Circles of Crowdsourcing: The Social Organization of Participatory Sensing

Michael Muller, Susanne Hupfer, Stephen Levy, Daniel Gruen, Andrew Sempere, & Reid Priedhorsky
IBM Research
One Rogers Street, Cambridge, MA, USA 02142
{michael_muller, Susanne_Hupfer, levysn, daniel_gruen, asemper, reidpr} @ us.ibm.com

ABSTRACT
We describe an extension of participatory sensing applications into social media services. We analyze the formal structures of these new services, and outline an agenda for research into metrics and analytics for these hybrid social+map structures.

Author Keywords
Participatory sensing, crowdsourcing, application categories, metrics

ACM Classification Keywords
H.5.3 Group and organizational interfaces.

General Terms
Human factors.

INTRODUCTION
As participatory sensing applications become more important [3, 5], researchers have begun to develop abstractions to describe and compare those applications (e.g., [21]). This short paper presents an analytic framework to combine the formal, map-based aspects of these crowdsourcing applications, and the social aspects of the collaborations that are enabled by these applications. One of the goals is a set of metrics based on the framework. While researchers have explored metrics for mobile collaborative applications, most of that work has focused on impacts on individual users (e.g., [12]), technology performance (e.g., [14]) or characterizing the movements of users [16] or user's public-transit vehicles [17]. We begin to develop the metrics based on the combination of geographic and social requirements.

PARTICIPATORY SENSING APPLICATIONS
We base our analysis on current map-based participatory sensing applications, and we extend the analytic space with a project that we are currently developing, called OurMaps.[1] In most participatory sensing applications, users collaborate asynchronously by adding data to a map (e.g., [3]) – a form of locality-anchored collective intelligence [2] that can have high accuracy when compared with professionally-sourced map information [8]. For example, in an Open311 application [11], residents of a city may add complaints about city problems to a shared database of problem reports (e.g., road hazards, graffiti, unsafe buildings, broken streetlamps, etc.) (e.g., [10]). In an emergency management context, citizens add updated information about changing hazard conditions [9]. In a citizen science application, participants contribute data observations at specific locations to a shared project that has been organized by scientific staff (for review, see [21]). In cyclist applications, members add or view routes, and correct inaccuracies in online maps [7, 15]. In consumer-oriented applications, users add rating or comment data to objects or businesses at specific locations [22], or indicate the availability of items for exchange or contribution [6].

These participatory sensing applications have the following common attributes:

- Each is based on a map, with at least one form of primitive data item that represents a location
- Each location has one or more associated data attributes

These applications differ from one another in terms of

- The type or types of objects represented at each location (e.g., bird-sightings vs. road hazards…)
- The type or types of associated data attributes (e.g., type-of-business vs. rating-of-service-quality)
- The permissions of users to
  - Add data attributes to locations (e.g., describing a location vs. evaluating/rating a location)
  - Add locations

In general, participatory sensing applications also share a set of common limitations. Each application is designed around a single purpose. If a user wants to contribute, s/he must find a participatory sensing application that

[1] Fictitious project name for blind review.

MobileHCI 2011, Aug 30–Sept 2, 2011, Stockholm, Sweden.

