# Towards Situation-based IT Management During Natural Disaster Crisis

Abdelmalek Benzekri
Institut de Recherche en Informatique de Toulouse
Université de Toulouse 3 Paul Sabatier
Toulouse, France
Abdelmalek.Benzekri@irit.fr

Romain Laborde
Institut de Recherche en Informatique de Toulouse
Université de Toulouse 3 Paul Sabatier
Toulouse, France
Romain.Laborde@irit.fr

Arnaud Oglaza
Institut de Recherche en Informatique de Toulouse
Université de Toulouse 3 Paul Sabatier
Toulouse, France
Arnaud.Oglaza@irit.fr

Maleerat Sodanil
Faculty of Information Technology and Digital Innovation
King Mongkut's University of Technology North Bangkok
Bangkok, Thailand
Maleerat.m@itd.kmutnb.ac.th

Hatahairat Ketneechairat
Department of Information and Production Technology Management
College of Industrial Technology
King Mongkut's University of Technology North Bangkok
Bangkok, Thailand
hathairat.k@cit.kmutnb.ac.th

***Abstract*—To face disaster relief challenges, crisis management requires operational commitment and efficient coordination of all stakeholders. Deployment of new communication channels at the level of the infrastructure but also at the level of social media streams needs strengthened emergency response processes. We discuss open questions in building an effective decision support system to help crisis decision cells identifying early warnings and situation-specific awareness and figure out the right actions/partnerships to coordinate.**

***Keywords— crisis management ; policy-based management ; situation awareness ; network infrastructure ; social media ; machine learning ; natural language processing.***

## I. INTRODUCTION

Resilience against natural disasters is a field of growing importance, especially given the current changes in climate and environment. A crisis, whose cause can be accidental or intentionally induced, is a sudden situation, unexpected with severe adverse consequences for humans and organizations.
According to Asia-Pacific Economic Cooperation (APEC) Business Advisory Council, the Asia-Pacific region experiences over 70% of the world's natural disasters [1]. With the heavy floods, earthquakes and storm damaging parts of Asia-Pacific over the past years, it has become clear that disaster preparedness is an absolute must for this area. Nevertheless, this issue is not specific to Asia-Pacific countries only and European Environment Agency reported in 2017 [2] that "efforts to reduce disaster risk and at the same time adapt to a changing climate have become a global and European priority". As a consequence, research in this field is of joint interest being a challenge for both, European and Asian partners. As IT infrastructures are playing an increasing role in our economy, their resilience against natural disasters is of utmost importance. Promoting disaster resilient Information and Communication Technology (ICT) frameworks was one of the main recommendations of APEC Business Advisory Council to APEC Leaders in its 2014 report [3]. Network service providers also share this objective in the 2015 reports of the NGMN Alliance [4] that requires resilience of 5G networks during natural disasters.
Crisis management requires efficient collaboration between a certain number of public, as well as private actors, acting in a coordinated way in order to solve the crisis and reduce its impacts. Mobilizing institutional stakeholders, launching assessed processes, deploying emergency communications for disaster relief are among the response facilities.

The increasing adoption of wireless communication technologies – LTE/4G/5G, wifi, satellite – and the commercial infrastructures widely available or deployed on demand in case of a disaster, are at the heart of the information systems to consider [5]. Because of their nature, and the services they render, these information systems allow for incredible and amazing new usages and/or new sources of information. Actors may exchange and share all types of multimedia information (voice, photos, live videos, georeferenced information, etc) and content-rich services (social media) providing a better appreciation and awareness of the current situation allowing a more efficient and reliable coordination for decision making and strengthening emergency response.

These new communication channels allow crisis cells to involve citizens in a participative approach to extend and leverage both the information dissemination and collection perimeters [6]. They can be seen as a "place for harvesting" information during a crisis event to determine what is happening on the ground and providing relevant direct real-time feedbacks.

Given the huge amount of raw data from a large diversity of sources mostly unstructured, it becomes impossible for a human to process the whole and take the right decisions related to the identified crisis situations. Information sources analytics should help not only in defining and identifying situations, but also in building a decision support system. Such cross-fertilization analysis should be gathered within a dedicated environment integrating support functions such as storage, filter, aggregation, inference and fusion of data and their associated meta-data.

