

alone servers that are commonly used in the JPL AMMOS environment. The DISA-SS reusable components have greatly reduced the effort for each AMMOS subsystem to develop its own access control strategy.

The novelty of this work is that it leverages an open-source access management product that was designed for Web-

based applications to provide access control for Java thick clients and Java stand-alone servers. Thick clients and stand-alone servers are still commonly used in businesses and government, especially for applications that require rich graphical user interfaces and high-performance visualization that cannot be met by thin clients running on Web browsers.

*This work was done by Kam S. Tso and Michael J. Pajewski of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

*The software used in this innovation is available for commercial licensing. Please contact Dan Broderick at [Daniel.F.Broderick@jpl.nasa.gov](mailto:Daniel.F.Broderick@jpl.nasa.gov). Refer to NPO-48435.*

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## ➤ Tool for Automated Retrieval of Generic Event Tracks (TARGET)

**A generalized algorithm implementation is applied to scientific data sets for establishing events, such as tornadoes, both spatially and temporally.**

*Goddard Space Flight Center, Greenbelt, Maryland*

Methods have been developed to identify and track tornado-producing mesoscale convective systems (MCSs) automatically over the continental United States, in order to facilitate systematic studies of these powerful and often destructive events. Several data sources were combined to ensure event identification accuracy. Records of watches and warnings issued by National Weather Service (NWS), and tornado locations and tracks from the Tornado History Project (THP) were used to locate MCSs in high-resolution precipitation observations and GOES infrared (11-micron) Rapid Scan Operation (RSO) imagery. Thresholds are then applied to the latter two data sets to define MCS events and track their developments.

MCSs produce a broad range of severe convective weather events that are significantly affecting the living conditions of the populations exposed to them. Understanding how MCSs grow and develop could help scientists improve their weather prediction models, and also provide tools to decision-makers whose goals are to protect populations and their property.

Associating storm cells across frames of remotely sensed images poses a difficult problem because storms evolve, split, and merge. Any storm-tracking method should include the following processes: storm identification, storm tracking, and quantification of storm intensity and activity.

The spatiotemporal coordinates of the tracks will enable researchers to obtain other coincident observations to conduct more thorough studies of these events. In addition to their tracked locations, their areal extents, precipitation intensities, and accumulations — all as functions of their evolutions in time — were also obtained and recorded for these events. All parameters so derived can be catalogued into a moving object database (MODB) for custom queries.

The purpose of this software is to provide a generalized, cross-platform, pluggable tool for identifying events within a set of scientific data based upon specified criteria with the possibility of storing identified events into a searchable database. The core of the application uses an implementation of the connected component labeling (CCL) algo-

rithm to identify areas of interest, then uses a set of criteria to establish spatial and temporal relationships between identified components. The CCL algorithm is used for identifying objects within images for computer vision. This application applies it to scientific data sets using arbitrary criteria.

The most novel concept was applying a generalized CCL implementation to scientific data sets for establishing events both spatially and temporally. The combination of several existing concepts (pluggable components, generalized CCL algorithm, etc.) into one application is also novel. In addition, how the system is designed, i.e., its extensibility with pluggable components, and its configurability with a simple configuration file, is innovative. This allows the system to be applied to new scenarios with ease.

*This work was done by Thomas Clune of Goddard Space Flight Center; Shawn Freeman, Carlos Cruz, and Robert Burns of Northrop Grumman; Kwo-Sen Kuo of Caelum Research Corporation; and Jules Kouatchou of TetraTech AMT. Further information is contained in a TSP (see page 1). GSC-16665-1*

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## ➤ Bilayer Protograph Codes for Half-Duplex Relay Channels

**The proposed code is constructed by synthesizing a bilayer structure with a protograph.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Direct to Earth return links are limited by the size and power of lander devices. A standard alternative is provided by a two-hops return link: a proximity link (from lander to orbiter relay) and a deep-space link (from orbiter relay to Earth). Although direct to Earth return

links are limited by the size and power of lander devices, using an additional link and a proposed coding for relay channels, one can obtain a more reliable signal. Although significant progress has been made in the relay coding problem, existing codes must be painstakingly op-

timized to match to a single set of channel conditions, many of them do not offer easy encoding, and most of them do not have structured design.