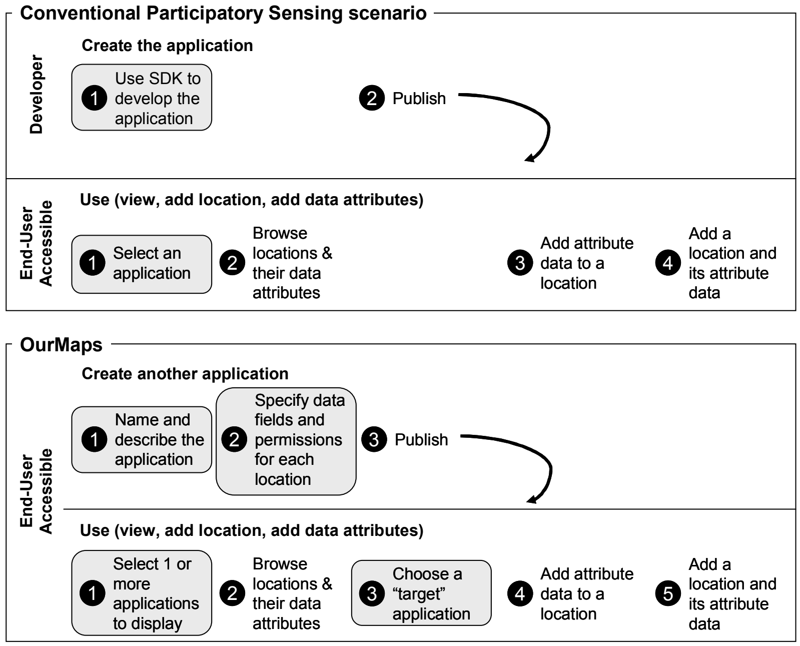

Figure 1. Contrast of the conventional Participatory Sensing approach vs. OurMaps. The grey rounded-rectangles highlight the differences.

corresponds to her/his interests or needs. Alternatively, a user with programming knowledge can develop a new participatory sensing application, but of course most users do not possess such knowledge.

Crowdsourcing of Participatory Sensing Applications

The OurMaps project extends this space of participatory sensing applications by allowing ordinary end-users to create their own applications, using a template-based approach to specifying an application that does not require programming knowledge (Figure 1). In this way, OurMaps provides for two types of crowdsourcing: (1) crowd-sourcing of the location-based data in an application, and also (2) crowdsourcing of the applications themselves.

A user who wants to create a new application begins by filling-in a template that establishes the name and description of the application, and several optional fields (such as the ability of users to rate the application as-a-whole). The user then fills-in a second template that describes the data attributes (data fields) that will be associated with each location. Additional fields allow to control whether the location can support ratings or comments by *multiple* end-users. There is of course a trade-off, in which the OurMaps approach has the cost of greater complexity, but also has the benefits of

- hosting multiple map-based applications in a single environment;
- supporting end-users to create collaborative map-based applications without programming skills; and
- allowing users to display multiple, overlaid maps on a single display (a mash-up-by-menu-selection feature).

This short paper is not intended as a system description of OurMaps. We use the novel characteristics of OurMaps to extend frameworks for participatory sensing applications.

CONCENTRIC CIRCLES OF CROWDSOURCING

Many social media afford some type of crowdsourcing. A blog service contains many blogs, and each blog contains both posts by the blog author(s), and comments by others (Figure 2A). A discussion forum server contains many forums, and each forum contains a topic posting by one person, and responses by others (Figure 2B). A simple map-based participatory sensing application is similar: The map contains many locations, each of which was contributed by a person, and optionally additional data attributes which may be contributed by others (Figure 2C).

The OurMaps architecture brings participatory sensing into a domain similar to conventional blogs and forums – i.e., OurMaps provides an environment in which multiple people can create and publish map-based applications for use by other people, who can not only view those applications but can also contribute their own data to them. OurMaps thus moves the participatory sensing paradigm from single-applications into social media services. Each map in OurMaps has a structural level similar to each blog in a blog service, or each forum in a forum discussion service. Based on the success of blogs, forums, and more innovative approaches to shared social artifacts (e.g., [18]), we anticipate that there will be additional fully-social versions of participatory sensing, similar to OurMaps. Therefore, it is worthwhile to think about the formal attributes of these new social structures.

