo was taken. An implication of this behaviour is that a photo taken at the University of Calgary would not have the university’s coordinates if the tweet was posted when the user arrived home. Instead, the tweet, which includes the photo, would have the user’s home coordinates.

In this case, their recommendation to improve SA would be for services like Twitter and Instagram to no longer strip geo-location from photos so that this rich piece of information can be shared, thereby increasing SA, a valuable commodity in emergency management.

## 7.5 Study limitations

This study had several limitations which may affect the validity of the results. However, as a checkpoint to validate features elicited in Chapter 5, it successfully served the purpose of providing insights into the tool, created a future development paths, and provided contacts who may be asked to review future iterations of the tool. The most noticeable limitation of the study was the small sample size of participants (ten). It is difficult to ascertain how many people are emergency management experts in Calgary, and thus continued use of snowball sampling may have revealed others in private companies in addition to the users from the U of C and the city.

Even though I received a lot of feedback on the pros and cons of commercial tools from the city, along with a series of useful features, a second limitation was that I was unable to bring anyone from the city back for an individual tool assessment. A user from this group may have provided additional feedback when they were operating the tool that they could not imagine while I was operating the tool.

Another limitation of the study was the quantity of tweets collected from BSD 2014. As mentioned in an earlier, Twitter's streaming API does not guarantee a return 100% of tweets sent within a specific period of time. Thus, to create a more complete Twitter database from which to run the training mode, purchasing firehose (full access) access from a Twitter third-party reseller would have provided complete access to all tweets sent during BSD 2014.

Piu is an early stage prototype, thus in order to obtain more conclusive results a further, more extensive case study would be necessary with a further refined tool, possibly including features found in the next chapter. This future study should involve two participants where one person is located in a remote room observing Piu Observer and Piu Word Cloud, while the Twitter monitor operates Piu Monitors from another room. Then, after running through a Twitter simulation, the participants could

be asked a series of question related to the event to understand what message the monitor (using Piu Monitor) was trying to send versus what information the observer (using Piu Observer and Piu Word Cloud) received. This setup would permit participants to dynamically interact with the tool and have a more complete understanding of the prototype, resulting in a more comprehensive understanding of the usefulness and efficiency of the interface and features. This could be considered for future work.

## **7.6 Conclusion**

The ten participants of the laboratory study and four participants of the pilot study were generally receptive to the interface and features of Piu. They found the tool intuitive with easy-to-use features relevant to the goal of providing filtered information into an EOC. Since I was not able to run a one-on-one study with anyone from the city, I only had data from U of C users who thought that the tool would be useful in their current role, during the 2013 floods, or during BSD 2014. During the evaluation, the participants provided a wide range of feedback on future enhancements, including use-cases not identified through the requirements elicitation process with emergency management experts.

## Chapter Eight: **Conclusion & Future Work**

This thesis presents Piu, a novel tool that can be used by an analyst to assess and filter social media in real-time for emergency management personnel. First, the overall motivation behind creating Piu was presented to understand the context in which it can be applied. Next, a discussion on the field of emergency management along with social media, and other tools that have been developed to manage social media during emergency events was presented. Following this, a prototype which played a critical role in the requirements elicitation process for a social media tool was discussed. To understand what type of information is being shared during campus events, I conducted an analysis of tweets during BSD 2014, a major University of Calgary event. Next, I described how requirements were elicited for Piu, a Twitter-based monitoring and assessing tool and how these requirements influenced its design. Finally, I provided results from the evaluations of Piu which formed the basis of my answers to the research questions in Chapter 1.

The remainder of this chapter summarizes the goals achieved and motivations behind research into a real-time social media tool for emergency response, as well as the contributions from this thesis. This is followed by an overview of possible future work in this area based on user-collected findings, and finally the conclusions of this thesis.

### **8.1 Goals Achieved**

There were two goals in this thesis; first, I intended to provide a set of features for a real-time social media analytics tool informed through interviews with emergency management experts. Secondly, I sought to understand the use-cases that emergency operations people see for such a tool.

Piu was developed through a series of interviews – some formal and others informal – with emergency management personnel. In a little under a year, I worked with emergency management experts to build an understanding of their organizations and responsibilities, and later elicited features

for a real-time social media analytics tool. Finally, I conducted an evaluation of the tool with a number of emergency management personnel to evaluate the usability and features of the tool. This primary goal was achieved, and based on the positive feedback and support from this community, future engagement could ensure Piu will be an even more useful tool for the emergency management domain.

The second goal intended to frame future development of Piu by creating smaller, simpler use-cases that can be applied when assessing whether new features would support those user-provided use-cases. Two of these new use-cases were discussed in the last chapter after they were shared by study participants.