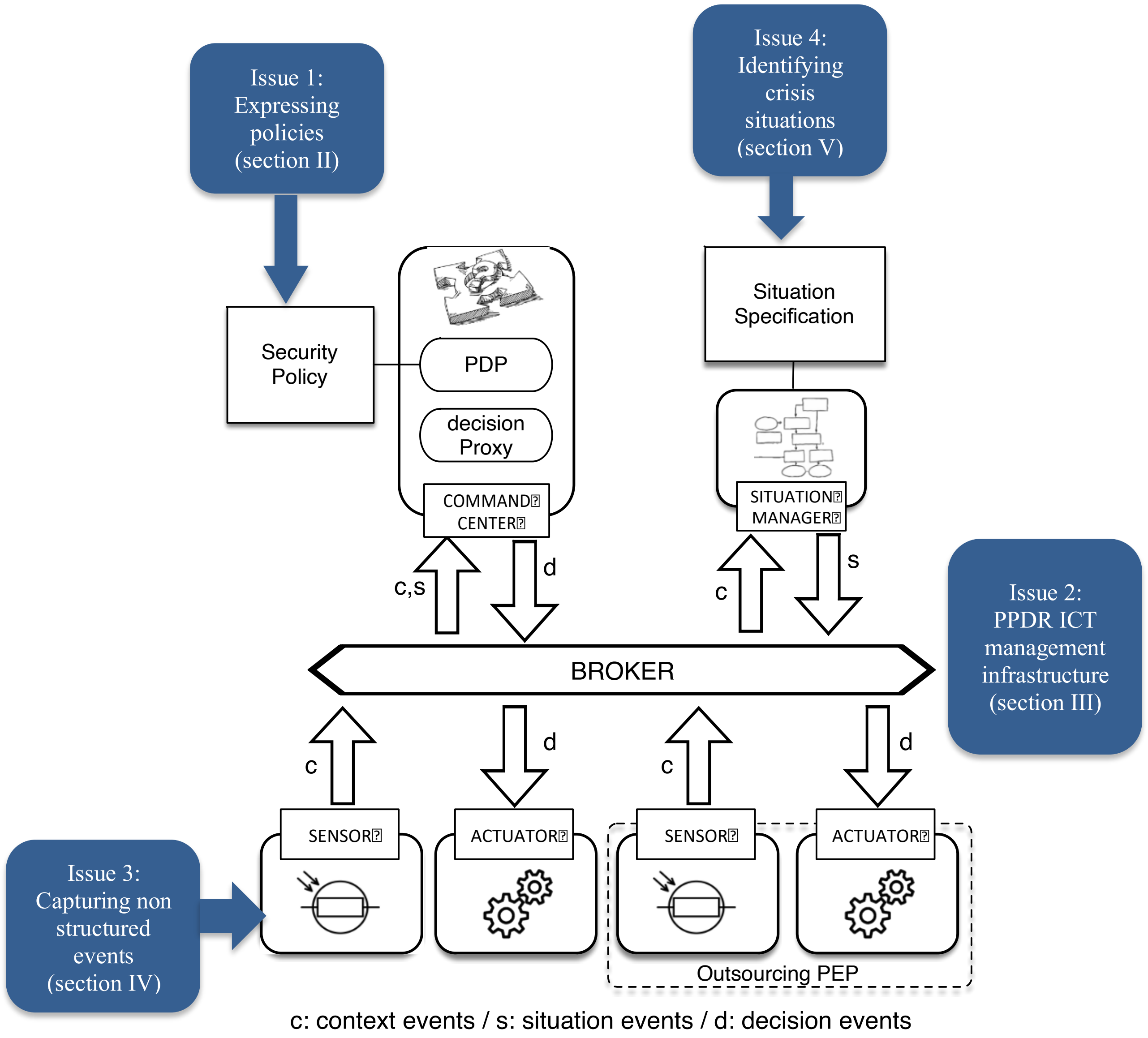

Figure 1. Open research questions

Crisis management processes involve complex management decisions to automatically adapt the deployed IT systems. As a consequence, crisis IT management systems require a better understanding of the dynamics of the environment which raises important research challenges on:

- Eliciting/expressing/validating adaptive systems requirements.
- Expressing/managing/validating adaptive security and/or management policies.
- Dynamically enforcing adaptive security and/or management policies.

