Crowdsourcing Sensor Tasks to a Socio-Geographic Network

Damian Lasnia[1], Arne Bröring[1], Simon Jirka[2] and Albert Remke[2]
[1]Institute for Geoinformatics, University of Muenster, Germany {d.lasnia, arneb}@uni-muenster.de
[2]52°North, Münster, Germany {jirka, remke}@52north.org

ABSTRACT

This work describes an approach of a socio-geographic network for crowdsourcing sensor tasks to a human sensor web. Users can register as human sensors at the system by defining their skills and impact area. Based on that information, submitted sensor tasks are forwarded to the most suitable human sensor. Motivated by their willingness to help, users can support others by supplying information about their local environment as responses to sensor task requests. This enables people to retrieve data which is currently not existing or publicly accessible on the Web. A person who is moving to another country and interested in renting a flat without knowing much about its environment is one example for a potential requester of human sensor tasks. Data contributed once to this human sensor web is henceforth available to the public via existing Web 2.0 platforms.

INTRODUCTION

Today, millions of people are connected with the World Wide Web to browse, communicate, and share information. In this context, a new kind of outsourcing has become popular: *Crowdsourcing* which stands for outsourcing jobs to the Web community. Individuals are working as freelancers in their spare time; solving problems, delivering resources and providing skills (Howe, 2006). The advantage for the ordering party relies on the diversity of skills and backgrounds within the large pool of potential collaborators (Brabham, 2008).

All of those freelancers are living inside, and are interacting with[in], a specific region that can be considered as an attribute in everyone's personal background. This attribute is called *impact area* here. Inside this impact area, a person is capable of acting as a *human sensor*. That means, she is able to provide measured or recorded data about the environment within an acceptable time limit and with low effort. However, a *requester* needs a platform to get connected with these "sensors" to submit task requests. Social networks are becoming important platforms for exchanging such user generated data, but common social networks are improper to crowdsource sensor data, since their connectivity is mainly based on a "Who knows whom"-connection (Breslin, 2008). We propose a socio-geographic network, a *human sensor web* (Juerrens, 2009), incorporating the user's impact area to connect him with the network through a "Where are you?"-connection.

This approach enables users to publish sensor tasks to the network community, and interested human sensors can accomplish the task to help the requester in decision making. An example scenario is a person who wants to move from the US to Germany. This person has found an accommodation advert with attached photos showing the inside of the building. But how does the surrounding area look like? How busy is the traffic around the building? Is it noisy during the day? These questions could be answered if corresponding sensor data would be available (Yu, 2006). This work describes an approach which enables users to submit requests for such sensor data to a human sensor web. A benefit of this approach for the entire community is the growth of publicly accessible geodata. Thereby, the contributed sensor data does not only become common property. It even becomes traceable in detail, since it will be contributed by a large community and not only by a single central authority (Flanagin, 2008).

BACKGROUND

The term *Crowdsourcing* was established by Howe who characterized the underlying business model as the new pool of cheap labor (Howe, 2006). The idea behind this is to harvest the society's wisdom, skill or creativity for solving a certain task. Currently, two methods are common to do this. In the *Open Call*-method a task requester initializes the process by creating an open call, a description of the problem, challenge or task that shall be solved by the crowd. The reward modalities for accepted solutions on that open call are part of its description as well as the submission deadline. An example for this approach is Innocentive[1], a platform for crowdsourcing scientific challenges. The submitter of an accepted solution earns cash awards. An alternative approach is the *Repository*-method. Freelancers are uploading their ready-to-use resources to specialized communities, so that interested parties are able to browse these websites and purchase the resources they need. An example for this approach is Istockphoto[2] which provides a catalogue of user generated photos, illustrations, videos and audio files.

The rise of online communities with geographic background or specific geographic features is another trend that has enriched the geographic information market: Volunteered geographic information consists of user generated content that is submitted to online communities by individuals (Goodchild, 2007). The simplest way to create such geographic information is to attach geotags to any kind of data or information. Examples for this approach are georeferenced articles on Wikipedia[3] or photos on Flickr[4]. Also, OpenStreetMap[5] is a popular example for a platform collecting user generated geodata to create a free map of the world.

