B B N
TECHNOLOGIES

Industry-Academia Collaboration in Government-Funded
Research and Development

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BBN Technologies

for
GECCO-2006: Evolutionary Computing in Practice (ECP):
Technology Transfer from Academia to Industry

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BBN Technologies

- 650 employees, headquarters in Cambridge, MA
- Perform R&D, technology transfer and systems development and integration activities in multiple areas that span the physical, computer, and information sciences
- Primary focus is on developing state of the art solutions for military and security customers
  - Mostly 6.2 and 6.3 levels
- Also develop solutions for commercial customers and transition inventions into commercially available products and services
- Comprised of multiple departments covering variety of domains
  - Intelligent distributed computing, Internet research, Mobile networking systems, Decision and security technologies, High performance computing, Sensor systems, Speech and language processing, Applied physics and tactical sonar
- Frequently work with university partners
- Rated CMM Level 2

BBN Interactions with Academia

- As prime on a team with university (and industry) partners
  - e.g., POIROT, ADROIT, KineVis, Quantum Network
- As partner on a team led by another company or by a university
  - e.g., Adaptive agents
- As co-contractors on R&D program
  - e.g., Ultra*Log, DAML
- University professors as consultants on projects
  - e.g., Game-based Training, KineVis
- Professional interactions via program committees, study groups, review boards and conference participation
  - e.g., NRC panel on Human-System Integration (BBNer is chair)
- Participation in and hosting of workshops and events
  - e.g., ECP, OpenCougaar Conference, Achieving Functional Integration of Diverse Neural Models (IJCNN05)
- BBN's Visiting Scientist program (come to us on your sabbatical…)
- BBN's Science Development Program Seminars (come give a talk)
- Undergraduate/graduate students as summer interns

What we each bring to the table

- Academia:
  - Experience in basic research
    - Innovative ideas in new domains
    - Multi-disciplinary collaboration
  - Prestige and name recognition
  - Strong experimentation capabilities
    - Proven experimental designs, methods and processes
    - Student population as subjects
  - Access to graduate students, research fellows
- Industry (BBN):
  - Experience/contacts with broad range customers
  - Strong integration and development capabilities
    - Focus on addressing customer needs
    - Reliable development and delivery of products
    - Proven development tools and methodologies; robust architectures
  - Large pool of experts and resources to draw on
    - Multiple technology domains
    - Strong and rapid contracting support

What we bring together

- Increased benefit to customer via:
  - Development and application of novel ideas to produce state-of-the-art solutions
  - Improved robustness of systems produced
  - Community engagement via publication, open-source products and new standards (improves chances of selling the next program)
- Reduced risk to customer via:
  - Dedicated development teams
  - Use of domain leaders to ensure relevance
  - Proven R&D and testing methods
- Increased chance of success in winning work
  - Complementary skill sets and domain expertise
  - Richer and more strongly founded technical vision
  - Many agencies encourage academia-industry collaboration

Relationships and Communication

- Relationship building and communication is key to developing and maintaining effective industry-academia partnerships and winning work.
- Build the right team
  - Exploit/share any existing customer relationships
  - Bring in teammates that one of us has worked well with before
- Meet (as often as feasible)
  - During proposal efforts and project execution, nothing beats face-to-face
  - Engage each other at conferences/workshops
- Be proactive
  - Suggest new ideas, new customers, new opportunities
  - Share lessons learned, information, insights on customer
  - Work with co-contractors to get ideas out of the lab
- Be responsive
  - Provide supporting materials, attend program meetings, reply to email/voicemail quickly (even if to say you're busy)
  - People like to work with people they can count on

Issues

- Be good teammates
  - A: Some academics only want to do their own thing
  - I: Respect academic schedules and constraints
- Address project and partner needs
  - A: Contribute actively to integration efforts
    - e.g., Counter example: No results for a long time and then a crunch leads to a perception of unreliability
  - I: Support need for publication
- Provide reliable resources
  - A: Be clear about resource availability/expectations
    - e.g., provide dedicated graduate student or research fellow
    - If providing code, what state is it in? (usable/stable/documented?)
  - I: Provide technical support to facilitate integration and minimize load on academic developers
    - e.g., CVS repositories, technical contact, APIs and supporting code
- Customer focus
  - Work together to solve the customer's needs, not to push individual ideas and techniques
  - Don't forget that the prime (A or I) is a customer too…

