# High-Level Sharing Policies And Their Effect On Asset-Task Assignment

Christos Parizas, Diego Pizzocaro, and Alun Preece
School of Computer Science and Informatics
Cardiff University, UK
Email: {C.Parizas,D.Pizzocaro,A.D.Preece}@cs.cardiff.ac.uk

Petros Zerfos
IBM T.J. Watson research Center
Hawthorne, NY, USA
Email: pzerfos@us.ibm.com

***Abstract*—Sharing of assets such as sensors and services is essential for effective coalition operations where two or more partners work in cooperation. Typically, user-created tasks compete for the use of relatively scarce assets in a highly dynamic operational environment. Efficient use of resources requires automated support for assigning assets to tasks, that takes into account policies on the sharing of assets. We consider two kinds of high-level sharing policy: the first based on a traditional asset ownership model where assets belong to a coalition partner and may or may not be shared with other partners; and the second based on an "edge" team-based model where users are grouped into teams spanning multiple coalition partners and the team has access to assets from any partner represented in the team. We compare the effect of these two kinds of sharing policy on the performance of an existing asset-task assignment protocol. We find that while the traditional ownership model allows slightly better performance, the difference is only marginal, so an "edge" team-based model offers a viable alternative sharing approach.**

## I. Introduction

Sensors and associated information services are increasingly used to support users in coalition operations, creating heterogeneous ad hoc networks on the field. In order to accomplish a mission, users create multiple heterogeneous sensing tasks which compete for limited sensing assets. Such operations are highly dynamic, with frequent changes in users' tasks and unstable availability of assets. The Multi-Sensor Task Allocation (MSTA) problem, which tries to allocate sensors to the tasks they best serve, has been addressed in previous work [1], as has the composition of sets of sensor network services to meet users' requests [2].

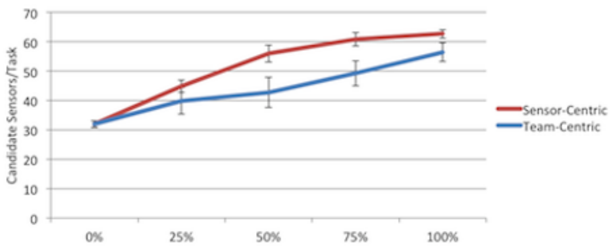
In coalition operations usually two or more partners act together to achieve a set of common mission objectives. A critical issue in such operations is the sharing of sensor and service assets among the coalition partners. Traditional approaches to asset sharing in a coalition context are based on asset ownership and the granting of permission for partners to access particular assets owned by another partner; these permissions are defined by means of policies [3]. While there are numerous variations in these policies in practice we consider an abstract model where an asset is either kept for the exclusive use of the owning partner or made available for any partner's use. A recent trend in managing coalition operations has been to consider the formation of cross-partner teams operating at the "edge" of the network with permission to access assets from all member partners [4]. We aim to compare this kind of team-centric sharing model with the traditional ownership model, by integrating the models with our MSTA protocol and exploring the effect on performance of varying degrees of sensor sharing and team membership.

## II. Policy Models and Assumptions

In this study we assume that a coalition is already formed (the partners are known). Much previous work on policies governing sensor management is concerned with fine-grained access to sensors as services [3]; in contrast, here we are concerned with higher-level policies on how users may access assets for their mission tasks. The two views are compatible however, as we will show below. We compare two high-level approaches to asset sharing. In both approaches, each asset is owned by a single coalition partner.

- *Sensor-centric sharing model:* Each asset is either kept for the exclusive use of the owning partner or made available for any partner's use. In our experiments, we apply different sharing ratios from 0% to 100% increasing them linearly by 25% for each experiment. A 0% sharing ratio means that the coalition partners do not share any of the assets they own while a 100% sharing ratio means that the coalition partners share all of the assets they own with the entire coalition.
- *Team-centric sharing model:* A team is a group of users. A homogeneous team comprises members from a single coalition partner, while a heterogeneous team contains members from two or more partners. We follow the "edge" model of allowing users participating in the same team to share assets freely; therefore, a team is considered to have access to all assets owned by any coalition partner represented in the team. In this approach we keep the sharing ratio (as above) stable at 0% and experiment by applying different degrees of team heterogeneity from 0% to 100%, increasing linearly by 25% for each experiment. 0% heterogeneous teams means that all teams on the field are formed by users from the same coalition partner while 100% heterogeneity means that all the teams are comprised of users from different partners.