Situational Awareness (SA), describes the idealized state of understanding what is happening in an event involving many actors and other moving entities, especially with respect to the needs of command and control operations. SA theory provides an interesting construct to structure the dynamics of the environment in a consistent way [7]. Endsley and Garland [8] define SA as “the perception of the elements in the environment within a volume of time and space (level 1), the comprehension of their meaning (level 2), and the projection of their status in the near future (level 3)”. Since “knowing what’s going on so you can figure what to do” [9] is a good principle, situation awareness can facilitate the decision making process. Although this construct was initially developed in the military domain, researchers are now trying to apply it to other areas such IT risk management [10] or incidence management in 5G networks [11].

In this article, we intend to consider open issues related to a holistic approach to improve crisis management efficiency during disaster by applying situation awareness principles to dynamic IT crisis management.

A situational awareness perspective is sound for anticipating how individuals, groups and communities can use information contributed by others especially in a social media context. We will discuss what social media may contribute to situational awareness. We expect to launch situation characteristics extraction as well as situational updates labeling from, for instance tweets in the Thai language. Natural Language Processing techniques will be assessed contributing in detecting and extracting emergency knowledge from the social media streams. These situational information will be hence transformed into structured information relevant for the definition of operational policies.

Besides, we have developed dynSMAUG, a dynamic security management framework driven by situations [12] that combines a dynamic policy based management system with situation awareness. On the basis of our dynSMAUG system (Figure 1), we investigate how to integrate unstructured information coming from social media to dynamic IT management and adapt our management system to crisis management. This analysis highlights broader open research questions related to governing the operational IT infrastructure resilience as well as aligning crisis information system during natural disaster crises.

The rest of the article is structured as follows. Sections 2 to 5 describe the open research questions and related works. Section 6 complements this analysis by listing recent and current related research projects. Finally, Section 7 concludes the article.

## II. EXPRESSING EMERGENCY/CRISIS PROCEDURES INTO THE MANAGEMENT SYSTEM

Our dynamic management system has to operate within a global crisis management plan. The security and management decisions taken by our command centre must comply with the existing emergency procedures. The main goal should be to investigate the expression of emergency procedures using a situation driven policy language. The idea consists in finding official crisis procedures and express them into our language. However, how to write policies to dynamically manage IT systems during natural disaster crisis?

McHugh and Sheth [13] describe how to construct an emergency procedure flowchart where “The objective of the emergency procedures is to be able to protect lives and minimize damage to assets and to try to ‘nip the incident in the bud’ before it escalates into a disaster.” They highlight the process to develop flow charts for emergency procedures, which in themselves are only able to summarize what needs to be done and should be used during top-level designs, trainings and awareness campaigns.

Hanachi et al. [14] advocate to go further “transforming a plan into a process providing an accurate and machine-readable specification of actions to be done in the field, a better common understanding between stakeholders responsible for these actions and a means to analyse, simulate and evaluate the crisis response before launching it…”

The ideal crisis policy language should address the expression of the policies governing crisis resolution at the business level. This language should also allow decision crisis cells to base their policies on relevant facts observed by the sensors in the impacted field and on the available business knowledge extracted from the plans, the stakeholders and their capacities.

We think that our situational awareness policy language is a good candidate to meet the crisis resolution processes requirements. In dynSMAUG, security policiesare expressed in a generic way: “when situation and conditions then authorization decision and/or obligation(s)”.

On the one hand, situations allow capturing the dynamic constraints (time, location, etc.) and organize them into a stable and logical concept. Situation oriented policies are simpler and more readable. Also, managing high level policies, close to the decision crisis cell needs, reduces the gap between policies requirements and the effective policy enforced by stakeholders, and then limits the policy translation errors. On the other hand, making policies more independent from technical constraints minimizes the impact of changing mechanisms and simplifies the policy life cycle management.

This approach has proven to be generic being applied to different use cases such as dynamic security management [12], service-oriented architectures [15], virtual organizations [16], healthcare urgency management by enforcing break-the-glass [17] or permissions-based workflow management [18].