BBN as Teammate

- Adaptive Agents project
  - DARPA Taskable Agent Software Kit (TASK) program
  - Massachusetts Institute of Technology prime, with BBN
    - MIT Principal Investigator is a Visiting Scientist at BBN
  - Basic and applied research to study the construction of agents as hierarchical structures of elementary adaptive modules (EAMs) - purpose structures that can tune themselves so as to adapt to changing environments and requirements.
    - Provided a testbed for the development of multi-agent systems in operational applications such as vehicle control and coordination in transport networks and unmanned aerial vehicle (UAV) surveillance
  - Friendly relationship with co-contractor EC practitioner (Hampshire College), with exchange of ideas and designs throughout project
  - Final prototype applied genetic programming for on-line learning of UAV control logic in response to large changes in the environment
    - Used a second, fast simulator as a 'mental model' for fitness evaluation within a larger UAV simulation
    - Applied ECJ (Evolutionary Computation in Java) package developed at George Mason University's ECLab Evolutionary Computation Laboratory

BBN-Academia as Co-Contractors

- Ultra*Log
  - DARPA IXO project (2000-2004) project focused on creating survivable large-scale distributed agent systems capable of operating effectively in very chaotic environments.
  - BBN had role of system integrator for a large group of co-contractors, including academic members (e.g., University of Memphis, Stanford)
  - BBN developed a process to produce a coherent set of code. Integration schedule needed to balance academic, industrial and government constraints.
  - Applied BBN's GA-based Vishnu reconfigurable scheduler to provide distributed logistics scheduling capabilities.
  - Transition via open architectures and open source
- DARPA Agent Markup Language (DAML) program
  - BBN as the overall system integrator for DAML.
  - International team to bring DAML technology to fruition, including: World Wide Web Consortium (W3C), Yale University, Stanford University, MIT, BBN, and a dozen additional contractors

Academia as Consultants

- Game-based training and assessment of human performance
  - Proposed effort for ONR (Capable Manpower program)
  - BBN prime, with several industry teammates. Two academics as consultants to advise on relevance, assist in evaluation of products, and assist in transitioning products to military customers
  - Based on an open-source gaming engine (Delta3D) developed by Naval Postgraduate School (NPS).
  - Proposed transition through open-source software and via testing and deployment in military academic environment (i.e., NPS)

BBN as Prime

- POIROT (Plan order induction based on reasoning from one trial)
  - DARPA project (Integrated Learning program) to develop a system that integrates a variety of reasoning/learning techniques to learn new tasks based on observing humans doing the tasks
  - BBN prime, with over 10 academic and 4 industry teammates. BBN has the role of architect and integrator. Academics will contribute ideas, design, representations and products.
- ADROIT (Adaptive Dynamic Radio Open-source Intelligent Team)
  - DARPA Adaptive Cognition-Enhanced Radio Teams (ACERT) program
  - Goal is to develop open source software to improve wireless connectivity and performance in unpredictable urban environments based on highly adaptive networks of software defined radios.
  - BBN leads a world-class, interdisciplinary team with one industry and 3 academic (University of Kansas, MIT, UCLA) partners.
  - Academic partners will contribute ideas, algorithms and products in areas of routing and forwarding, channel access schemes, and software radios
  - Evolutionary computation may play a role in future years for learning new mechanisms for cognitive control of networking behavior