These models are compatible with the approach taken to service composition in [2]. There, the goal was to determine sets of compatible services (assets) that can serve a user's request. The MSTA work considers only sensors, which are



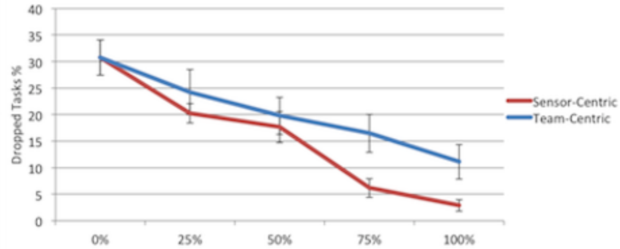




Fig. 1. Sensor-centric vs team-centric sharing models: effect on dropped tasks and candidate sensors per task.

the most constrained type of asset. Under the sensor-centric sharing model, the set of compatible services is constrained to be a subset of the services accessible to the coalition partner of which the requesting user is a member. Under the team-centric sharing model, the set of compatible services is constrained to be a subset of the services accessible to the set of coalition partners represented in the team of which the requesting user is a member.

## III. Simulation Settings and Experiments

In our experiments we use the Repast symphony agent-based simulation environment (repast.sourceforge.net). In our scenario we assume 2 coalition partners, 250 sensor and 50 user nodes, which are randomly deployed on a 2D grid. The sensor and user nodes are equally distributed to the two partners and the task creation rate is 5/5 tasks per timestep. In the team-centric sharing approach the teams are formed at the beginning of the simulation and they remain stable throughout the simulation.

We consider a task *dropped* either if no sensing resources can satisfy its utility demand, or if no sensing resources can support it on time. When a user creates a task the assignment system determines a list of possible sensors that can serve this task based on task requirements and sensors capabilities. These sensors are the *candidate sensors per task*. We compare the performance of the MSTA protocol under the two sharing models by considering the variation of the dropped tasks and the candidate sensors per task.

## IV. Results and Discussion

Figure 1 shows the comparison of the two different sharing models. To start with, both approaches have a common starting point because we start our experiments by sharing nothing (0% sensor sharing ratio, 0% team heterogeneity). From an overall perspective, the sensor-centric sharing approach is more effective due to the fact that only an average of 80% of the total users belong to teams and thus there is an extra 20% of users that do not benefit from the team sharing model. Looking at the sensor-centric results in more detail, the number of candidate sensors per task when the sharing ratio (SR) = 100% is twice as much as when SR = 0%, and the total dropped tasks when SR = 100% is almost 8 times smaller than for SR = 0%. Moreover, the values of both variables in the first approach change logarithmically while we vary SR linearly, and we can witness an adequate performance of the protocol when SR is higher than 75%. In the team-centric sharing approach when there is 100% heterogeneous teams, the number of candidate sensors per task almost doubles and the dropped tasks triples from when team heterogeneity is 0%, and there is a linear pattern corresponding to the degree of the team heterogeneity and the examined variables.

Overall, however, while the sensor-centric model performs better than team-centric sharing, it does not do so by a large margin. Therefore, if a coalition prefers to use team-centric sharing in view of evidence that it provides improved operational agility [4] our study shows that reasonable performance in automated asset-task assignment can be achieved by doing so, compared to the more traditional asset ownership model.

## V. Future work

In future work, we plan to experiment with (1) an enriched user model that takes rank into account, (2) an increased number of coalition partners, (3) user mobility models, and (4) different coalition asset ownership proportions — to consider, for example, cases where one partner owns a “dominant” proportion of assets compared to the other partners.

**Acknowledgment:** This research was sponsored by the US Army Research Laboratory and the UK Ministry of Defence and was accomplished under Agreement Number W911NF-06-3-0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the US Army Research Laboratory, the US Government, the UK Ministry of Defence or the UK Government. The US and UK Governments are authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation hereon.

## References

[1] D. Pizzocaro, A. Preece, F. Chen, T. L. Porta, and A. Bar-Noy, “A distributed architecture for heterogeneous multi sensor-task allocation,” in *Proc 7th IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS’11)*, 2011.

[2] S. C. Geyik, B. K. Szymanski, and P. Zerfos, “Robust dynamic service composition in sensor networks,” *IEEE Transactions on Services Computing*, to appear.

[3] R. Dilmaghani, S. Geyik, K. Grueneberg, J. Lobo, S. Y. Shah, B. K. Szymanski, and P. Zerfos, “Policy-aware service composition in sensor networks,” in *Proc 9th International Conference on Service Computing (SCC 2012)*, 2012.

[4] D. S. Alberts, R. K. Huber, and J. Moffat, *NATO NEC C2 Maturity Model*. CCRP, 2010.