May 2008 Volume 1, Issue 2

# **ITA Newsletter**

US/UK International Technology Alliance in Network and Information Sciences



# Welcome

With the second issue of the ITA newsletter comes the second anniversary of the ITA programme. Tien and Greg offer their thoughts on reaching this significant milestone. In addition we have articles from Seraphin Calo on the policy technology demonstration and Zhengguo Sheng, Zhiguo Ding and Kin K. Leung from Imperial College on Cooperative Wireless Networks. We've also included a report from the recent Stakeholders Review Board meeting together with highlights from the programme and the announcement of the second ITA Conference in September. There will also be a special issue of the British Computer Society's *The Computer Journal* to be published next year which will focus on research work from the ITA.

Please contact me with any suggestions, comments or articles for publication in the newsletter.

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# **ITA after Two Years**

Tien Pham (US ARL-SEDD) and Greg Cirincione (US ARL-CISD)

May 2008 marks the second anniversary of a unique and exciting collaboration between the US and the UK via the International Technology Alliance (ITA) in Networks and Information Sciences. From our perspective, the ITA program has also been a very unique and exciting experience in many ways. As with any major program that is the first of its kind, there seems to be a lot of interest and skepticism at the same time. Thanks to the collaborative effort from many people within the ITA, from the management team and TAL's to the PC's and researchers, we see many exciting things that would not have happened without the ITA. The feedback that we have received during the Executive Steering Board (ESB) and the Stakeholder Board (SB) review meetings have been very positive but our leadership has expressed to us how important this program is to our respective countries and has challenged us to do better. We know that despite our successes, we still have a lot of work to do as the ESB and SB have challenged us to make certain that (i) the research is focused and addresses key coalition military needs; (ii) the collaborations are deep and genuine, both cross-Atlantic and cross-TA; and (iii) technology transitions happen quickly and have real impact on Net Centric Operations (NCO) for both US and UK forces.

As GTAL's, we are committed to spend the time to make the ITA a success and we have seen our roles expanded to ensure that the challenges put forth by the ESB and SB are met. One of our critical roles is to be the "bridge" that connects the researchers to the end-users of ITA technologies. This allows researchers to focus on performing seminal research while the users are engaged with the researchers mainly through the TAL's to understand the users' needs, identify key technology components, and potential transition opportunities. Within TA2 and TA3, we have seen the impact of this approach as we have seen genuine

cross-Atlantic collaborations expand and grow. We communicate constantly via email and via teleconference, mostly between the hours of 0900 US/1400 UK and 1200 US/1700 UK of course. We have had numerous of task-level, project-level and TA-level meetings, retreats and workshops with good participations. In addition, we have had meaningful sidebar meetings at other programs reviews at ARL and at the Annual Conference of the ITA and other related conferences such MILCOM and SPIE Defense & Security Symposium.

Over the last year, we have seen true cross-TA collaborations deepen. Ironically, prior to the ITA, we had not collaborated on a personal-level even though we have worked at ARL for more than 20 years. Through the ITA, we have not only established close collaborations between TA2 and TA3, but we have expanded collaborations between our two respective directorates within ARL, the Computation & Information Sciences Directorate (CISD) and the Sensors & Electron Devices Directorate (SEDD). For instance, over the last year we have collaborated on the following:

- We co-authored a paper along with Dinesh Verma (IBM US) and Gavin Pearson (Dstl) on "ISR Fusion for Coalition Operations" for FUSION 2008, Cologne, Germany. The paper will be presented as part of a Special Session on "Fusion on Interacting Physical, Perceptual and Policy Levels." The paper presents a framework based on the sensor fabric for performing policy-aware fusion within an ad-hoc of network of ISR assets.
- 2) We developed a Coalition Warfare Project (CWP) proposal on "ITA Sensor & Policy Tools and Protocols for Networking of Disparate ISR Assets" with the help from Gavin Pearson. CWP is sponsored by the US Office of the Secretary of Defense (OSD) and provides direct funding for two years to sponsor rapid development and transition of interoperability technologies for coalition operations. We see the CWP as an excellent source of transition opportunities.
- 3) We are sponsoring OTA2 transition contracts with IBM US to develop light-weight policy technology from TA2 and IBM UK to develop the sensor fabric technology from TA3 respectively. Our users have expressed strong interest in developing these technologies further and integrating them into a flexible testbed that can be analyzed and tested against a variety of sensor systems/platforms and ISR assets from ARL-SEDD and linking them via the sensor fabric to the ARL Wireless Emulation Laboratory (WEL), which can emulate 96-node size ad-hoc networks, from ARL-CISD. Once networked and linked, algorithms and tools for policy, routing, fusion, sensor-assignment and others can be deployed and evaluated in a scalable network environment with real sensor inputs.