## **8.2 Motivation**

As mentioned earlier, the major impetus behind this work was the lack of research involving both emergency management experts in the design of a tool, and emergency management personnel with real experience in the evaluation of such tools.

## **8.3 Contributions**

The contributions of this thesis are as follows:

1. Insights gathered by analysing the tweets sent during the University of Calgary's annual Bermuda Shorts Day 2014 when five young people lost their lives at an off-campus house party. After analysing the tweets, I saw that Twitter did not break any new information on the event than what was reported by conventional news media. Furthermore, I saw that the tweets shared during this event related more about the participants' mood during different phases of the event: prior, during, and after the event (and when murders became public). These insights can inform that when designing a tool, supporting users monitoring Twitter (or another social media

platform) needs tools to annotate or comment on posts to enrich the information before decision-makers read those posts.

2. Through requirements elicitation and an evaluation study with emergency management personnel from the City of Calgary and the University of Calgary, there was great interest from supporting personnel in ‘pinning’ noteworthy tweets. Within a set of tweets arriving via keywords, users were interested in applying further filters to see tweets that met their sub-interests. Other areas that deserve more examination with the experts include maps, and what to place on them, along with features from commercial tools.

Lastly, two unexplored areas in Piu that require further conversations with councillors include a dashboard for the city councillor who does not work in the EOC nor do they filter and assess tweets, and a mechanism to preserve coordinates from shared photos.

## **8.4 Future Work**

Along with redefining the unimplemented features below the feature enhancements listed in section 7.4.2 should be incorporated in future versions of Piu prior to its evaluation.

### **8.4.1 Unimplemented Features**

Three features elicited during requirements elicitation were not implemented:

- I. FR6 – Analyze tweet text for street location (live or training)
- II. FR9 – Capture and store media while stream is active (live or training)
- III. FR10 – Communicate directly with a user (live-only)

*“FR6 – Analyse tweet text for street location (live or training)”*, was not implemented due to the complexity and limited test data to actually have the feature in a state that could properly be evaluated by the users. As discussed in Chapter 5, this feature would require processing of a tweet to retrieve the different components, and then to use a tool like the Google Map API to assess if a

geolocation could be created for the text. In Calgary, the city is divided into four quadrants (NW, NE, SE, and SW), where cross-streets repeat (e.g. 17<sup>th</sup> and 14<sup>th</sup>, Centre and 1<sup>st</sup>). As a result, the ambiguity created by assessing such a tweet would require a user to decide from a number of choices. Based on the information above, this feature was not implemented.

*“FR9 – Capture and store media while stream is active (live or training)”* was not implemented as media can be attached to tweets in a number of different ways. First, if the user allows Twitter to host the media, the media forms part of the “media\_url” portion of the JSON object. Second, occasionally other websites host the media. For example, media could be stored on Instagram, or other websites. Without clear documentation from Twitter indicating that it ensures that all URLs in tweets are legitimate, it meant Piu could fall prey to schemes that would grant third-party sites access to a Twitter account. Also, if this feature were implemented for Twitter-based media, it would have resulted in files saved to a web-shared folder by other applications, again posing potential security risk with no real benefit. Consequently, this feature was not implemented.

Finally, *“FR10 – Communicate directly with a user (live-only)”* is a feature that was desired, but Twitter has rules regarding direct communication between two Twitter users. Twitter does this through a feature called “direct messaging” whereby two users first have to follow each other before being able to direct a private message to that user. The goal described by the experts during requirements elicitation was to communicate with the user even if s/he was not following the expert’s account. This could be supported by Twitter if they were the arbiter declaring that a verified account holder, like the Calgary Police Service, could send messages to a user’s account even if they were not a follower. However, since this requires changes to the Twitter API, it was deemed to be out-of-scope for this prototype.

## 8.5 Conclusion

In Chapter 1, I asked two questions that I have not addressed directly:

- But in the age of social media, how could the EOC be sure it was receiving and disseminating accurate, timely information?
- How can we build a tool that can support a human process and assess tweets as emergency events unfold so that they may communicate with their EOC colleagues better

The development of Piu provides answers to both questions by providing the social media analyst with a tool that allows them to flag information of interest to EOC team members. EOC team members know that the information they are seeing has been triaged by a colleague, not an automated process, providing accountability to the team.

The main aim of my research was to create a tool that would support assessing and filtering tweets in real-time for emergency management personnel. Twitter was chosen due to its open API, however, other social media services with public APIs can be added to Piu. The overview on emergency management and emergency planning, along with the survey on current social-media analytic tools validated that a tool like Piu did not exist and was necessary. I have shown that Piu is well-designed and easy-to-learn and use, and while Piu is not commercial-ready, the use-cases presented in the thesis provides potential areas which professionals and researchers in emergency management may explore when building or extending similar tools for human social media analysts.

