To:

2009 Design Science Award Selection Committee

Dear Committee Members:

Please find our nomination for the 2009 Design Science Award. As per the submission guidelines, please find the requested information

1. A) **Name of Nominees**:

Johan Perols, Assistant Professor of Accountancy, School of Business Administration, University of San Diego, San Diego, California 92110, USA;
Email: jperols@sandiego.edu; Phone: (619) 260-2915.

Kaushal Chari, Professor & Chair, Information Systems & Decision Sciences, 4202 E Fowler Avenue, CIS1040, University of South Florida, Tampa, Florida 33620-7800, USA;
Email: kchari@usf.edu; Phone: (813)-974-6768.

Manish Agrawal, Associate Professor, Information Systems & Decision Sciences, 4202 E Fowler Avenue, CIS1040, University of South Florida, Tampa, Florida 33620-7800, USA;
Email: magrawal@usf.edu; Phone: (813)-974-6716.

B) **Nomination:** Self

C) **Project Title**: Information Market-Based Decision Fusion

D) **Summary**:

In multi-classifier combination, combiner methods are used to combine statistical and machine learning models to increase prediction performance. The goal of our research project was to develop a new and improved combiner method to improve decision making in domains where statistical and machine learning models provide decision support, such as fraud detection, breast cancer detection, corporate bankruptcy prediction, credit approval, etc. In addition to improving prediction performance, we also wanted to create a more flexible method that was suitable for multi-agent software systems.

To accomplish our research objective, we developed a combiner method based on ideas from the information markets literature in economics. Information markets, also known

as prediction markets, are markets designed to aggregate information from market participants by allowing bets on different future events, for example, whether a democrat or a republican will win the next presidential election. Market equilibrium prices can then be used to derive the market's probability predictions of future events. In our approach, we created a combiner method that used markets, where the market participants were statistical and machine learning models embedded in software agents. These agents developed their own predictions of future events and then placed bets in the market based on these predictions and the current market prices.

By using a market mechanism to aggregate information, based on market participants that were independent of the aggregation mechanism, we were able to design an artifact (i.e., the combiner method), that was highly flexible and well suited for information aggregation in multi-agent system architectures. The designed artifact was shown to perform better than the three benchmark methods via extensive experimental evaluation using 17 different datasets and 22 statistical and machine learning models.

To summarize, by combining work in economics with machine learning we developed a novel artifact that provided a superior approach for classification problems. Papers from the research project were presented at conferences such as the International Conference on Information Systems (ICIS), Workshop on Information Technology and Systems (WITS) and the University of Utah Winter Conference on Business Intelligence, and culminated in a journal article that recently appeared in Management Science.

E) **Relevance to Design Science**:

Our research project was motivated by real world classification problems such as fraud detection. In developing and evaluating our artifact we followed design science principles laid out by Hevner, et al. (2004). First of all, we designed an artifact, the combiner method, with the general goal of improving the predictive performance of statistical and machine learning models. This problem domain was highly relevant as statistical and machine learning models provided decision support in a wide variety of important domains. An improvement in predictive performance had the potential to improve decision making in these domains. The effectiveness of the designed artifact was experimentally evaluated using 17 different datasets representing decision domains ranging from breast cancer detection to credit approval classification and 22 of the most common statistical and machine learning models. The predictive effectiveness was assessed using a relevant performance measure that took into account differences in class distribution and misclassification costs. Furthermore, the effectiveness of the combiner method was examined as the number of agents (statistical and machine learning models) in the market and misclassification costs were manipulated.

The artifact design was grounded in research from information markets in economics, and from multi-classifier combination in machine learning. Furthermore, the implementation of the aggregation mechanism used a binary search algorithm and formal results derived for the betting behavior of agents. By designing, implementing and evaluating a novel artifact, designed to address a relevant problem, and showing the utility of the artifact in addressing this problem, all done using rigorous design science steps, our research made a direct contribution to the design science literature as well as to the machine learning literature.

To summarize, our research made the following notable contributions to the design science literature:

1) using analytical results for designing an artifact,
2) developing a multidisciplinary approach to solve a relevant problem for practice,
3) undertaking rigorous experimentation and extensive statistical analysis to validate the utility of an artifact.

F) **Certification**: This research was conducted at the University of South Florida when the first author was a graduate student.

G) **List of Supporting Documents**:

- Perols J., and M. Agrawal, "Information Fusion and Information Markets in Multi-Agent System," Proceedings of the Workshop on Information Technology & Systems (WITS), 2005.

- Perols J, K. Chari and M. Agrawal, "Information Market Based Decision Fusion," Proceedings of the International Conference on Information Systems (ICIS), Milwaukee, Wisconsin, December 2006.

- Perols J., K. Chari, M. Agrawal, "Information Market Based Approach for Decision Fusion," Management Science, Vol. 55, No. 5, May 2009, 827-842.

Thank You.

Sincerely,

Kaushal Chari