## III. HOW TO ADAPT THE DYNSMAUG ARCHITECTURE TO NATURAL DISASTER CRISIS ENVIRONMENT?

Resilience of networks is also under active consideration by network service providers being one of the main goals of future 5G networks. The NGMN Alliance [4] requires that “5G should be able to provide robust communications in case of natural disasters such as earthquakes, tsunamis, floods, hurricanes, etc.” From a more technical point of view, 5G networks are expected, by the 5GPP (https://5g-ppp.eu/), to be a multi-access network in order to deserve 7 trillion wireless devices serving over 7 billion people creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision. To reach such one-network-fits-all concept, 5G adopts a new paradigm for computing and infrastructure including Software Defined Networks (SDN), Network Function Virtualization (NFV) and Cloud Computing [4], [19]. The objective is enabling the automation of network service provisioning and management as software functions running on commodity hardware to support efficient network resource utilization, quicker operational changes, and faster service provisioning cycles. The benefits expected are the shared infrastructure, the services deployment cost and the promising disruptive technologies [13], [20], [21].

We envision building a self-organized Public Protection and Disaster Relief (PPDR) network using a two-tier architecture that introduces two classes of spectrum users: a) primary users -- the users owning a license to operate on a particular frequency, and b) secondary users – unlicensed users who access a particular frequency only if the respective primary users do not need it. The PPDR will act as primary user in the frequencies allocated to it (698 – 703/753 – 758 MHz and 733 – 736/788 – 791 MHz) and use it for mission-critical application such as voice. On the other hand, to enable new application, such as the exchange of high-definition videos and images, PPDR will access other spectrum in the role of secondary user.

This architecture can significantly improve the performance of the PPDR network, however, it requires the PPDR radios, especially when acting as secondary user, to be cognitive. This means radios capable of intelligently adapting parameters, such as transmission frequency, power, etc.

The vision we would like to share can get materialized thanks to the 3 following actions:

- Technologies such as mmwave, drones, MIMO and C-RAN can be combined and utilized in the design of the new network architecture. The idea is to adapt the network to priorities and users/network conditions so as to deliver ultra-high bit rates over targeted geographical areas. In case of emergency, mobile access network elements (mainly BS elements carried by drones and ground mobile BSs) can be utilized for better spectrum management and throughput delivery. In this context, we plan to conceive algorithms able to dynamically and quickly make decisions on optimal number and locations of resources to be allocated.

- The design of a mechanism that, depending on the traffic's quality of service requirements and possibly on external events (e.g. an emergency situation), can decide dynamically whether to transmit the traffic over the PPDR dedicated frequencies, thus setting the radio to act as primary user, or over spectrum accessed opportunistically, thus setting the radio to act as secondary user. This mechanism can also participate in the dynamic reconfiguration of network components (such as edge gateways) and can be implemented as part of a Network Functions Virtualization (NFV) architecture deployed at the PPDR level [20], [22].
- The current design of dynSMAUG includes single points of failure (the command center and the situation manager) which does not meet crisis IT requirements. We intend to distribute this entity to dynamically adapt dynSMAUG to 5G network requirements during natural disaster crisis.

## IV. HOW TO CAPTURE NON STRUCTURED CONTEXT EVENTS? FOR INSTANCE, TWEETS IN THAI

This section targets situation characteristics extraction as well as situational updates labelling from social media in general and for instance tweets in the Thai language. Natural Language Processing (NLP) techniques are contributing in detecting and extracting emergency knowledge from the social media streams. These situational information are hence transformed into structured information relevant for the characterization of the situations under operational deployment.

NLP is a kind of machine learning and artificial intelligence that can be used to interact with human and computers in natural languages. The objective of NLP is to achieve human-like comprehension of texts/languages. Named Entity Recognition (NER) is a part of NLP information extraction that seeks to locate and classify named entities in text into pre-defined categories such as the names of persons, organizations, locations, expressions of times etc. NER solutions can be divided into rule-based, machine learning based and hybrid methods [23].

