Sensor Web Dynamic Replanning

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1 Assumptions

This short position paper falls into the second category of position papers, namely it "identifies and expounds on a key component, that provides a deeper perspective into a subset of the concept." We assume that a sensor web exists; we use the definition from the ROSES-05 AIST NRA section. We describe in general the *dynamic replanning* of a sensor web with some sensor systems that can be "controlled" (i.e., tasked), and some that cannot be controlled. We assume all necessary capabilities exist for communication of commands and sensor data, storage of sensor data, and access to the stored sensor data.

We then describe very briefly what we are focusing on in our AIST project.

2 Sensor Web Dynamic Replanning Concept

Dynamic replanning of a sensor web utilizes complementary and cooperative suites of heterogeneous sensor assets that can be triggered by observation data and/or predictive models to adaptively respond to significant events and provide enhanced understanding of temporal Earth phenomena. An event-driven use of a sensor web would be to task sensor resources in response to observation-triggered cues for phenomenon. The events and phenomena that present the largest potential payoff for the use of dynamic replanning are characterized by being localized and transient, e.g., weather (tornadoes, hurricanes, etc.), harmful algal blooms, volcanic eruptions, seismic activities, oil spills, and search and rescue. Two types of input objectives can drive the optimized replanning – time critical environmental phenomena and less time-sensitive earth science objectives – to produce an optimized tasking plan for each controllable sensor system that optimizes the allocation of sensor, data and communication resources across all the sensor systems. Dynamic replanning thus reduces both response time and false alarm rates dealing with the time critical environmental phenomena and maximizes the science value from the data gathering activities.

3 High-Level Functional Architecture

A high-level functional architecture for sensor web dynamic replanning is illustrated in Figure 1. The architecture is a closed-loop planning and control decision-making system. Sensor system data are inputs to the system. The system monitors the input, and when appropriate, replans and executes a new plan that optimizes the tasking of available sensing assets from the set of controllable systems to gather data.

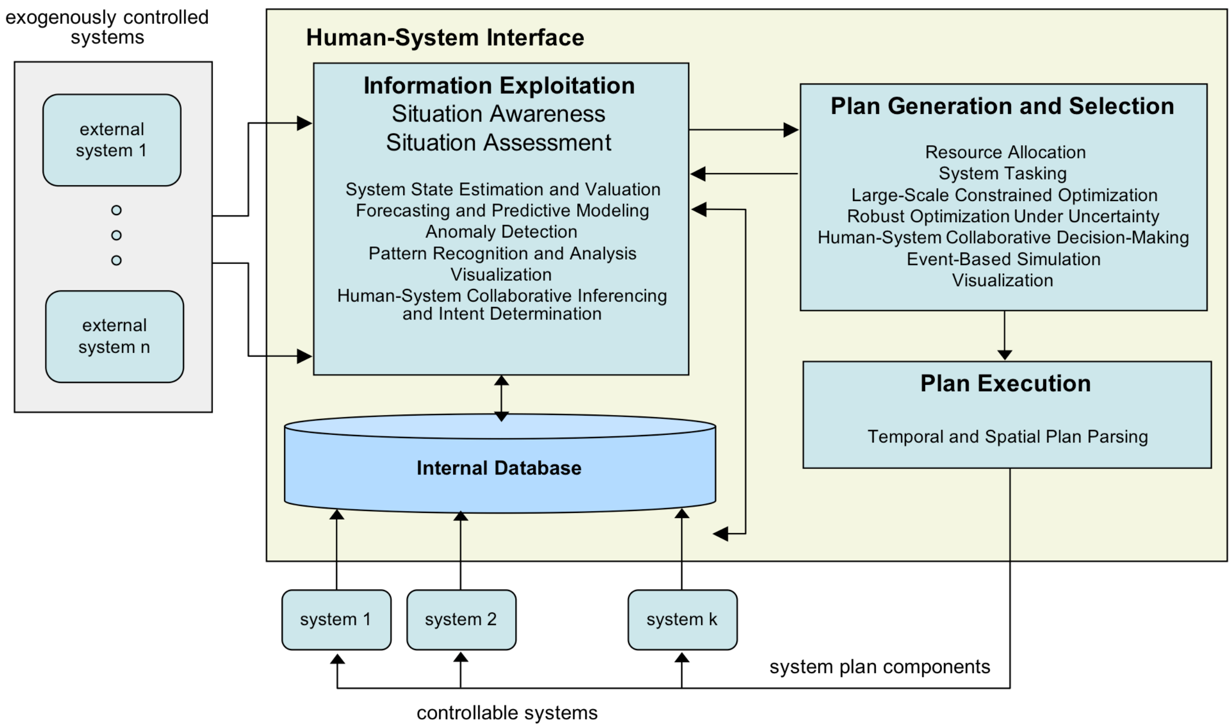

Figure 1: High-Level Functional View of Sensor Web Dynamic Replanning

Situation Awareness and Assessment:

Existing observation data stored in data archives (e.g., Goddard's Earth Sciences Data and Information Services Center (GES DISC), the Air Force Weather Agency) and data provided in near real time are exploited to gain situation awareness (estimation of system state) and situation assessment (forecasting and predictive modeling, anomaly detection, pattern recognition and analysis).