BBN as Prime

- Kinetic Visualization (KineVis) project
  - DARPA project to develop data visualization technologies that use motion to illuminate patterns and connections in very complex data sets where traditional highlighting methods prove inadequate
  - BBN is prime, with University of New Hampshire performing basic research and conducting human subject experimentation, and University of Massachusetts using their existing Universal Visualization Platform (UVP) as a testbed for conducting engineering studies (to answer questions about how well our new techniques integrate with existing systems)
  - Academic consultant for certain tasks
- DARPA Quantum Network project
  - DARPA project to develop the world's first quantum cryptography network Introduces extremely high levels of security for Internet-based communications systems by encrypting and decrypting messages with keys created by quantum cryptography.
    - Operating continuously since 2004, now with 10 nodes
  - BBN is prime, with Harvard University Applied Physics Dept. providing theory, Boston University providing photonics, U. Rochester providing superconducting detectors and MIT providing quantum eavesdropping

BBN-Academia Experimentation

- Stereoscopic Digital Mammography (SDM) project
  - Technology developed at BBN, and evaluated in collaboration with Emory University.
  - SDM is a mammography system that provides a three-dimensional, in-depth image of the breast. Previous work has shown that this new system, which is not yet FDA approved, enables a radiologist to detect and interpret breast lesions that a standard digital mammogram may fail to capture.
  - During development of this and related technologies, BBN has provided technical expertise in human visual perception and classifier development, and our academic (medical) collaborators have provided the needed radiological expertise to understand the diagnostic images, and served as readers in our reading studies to test our systems.
  - Currently conducting a clinical trial of the ability of stereo mammography to improve lesion detection and reduce unnecessary recall of patients compared to standard (non-stereo) digital mammography. This trial is taking place at the Breast Imaging Center at Emory University.

BBN and Evolutionary Computation

- BBN is committed to Evolutionary Computation
  - As a core technology to solve complex problems
  - As a component technology to support a larger system
  - As a method for enabling robust, adaptive systems
  - By developing novel approaches and uses for EC
  - By producing useful tools to support EC development
- We tend to use in-house EC labor
- …but we are happy to work on a team where we are the liaisons between EC practitioners and architecture developers
- We have used/will consider using academic-developed tools
  - e.g., ECJ (GMU), VGJ (Visualizing Graphs with Java, Auburn University), SNNS/ENZO (Stuttgart Neural Net Simulator), ns-2 (Network Simulator, USC/ISI)
- We regularly publish results of our EC efforts

Evolutionary Computation Projects

- Planning:
  - Ultra*Log
  - Logistics Decision Support System (LDSS)
- Networking:
  - Salamander: Dynamically reconfigure data networks w/ wireless links
  - Exploiting Robotic Network Mission Interactions (ERNI): Applied GA to optimize the parameters of a robot ad hoc network
- Scheduling:
  - Vishnu Reconfigurable Scheduler
  - Scalable Agent-based Scheduler Simulator Infrastructure (SASSI)
  - AirCAMS: Aircrew scheduler for airlift and air refueling squadrons
  - BEST™ Field Service Scheduler
- Robotics:
  - Advocates and Critics for Tactical Behaviors (ACTB)
  - Adaptive Agents
- Other:
  - Shooter detection (Boomerang)
  - Sonar processing: Tune to underwater targets and environment

Summary

- Government R&D is a rich opportunity for Industry-Academia collaboration
- EC is an important supporting technology for developing flexible, robust applications
- BBN is committed to the application of EC
- BBN-Academia collaboration is a key aspect of our business
- Be proactive and help us develop customer relationships so we can win work together
- Do you need help taking your research to a prototype stage for a customer? Call us.
- BBN is a natural partner for transitioning ideas, algorithms and products out of academia

Who We Are

- Talib Hussain: thussain@bbn.com
  - EC for planning, robotics, network optimization, neural networks
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- David Montana: dmontana@bbn.com
  - Significant experience in applying EC to a broad range of problems. Key designer of Vishnu.
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  - EC for logistics, robotic control. Vishnu in agent architectures
- Marshall Brinn: mbrinn@bbn.com
  - EC for shooter detection (Boomerang)
- Wallace Feurzeig: feurzeig@bbn.com
  - Use of EC for learning and adaptive agents in UAV control
- Stephen Milligan (BBN's Chief Scientist): milligan@bbn.com
  - Application of EC for variety of domains
- Please visit vishnu.bbn.com for more information on our Vishnu reconfigurable scheduler