Many related works have analysed twitter streams for crisis detection. Thusly in [24], the authors analysed the contribution of twitter to situational awareness during two natural hazards events. Corvey et al. [25] pointed out that using twitter in mass emergency requires NLP techniques. Neubig et al. [26] quickly created a NLP system to aid the relief efforts during the 2011 East Japan Earthquake and were able to effectively deliver new information about the safety of over 100 people in the disaster stricken area to a central repository for safety information. Ifrim et al. [27] proved that aggressive lettering of tweets based on length and structure, combined with hierarchical clustering of tweets and ranking of the resulting clusters, achieves encouraging results in detecting events from twitter. Klein et al. [28] proposed a combined structural and content based analysis approach to detect and extract emergency knowledge from twitter streams. Finally, Imran et al. [29] presented human-annotated Twitter corpora collected during 19 different crises that took place between 2013 and 2015. They used these corpora to train machine-learning classifiers to demonstrate the utility of the annotations.

However, these related works do not deal with Thai language that has specific features such as not marking word boundaries. As a consequence, an NLP model dedicated to twitter messages in Thai is required. We can reuse some existing tools like LexTo [30] or pyThaiNLP [31]. They will let us focus on how to turning text-based social media stream into structured events augmenting the knowledge on the disaster relief and the crisis resolution.

All these cited related works show how to turn social media streams into structured events augmenting the knowledge one may have in the disaster relief and in the crisis resolution. However, social media being not trusted information may convey fake news. This issue is still an open question but more and more researchers are focussing on it [32].

## V. HOW TO CALCULATE A NATURAL DISASTER CRISIS SITUATION?

As pointed out by Castillo [33], "Social media is an invaluable source of time-critical information during a crisis. However, emergency response and humanitarian relief organizations that would like to use this information struggle with an avalanche of social media messages that exceeds human capacity to process." Situation awareness theory provides a relevant support to deal with such issues.

A situation is a particular time frame of interest that has a beginning, a life span and an end [34]. The beginning and the end of a situation are determined by combining multiple events coming from multiple sensors and occurring at different moments. Indeed, a situation involves multiple entities and multiple conditions. The beginning and the end of a situation cannot be simple events captured by a unique sensor. In addition, events being instantaneous, combining multiple events requires complex temporal operators (event ordering, event existence/absence, time windows, etc.) to specify the beginning and end of situations.

Currently, situations in dynSMAUG are described using Complex Event Processing techniques [35]. CEP solutions allow to specify complex events through complex event patterns that match incoming event notifications on the basis of their content as well as some ordering relationships on them. We choose the open source event processing implementation called Esper, which is maintained by Espertech. For specifying complex event patterns, Esper offers a stream-oriented language called Event Processing Language (EPL) that is an extension of SQL for processing events (e.g., windows definition and interaction, timed-data arithmetic definition, etc.). We previously showed it is possible to combine real time events with log events to calculate situations [36].

This specification-based identification approach does not scale because situations identification rules become too hard for a human in such a Big data context that includes plenty of sensors and very complex situations [14].Therefore, we have to investigate Machine Learning for crisis situations identification. We can benefit from initiatives like The Humanitarian Data Exchange that provides open crisis data related to previous disasters such as Typhoon Yolanda [37].

## VI. RELATED RESEARCH PROJECTS

Many research projects have investigated these issues and we can list the following ones.

The H2020 TransCrisis project [38] - Enhancing the EU's transboundary crisis management capacity (2015 - 2018) has studied the crisis management capacities the EU and how political leaders have made use of these crisis management capacities. This framework deals with transboundary crisis management at the EU level.

The H2020 DARWIN project [39] - Expecting the unexpected and know how to respond (2015 - 2018) has focused on improving responses to expected and unexpected crises affecting critical societal structures during natural disasters (e.g. flooding, earthquakes) and man-made disasters (e.g cyber-attacks). To achieve this, DARWIN developed European resilience management guidelines aimed at critical infrastructure managers, crisis and emergency response managers, service providers, first responders and policy makers.

The H2020 5G-MoNArch project [40] - 5G Mobile Network Architecture for diverse services, use cases, and applications in 5G and beyond (2017-2020) proposes a flexible, adaptable, and programmable 5G architecture by combining virtualisation, slicing and orchestration of access with inter-slice control and cross-domain management, experiment-driven optimization, cloud-enabled protocol stack.

The H2020 MATILDA [41] - A Holistic, Innovative Framework For The Design, Development And Orchestration Of 5g-Ready Applications And Network Services Over Sliced Programmable Infrastructure (2017-2020) designed and implemented a holistic 5G end-to-end services operational framework tackling the lifecycle of design, development and orchestration of 5G-ready applications and 5G network services over programmable infrastructure, following a unified programmability model and a set of control abstractions.