Collecting sensor data by considering humans as sensors is a recent research field that is influenced by concepts of volunteered geographic information, Crowdsourcing, and the participatory Web 2.0 (Madden, 2006). Key contents of this development are location based services, collaboratively generated data pools and specialized hardware components. Their operational environments may be single buildings or entire cities. Also, current topic of research is how human sensors can contribute their eye witness reports to enhance disaster management (Poser, 2008). Table 1 compares recent approaches in this research area with different characteristics.

	Sensor Data	Data-Transmission	Network
Citysense	None (only position)	Real-Time	Mobile phone network
Social sensing	E.g. noise-level	Real-Time	Ad-hoc social network
PEIR	Amount of carbon dioxide	Delayed	Community
Folksonomic Urban Sensing	Amount of Carbon dioxide, Atmospheric pressure, Temperature, Humidity	Delayed	Not specified

Table 1: Applications that use humans as sensor nodes

1 http://www.innocentive.com
2 http://www.istockphoto.com
3 http://www.wikipedia.org
4 http://www.flickr.com
5 http://www.openstreetmap.org

Citysense is interested in the human sensor's spatial dispersion, while Social sensing takes additional sensor data by taking nearby sensor nodes into account (Breslin, 2008). Both applications are location based services. PEIR is a prototype web application that aims at exploring certain human impacts on the environment. Folksonomic Urban Sensing visualizes collected data generated by shared sensing with specialized gadgets (Miyaki, 2008).

A HUMAN SENSOR WEB FOR CROWDSOURCING SENSOR TASKS

This work proposes a generic sensor data request application to establish a worldwide public human sensor web. The approach consists of a socio-geographic network where everyone can register to request sensor data by posting sensor tasks and retrieve answers to those tasks. The amount of effort for solving a task strongly correlates with the distance between a user's location and the location where a sensor task has to be performed. Furthermore, specific equipment may be needed to perform certain sensor tasks. Thus, every user has to specify an individual sensor node data sheet, containing information so that sensor tasks can be automatically forwarded to the most suitable human sensors. Social networks are capable of managing user profiles and provide communication functionality. For this reason a social network platform is chosen as the technological basis for our socio-geographic network. The provided sensor data is hosted on existing Web 2.0 platforms in order to embed the human sensor network into the existing web infrastructure instead of creating a parallel structure.

Potential

The success of a social network is strongly linked to the amount of registered users. So, there has to be a motivation to participate. Due to the fact that users will represent their geographic homeland, they will be the experts for this area and their localism will be a driving force to contribute. A more rational reason may be that people would like to be part of such a network, because they get empowered by the possibility to request sensor tasks worldwide. People are also participating in Web 2.0 applications to promote themselves, while others like to see themselves as part of a large network (Goodchild, 2007). However, at least every participant is able to learn new skills how to create geographic data. Those arguments may lead enough people to the registration form to start remote sensing the world in a new way.

The amount of people who are willing and motivated to participate as human sensors is just one constraint for the potential of a worldwide human sensor web. They also have to be technologically able to participate. The theoretical amount of potential human sensors may be derived on the basis of over 4 billion mobile devices and 1.1 billion PCs (Nokia, 2008), provided that Internet access is available everywhere. But even if every human is equipped with a mobile phone and Internet access, a human sensor network can only provide sensor data regularly from places where people are living. Thus, a worldwide human sensor network may provide sensor data from inhabited places (mainly urban areas that lay inside developed regions) with low effort, but never from the earth's whole surface.

Human Sensors

Human sensor tasks may be divided into two categories. The first category contains those tasks, which require human senses: Does it rain? How many people are at the beach? Is it noisy? Answers on these questions are always subjective due to different understandings and experiences. The second category of human sensor tasks contains those tasks that are performed by an additional sensor device. Such devices may vary between a stick that is combined with a chain to measure water levels, and a modern mobile phone that may own several electronic sensors by default (accelerometers, camera, microphone or thermometer). If these devices are used properly they deliver objective results, which is an advantage to the first category of sensor tasks. In future, an intelligent user interface should enable users to manage an inventory list. Derived from that list, appropriate sensor tasks based on the existing equipment can be forwarded to the user.

The Platform Design

Figure 1 provides a schematic view on the human sensor web platform developed within this work.