In summary, the ITA has been a very challenging and rewarding experience for us. We are constantly strategizing on ways to foster further collaborations within the ITA and with the community at large. We firmly believe that the relationships and collaborations that we have developed under the ITA programme will be lasting and meaningful.

## Outcome of "Extraordinary" chairpersons Stakeholders Review Board meeting-

Pearl Gendason, ARL

Dr. John Parmentola, Director Research & Lab Management, Assistant Secretary of the Army (Acquisition, Logistics, and Technology), and Dr. Mike Steeden, Director Dstl, conducted an "Extraordinary" chairpersons Stakeholders Review Board meeting on 4 April 2008 at the U.S. Army Research Laboratory, Adelphi, MD. The purpose was to address issues raised at the 7 Nov 2007 Executive Steering Board with respect to better articulation of the challenges and utilizing matrices to show where the important technology gaps existed and a practical proposition to go forward.

Two ITA Grand Challenges were presented and both were determined to be very formidable, important and appropriate by the co-chairs.

The two Grand Challenges are:

- To ensure that coalition warfighters at tactical levels get the right information at the right time
  - Even when they do not know they need it
  - Even if this requires the network to mediate access to information based on resources, risk, and tactical context

- To enable coalition warfighters at the tactical level to work collaboratively to share knowledge, build trust, and solve problems across space and across cultural boundaries
  - And to enable this to happen rapidly

Dr. Steeden raised the possibility of a 3rd Grand Challenge for consideration when the next Stakeholders Board meeting is conducted October 31, 2008: "Assure solutions to the two grand challenges are robust and sustainable around coalition operations."

Each challenge must lead to a way of deriving goals and targets that can be evaluated and assessed and there must be a method to "roadtest" the solutions. Dr. Gowens indicated that from the "grand challenges" the subset of "hard problems" is derived using the matrices and they are then tested in the scenario context. There will be further iterations of the hard problems at the boot camp to obtain researchers input and buy in. The hard problem articulation will also be a part of the framework for the Peer Review assessment in Sep 2008.

Dr. Parmentola and Dr. Steeden said the team had done great work in defining the problems and developing a coherent architecture. They look forward to seeing how it is further refined and used to measure progress towards goals and to guide the investment strategy to allocate resources.

## **ITA Project Highlights for the Quarter**

In TA1, work on the physical and medium access control (MAC) layer power estimation, dynamic policy refinement, inter-domain routing in geometric random graphs, and bio-inspired data harvesting has been accepted for publication in various refereed journals and conferences. Details of the 2008 Biowire workshop have been announced. This workshop will bring researchers in the biology and networking communities together to exchange ideas and technologies with the goal of improving the design and operation of wireless network sysems through the use of techniques proven to be successful in biological systems.

In TA2 there has been further advances in policy based security management. Elements of their formal model of policy refinement have been put in place by identifying the kinds of information the model should include together with an undertanding of how this would be used by the process of refinement. From this a clearer understanding of the role policies will play in refinement and the types of outputs expected from the refinement processes. Within the security tasks of this TA, advances have been made in adapting threshold signature schemes to work in challenging network environments. Investigation of existing protocols has led to what the researchers believe to be the first practical solution for dynamic and communication constrained scenarios and was published at one of the two leading annual cryptography conferences.