The H2020 SLICENET [42] - End-to-End Cognitive Network Slicing and Slice Management Framework in Virtualised Multi-Domain, Multi-Tenant 5G Networks (2017-2020) aimed at creating and demonstrating the tools and mechanisms to achieve "networks as a service" where logical network slices are created and allocated to flexibly and efficiently in a multi-operator environment.

The H2020 5G ENSURE [43] – 5G Enablers for Network and System Security and Resilience (2015 – 2018) proposed the design of an overall security architecture including authentication, authorization and accounting, privacy, trust, security monitoring, and network management and virtualization isolation.

The H2020 SELFNET [44] – A Framework for Self-Organized Network Management in Virtualized and Software Defined Networks (2015 – 2018) designed an autonomic network management framework targeting the integration of SDN, NFV, Self-Optimizing Network, Cloud Computing, Artificial Intelligence and Quality-of-Experience, to address self-protection (to prevent distributed cyber-attacks), self-healing (to deal with network failures) and self-optimization (to enhance the QoE and network performance), and virtual infrastructure management.

The H2020 COHERENT [45] – Coordinated control and spectrum management for 5G heterogeneous radio access networks (2015 – 2018) defined a programmable unified management framework for heterogeneous 5G Radio Access Networks (flexible spectrum management, radio resources coordination and modelling, and RAN sharing).

The H2020 5G NORMA [46] – 5G Novel Radio Multiservice Adaptive Network Architecture (2015 – 2018) developed an adaptive networking architecture with flexible and context-aware network functions deployment in a multi-tenant scenario involving software defined network control, joint optimization of access and core network functions, and adaptive decomposition and allocation of network functions.

The ANR GéNéPi project (2014-2017) proposed a Mediation Information System dedicated to support the collaborative management of crisis situation. Especially, it aimed at exploiting very large quantities of and flows of data generated from crisis sites.

None of the previous works integrate social media crisis information and the crisis IT architecture deployment. The originality of our approach is thus twofold. First, we consider natural disaster crisis management as a big data issue and we would like to exploit social media especially in Thai language using machine learning techniques. Secondly, we advocate for a crisis IT management framework that integrates information coming from social media to dynamically adapt the network architecture and support the crisis management services.

## VII. CONCLUSION

Crisis management is definitely a big data issue given the incredible diversity, heterogeneity and number of channels that can contribute to a crisis resolution. To allow more efficient and reliable coordination for decision making and strengthening emergency response, crisis cells have to govern the operational IT infrastructure resilience as well as align its information system for a better appreciation and awareness of the situation being managed.

As it becomes impossible for a human to "harvest" and process the whole information, machine-learning techniques can help in identifying the right situations in which the right decision might be taken. Situation awareness theory provides the tools for expressing and deploying the right policies.

Using the dynSMAUG system as a concrete example, we highlighted open questions in building an effective decision support system to help crisis cells identifying early warnings and situation-specific awareness figuring out the right actions/partnerships to coordinate. Our future work will tackle these open questions to propose a situation-based IT management system during natural disaster crisis.

## REFERENCES

[1] H. KAMEZAKI, "ICT Infrastructure resilience against natural disasters in the Asia-Pacific region," Mar. 2015. [Online]. Available: http://www.adrc.asia/acdr/2015/documents/PF520_05_ABAC.pdf.

[2] European Environment Agency, "Climate change adaptation and disaster risk reduction in Europe," 15/2017, 2017. [Online]. Available: https://www.eea.europa.eu/publications/climate-change-adaptation-and-disaster/.

[3] APEC Business Advisory Council, "Building Asia-Pacific Community Mapping Long-Term Prosperity," 2014.

[4] 5G Initiative team, "NGMN 5G White paper," Next

Generation Mobile Networks Alliance, 2015. [Online]. Available: https://www.ngmn.org/fileadmin/ngmn/content/downloads/Technical/2015/NGMN_5G_White_Paper_V1_0.pdf.

[5] E. Villebrun, “Le Réseau Radio du Futur (RRF),” Jun. 14, 2018.

[6] “Risques : Prévention des risques majeurs.” [Online]. Available: https://www.gouvernement.fr/risques.