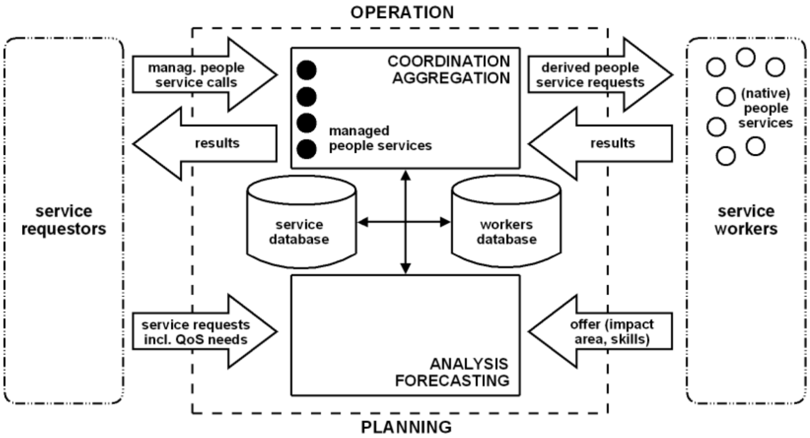

Figure 1: Schematic view of proposed pService platform (modified illustration according to Kern, 2009)

Activities that are displayed as arrows are the functionalities offered by the user interface. The offer arrow stands for creating and updating individual user profiles. Every registered user has to specify an impact area and a self-assessment about how good she is on solving specific sensor tasks. This information is stored in a workers database that is capable to perform spatial operations on impact areas. Only users who own such a sensor datasheet are able to act as service requester. Unregistered users are only able to query open calls and submit results. Service requests are necessarily specifying a certain sensor task that is supported by the network (what?), and a location where it has to be executed (where?). Beyond that, every request may specify general quality of service needs like predetermined timestamps (when?) or sensor task specific needs like a minimum resolution or accuracy (how?).

Submitted requests are stored in the service database and are published on the network. At the same time the server-sided planning component forwards the request to the registered users who are capable of solving the task. The more users are assigned, the higher the likelihood to receive a suitable result. The sensor task results are not directly hosted by the human sensor web, but uploaded to existing Web 2.0 platforms. Links to the uploaded data are forwarded to the task requester. Finally, the requester can accept one or more submissions. Accepted submissions can be rated, while declining a submission can be commented by the requester, so that the submitter can learn from his mistakes. The rating data is not publicly available. It is only used to estimate the quality of service. While the underlying rating of such a quality of service estimation is subjective to some extent, trust may be used as a proxy for the quality of human sensor data as well (Bishr, 2007). The friend list concept of social networks may be modified by a socio-geographic network to a trust list for establishing a trust-rating-system. The more people are trusting in someone, the higher the likelihood that submitted data was collected faithfully.

IMPLEMENTATION

The above described approach has been implemented by using a combination of Mahara[6], OpenLayers[7], GeoServer[8] and PostGIS[9] to provide interactive web mapping functionality. Users are able to query, create, update and delete spatial features upon an OpenLayers Web Feature Service (WFS) layer. The WFS is provided by GeoServer and built upon a PostGIS database. This architecture stack is embedded into Mahara, which provides user management, content sharing and notification capabilities, to create a socio-geographic network application.