In TA3, researchers initiated an effort to define a Mission Abstraction Requirements Structure (MARS) by which a mission planner can specify information requirements and associated Qol. An approach to calculating Qol at all levels of abstraction in a sensor network using empirically-tuned analytic stochastic has also been defined. Researchers are continuing their close collaboration on sensor fault detection and management in the context of a two-tiered architecture (covering operations both local to the sensor and for the entire sensor network) and several application scenarios. Work continues in the use of stochastic process models in the definition and calculation of Qol for event detection in tactical sensor networks.

In TA4, advances have been made in the study of 'Linguistic Sources of Miss-Communication' which were presented at the NATO symposium on 'Adaptability in Coalition Teamwork'. There has been a successful experiment involving soldiers from a UK Battalion who participated in using instrumented commercial game simulations which capture communications and behaviour for use in studies of mission adaptive planning. Similar studies have also been undertaken with cadets from the U.S. Army Military Academy. We have developed a lightweight semantic wrapping technique to enable rapid semantic integration among multiple existing data sources. The use and derivation of rationale has been added to our 'Collaborative Planning Model'. This allows an overlay of the dependencies between plan components to be included in the view of the plan, assisting the exploration of human aspects in the communication of plans and intent.

## **Technical Corner**

#### ITA Policy Technologies Demonstration, Seraphin B. Calo, IBM US

The overall objective of Project 4 in Technical Area 2 is to provide the ability to adapt system behaviors to meet highlevel user-specified security goals in a coalition environment. To accomplish this, end-to-end policy mechanisms must be developed that capture the security requirements of the system, transform them into constraints on the system resources, and execute the appropriate actions that enforce these policies, taking into account the current state of the system along with trust and risk factors pertinent to that state. There are many research challenges that must be overcome to realize such a vision.

As a way of exploring the kinds of capabilities that are necessary and assessing the value that they provide, a proof of concept prototype has been developed that captures key elements of the policy analysis and refinement processes. It includes capabilities for authoring and updating policies, for viewing policy sets, for performing various types of analysis, and for two basic kinds of transformation.

The authoring program enables users to author policies in natural language. The policy statements are then parsed and put into a structured format. The author can then view the policies to check that they have been parsed correctly. The policies can be modified, and the sets of policies can be visualized in various ways. Additional policies may be authored in natural language or they may be authored directly in the structured format by selecting appropriate elements from each of the designated semantic categories.

The Search and Rescue in Urban Territory vignette from the Holistan scenario has been used as a motivating context. In our demonstration scenario there are thus three policy sets: the Holistan U.S. Policy Set, the Holistan U.K. Policy Set, and the Rescue Mission Policy Set. The assumption is that both the U.S. and the U.K. have their own policies, and a set of policies must be developed for the coalition mission. The three policy sets can be selected together and mapped from their structured format into a given policy language. The combined policy set can then be analyzed by various tools. The prototype currently supports Conflict Detection, Dominance Analysis, Coverage Analysis, and rule based Transformation.

The conflict analysis routine looks at all of the policies in the set and determines which are simultaneously applicable. For those that are simultaneously applicable, it checks to see if the prescribed actions are incompatible. If it cannot determine incompatibility, it refers the policies to the user for inspection. Dominance Analysis checks to see if any of the policies are redundant. A policy rule is dominated by another set of policy rules if adding the new rule to the set will not change the behavior of the system in any way. Coverage Analysis provides information on whether all ranges of the variables in the policies selected are represented. The current version of the prototype incorporates a feedback channel from the analysis component to the authoring component that suggests new policies to replace sets of policies with incomplete coverage.

The rule based Transformation routine transforms the policies in a policy set based on transformation rules that have been previously determined by a subject matter expert. This allows higher level abstractions to be mapped to the particular security mechanisms that will implement them.

The prototype has been accepted for presentation at the 2008 IEEE Workshop on Policies for Distributed Systems and Networks (Policy 2008). Work is underway to combine the policy management functionality with the ITA Sensor Fabric being developed as part of Project 8 in Technical Area 3. An integrated demonstration is being planned for submission to the Second Annual Conference of the International Technology Alliance.