A high-performing LDPC (low-density parity-check) code for the relay channel addresses simultaneously two important

issues: a code structure that allows low encoding complexity, and a flexible rate-compatible code that allows matching to various channel conditions. Most of the previous high-performance LDPC codes for the relay channel are tightly optimized for a given channel quality, and are not easily adapted without extensive re-optimization for various channel conditions. This code for the relay channel combines structured design and easy encoding with rate compatibility to allow adaptation to the three links involved in the relay channel, and furthermore offers very good performance. The proposed code is constructed by synthesizing a bilayer structure with a protograph. In addition to the contribution to relay encoding, an improved family of protograph codes was produced for the point-to-point AWGN (additive white Gaussian noise) channel whose high-rate mem-

bers enjoy thresholds that are within 0.07 dB of capacity.

These LDPC relay codes address three important issues in an integrative manner: low encoding complexity, modular structure allowing for easy design, and rate compatibility so that the code can be easily matched to a variety of channel conditions without extensive re-optimization. The main problem of half-duplex relay coding can be reduced to the simultaneous design of two codes at two rates and two SNRs (signal-to-noise ratios), such that one is a subset of the other. This problem can be addressed by forceful optimization, but a clever method of addressing this problem is via the bilayer lengthened (BL) LDPC structure. This method uses a bilayer Tanner graph to make the two codes while using a concept of “parity forwarding” with subsequent successive decod-

ing that removes the need to directly address the issue of uneven SNRs among the symbols of a given codeword. This method is attractive in that it addresses some of the main issues in the design of relay codes, but it does not by itself give rise to highly structured codes with simple encoding, nor does it give rate-compatible codes. The main contribution of this work is to construct a class of codes that simultaneously possess a bilayer parity-forwarding mechanism, while also benefiting from the properties of protograph codes having an easy encoding, a modular design, and being a rate-compatible code.

*This work was done by Dariush Divsalar of Caltech, and Thuy Van Nguyen and Aria Nosratinia of the University of Texas at Dallas for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-47539*

## ➤ Influence of Computational Drop Representation in LES of a Droplet-Laden Mixing Layer

**For numerical simulations of such flows, fine-grid LES is not as accurate as coarse-grid LES.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Multiphase turbulent flows are encountered in many practical applications including turbine engines or natural phenomena involving particle dispersion. Numerical computations of multiphase turbulent flows are important because they provide a cheaper alternative to performing experiments during an engine design process or because they can provide predictions of pollutant dispersion, etc. Two-phase flows contain millions and sometimes billions of particles. For flows with volumetrically dilute particle loading, the most accurate method of numerically simulating the flow is based on direct numerical simulation (DNS) of the governing equations in which all scales of the flow including the small scales that are responsible for the overwhelming amount of dissipation are resolved. DNS, however, requires high computational cost and cannot be used in engineering design applications where iterations among several design conditions are necessary. Because of high computational cost, numerical simulations of such flows cannot track all these drops.

The objective of this work is to quantify the influence of the number of computational drops and grid spacing on

the accuracy of predicted flow statistics, and to possibly identify the minimum number, or, if not possible, the optimal number of computational drops that provide minimal error in flow prediction. For this purpose, several Large Eddy Simulation (LES) of a mixing layer with evaporating drops have been performed by using coarse, medium, and fine grid spacings and computational drops, rather than physical drops. To define computational drops, an integer  $N_R$  is introduced that represents the ratio of the number of existing physical drops to the desired number of computational drops; for example, if  $N_R=8$ , this means that a computational drop represents 8 physical drops in the flow field. The desired number of computational drops is determined by the available computational resources; the larger  $N_R$  is, the less computationally intensive is the simulation. A set of first order and second order flow statistics, and of drop statistics are extracted from LES predictions and are compared to results obtained by filtering a DNS database. First order statistics such as Favre averaged stream-wise velocity, Favre averaged vapor mass fraction, and the drop stream-wise velocity, are predicted

accurately independent of the number of computational drops and grid spacing. Second order flow statistics depend both on the number of computational drops and on grid spacing. The scalar variance and turbulent vapor flux are predicted accurately by the fine mesh LES only when  $N_R$  is less than 32, and by the coarse mesh LES reasonably accurately for all  $N_R$  values. This is attributed to the fact that when the grid spacing is coarsened, the number of drops in a computational cell must not be significantly lower than that in the DNS.

Results indicate that for large  $N_R$  values, the fine-grid LES is not as accurate as coarse-grid LES, besides being computationally more intensive. This is attributed to the fact that a fine-grid LES used in conjunction with a reduction in the number of followed drops from the physical to a computational drop field implies that there is necessarily a smaller number of drops in a computational cell than in DNS; this aspect naturally influences the flow development and biases it from the filtered DNS. The key to success seems to be having approximately the same and not a significantly smaller number of drops in the computational cell volume in LES as compared to those