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Broadening the Scope

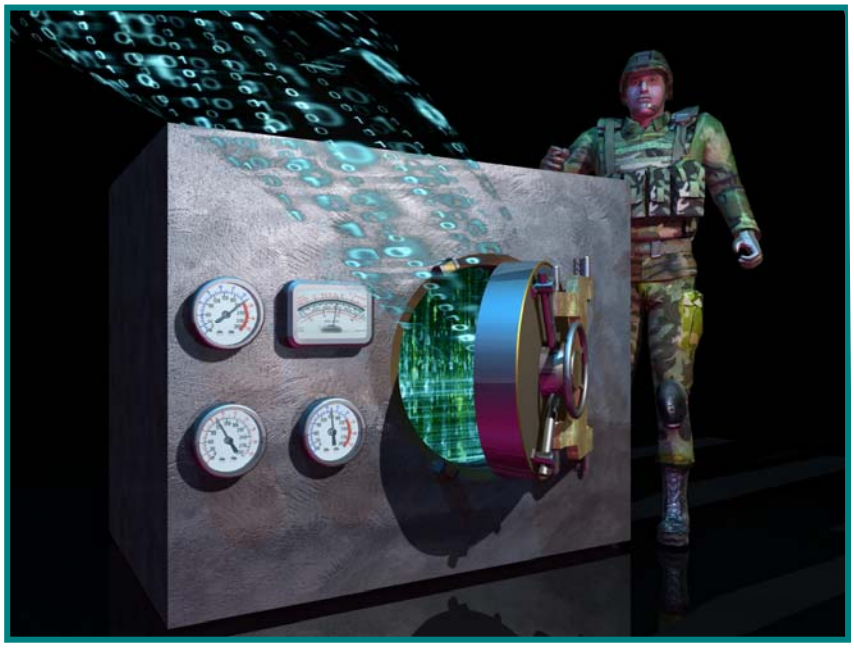
How do we make our information processing systems truly become the trusted, reliable, and transparently accessible backbone of our military forces? IPTO's cognitive computing agenda depends heavily on the underlying computing, communications, and software infrastructure. We need to think not only about the kinds of supporting architectures needed for enabling new generations of cognitive systems, but also the crucial issues of trust, security, reliability, and data access.

First, we need to be able to trust our information systems.

As our hardware and software systems become more complex, error-prone, and potentially vulnerable to attack, we need to rethink how we harden, verify, and validate them and, perhaps even more important, how we develop new programming models that can deal with inherent uncertainty. All these issues will affect the security of our systems.

But as good as we may become at this monumental task, we need to acknowledge that no systems can ever be made fully secure. When systems become compromised, we need to know. We need to build in the hooks for pushing cognition (that is, monitoring, diagnosis, and analysis) to all layers of our systems without incurring unacceptable performance degradation. And when compromised, our systems need self-repair capabilities. They need to both handle immediate threats and build up repositories of defenses over time. Creating hyper-secure and self-repairing information systems is a deep and complicated problem that is critical to the future of our warfighting capabilities.

Next, advanced computing platforms. Military applications will continue to demand faster processing and higher productivity from our information systems. This means real-time computing and beyond. In the heat of battle, our decision makers need to be able to run complex simulations to analyze multiple strategies simultaneously, much the way humans do, to select an optimal path in a timely way. To do this, we will need to push the frontiers of innovation in computing architectures for both large-scale and embedded systems and from the perspective of both novel hardware and productivity-enhancing software. In addition to riding Moore's Law and achieving ever increasing processing rates, we need to create new processing architectures that are better suited to cognitive processing structures. In



the short term, this may mean dynamically morphable micro-architectures and runtimes. But, we should also be looking to a farther future where uncertainty and inconsistency are a way of life.

Next, what about the thorny problem of software productivity? To realize the full potential of the future high-performance computing architectures that IPTO is creating, we need to make commensurate investments in their high-productivity computer language environments. We need to enable transparent access through secure cyberspace to any available high-performance computing resources. Today, development of software systems is one of the most time- and labor-consuming jobs within DoD. And today's novel software will always be tomorrow's outdated legacy code. How do we deal with upgrading outdated code, integrating heterogeneous software of varying pedigrees, and validating the increasingly complex software systems that are the backbone of our military forces? This is a long-standing, enormous challenge that will require innovative ideas about how we can make software development a more transparent process, leading to flexible code that can anticipate interfaces with other software and adapting to evolving military missions.

Finally, we need to exploit these technologies to manage and make sense of the increasingly massive quantities of data that we acquire. We need to provide the warfighter with a broad span of situation-relevant knowledge and turn data into actionable information. Today, warfighters and decision makers are either inundated with too much irrelevant data or deprived of timely critical information. We need to change the game. The technologies needed to do this include deep, rapid search and correlation across disparate, heterogeneous sources; real-world models; and simulation capabilities for projecting future states. Our warfighters need to process huge quantities of data to detect patterns, test hypotheses, and essentially turn a chaotic picture into coherent knowledge and insights.

These are just some of the DARPA-hard problems we need to address to make our ambitious agenda a reality. There are unlimited challenges and opportunities ahead. We look to you for the far-reaching ideas and innovative systems that will form the foundation of our future.