#### **Researcher Corner**

# Cooperative Wireless Networks: From Radio to Network Protocol Designs, Zhengguo Sheng, Zhiguo Ding and Kin K. Leung, Imperial College, U.K.

The launch of International Technology Alliance (ITA) project offers a golden opportunity for new collaborations among researchers across the Atlantic Ocean. The objective of this project is to investigate all aspects of network sciences for the U.S. and U.K. military. One of the investigation topics in the Technical Area of Network Theory focuses on wireless ad-hoc networks and various aspects of their system performance. The goal of our work is to study new physical-layer

techniques and the associated designs of upper-layer protocols, including medium access control (MAC), routing and transport protocol, and ultimately to improve the overall quality of service (QoS) at the application level in the wireless networks. These new technologies are expected to *save energy*, *enhance efficiency* and *reduce cost*, thus enabling new network-centric operations, which otherwise cannot be supported by existing techniques.

Among many potential candidates of physical-layer techniques, multiple-input multiple-output (MIMO) antenna has received significant attention, which can provide spatial diversity and hence represents a powerful technique for mitigation of interference and multi-path fading. Towards our goal cooperative communication is studied as an alternative and low-cost way to achieve spatial diversity. The key feature of cooperative transmission is to encourage single-antenna devices (e.g., those carried by soldiers) to share their antennas cooperatively such that a virtual and distributed antenna array can be constructed and, as a result, reception reliability can be improved and power consumption can be reduced significantly.

Our starting point is the design of physical layer combined with network coding. We are motivated by the fact that network coding has been well known for its capability to increase system throughput. The broadcast nature of radio propagation makes wireless networks ideal for the application of network coding. In order to develop physical-layer protocols using network coding for practical environments, jointly with our collaborators, Don Towsley and Dennis Goeckel, at UMass and with inputs from Ananthram Swami at the U.S. Army Research Lab, we have devised and studied new protocols for several cooperative network scenarios with single source-destination pair and multiple access channels. It has shown that the proposed protocols can achieve better robustness performance and higher system throughput simultaneously. Furthermore, by combining opportunistic strategies with non-orthogonal transmissions, the spectral efficiency of wireless cooperative transmission can be improved, which yields a better achievable diversity-multiplexing trade-off compared with most existing transmission protocols.

With a better understanding of physical-layer techniques, it becomes *critically important* to study how the performance gain of cooperative diversity at the physical layer can be reflected at the networking layers, thus ultimately improving application performance. Our approach is to achieve that by tailoring the designs of network protocols for the new physical-layer techniques. For example, by encouraging nodes to share their antennas, the transmission pattern could yield a new routing structure at the network layer, termed as cooperative links, which are different from the direct transmission links in the sense that besides the source and destination nodes for a transmission, intermediate nodes are also involved in relaying the transmitted signal between the two nodes. We first proposed a new algorithm of distributed beamforming which weighs the output of each relay node appropriately such that the quality of the combined received signal at the destination node is improved in a distributed way. We further devised new approaches of cross-layer optimization for cooperative networks, and proposed a joint physical-MAC distributed approach for relay selection, which has been shown to achieve full diversity gain. Through analysis of two different types of routing optimization, it can be shown that criteria using cooperative transmission can typically yield more efficient routes than the non-cooperative schemes. Motivated by this result, two QoS routing algorithms have been proposed, which can achieve better error performance than traditional distance vector algorithm and drastically reduce the transmission power in a distributed manner, while satisfying pre-specified performance requirements.

In our view, these benefits make cooperative wireless networks capable of combating radio unreliability and meeting military application requirements of high-speed and high-quality services with high energy efficiency. In addition, the project addresses key issues of cooperative networks from the theoretical aspects of information theory and cross-layer optimization, which offers a better understanding of the fundamental limits of cooperative networks. The acquired new insights could also provide a precise guideline for the efficient designs of practical and reliable communications systems. Hence these results will potentially have a broad impact across a range of areas, including wireless communications, network protocols, radio transceiver design and information theory.

