Information Technology

Educational NASA Computational and Scientific Studies (enCOMPASS)

This project bridges the gap between computational objectives and needs of NASA's scientific research, missions, and projects, and academia's latest advances in applied mathematics and computer science.

Goddard Space Flight Center, Greenbelt, Maryland

Educational NASA Computational and Scientific Studies (enCOMPASS) is an educational project of NASA Goddard Space Flight Center aimed at bridging the gap between computational objectives and needs of NASA's scientific research, missions, and projects, and academia's latest advances in applied mathematics and computer science. enCOMPASS achieves this goal via bidirectional collaboration and communication between NASA and academia. Using developed NASA Computational Case Studies in university computer science/engineering and applied mathematics classes is a way of addressing NASA's goals of contributing to the Science, Technology, Education, and Math (STEM) National Objective. The enCOMPASS Web site at http://encompass.gsfc.nasa.gov provides additional information.

There are currently nine enCOMPASS case studies developed in areas of earth sciences, planetary sciences, and astrophysics. Some of these case studies

have been published in AIP and IEEE's Computing in Science and Engineering magazines. A few university professors have used enCOMPASS case studies in their computational classes and contributed their findings to NASA scientists. In these case studies, after introducing the science area, the specific problem, and related NASA missions, students are first asked to solve a known problem using NASA data and past approaches used and often published in a scientific/research paper. Then, after learning about the NASA application and related computational tools and approaches for solving the proposed problem, students are given a harder problem as a challenge for them to research and develop solutions for.

This project provides a model for NASA scientists and engineers on one side, and university students, faculty, and researchers in computer science and applied mathematics on the other side, to learn from each other's areas of

work, computational needs and solutions, and the latest advances in research and development. This innovation takes NASA science and engineering applications to computer science and applied mathematics university classes, and makes NASA objectives part of the university curricula. There is great potential for growth and return on investment of this program to the point where every major university in the U.S. would use at least one of these case studies in one of their computational courses, and where every NASA scientist and engineer facing a computational challenge (without having resources or expertise to solve it) would use enCOMPASS to formulate the problem as a case study, provide it to a university, and get back their solutions and ideas.

This work was done by Nargess Memarsadeghi of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16288-1

Coarse-Grain Bandwidth Estimation Scheme for Large-Scale Network

A new analytical approach, called the "leveling scheme," was developed to model the mechanism of the network data flow.

NASA's Jet Propulsion Laboratory, Pasadena, California

A large-scale network that supports a large number of users can have an aggregate data rate of hundreds of Mbps at any time. High-fidelity simulation of a large-scale network might be too complicated and memory-intensive for typical commercial-off-the-shelf (COTS) tools. Unlike a large commercial wide-area-network (WAN) that shares diverse network resources among diverse users and has a complex topology that requires routing mechanism and flow control, the ground

communication links of a space network operate under the assumption of a guaranteed dedicated bandwidth allocation between specific sparse endpoints in a star-like topology. This work solved the network design problem of estimating the bandwidths of a ground network architecture option that offer different service classes to meet the latency requirements of different user data types.

In this work, a top-down analysis and simulation approach was created to size

the bandwidths of a store-and-forward network for a given network topology, a mission traffic scenario, and a set of data types with different latency requirements. These techniques were used to estimate the WAN bandwidths of the ground links for different architecture options of the proposed Integrated Space Communication and Navigation (SCaN) Network.

A new analytical approach, called the "leveling scheme," was developed to model the store-and-forward mechanism

of the network data flow. The term "leveling" refers to the spreading of data across a longer time horizon without violating the corresponding latency requirement of the data type. Two versions of the leveling scheme were developed:

1. A straightforward version that simply spreads the data of each data type across the time horizon and doesn't take into account the interactions among data types within a pass, or between data types across overlapping passes at a network node, and is inherently sub-optimal.

2. Two-state Markov leveling scheme that takes into account the second order behavior of the store-and-forward mechanism, and the interactions among data types within a pass.

The novelty of this approach lies in the modeling of the store-and-forward mechanism of each network node. The term store-and-forward refers to the data traffic regulation technique in which data is sent to an intermediate network node where they are temporarily stored and sent at a later time to the destination node or to another intermediate node. Store-and-forward can be applied to both space-based networks that have intermittent connectivity, and ground-based networks with deterministic connectivity. For ground-based networks, the store-and-forward mechanism is used to regulate the network data flow and link resource utilization such that the user data types can be delivered to their destination nodes without violating their respective latency requirements.

Detection of Moving Targets Using Soliton Resonance Effect

NASA's Jet Propulsion Laboratory, Pasadena, California

The objective of this research was to develop a fundamentally new method for detecting hidden moving targets within noisy and cluttered data-streams using a novel "soliton resonance" effect in nonlinear dynamical systems.

The technique uses an inhomogeneous Korteweg de Vries (KdV) equation containing moving-target information. Solution of the KdV equation will describe a soliton propagating with the same kinematic characteristics as the target. The approach uses the time-dependent data stream obtained with a sensor in form of the "forcing function," which is incorporated in an inhomogeneous KdV equation. When a hidden moving target (which in many ways resembles a soliton) encounters the natural "probe" soliton solution of the KdV equation, a strong resonance phenomenon results that makes the location and motion of the target apparent.

Soliton resonance method will amplify the moving target signal, suppressing the noise. The method will be a very effective tool for locating and identifying diverse, highly dynamic targets with ill-defined characteristics in a noisy environment.

The soliton resonance method for the detection of moving targets was developed in one and two dimensions. Computer simulations proved that the method could be used for detection of singe point-like targets moving with constant velocities and accelerations in 1D and along straight lines or curved trajectories in 2D. The method also allows estimation of the kinematic characteristics of moving targets, and reconstruction of target trajectories in 2D. The method could be very effective for target detection in the presence of clutter and for the case of target obscurations.