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## APPENDIX A: PRE STUDY QUESTIONNAIRE

- 1) Name of your employer? \_\_\_\_\_
- 2) What is your job title? \_\_\_\_\_
- 3) How many years have you held your current position? \_\_\_\_\_
- 4) How many years have you worked/ trained in emergency events? \_\_\_\_\_

5) Do you have a personal social media account?  Yes  No

6) If yes, circle those services for which you hold an account?

Facebook  Pinterest

Flickr  Twitter

LinkedIn  Tumblr

Instagram  YouTube

Other \_\_\_\_\_

7) Does your employer use social media?  Yes  No

8) If yes, check all those services that you are aware your company uses:

	Yes	No	Don't Know		Yes	No	Don't Know
Facebook	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Pinterest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Flickr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Twitter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
LinkedIn	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Tumblr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Instagram	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	YouTube	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	_____						

9) I have previous experience with a digital tabletop  Yes  No

10) I have previous experience with a tablet  Yes  No

11) I have previous experience with working large wall displays  Yes  No

## **APPENDIX B: POST STUDY OPEN INTERVIEW QUESTIONS**

- 1) What are your impressions about the prototype you are seeing?
  
- 2) What improvements / enhancements would you suggest?
  
- 3) How does your employer use social media today (as input)?
  
- 4) How does your employer use social media today (as output)?
  
- 5) What tools does your company use to monitor / manage social media sites like Twitter?
  
- 6) Who monitors / manages the social media accounts for your company?
  
- 7) Does your company employ on-demand consultants to manage / monitor social media during times of crisis (or emergency events)?

## APPENDIX C: SAMPLE RUNTIME COMMANDS FOR PIU TWEET COLLECTOR

The following code allows the collector to run in search mode with the 'yyc' keyword.

```
java -jar TwitterXML.jar -search -filename "search_calgary"  
-query "yyc"
```

Whereas, the following code allows the collector to run in streaming mode with the same keywords as above.

```
java -jar TwitterXML.jar -streaming -filename "stream_calgary"  
-query "yyc"
```

Furthermore, to support the case where multiple concurrent events were taking place, the Piu collector code provides multiple concurrent event support; thereby permitting the following to run concurrently

```
java -jar TwitterXML.jar -streaming -filename "stream_calgary"  
-query "london, #flooding"
```

```
java -jar TwitterXML.jar -search -filename "search_calgary"  
-query "London, #flooding"
```

```
java -jar TwitterXML.jar -streaming -filename "search_calgary"  
-query "bsd, #ucalgary, #yyc"
```

```
java -jar TwitterXML.jar -search -filename "search_calgary"  
-query "bsd, #ucalgary, yyc"
```

## APPENDIX D: SAMPLE MS SQL STORED PROCEDURE

The figure below shows three highlighted areas of the SQL Server stored procedure:

```
ALTER PROCEDURE [dbo].[sp_InsertTweets]
-- Add the parameters for the stored procedure here
@text NTEXT,
@id varchar(50),
@media NTEXT,
@created DATETIME,
@place NTEXT,
@hashtags NTEXT,
@geolocation GEOGRAPHY,
@retweetCount INT,
@favoritesCount INT,

@userLocation NCHAR(255),
@userName NCHAR(255),
@userDescription NTEXT,
@userScreenName NCHAR(100),
@userLang NCHAR(2),
@userVerified BIT,
@followersCount int,
@friendsCount int
AS
-- SET NOCOUNT ON added to prevent extra result sets from
-- interfering with SELECT statements.
SET NOCOUNT ON;

IF NOT EXISTS (SELECT 1 FROM tblTwitterUsers WHERE screenname = @userScreenName)
BEGIN
INSERT INTO tblTwitterUsers(name, screenname, description, lang, location, verified, followersCount, friendsCount)
VALUES(@userName, @userScreenName, @userDescription, @userLang, @userLocation, @userVerified, @followersCount, @friendsCount);
END

IF NOT EXISTS (SELECT 1 FROM tblTweets WHERE tweetID = @id)
BEGIN
-- Insert statements for procedure here
INSERT INTO tblTweets(text, tweetID, media, created, place, hashtags, geolocation, screenname, retweetCount, favouritesCount)
VALUES (@text, @id, @media, @created, @place, @hashtags, @geolocation, @userScreenName, @retweetCount, @favoritesCount);
END
```

