Abstract for CPS PI Meeting (Collaborative Research):
Distributed Coordination of Agents For Air Traffic Flow Management

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Abstract : This project addresses the management of the air traffic system, a cyber-physical system where the need for a tight connection between the computational algorithms and the physical system is critical to safe, reliable and efficient performance. Indeed, the lack of this tight connection is one of the reasons current systems are overwhelmed by the ever increasing traffic and suffer when there is any deviation from the expected (e.g., changing weather).

Multiagent coordination algorithms are ideally suited to address this problem. However, to be applicable to this complex real world problem, the interactions among the agents need to be taken into account before the contributions of an agent can be ascertained. In this project, we study the impact of agent actions, rewards and interactions on system performance using data from real air traffic systems. The objectives of this project are to:

1. Derive reward estimation kernels to augment a new event-based air traffic simulator;
2. Analyze the impact of modifying agent actions and rewards; and,
3. Demonstrate the effectiveness of selecting agents' actions and rewards with real air traffic data obtained from historical congestion scenarios.

The intellectual merit of this project lies in its addressing the agent coordination problem in a physical setting by shifting the focus from "how to learn" to "what to learn." This paradigm shift allows us to separate the advances in learning algorithms from the reward functions used to tie those learning systems into physical systems. By exploring agent reward functions that implicitly model agent interactions based on feedback from the real world, we aim to build cyber-physical systems where an agent that learns to optimize its own reward leads to the optimization of the system objective function.

The broader Impact of this proposal is in providing new air traffic flow management algorithms that will significantly reduce air traffic congestion. The potential impact can not only be measured in currency ($41B loss in 2007) but in terms of improved experience by all travelers, providing a significant benefit to society. In addition, the PIs will use this project to train graduate and undergraduate students (i) by developing new courses in multiagent learning for transportation systems; and (ii) by providing summer internship opportunities at NASA Ames Research Center.

Progress to date has been on two fronts with first year activities directly supporting the first and third objectives. First, we have focused on developing a Fast, Event-based Air Traffic Simulator (FEATS). Unlike other simulators (e.g., FACET) which takes hours to complete a simulation, a FEATS simulation of equal airspace may take only minutes. This performance gain is achieved by using an event-based model of flight rather than a minute-by-minute simulation, and abstracting features that are not directly related to the project goals. This combination not only allows for fast simulation, but can also allow a more accurate simulation of specific events. Second, we have identified and obtained two real world data sets to explore the performance our algorithms (New York and Chicago). Because the design of FEATS directly allows for interfacing with real world data (all current airports in the lower United States are modeled, complete with accurate air traffic data) this coupling is a natural feature that will allow the use of state-of-the-art agent coordination algorithms in a realistic air traffic simulation with real world data.