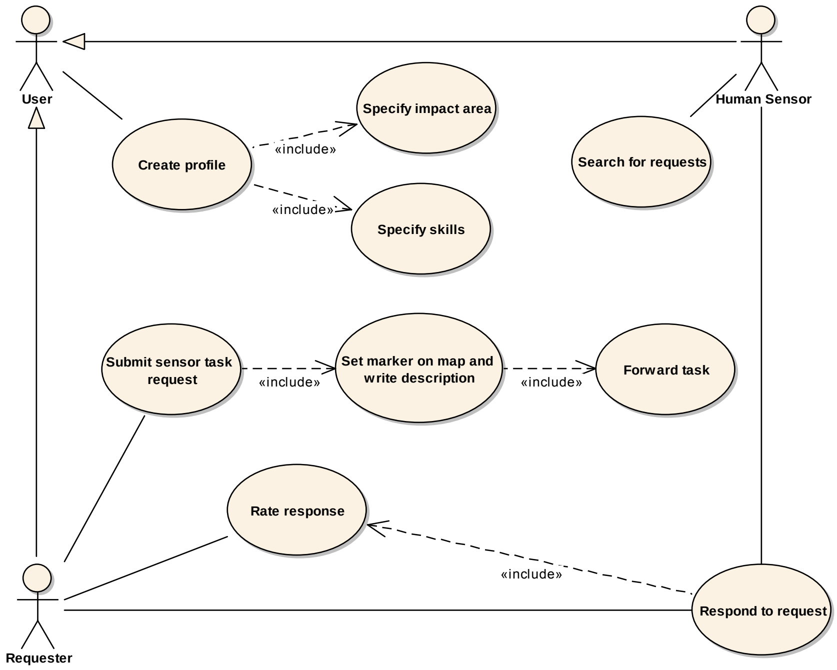

Figure 2: Use case diagram of main system functionalities

The use case diagram shown in Figure 2 depicts the basic functionalities offered by the system. First, it allows users to create their personal profiles. Besides contact information, users can specify a sensor node data sheet. This includes the definition of their skills so that the system is able to forward task requests accordingly. Additionally, the user has to specify an impact area (see Figure 3) within which she/he can act as a human sensor.

[6] http://mahara.org
[7] http://openlayers.org
[8] http://geoserver.org
[9] http://postgis.refractions.net

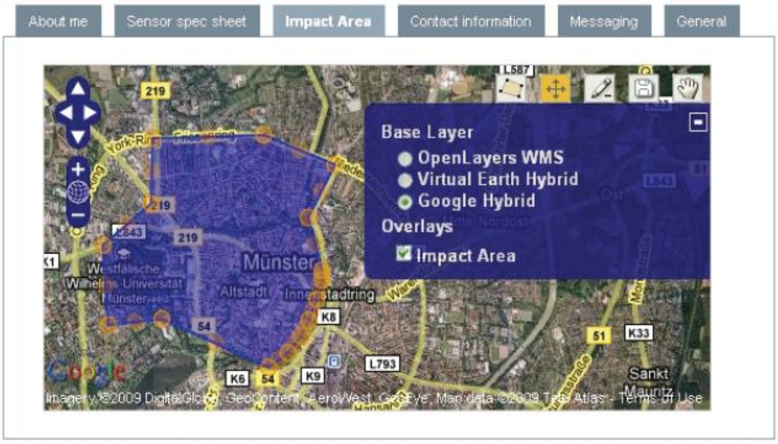

Figure 3: Edit Profile, Impact Area

A registered user can submit a new sensor task. Besides a general description, the task's location can be defined by using the map (see Figure 4). Further, the task description may contain special instructions (e.g., "no people on the photo, please"). In future, advanced user interfaces should also provide menu items that are designed to specify minimum quality needs, such as minimum resolution or frames per second. As a simple example of a task, a requester could ask the community to provide him/her a video of the "Sankt Paulus Dom" in Münster, Germany when its bells are ringing.

Figure 4: Requesting a sensor task

In consequence to the task submission, the system analyzes which impact areas contain the location of the task request and forwards it to the according human sensors. A message notifies a user about the existence of a task within his impact area (Figure 5).

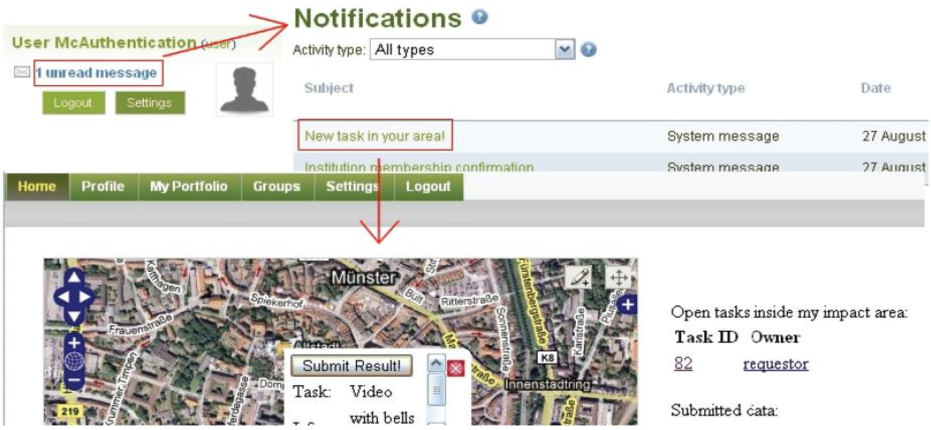

Figure 5: "New task in your area!"-Notification

Then, a user may answer to such a task to help the requester. In the above outlined example, a human sensor would videotape the dome and upload the data to a video sharing site (e.g., YouTube) to submit the link to this video to the human sensor web portal. The task requester is notified about the submission and can access the recorded video.