[7] M. R. Endsley, “Situation awareness misconceptions and misunderstandings,” *Journal of Cognitive Engineering and Decision Making*, vol. 9, no. 1, pp. 4–32, 2015.

[8] M. R. Endsley and D. J. Garland, “Theoretical underpinnings of situation awareness: A critical review,” *Situation awareness analysis and measurement*, vol. 1, p. 24, 2000.

[9] E. C. Adam, “Fighter cockpits of the future,” in *Digital Avionics Systems Conference, 1993. 12th DASC., AIAA/IEEE*, 1993, pp. 318–323.

[10] J. Webb, A. Ahmad, S. B. Maynard, and G. Shanks, “A situation awareness model for information security risk management,” *Computers & Security*, vol. 44, pp. 1–15, Jul. 2014, doi: 10.1016/j.cose.2014.04.005.

[11] L. I. Barona López, Á. L. Valdivieso Caraguay, J. Maestre Vidal, M. A. Sotelo Monge, and L. J. García Villalba, “Towards Incidence Management in 5G Based on Situational Awareness,” *Future Internet*, vol. 9, no. 1, p. 3, Jan. 2017, doi: 10.3390/fi9010003.

[12] R. Laborde, A. Oglaza, A. S. Wazan, F. Barrère, and A. Benzekri, “A situation-driven framework for dynamic security management,” *Annals of Telecommunications*, vol. 74, no. 3–4, pp. 185–196, 2019.

[13] C. M. Machuca *et al.*, “Technology-related disasters: A survey towards disaster-resilient Software Defined Networks,” in *2016 8th International Workshop on Resilient Networks Design and Modeling (RNDM)*, Sep. 2016, pp. 35–42, doi: 10.1109/RNDM.2016.7608265.

[14] J. Ye, S. Dobson, and S. McKeever, “Situation identification techniques in pervasive computing: A review,” *Pervasive and Mobile Computing*, vol. 8, no. 1, pp. 36–66, Feb. 2012, doi: 10.1016/j.pmcj.2011.01.004.

[15] R. Laborde, F. Barrère, and A. Benzekri, “Toward authorization as a service: a study of the XACML standard,” in *Proc of the 16th Communications & Networking Symposium*, 2013, p. 9.

[16] B. Nasser, R. Laborde, A. Benzekri, F. Barrere, and M. Kamel, “Dynamic creation of inter-organizational grid virtual organizations,” *First International Conference on e-Science and Grid Computing,* pp. 405–412, 2005.

[17] B. Kabbani, R. Laborde, F. Barrère, and A. Benzekri, “Managing Break-The-Glass using Situation-oriented authorizations,” in *9ème Conférence sur la Sécurité des Architectures Réseaux et Systèmes d’Information-SAR-SSI 2014*, 2014, p. 0, Accessed: Aug. 28, 2015. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01120112/.

[18] B. Kabbani, R. Laborde, F. Barrere, and A. Benzekri, “Specification and enforcement of dynamic authorization policies oriented by situations,” in *New Technologies, Mobility and Security (NTMS), 2014 6th International Conference on*, 2014, pp. 1–6, Accessed: Aug. 28, 2015.

[19] G. Arfaoui, J. M. S. Vilchez, and J.-P. Wary, “Security and Resilience in 5G: Current Challenges and Future Directions.,” 2017, pp. 1010–1015.

[20] A. S. da Silva, P. Smith, A. Mauthe, and A. Schaeffer-Filho, “Resilience support in software-defined networking: A survey,” *Computer Networks*, vol. 92, pp. 189–207, Dec. 2015, doi: 10.1016/j.comnet.2015.09.012.

[21] P. N. Tran and H. Saito, “Disaster Avoidance Control against Tsunami,” in *2016 28th International Teletraffic Congress (ITC 28)*, Sep. 2016, vol. 01, pp. 26–34

[22] K. Nguyen, Q. T. Minh, and S. Yamada, “A Software-Defined Networking Approach for Disaster-Resilient WANs,” in *2013 22nd International Conference on Computer Communication and Networks (ICCCN)*, Jul. 2013, pp. 1–5, doi: 10.1109/ICCCN.2013.6614094.

[23] X. Dong, H. Lin, R. Tan, R. K. Iyer, and Z. Kalbarczyk, “Software-defined networking for smart grid resilience: Opportunities and challenges,” in *Proceedings of the 1st ACM Workshop on Cyber-Physical System Security*, 2015, pp. 61–68.

