
Patents

Accurate A/D Converter

Conventional charge-coupled-device (CCD)-based pipelined analog-to-digital converters (ADC) are limited in resolution and/or speed by layout constraints: higher signal-to-noise ratio requires processing more charge, which requires that storage gates be wider or longer. Both of these size increases reduce maximum operating speed. This new multiple-pipeline approach provides a means of handling arbitrarily large signal charges without compromising speed. The signal-processing pipeline is divided into multiple smaller “slave” pipelines, all controlled simultaneously by a single “master” ADC. Each slave pipeline can have gate dimensions compatible with high-speed CCD operation. The charges in the slave pipelines collectively represent the signal. The output charge differences of the slave pipelines can be combined after some number of stages for further processing. Inventor Michael P. Anthony, formerly a member of the Analog Device Technology group at Lincoln Laboratory, is now chief technology officer at Kenet, which spun out of the Laboratory in 2002. Anthony and group leader Gerald Sollner cofounded Kenet, along with former Lincoln Laboratory staff member and Kopin CEO John Fan and Kopin CFO Paul Mitchell. Kenet has an exclusive license to the patent.

Inventor: Michael P. Anthony

Title: “Charge-Domain A/D Converter Employing Multiple Pipelines for Improved Precision”

Date issued: 21 March 2006

U.S. Patent No.: 7,015,854

Efficient Error Correction

One application of error correcting code is to protect data by appending redundant (e.g., check sums) to it and then storing different parts of data in different location. If this process is done and some of the locations lose their part (or their part is destroyed) it will still be possible to reconstruct the original data. Reed Solomon codes (a Lincoln Laboratory invention) are a famous such error correcting code. A Reed Solomon code is “perfect” in the sense that it is impossible to have the same protection against data loss with fewer redundant bits. However, for large blocks, Reed Solomon codes are slow.

This patent describes an error correcting code targeted to large block sizes that is a little less efficient than Reed Solomon codes (i.e., it needs more redundant bits) but is vastly faster. This patent is part of a class of error correcting codes called low density parity codes (LDPC). Based on our empirical experiments, our code is faster than comparable LDPC codes

Inventors: Leslie Servi, Eushiuan T. Tsung, Joseph A. Cooley, and Jeremy L. Mineweaser

Title: “Method and Apparatus for Protecting Data”

Date issued: 18 April 2006

U.S. Patent No.: 7,032,166

Storm Predicting Algorithm

A technique for automated, short-term (0 to 2 hr) forecasting of precipitation uses multiple sensor data sources, including radar and satellite weather data. An important component of the invention is a phenomenological weather classification algorithm. The algorithm uses image processing techniques to identify geographic areas of line, cell, and stratiform weather. Radar precipitation images are filtered to extract multiple storm scales and then tracked to produce multiple tracking scales of storm motion. Motion-correcting and time-differencing successive radar scans measure storm growth and decay. The motion fields, weather classification images, satellite data, and growth and decay indicators are fed into a storm model that uses fuzzy logic to produce a growth and decay forecast of precipitation. This invention provides substantial improvement in accuracy over previous storm-term forecasts.

Inventors: Marilyn M. Wolfson, Richard Johnson, Jr., Barbara Forman, William Dupree, Kim T. Calden, Robert Boldi, Carol Wilson, Robert G. Hallowell, and Richard L. Delanoy

Title: “Method and Apparatus for Short-Term Prediction of Convective Weather”

Date issued: 13 June 2006

U.S. Patent No.: 7,062,066

Theses

Geosynchronous Satellite Maneuver Detection and Orbit

Benjamin S. Aaron, S.M. (MIT, Aerospace Engineering, May 2006).

- This study uses angles only ground based optical tracking to detect maneuvers and recover orbits for geosynchronous satellites. Using software from Analytical Graphics Inc., a sequential estimation filter was “tuned” and validated. Then, a parametric study of maneuver size and time required to detect a maneuver was done via simulation. The thesis discusses simulated maneuvers ranging from Δv 's of 0.01 m/s to 1.0 m/s, and examines multiple methods to recover the orbit after such maneuvers are detected. This work is an important part of developing more automatic methods of detecting maneuvers for a large population of active geosynchronous satellites.

Optical Sensing of Biomolecules Using Microring Resonators

John C. Aldridge, Master's Research Project (Photonics, Boston University, 2006).

- Integrated devices featuring resonant cavity technology have recently become popular for research in biological and chemical sensing, thanks to their compact size and potential for high sensitivity. Our testbed demonstrated optical sensing of biomolecules using microring resonators and a commonly known protein chemistry. Utilizing the selective affinity of avidin for biotin, we applied a solution containing biotinylated lectin to a microring surface previously treated with avidin, initiating molecular binding at that surface. This interac-

tion changed the effective index of the cavity, and produced a shift in the resonant optical wavelength. By detecting changes in the round-trip transmission of light through waveguides coupled to the resonator, we measured this shift.

