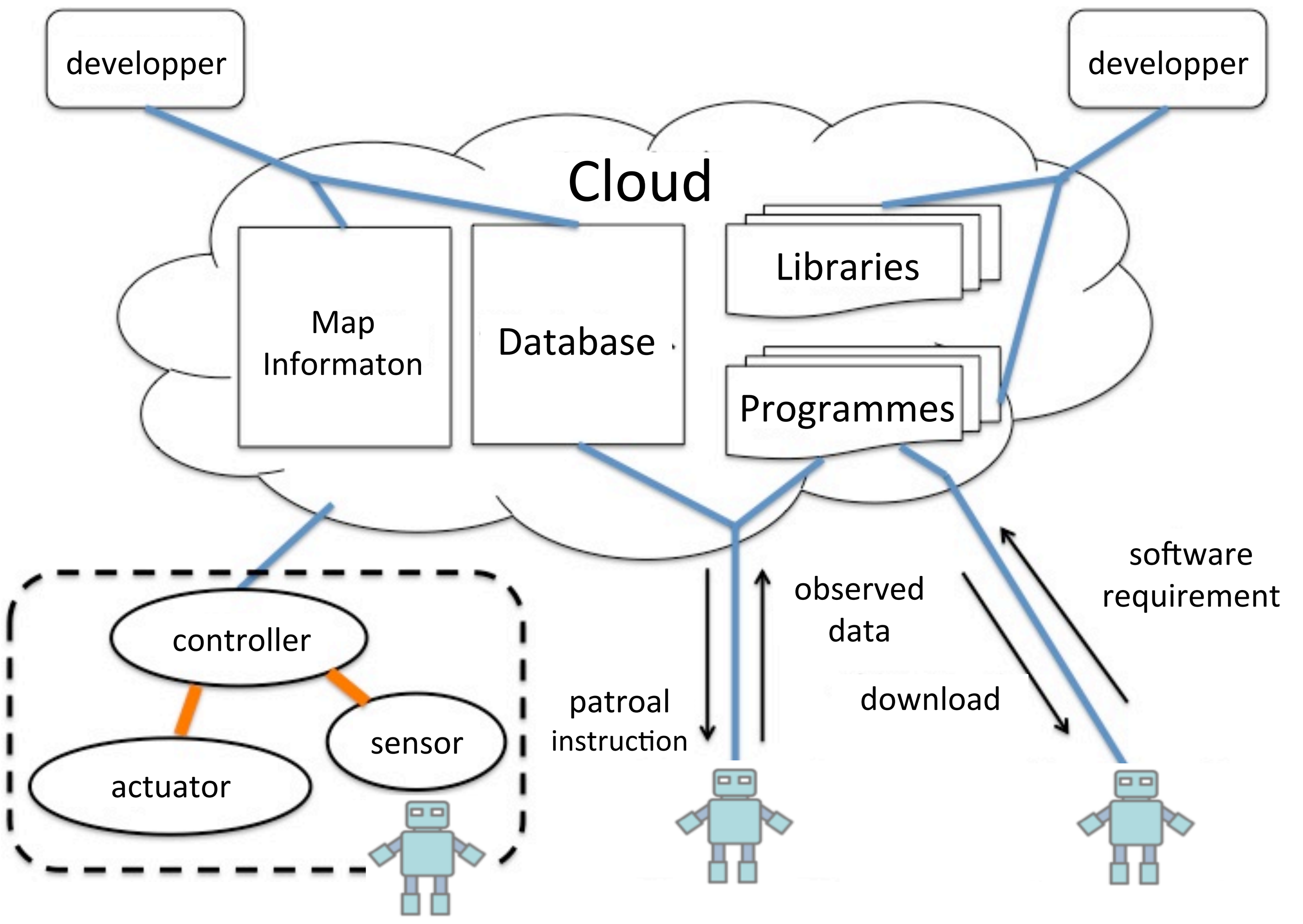
A Proposal of the Data Center Environmental Monitoring System with Cloud Enabled Robots

Kotaro Takaura, Manabu Higashida, Shinji Shimojo (Osaka University)