Input parameters

Insert into tblTwitterUsers

Insert into tblTweets

Figure 8.1 – MS SQL Server stored procedure

- 1.) Input parameters – this list of parameters dictates the type of parameters that would be accepted by the stored procedure. For instance, the variable **@favoritesCount** is set as an integer, and thus will not accept strings.
- 2.) Insert into tblTwitterUsers – through a call to this stored procedure, this code block allows me to check if the user who created this tweet is already in the database. If they exist in the database, I do nothing, however if they do not exist, I will insert this user into the database.
- 3.) Insert into tblTweets – though I created a primary key in tblTweets to prevent duplicate entries, it is more efficient to check if a tweet exists in the table with this **tweetID** rather than attempting and failing at insertion due to table restrictions.

In both the Java code and the Node.js code below, the call to the stored procedure are parameterized such that *integers*, *strings*, and *dates* are identified before executing the stored procedure. For Java, the parameterization is enabled through calls like the one below where I indicate that we are passing a string before the variable is set:

```
        cStatement.setString(1, tweetObject.getTweet());

cStatement = conn.prepareCall("{call dbo.sp_InsertTweets(?,?,?,?,?,?,?,?,?,?,?,?,?) }");

// 1 @text
cStatement.setString(1, tweetObject.getTweet());
// 2 @id
cStatement.setString(2, tweetObject.getId());

String mediaURL = Arrays.toString(tweetObject.getMediaURL());
mediaURL = mediaURL.replace("[", "").replace("]", "");
// 3 @media
if("").equals(mediaURL) {
    cStatement.setString(3, null);
} else {
    cStatement.setString(3, mediaURL);
}
// 4 @created
cStatement.setTimestamp(4, forSQLTimestamp);
// 5 @place
cStatement.setString(5, tweetObject.getCountry());
// 6 @hashtags
cStatement.setString(6, tweetObject.getHashtags());
// 7 @geolocation
cStatement.setObject(7, null);
// 8 @retweetCount,
cStatement.setInt(8, tweetObject.getRetweetCount());
// 9 @favoritesCount,
cStatement.setInt(9, tweetObject.getFavoritesCount());
```

**Figure 8.2 – Java code**

For Node.js, parameterization is done by escaping the variable like the one below so that a string is enclosed by ‘ ‘:

```
query += "@userLang='" + tweetObject.user_lang + "'";
```

```

var tweetMessage = tweetObject.tweet;

var query = "EXEC sp_InsertSavedTweets @text='" + tweetObject.tweet.replace(/'/g, "''") + "', @id=" + tweetObject.tweetId + ", ";
//
// is there media ?
//
if (tweetObject.media) {
    query += "@media='" + tweetObject.media_url + "', ";
} else {
    query += "@media=NULL, ";
}

//
// run the stored procedure to save the tweet
//
sql.query(conn_str, query, function (err, results) {

    if (err) {
        var emit_message = "[ERROR]: Could not save the message '" + tweetMessage + "'."
        io.sockets.emit('save_message', emit_message);
        console.log("[save message DB ERROR]: " + err + " <<<<>>> " + query);
    }
}

```

**Figure 8.3 – Node.js code**

## **APPENDIX E: ETHICS**

This appendix contains the consent form used for the study presented in this thesis.



---

**Name of Researcher, Faculty, Department, Telephone & Email:**

Alemayehu Seyed – PhD Student Department of Computer Science	Apoorve Chokshi – MSc. Student Department of Computer Science
[Redacted]	

**Supervisor:**

Frank Maurer – Professor  
Department of Computer Science

**Title of Project:**

Requirements Elicitation (on the use of social media during emergency events)

**Sponsor:**

NSERC SurfNet Strategic Network

---

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

**Purpose of the Study**

The purpose of this study is to seek an evaluation on a social media prototype for use during an emergency event, and to seek requirements on how social media could be used during emergency events. We are interested in learning more about emergency events, and would like to gather requirements for the future. If you are interested we invite you to participate in this study.

**What Will I Be Asked To Do?**

If you agree to participate in this study, you will be asked to participate in the following different research activities:

1. You will be asked to complete a short questionnaire about emergency operation centres and your background experience. This questionnaire should take no more than 5 minutes to complete.
2. You will be asked to evaluate a social media prototype. A researcher will observe, take notes, and videotape your responses for 45 minutes or until you feel comfortable with your answers.
3. After completing the study, you may be asked to participate in a post-study interview about your experience in the study, provide some additional background about your experience with emergency operation centres and any further thoughts. This interview should last no longer than 20 minutes.

The whole process was designed to last no longer than approximately 70 minutes, although if you feel that you can discuss longer on certain topics or may have additional insights you think that are important, feel free to talk

about it.