Safety Analysis of TCAS on Global Hawk Using Airspace Encounter Models

Thomas B. Billingsley, Master's Thesis (MIT, Aeronautics and Astronautics, June 2006).

- The U.S. Air Force is seeking to equip the Global Hawk unmanned aerial vehicle (UAV) with the Traffic Alert and Collision Avoidance System (TCAS) to reduce the probability of mid-air collision. In order to evaluate TCAS effectiveness, Lincoln Laboratory developed a fast-time simulation tool that computes the mean probability of a near mid-air collision for a large number of close encounters between two aircraft. Airspace encounter models enable sets of encounters to be simulated that are statistically representative of the aircraft encounters that actually occur in the airspace.

The TCAS logic is implemented in the simulation tool and the aircraft responses during the encounters, with and without TCAS, are simulated in parallel. For this thesis, encounter models were developed that reflect Global Hawk's flight characteristic: its mission profile includes slow, steep climbs and descents, and shallower turns than a conventional aircraft. The new encounter models were then implemented in the simulation tool, and millions of encounters between Global Hawk and a conventional aircraft were simulated.

The model showed that TCAS provided a significant safety improvement to Global Hawk over a Mode S transponder alone.

Securing Group Communication in Dynamic, Disadvantaged Networks: Implementation of an Elliptic-Curve Pairing-Based Cryptography Library

Rob Figueiredo, Master's Thesis (MIT, Electrical Engineering and Computer Science, September 2006).

- This thesis considers the problem of securing communication among dynamic groups of participants without relying on an online group keying service. We offer the design and implementation of the Public Key Group Encryption (PKGE) service. It is a cryptography library, written in C, and designed to be shared among all communications applications on any particular system. PKGE imposes low communication overhead and embraces disconnected operation, making it especially appropriate for deployment in low-bandwidth tactical environments. PKGE provides forward-secure confidentiality and authentication among any subset of users using small communication overhead by bringing together a number of cryptographic developments, with the piece de resistance being Collision-Resistant Broadcast Encryption.

We developed a plugin for Gaim2 that enables secure conferencing over such Gaim-supported protocols as Jabber, IRC, AIM, and ICQ. PKGE and its Gaim plugin may be run and further developed under Windows, Mac OS X, and Linux.

YAMA: A System for Marking Network Traffic

Nestor Felipe Hernandez Gonzalez, Master's Thesis (MIT, Electrical Engineering and Computer Science, August 2006).

- Computer security performance analysis requires precise labeling of traffic as either background or attack traffic. When an experiment is performed online, it may also be important to identify traffic from the security system. Today this is tedious and difficult, requiring personnel with a deep understanding of multiple protocols. YAMA (Your Able Marking Aide) is a tool that labels sessions and packets associated with a set of user actions given those actions, the traffic, and a network configuration.

Towards a Deployable Framework for Delegation of Authority in Network Applications

Will Stockwell, Master's Thesis (MIT, Electrical Engineering and Computer Science, August 2006).

- The Delegation Framework is a collection of programs, network protocols, and library interfaces that provide fine-grained delegation of authority to network systems. The design and implementation of the Delegation Framework focus on addressing some of the stumbling blocks that have prevented delegation systems from becoming widely deployed in real world network applications. The Delegation Framework makes it possible to integrate del-

egation into an existing client-server network application without modification to the network application protocol. A dynamic library interposition implementation also make it possible to integrate delegation into large classes of legacy client and service programs with minimal or no manual source code modification. An integration case study describes the process of grafting the Delegation Framework onto a simple Apache- and MySQL-based network application and analyzes the added overhead incurred by the application. YAMA 1.0 correctly associates the action of visiting a specific site with 90% of all HTTP packets, and 99% of both HTTP GET and DNS packets. Furthermore, YAMA 1.0 produces zero false positives when given a high-level event indicating a user visited one website and packets from a different site.

11th Annual High Performance Embedded Computing (HPEC) Workshop at Lincoln Laboratory

18–20 September 2007

Theme:

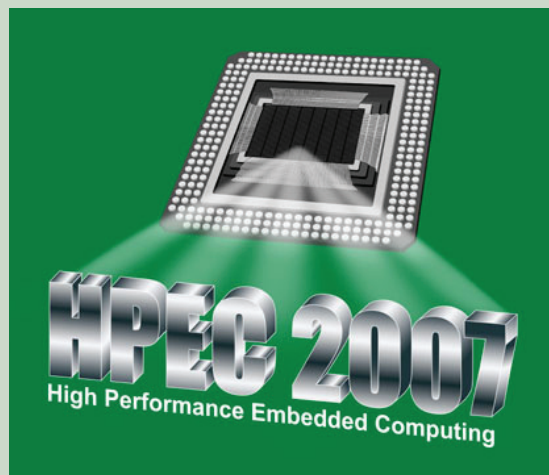
Multicore Processors and Their Impact on DoD HPEC Systems