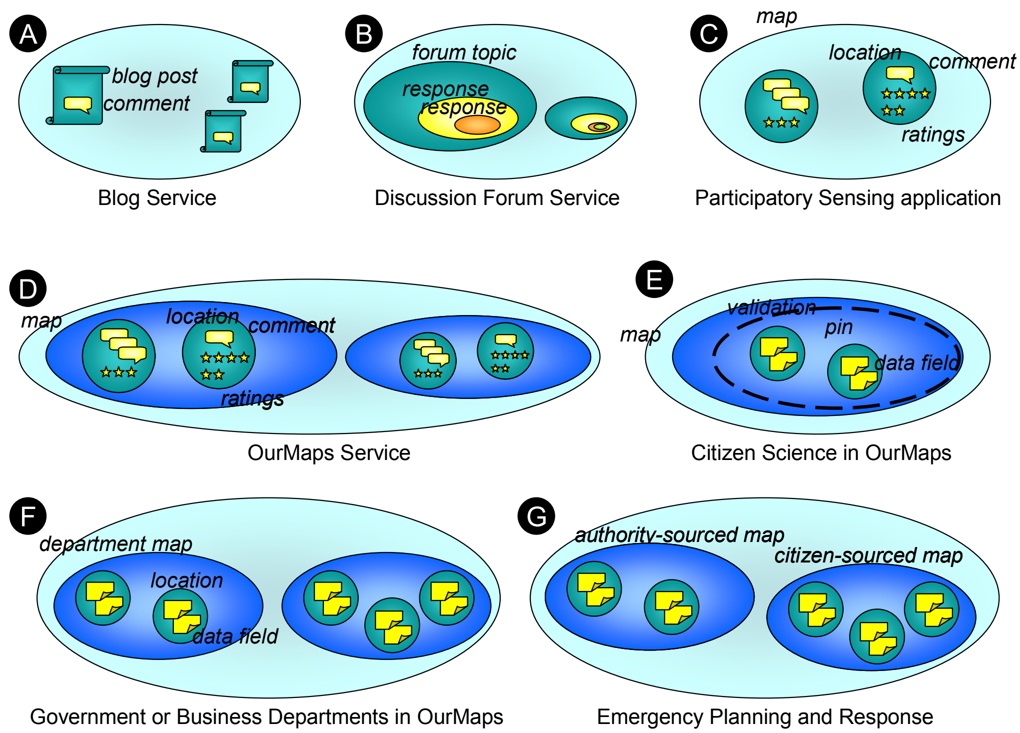

Figure 2. Concentric circles of social media. A. Blogs. B. Discussion forums. C. Conventional Participatory Sensing applications. D. OurMaps service. E. Citizen Science validation structures in OurMaps. F. Departmental structures in OurMaps. G. Emergency planning and response in Our Maps.

In formal terms, we can think of each of these application configurations in terms of concentric circles of objects and their attributes. For blogs, there is a structural limit on the number of concentric circles: *service / blog / post-or-comment.* Interestingly, for discussion forums, there is no formal limit on the concentrism: *service / forum / topic / reply / reply-to-reply…* On the single map of a participatory sensing application, there is a structure similar to blogs: *service==map / location / data-attribute.* In OurMaps and other services based on participatory sensing, there is also a formal limit: *service / map / location / data-attribute.* However, unlike the other social media services, maps are not simply collections of text artifacts (or user-changeable visualizations). Maps have their own concrete reality, and therefore it becomes interesting to examine the intersection of the hierarchical "givens" of maps with the diverse structures of human social arrangements.

Figures 2E-2G provide examples of more complex interactions of the geographic world and the social world.

Citizen Science. In most citizen science applications, there is a data-quality validation "protocol" that intervenes between the contribution of a data observation, and its acceptance and appearance on the common map [WIG], as shown in Figure 2E.

Department structures. In government or business organizations, each department may create its own application within the common OurMaps environment, to manage departmental facilities or mobile workers (Figure 2F). In this example, there is an additional concentric layer of the business or government organization, that intervenes between the map (which is common to all OurMaps applications) and the locations that are managed or staffed by each department.

Emergency Response. In the more challenging domain of emergency response, there may be one application with authority-sourced information (e.g., locations of hospitals, emergency workers) and a second application with citizen-sourced information about real-time changing circumstances (flood waters, wildfires), displayed on a common map, as shown in Figure 2G. In this example, the intervening layer differentiates not only the type of information in each application, but the permissions of who is allowed to update each type of information.

A longer report will consider these intersections of geography and sociality in more detail.

RESEARCH AGENDA FOR MAP-BASED SOCIAL MEDIA

Similarly to metrics for other social media (e.g., [20]), participatory sensing metrics will need ways to characterize patterns of contribution patterns by persons, and patterns of topics. In the extended analytic space of this report, metrics of people's contributions to blogs [1], microblogs [13], and discussion forums [4] may be adapted for contributions to participatory sensing applications, but they will require modifications for people who contribute across the kinds of organizational and social-process boundaries described in Figures 2E-2G.[2]

When multiple people contribute comments and ratings to a location, the resulting information structure is similar to a discussion forum, and therefore content-analysis metrics from the long history of discussion analyses [19] will be useful. Metrics to track topics over time [23] may be particularly important for quickly-changing conditions in an emergency response scenario.

It is relatively easy to compute metrics – i.e., to count people and contributions across space and across time. It will be more interesting to consider analytics – i.e., a conversion of the counts into comparable, scaled values that can be used for tracking trends in people and in topics, and for recommendations and other services. Finding meaningful transformations from social metrics to social analytics will require some experience with the metrics, and we are just beginning to study the social metrics for participatory sensing.

