METEOROLOGICAL COMMAND & CONTROL: ARCHITECTURE AND PERFORMANCE EVALUATION

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Meteorological Command & Control is the software architecture that performs the main control loop of our radar sensor network in southwestern Oklahoma. In this control loop data is ingested from the radars, meteorological features are identified in this data, features are reported to end-users, and each radar’s future scan strategy based on detected features and end-user requirements is determined. In this paper, we will present results from a performance evaluation of the MC&C software architecture. This evaluation is based on data taken from several experiments.

Collaborative adaptive sensing of the atmosphere (CASA) is a new paradigm for detecting and predicting hazardous weather using a dense network of short-range, low-powered radars to sense the lowest few kilometers of the earths atmosphere ([1]). This new paradigm is achieved through a distributed, collaborative, adaptive sensing (DCAS) architecture. Distributed refers to the use of large numbers of small radars, whose range is short enough to see close to the ground in spite of the Earth’s curvature and to avoid resolution degradation caused by radar beam spreading. Collaborative operation refers to the coordination of the beams from multiple radars to cover the blind regions of their neighbors (cone of silence) and to simultaneously view the same region in space (when advantageous), thus achieving greater sensitivity, precision, and resolution than possible with a single radar. Adaptive refers to the ability of these radars and their associated computing and communications infrastructure to dynamically reconfigure in response to changing weather conditions and end-user needs. The principal components of a CASA DCAS system includes the sensors (radars); algorithms that detect, track, and predict meteorological hazards; interfaces that enable end-users to access and interact with the system; storage; and an underlying substrate of distributed computation that dynamically processes sensed data and manages system resources. IP1 is a prototype CASA DCAS system, located in southwestern Oklahoma, whose goal is to detect tornados within 60 seconds of formation and to track tornado centroids. At the heart (or perhaps more appropriately, the brains) of IP1 is its Meteorological Command and Control (MC&C) that performs the system’s main control loop. In this sense, IP1 is truly a closed-loop, end-to-end system, from the sensing radars through the computing and communication infrastructure and algorithms, to the end-users ([2], [3]). Unlike existing architectures, like NEXRAD ([4]) where the radars execute predefined scanning patterns (VCP) and data are pushed to the end-users independent of their preferences, a DCAS system is a pull system where the sensing resources dynamically adapt to end-user needs and preferences.

In this paper, we describe the architecture of the MC&C and evaluate its performance in an operational testbed, with actual weather events and end-user considerations driving the system. We first introduce the end-to-end architecture that spans the system from the radars to multiple end-user groups. The overall architecture is a user- and data-driven closed-loop soft real-time system, in which a blackboard decouples timing dependencies between data ingest and the generation of radar control commands. We will see how
end-user considerations are deeply embedded into radar control via a utility-based approach. The architecture is also modular (as evidenced by the use of multiple independently-develop meteorological detection algorithms, and the ability to ingest data from multiple exogenous sources), making modifications and the addition of new functionality fairly easy. Finally, we demonstrate and analyze MC&C performance in an operational testbed based on data from several experiments. Our results show that the system is capable of real-time data processing, radar control optimization, and user-driven collaborative adaptive for sensing of the atmosphere. We show detailed results from several severe weather events that occurred during the experiment phases. The results of this in-depth analysis show that the system is capable of real-time data processing and optimization for the control of the radars, and sensing of the atmosphere is performed according to the end-users' needs. In addition, we will also present initial analysis data from an experiment with a fully distributed MC&C which we will execute during our Spring 2008 experiment. In this case, there exists no centralized MC&C but each radar will run its own distributed version of the MC&C. Each instance of the distributed MC&C shares detections and tasks in its dual-Doppler regions with its neighbor radars. This sharing of information between the radars is achieved by a negotiation protocol [5].

1. REFERENCES