Sponsors:

- Defense Advanced Research Projects Agency (DARPA) Information Processing Technology Office
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- High Performance Computing Modernization Office
- Missile Defense Agency

The annual High Performance Embedded Computing (HPEC) Workshop provides an opportunity for researchers from academia, industry, and government to discuss developments in real-time embedded computing, high performance sensor processing, and other military computing applications. In addition to talks by authoritative invited speakers, the workshop will feature an interactive panel on the “Multicore Meltdown,” which will address the form-factor challenges that these new computer architectures will face for embedded applications. HPEC 2006—the tenth-anniversary workshop—had more than 400 attendees and more than 70 posters and presentations.

For information about HPEC 2007, or to see the proceedings from previous HPEC workshops, go to www.ll.mit.edu/hpec.



Honors and Awards

The Lincoln Laboratory Technical Excellence Award has been given to two staff members: **Robert G. Atkins** and **Lawrence M. Candell**. Atkins, leader of the Advanced Capabilities and Systems group, was cited for his leadership in architecting and developing advanced systems for addressing complex and nontraditional problems. Candell, leader of the Advanced Space Systems and Concepts group, was recognized for developing optical and radar sensors for communications and surveillance, in particular for the application of a broad systems approach to sensor development that yields significant capability on short timelines.

Seven teams have received the 2005/2006 MIT Lincoln Laboratory Team awards for significant achievements during the year:

- **Advanced Concepts and Algorithms Team**, led by **Robert H. Whiting**, associate leader of the Ranges and Test Beds group;
- **Critical Measurements and Counter Measures Team**, led by **Gregg A. Shoults**, assistant leader of the Intelligence, Test, and Evaluation group;
- **Directed Energy Countermeasure Assessment Team**, led by **Edwin S. David**, assistant leader of the Advanced System Concepts group;
- **Mars Laser Communications Demonstration Team**, led by **Roy S. Boudurant**, associate head of the Communications and Information division; **Don M. Boroson**, leader of the Optical Communications group; **Lawrence M. Candell**, leader of the Advanced Space Systems and Concepts group; and **Joseph J. Scozzafava**, associate leader of the Mechanical Engineering group;
- **Network Centric Security Technology Team**, led by **Robert K. Cunning-**

A list of recent presentations and published articles by Lincoln Laboratory staff can be found on the Laboratory website, www.LL.mit.edu/news/publications.

ham, associate leader of the Information Systems Technology group;

- **Systems Analysis Performance Team**, led by **Michael P. Shatz**, leader of the Advanced System Concepts group;
- **Terminal Doppler Weather Radar Open Processor Project Team**, led by **Gabriel R. Elkin**, a member of the staff at the Reagan Test Site on Kwajalein.

Scott D. Coutts of the Ranges and Test Beds group has received the Best Presented Paper award for his paper “Distributed Coherent Aperture Measurements for Next Generation Radar,” which was presented at the 2005 Tri-Services Radar Symposium, held in June 2005 in Monterey, California. **Kevin M. Cuomo** of the Ranges and Test Beds group and **Linda J. Maciel** and **Jean E. Piou** of the Intelligence, Test, and Evaluation group received an Honorable Mention award for “Super Resolution and 3D Imaging of Ballistic Missile Systems,” also given at the 2005 Tri-Services Radar Symposium. The awards were presented at the 2006 Tri-Services Radar Symposium, held at Lincoln Laboratory in June.

Scott A. Hamilton, assistant leader of the Optical Communications group, was elected an IEEE Senior Member in August 2006.

Pratap N. Misra of the Surveillance Systems group has been named a Fellow of the IEEE for contributions to global satellite navigation systems.

Jinendra K. Ranka of the Quantum Electronics group has been elected a Fellow of the Optical Society of America for contributions to ultrafast nonlinear optics, including discovery of supercontinuum generation in photonic crystal fibers.

William Z. Lemnios, retired former head of the Radar Measurement division, was a member of the team receiving a Technology Pioneer Award from the Missile Defense Agency for the development of X-band radar for missile defense.

Leslie Servi of the Integrated Sensing and Decision Support group was recently elected to the Board of Directors of the Institute for Operations Research and the Management Sciences.

Jerry D. Welch of the Surveillance Systems group has received, in a collaborative effort with NASA, the FAA, and MITRE, a 2005 Best Paper Award from the American Institute of Aeronautics and Astronautics (AIAA) for “Multi-Center Traffic Management Advisor: Operation Test Results.” This award was presented at the AIAA Aviation Technology, Integration and Operations Conference in September 2006.

John M. Wozencraft, MIT Professor Emeritus and a former head of the Communications and Information Technology division, received the 2006 IEEE Alexander Graham Bell Medal for the development of sequential decoding and the signal space approach to digital communications.