• Background and Purpose

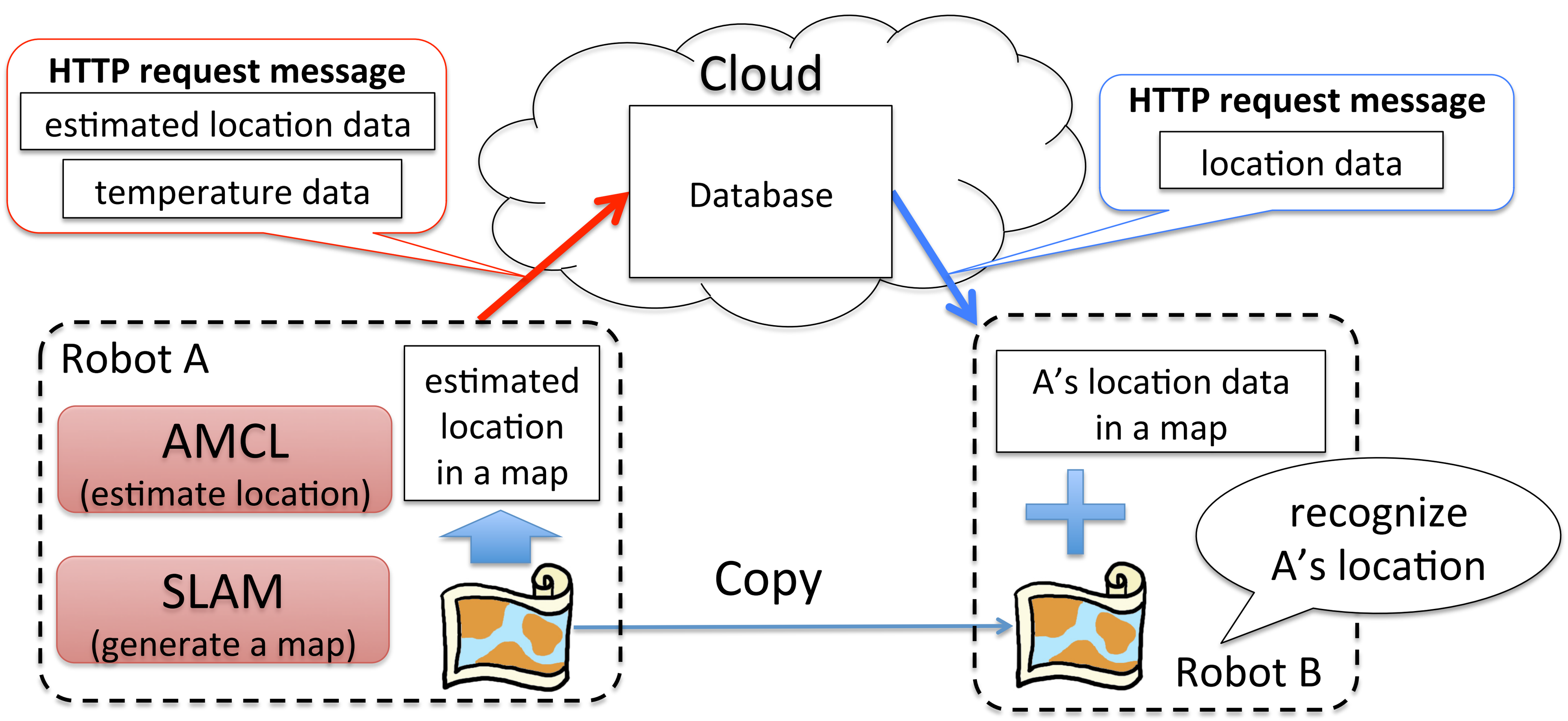
In this research, we focus on "Cloud Robot", the concept of coordination between robots and cloud as a crowd of web services. Cloud Robots enable to process large volumes of data that is acquired by robots with cloud computing. This brings benefits of decreasing the size of hardware of robots. It is also possible to decide behavior of robots based on processed data. Cloud Robots are expected its use in case of that robots coordinate with each other autonomously, but it's not practical now.

We therefore propose the data center environmental monitoring system as a case study that uses cloud robots. It is usually operated with fixed sensors. We implement that system so that environment data is gatherd at multiple points and so as to investigate whether or not the precision of positional information is accurate enough, compared with the simulated heat flow analysis of the data center environment.