CONCLUSION

In this short paper, we have extended the analytic space of participatory sensing applications [2, 3, 5, 7, 8, 9, 10, 14, 15, 17, 21], showing how those applications can become fully social media through an approach similar to blog and forum services [1, 4, 13, 19, 20, 23]. We have considered some of the hybrid structures that would result from the combination of geographic structures and social/organizational structures. Finally, we have outlined some of the resulting research challenges to develop metrics and analytics based on those new structures that can be used in future collaborative mobile services.

REFERENCES

1. Akritidis, L., Katsaros, D., & Bozani, P., 'Identifying influential bloggers: Time does matter,' *Proc. WI-IAT 2009*.
2. Brabham, D.C., Sanchez, T.W., & Bartholomew, K., 'Crowdsourcing public participation in transit planning: Preliminary results from the Next Stop design case,' presented at National Trans. Res. Bd. Nat. Acad, , 2010.
3. Campbell, A.T., Eisenman, S.B., Lane, N.D., Miluzzo, E., Peterson, R.A., Lu, H., Zheng, X., Musolesi, M., Fodor, K., & Ahn, G.-S., 'The rise of people-centric sensing,' *Internet Comp. 12* (4), 12-21, 2008.
4. Castro-Herrera, C., Cleland-Huang, J., & Mobasher, B., 'A recommender system for dynamically evolving online forums,' *Proc. RecSys 2009*.
5. Cuff, D., Hansen, M., & Kang, J. (2008), 'Urban sensing: Out of the woods,' *Communications of the ACM 51*(3), March 2008.
6. Freecycle, www.freecycle.org, n.d.
7. Grashoff, P., Wigan, M., & Benjanmins, M., 'Cooperative web based bicycle routing database for trip planning, including dynamic weather integration,' *Proc. Int. Road Weather Conf 2010*.
8. Hakkay, M., 'How good is volunteered geographical information? A comparative study of OpneStreetMap and Ordnance survey datasets,' *Env. Plan. Des. 37*(4), 682-703.
9. Jiang, M., & McGill, W.L. (2010), 'Human-centered sensing for crisis response and management analysis campaigns,' *Proceedings of ISCRAM 2010*.
10. King, S.F., & Brown, P. (2007), 'Fix my street or else: Using the internet to voices local public service concerns,' *Proceedings of ICEGOV 2007*.
11. Open311 (n.d.), *Open311 Wiki*, http://wiki.open311.org/Main_Page .
12. Oulasvirta, A., Tamminen, S., Roto, V., & Kuorelahti, J., 'Interaction in 4-second bursts: The fragmented nature of attentional resources in mobile HCI,' *Proc CHI 2005*.
13. Pal, A., & Counts, S., 'Identifying topical authorities in blogs,' *Proc WSDM 2011*.
14. Payton, J., & Julian, C., 'Integrating participatory sensing in application development practices,' *Proc. FoSER 2010*.
15. Priedhorsky, R., Masli, M., & Terveen, L. (2010), 'Eliciting and focusing geographic volunteer work,' *Proceedings of CSCW 2010*.
16. Thaker, G.S., Helmy, A., & Hsu, W.-J., 'Similarity analysis and modeling in mobile societies: The missing link,' *Proc. CHANTS 2010*.
17. Thiagarajan, A., Biagioni, J., Gerlich, T., & Eriksson, J., 'Cooperative transit tracking using smart-phones,' *Proc. SenSys 2010*.
18. Viégas, F.B., Wattenberg, M., van Ham, F., Kriss, J., & McKeon, M., 'ManyEyes: A site for visualization at internet scale,' *IEEE Trans. Vis. Comp. Graph. 13*(6), 1121-1128, 2007.
19. Wanas, N., El-Saban, M., Ashour, H., & Ammar, W., 'Automatic scoring of online discussion posts,' *Proc WICOM 2008*.
20. Wang, J., Li, Q., Chen, Y.P., & Lin, Z., 'Recommendation in internet forums and blogs,' *Proc. ACL 2010*.
21. Wiggins, A., & Crowston, K. (2010), 'From conservation to crowdsourcing: A typology of citizen science,' *Proceedings of HICSS 44*.
22. Yelp, www.yelp.com, n.d.
23. Yong, J., & Leskovec, J., 'Patterns of temporal variation in online media,' *Proc. WSDM 2011*.

[2] Social network analysis will also contribute, but that topic is beyond this short paper.