Planning and Execution:

Planning and execution supports a full range of operational autonomy, from manual operator control to full autonomy. To make the solution of the complex sensor web planning problems tractable, the problems are hierarchically decomposed into simpler, decoupled subproblems that can be solved (nearly) independently. The hierarchical architecture decomposition preserves system-level objectives while respecting local constraints, and defines interactions and information exchanges between levels. This enables inter-level negotiation and permits local autonomy so that decisions are made at the lowest appropriate level. The hierarchical decomposition aggregates planning information and system dynamics from lower levels to higher levels in the hierarchy.

4 Draper AIST Project

Our current project builds upon two pre-existing threads of work from previous AIST-funded projects: the first one consists of development of Draper's Earth Phenomena Observing System (EPOS) for experiments with EO-1, and the second consists of research at extending EPOS's sensor web replanning capabilities

For 24 hours per day and 7 days a week, we autonomously download, process and store cloud data generated by the Air Force Weather Agency (AFWA), including Stochastic Cloud Forecast Model (SCFM) data. The SCFM data includes forecasts provided every six hours for 3-hour periods up to 84 hours in the future. The cloud forecast data is input to EPOS, which processes it and produces target selections and associated value-added metrics. We provide tasking inputs for the Hyperion instrument on EO-1; this has achieved increased value of observation data by producing a higher proportion of cloud-free scenes.

The functional architecture for this subset of EPOS's capabilities is illustrated in Figure 2.

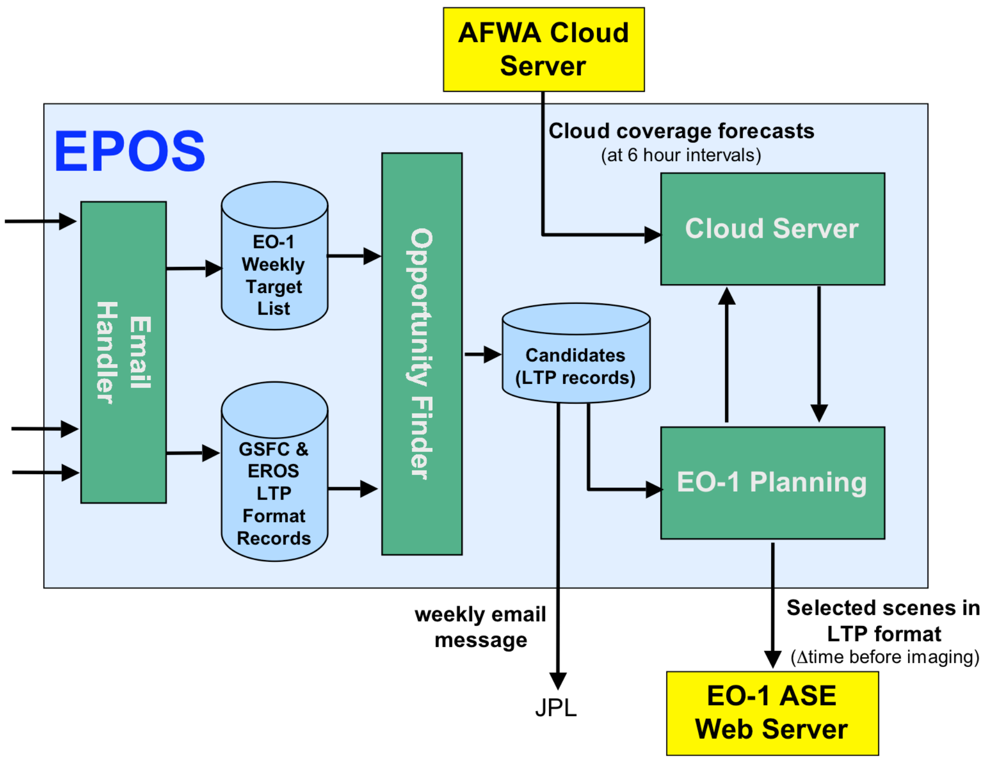

Figure 2: Functional Architecture of the Subset of EPOS Used for Experiments with EO-1

In previous AIST-funded work, we demonstrated in simulation the ability to optimize the tasking of up to 105 space-based sensors and approximately 1500 targets on Earth. We are currently extending this dynamic replanning capability of EPOS to include the planning of a fleet of USVs (Unmanned Surface Vessels) with in-situ sensing capabilities in coordination with the space-based sensor tasking. We will then extend the work to include the replanning of sensors on a fleet of UAVs (Unmanned Aerial Vehicles). In addition, we are identifying additional data sources and data mining requirements that will provide input to planning for two applications of interest to the science community and the larger society as a whole: harmful algal blooms and hurricanes.