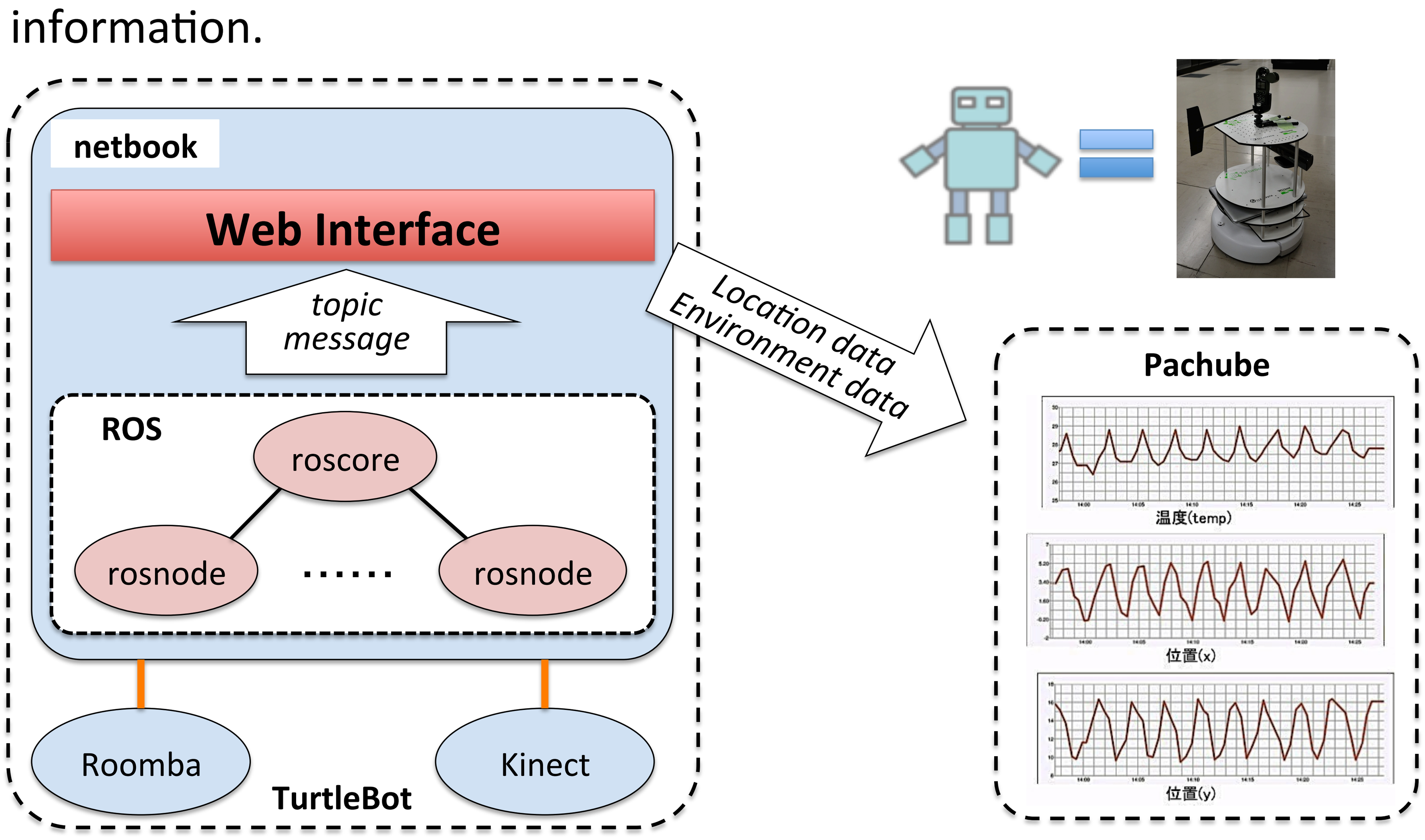
• Approach

The system proposed in this study is implemented by a robot that patrols and monitors the environment of a data center and a Web service that logs the data acquired by this robot. We focused on the ROS (Robot Operating System), robot meta-operating system, that includes an AMCL (Adaptive Monte Carlo Localization) package that the robot can use to find it's own location, and SLAM (Simultaneous Location and Mapping) that generates a map from spatial information acquired by Kinect (Microsoft). We use patrol and monitoring robots controlled by this operating system.