[24] S. Vieweg, A. L. Hughes, K. Starbird, and L. Palen, “Microblogging during two natural hazards events: what twitter may contribute to situational awareness,” in *Proc of the SIGCHI conference on human factors in computing systems*, 2010, pp. 1079–1088.

[25] W. J. Corvey, S. Vieweg, T. Rood, and M. Palmer, “Twitter in mass emergency: what NLP techniques can contribute,” in *Proc of the NAACL HLT 2010 Workshop on Computational Linguistics in a World of Social Media*, 2010, pp. 23–24.

[26] G. Neubig, Y. Matsubayashi, M. Hagiwara, and K. Murakami, “Safety Information Mining—What can NLP do in a disaster—,” in *Proceedings of 5th International Joint Conference on Natural Language Processing*, 2011, pp. 965–973.

[27] G. Ifrim, B. Shi, and I. Brigadir, “Event detection in twitter using aggressive filtering and hierarchical tweet clustering,” 2014.

[28] B. Klein, X. Laiseca, D. Casado-Mansilla, D. López-de-Ipiña, and A. P. Nespral, “Detection and extracting of emergency knowledge from twitter streams,” in *International Conference on Ubiquitous Computing and Ambient Intelligence*, 2012, pp. 462–469.

[29] M. Imran, P. Mitra, and C. Castillo, “Twitter as a lifeline: Human-annotated twitter corpora for NLP of crisis-related messages,” *arXiv preprint arXiv:1605.05894*, 2016.

[30] “LexTo : เล็กซ์โต ( โปรแกรม ตัดคำภาษาไทย แบ่งคำภาษาไทย ).” http://www.sansarn.com/lexto/ (accessed Nov. 02, 2020).

[31] *PyThaiNLP/pythainlp*. PyThaiNLP, 2020.

[32] A. Bondielli and F. Marcelloni, “A survey on fake news and rumour detection techniques,” *Information Sciences*, vol. 497, pp. 38–55, 2019.

[33] C. Castillo, *Big crisis data: social media in disasters and time-critical situations*. Cambridge University Press, 2016.

[34] A. Adi and O. Etzion, “Amit-the situation manager,” *The VLDB Journal—The International Journal on Very Large Data Bases*, vol. 13, no. 2, pp. 177–203, 2004.

[35] D. Luckham, “An Introduction to Complex Event Processing in Distributed Enterprise Systems,” in *The Power of Events*, Springer, 2002.

[36] A. Benzekri, R. Laborde, A. Oglaza, D. Rammal, and F. Barrère, “Dynamic security management driven by situations: An exploratory analysis of logs for the identification of security situations,” in *2019 3rd Cyber Security in Networking Conference (CSNet)*, 2019, pp. 66–72.

[37] “Open Crisis - Humanitarian Data Exchange.” https://data.humdata.org/organization/open-crisis (accessed Nov. 02, 2020).

[38] “Home,” *TransCrisis.* https://www.transcrisis.eu/ (accessed Nov. 02, 2020).

[39] “DARWIN,” *DARWIN.* https://h2020darwin.eu/ (accessed Nov. 02, 2020).

[40] “5G Mobile Network Architecture – for diverse services, use cases, and applications in 5G and beyond.” https://5g-monarch.eu/ (accessed Nov. 02, 2020).

[41] “The Matilda Project.” https://www.matilda-5g.eu/ (accessed Nov. 02, 2020).

[42] “SLICENET – SLICENET.” https://slicenet.eu/ (accessed Nov. 02, 2020).

[43] “5G ENSURE,” *5G ENSURE.* http://www.5gensure.eu/ (accessed Nov. 02, 2020).

[44] “SELFNET-5G – SELFNET-5G.” https://selfnet-5g.eu/ (accessed Nov. 02, 2020).

[45] “EU H2020 COHERENT | EU H2020 COHERENT.” http://www.ict-coherent.eu/coherent/ (accessed Nov. 02, 2020).

[46] “5G NORMA - 5G Novel Radio Multiservice adaptive network Architecture.” http://www.it.uc3m.es/wnl/5gnorma/ (accessed Nov. 02, 2020).