## ITA Members in the News/Honored

Professor **Erol Gelenbe** is the recipient of the ACM SIGMETRICS Achievement Award, to recognize his distinguished career contributions in performance modeling and in the training of the next generation of performance evaluation researchers. Erol currently holds the Dennis Gabor Chair at Imperial College London. He will receive his award at ACM SIGMETRICS 2008. Further information about Erol is available on the conference Web site: <u>http://www1.cs.columbia.edu/~sigmet08</u>

# Other Announcements Annual Conference of ITA (ACITA) 2008

#### Imperial College London; September 16-18 2008

This is the second conference of the International Technology Alliance (ITA) program jointly funded by the U.S. Army and U.K. Ministry of Defence. A key objective of the ITA program is to foster trans-national collaborations between alliance member universities, industries and government organizations. The main purpose of this annual conference is to provide a forum for associated researchers to present and share their scientific findings, as a way to further enhance and establish collaborations among alliance members.

Attendance at the conference is by invitation only. All ITA Alliance members are automatically invited to the conference. A limited number of non-ITA participants will be invited.

Further details regarding this event please visit the ACITA Web site at http://www.usukita.org/?q=acita\_2008

#### Call for Papers for a special issue of The Computer Journal

A special Issue on "Advances in Sensing, Information Processing and Decision Making for Coalition Operations" within the US/UK International Technology Alliance is being organized by the British Computer Society's 51 year-old archival research journal in computer science, *The Computer Journal*, whose Editor-in-Chief is Prof. Erol Gelenbe. The editors for this special issue are Erol Gelenbe, Tien Pham, Tom La Porta and Tim Norman.

May 2008 marks the second anniversary of a unique collaboration between the US and the UK via the International Technology Alliance (ITA) in Networks and Information Sciences. The ITA jointly conducts collaborative research in

- (i) Network theory
- (ii) Security across a system of systems
- (iii) Sensor information processing and delivery, and
- (iv) Distributed coalition planning and decision making.

The research focused on enhancing distributed, secure, and flexible sensing, information processing and decision making to improve Network Centric Operations (NCO), and expects to achieve research results that would not have been possible without the synergies gained from US-UK collaborations.

This special issue highlights the collaborative research in the ITA program and discusses advances in *sensing, information processing and decision making for coalition operations.* The call for papers solicits (i) technical papers presenting significant ITA research contributions, as well as (ii) high-quality tutorial-style papers that set out the context of the ITA (vision) and review research being conducted within the ITA (contributions to this vision). Topical areas include, but are not limited to the following.

#### Scope of Topics

- Information Processing for Heterogeneous Sensor Networks
- Policy-aware Sensor & Information Fusion
- End-to-end Quality of Information (QoI)
- Qol based Network Design and Analysis
- Dynamic Sensor Mission Assignment
- Mission-based Network Configuration & Information Dissemination
- Collaborative Processing & Decision Making among Human-based and Sensor-based Systems

This special issue is open to Alliance members only; papers submitted by members of institutions not associated with the ITA program will not be considered. Alliance members are cordially invited to submit original contributions in any of

topic areas relating to sensing, information processing and systems for decision making in coalition operations theme. Papers highlighting results of collaboration across nations or several project areas are particularly encouraged.

The paper formatting instructions can be found at:

http://www.oxfordjournals.org/our\_journals/computer\_journal/for\_authors/index.html,

It is suggested that the length of manuscripts, including figures and references, should not exceed 10 pages.

To avoid any errors in handling, papers for submission to the special issue, in final formatted form (PDF file), should be forwarded directly to Dr. Tien Pham at <u>tien.pham1@arl.army.mil</u> and Prof. Erol Gelenbe at <u>e.gelenbe@imperial.ac.uk</u> rather than being uploaded to the journal's submission system.

Schedule for Submissions:

Submission Deadline:	August 1, 2008
Notification:	October 1, 2008
Revision Due:	November 1, 2008
Final Notification:	December 15, 2008
Final Manuscript Due:	December 30, 2008
Publication Date (tentative)	February 1, 2009