Spatiotemporal Event Diffusion: A Formal Model and Framework

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Current research into fundamentals relating to modeling geographic dynamics over space and time including event-based modeling can contribute to the topic of visualizing and understanding the spatiotemporal dynamics of a global diffusion of ideas. In this position paper on creating and mapping information landscapes based on the diffusion of ideas, ongoing research in geospatial event modeling is discussed. Research is underway on a framework for modeling the dissemination of alerts during hazardous events. For this work, we are interested in events and their sequences and possible patterns, and consider these with regard to possible diffusion or dissemination strategies for space-time event information. Although we focus on diffusion of event notifications, the framework can be generalized for other information landscapes.

In the wake of a hazard event, for example, a possible water main break where water floods a nearby road or toxic smoke from a landfill fire, information about the event spreads through space in different ways. Notification services are designed to assist diffusion of the news, alerting citizens of any precautions or actions that are necessary. Ongoing research into a formal model for event notifications examines the components in the event notification process including dissemination of information and how alerts can be spread in space-time. Previous research includes ontology design for supporting notification systems that automatically adapt notifications for user groups with different accessibilities to information (Malizia et al. 2010), context-aware event notification systems that flexibly notify users based on current context (Lee et al. 2005), identification and notification of users using online social networks (Pho et al. 2011), and how the underlying semantics of events can enhance an information system's ability to detect events (Stewart Hornsby and Cole 2007)

Event notifications are spatiotemporal processes, where alerts are spread through both space and time. In order to more precisely target the potential impacted recipients, five different strategies for diffusing information about events are proposed, including *flooding*, *gossip*, *hierarchy, location-constrained* and *time-constrained* approaches. These approaches are drawn from sensor network studies where individuals are modeled as mobile units (Nittel et al. 2004). A *flooding* strategy is where all individuals in the impacted space-time region for an event receive the alert information (Chang et al. 2012). For example, universities commonly use a flooding strategy to notify the university community if a serious event has occurred on or near the campus. For these cases, the campus community will receive an alert by phone, email, or text message regardless of where they are at the time, or time of day. *Gossip* refers to cases where certain individuals will get notified first, and they then relay the alert to *N* other people, and the relay continues until recipients find the alert information irrelevant and stop

passing on information. In this case, different recipients receive the alert information at different times, and the overhead of information dissemination is distributed. A third strategy is a *hierarchical approach* where alerts are disseminated through different levels. For example, an alert may be spread from a county level to towns, and then to more local districts. *Location-based* approaches refer to cases where due to the known extent of the event, only individuals in specific regions or particular locations need to receive information. A water main break, for example, commonly has a notification area that is restricted based on the size of the main and expected extent of possible flooding (e.g., no more than two roads may be affected). If an individual enters a hazard area, they will receive an alert. Once they leave the affected area, no further notification occurs. Location-based strategies may be extended to spatiotemporal strategies highlighting the role of time. Just as a location-constrained approach controls the spatial range of event notification, *time-constrained strategies* tailor event notifications on a temporal dimension. A closed road may require notification around the clock since the road could be used at any time. Notifications about flooding that is expected to prevent individuals from reaching their workplace or parking their cars, may have more time-sensitive properties as these alerts need to be disseminated prior to the time when people travel to work. Since individual mobility is closely associated with time of the day, time-constrained notifications are an approach to help accurately target impacted recipients.

A formal model of strategies for disseminating alert information according to one of the above approaches includes operators *broadcast*, *report, tell,* and *exchange* that will be described in more detail at the workshop. These operators can be combined in different ways to capture more complex descriptions of dissemination and model sequences of information dissemination.

References

Chang, D., Cho, K., Choi, N., Kwon, T., and Choi, Y. (2012). A probabilistic and opportunistic flooding algorithm in wireless sensor networks. *Computer Communications*, *35* (4): 500-506.

Lee, G. J. Naganuma, T. and Kurakake, S. (2005). Efficient matching in a context-aware event notification system for mobile users, *in Proceedings of the 4th International Workshop on Distributed Event-Based Systems* (DEBS'05).

Malizia, A., Onorati, T., Diaz, P., Aedo, I., and Astorga-Paliza, F. (2010). SEMA4A: An ontology for emergency notification systems accessibility. *Expert Systems with Applications*, 37 (4): 3380-3391.

Nittel, S., Duckham, M. and Kulik, L. (2004). Information dissemination in mobile ad-hoc geosensor networks. In M. Egenhofer, C. Freksa & H. J. Miller (Eds.), *Proceedings of the International Conference on GIScience*, Lecture Notes in Computer Science, 3234, Springer, pp. 206-222.

Pho, H., Han, S. C., and Kang, B. H. (2011). Emergency-affected population identification and notification by using online social networks software engineering, business continuity, and education. *Communications in Computer and Information Science*, 257: 541-550.

Stewart Hornsby, K. and S. Cole (2007). Modeling moving geospatial objects from an event-based perspective. *Transactions in GIS*, *11* (4), 555-573.

Zhang, X., Li, J.-T., Zhang, Y.-D., and Neo, S.-Y. (2010). Sensing geographical impact factor of multimedia news events for localized retrieval and news filtering advances in multimedia modeling. *Lecture Notes in Computer Science*, vol. 5916 Springer Berlin Heidelberg, pp. 567-576.