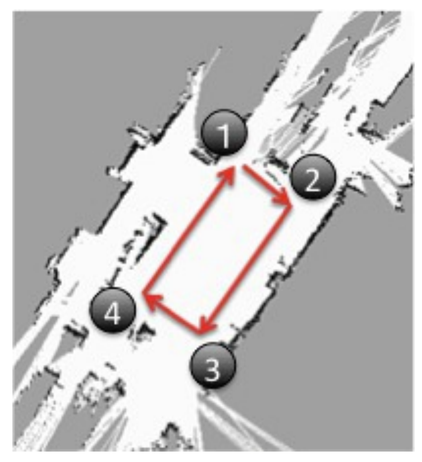
• Implementation

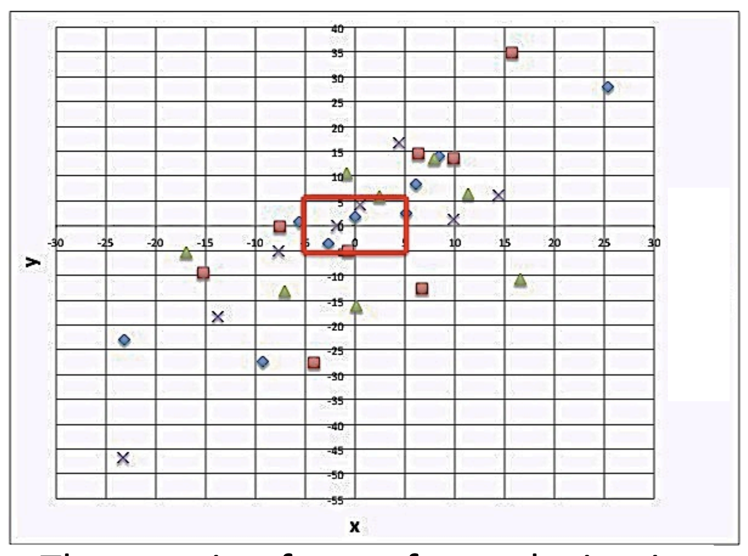
We use TurtleBot as the hardware of the robots that perform patrol and monitoring, which consists of a netbook incorporated ROS into, a Roomba (made by iRobot) to enable it to move and a Kinect sensor (Microsoft) to provide it with spatial awareness. We implement a prototype data center patrol and monitoring system by building a web interface capable of linking with Pachube onto a TurtleBot, which is a web service that logs environment data included with GPS information.



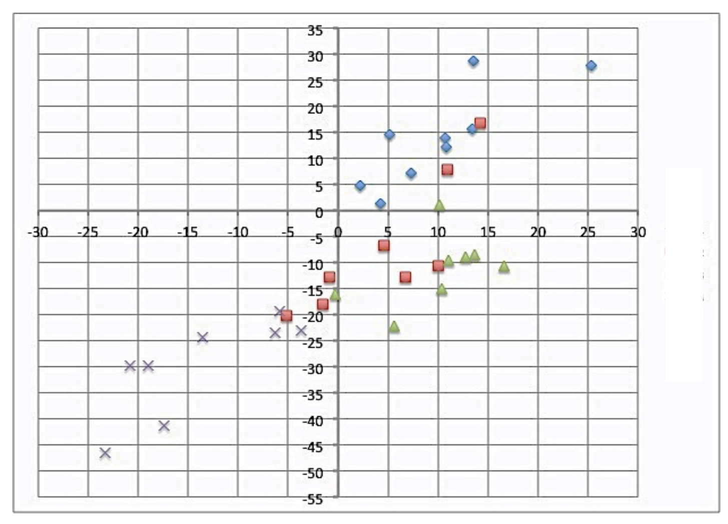
• Results

We confirmed the operation of a prototype that was made to read the generated map. In each of measurement results, we confirmed that the offset from real world was roughly between +25 cm and -25 cm in the x-axis direction, and roughly between +35 cm and -45 cm in the y-axis direction. Since the spacing between grid points in the simulated heat flow analysis aimed at feedback is 5 cm, we need to improve the precision.





The margin of error for each circuit at four real-world locations.



The cumulative margin of error for each circuit at four real-world locations.

• Summary

In this study, we proposed a patrol and monitoring system that uses cloud robots to monitor the interior environment of a data center, and we implemented a prototype and verified that it is possible to feed environment information back to the simulation model.

In the feedback of environment information to the simulation model, an issue for further study is how to acquire information with greater precision. It is thought that greater monitoring efficiency will be achieved by developing an automatic patrol system and by implementing cooperative monitoring with multiple robots.

• Future prospects

This research has made it possible for robots to work cooperatively in a small closed environment. In the future, we hope to develop a system that can cope with any number of robots, and to implement scalable robot services. To implement a service of this sort, it will be necessary to set up a network infrastructure that is suitable for cloud robots.

Contact : Kotaro TAKAURA E-mail : takaura.kotaro@ais.cmc.osaka-u.ac.jp