Your participation in this research is voluntary. You may refuse to participate altogether or in part. You may withdraw from participation in this study at any time without penalty or loss of benefits

### **What Type of Personal Information Will Be Collected?**

Should you agree to participate, we ask to videotape you in a focus group, and to audiotape your comments during a post-study interview. Other than these video and audio recordings, no other personal identifying information (such as your name) will be collected. By default, in all written publications and presentations based on this research, you will remain anonymous and your comments from the interviews will be referred to with either a participant number or a pseudonym.

In order to better communicate the results of this research in written publications and presentations, it may be helpful to share video (or still photographs from the video) of you in an interview or focus group. If you grant us permission to share video (or still photographs from the video) of yourself in an interview or focus group, in written publications or presentations of this research, there is a chance that you may be recognized and so we cannot guarantee your anonymity. We will never, however, reveal your name in association with your image.

Please note that, where intended reporting of photographed or videotaped images includes public display, the researchers will have no control over any future use by others who may copy the images and repost them in different formats or contexts, including online

I grant permission to be audio taped:	Yes: ___ No: ___
I grant permission to be videotaped:	Yes: ___ No: ___
I grant permission to have my company's name used:	Yes: ___ No: ___

### **Are there Risks or Benefits if I Participate?**

There is no known harms or risks associated to the participation in this study.

You will NOT be compensated for your time.

### **What Happens to the Information I Provide?**

Participation in this research is completely voluntary and confidential. You are free to discontinue participation at any time during the study. Any information you contribute up to the point at which you choose to discontinue your participation will be retained and used in the study. No one except the researchers will be allowed to see or hear any personally identifiable information unless you have given permission for us to share video or photographs of you in our interview or focus group, in publications or presentations of this research. The audio/video tapes, questionnaires and interview data will be kept on password-protected university computers or in a locked cabinet only accessible by the researchers. The data will be stored for five years, after which it will be permanently erased.

---

### **Signatures**

Your signature on this form indicates that 1) you understand to your satisfaction the information provided to you about your participation in this research project, and 2) you agree to participate in the research project.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) \_\_\_\_\_

Participant's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher's Name: (please print) \_\_\_\_\_

Researcher's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

### Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

*Alemayehu (Teddy) Seyed*  
*Department of Computer Science*



OR

*Apoorve Chokshi*  
*Department of Computer Science*



OR

*Frank Maurer*  
*Department of Computer Science*



If you have any concerns about the way you've been treated as a participant, please contact an Ethics Resource Officer, Research Services Office, University of Calgary at (403) 210-9863; email [cfreb@ucalgary.ca](mailto:cfreb@ucalgary.ca).

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

## APPENDIX F: CO-AUTHOR PERMISSION

This appendix contains the scanned copies or photos of the co-authors written permission to use the content of the following publications in this thesis and to have this work microfilmed:

- *ePlan Multi-Surface: A Multi-Surface Environment for Emergency Response Planning Exercises*. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Interactive Tabletops and Surfaces 2014, (ITS2014), Dresden, Germany, 2014.
- *Gesture Design and Feasibility in Emergency Response Environments*. Francisco Marinho Rodrigues, Teddy Seyed, Apoorve Chokshi, Frank Maurer. In Proceedings of the Workshop on Gesture-based Interaction Design: Communication and Cognition, (CHI2014), Toronto, Canada, 2014.
- *Managing Peripheral Interaction in Emergency Response Environments*. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Workshop on Peripheral Interaction: Shaping the Research and Design Space, (CHI2014), Toronto, Canada, 2014.



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April 20, 2015

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Gesture Design and Feasibility in Emergency Response Environments. Francisco Marinho Rodrigues, Teddy Seyed, Apoorve Chokshi, Frank Maurer. In Proceedings of the Workshop on Gesture-based Interaction Design: Communication and Cognition, (CHI2014), Toronto, Canada, 2014.

Managing Peripheral Interaction in Emergency Response Environments. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Workshop on Peripheral Interaction: Shaping the Research and Design Space, (CHI2014), Toronto, Canada, 2014.

Sincerely,



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May 11, 2015

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Sincerely,

A large black rectangular redaction box covering the signature of Francisco Marinho Rodrigues.

Francisco Marinho Rodrigues



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May 11, 2015

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Managing Peripheral Interaction in Emergency Response Environments. Apoorve Chokshi, Teddy Seyed, Francisco Marinho Rodrigues, Frank Maurer. In Proceedings of the Workshop on Peripheral Interaction: Shaping the Research and Design Space, (CHI2014), Toronto, Canada, 2014.

Sincerely,



Frank Maurer