CONCLUSIONS & OUTLOOK

This work proposes a concept of a human sensor web application, a crowdsourcing platform for sensor data, to enable users delivering volunteered geographic information in response to requested sensor tasks. Nowadays, more and more people are capable to request such information and are also willing to provide it. The increasing number of platforms that host user generated content is an indicator for this development. The developed prototype of a platform of a socio-geographic network can act as a starting point for further research and future work.

In our approach, the delivery of sensor data is based on a non-commercial voluntary association in a socio-geographic network. A future step could be the design of a commercial sensor request crowdsourcing application. Such a commercial approach would incorporate a new motivational factor.

This work embeds the impact area of a user into its social network profile. A future approach could enable users to transmit their real time location to solve tasks on the fly. This would invert the concept of location based services, since the user is working for the application and not the other way round.

In future, the developed system shall also integrate sensor web standards to grant compatibility with other sensor services and applications. The Sensor Web Enablement initiative (Botts, 2008) of the Open Geospatial Consortium defines such standards to make sensors discoverable, accessible and useable via the Web. The utilization of this standards framework within a human sensor web would enable the definition of tasks and the retrieval of collected data in an interoperable way.

ACKNOWLEDGEMENTS

This work is supported by the EC project GENESIS (FP7-223996), as well as the 52° North Sensor Web community which envisions a real time integration of heterogeneous sensors into a coherent information infrastructure.

BIBLIOGRAPHY

Bishr, M., Kuhn, W. (2007) Geospatial Information Bottom-Up: A Matter of Trust and Semantics. The European Information Society, Lecture Notes in Geoinformation and Cartography. Heidelberg: Springer, 2007, vol. 9, pp. 365–387.

Brabham, D.C. (2008) Crowdsourcing as a Model for Problem Solving: An Introduction and Cases. Convergence: The International Journal of Research into New Media Technologies, vol. 14, no. 1, pp. 75-90.

Breslin, J.G., Decker, S., Hauswirth, M., Hynes, G., Le Phuoc, D., Passant, A., Polleres, A., Rabsch, C., Reynolds, V. (2009) Integrating Social Networks and Sensor Networks. [Online]. Available at: http://www.w3.org/2008/09/msnws/papers/sensors.html.

Botts, M., Percivall, G., Reed, C., Davidson, J. (2008): OGC (R) Sensor Web Enablement: Overview and High Level Architecture. Lecture Notes In Computer Science, vol. 4540, pp. 175–190.

Flanagin, A.J., Metzger, M.J. (2008) The Credibility of Volunteered Geographic Information. GeoJournal, vol. 72, pp. 137–148.

Goodchild, M.F. (2007) Citizens as Sensors: the World of Volunteered Geography. GeoJournal, vol. 69, no. 4, pp. 211–221.

Howe, J. (2006) The Rise of Crowdsourcing. [Online]. Available at: http://www.wired.com/wired/archive/14.06/crowds_pr.html

Jürrens, E. H., Bröring, A., Jirka, S. (2009): A Human Sensor Web for Water Availability Monitoring. Proceedings of OneSpace 2009 - 2nd International Workshop on Blending Physical and Digital Spaces on the Internet. Berlin, Germany.

Madden, M., Fox, S. (2006) Riding the Waves of "Web 2.0" – More than a buzzword, but still not easily defined. [Online]. Available at: http://www.pewinternet.org/Reports/2006/Riding-the-Waves-of-Web-20.aspx

Miyaki, T., Rekimoto, J. (2008) Sensonomy: Envisioning Folksonomic Urban Sensing. Proceedings of UbiComp Workshop 2008. Seoul, South Korea.

Nokia Research Center (2008) Sensing the World with Mobile Devices – The Vision. Nokia Technology Insights series

Poser, K., Kreibach, H., Dransch, D. (2008) Humans as Sensors: Assessing the quality of information from the public for rapid flood loss estimation. *GI-Days 2008: Proceedings of the 6th Geographic Information Days*, ser. ifgiPrints, E. J. Pebesma, M. Bishr, and T. Bartoschek, Eds., vol. 32, Institute for Geoinformatics. Münster, Germany: University of Münster, pp. 117 – 122.

Yu, Y., Prasanna, V.K., Krishnamachari, B., Kumar, V.K.P. (2006) Information Processing and Routing in Wireless Sensor Networks. World Scientific Publishing Company.