

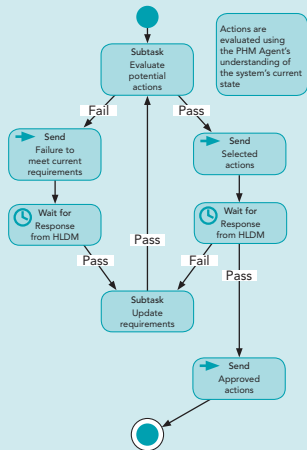
A certifiable reasoning engine for intelligent & autonomous systems

Building autonomous & intelligent systems

Autonomous and intelligent systems have come of age. Ranging from the next generation of Unmanned Air Vehicles (UAV) operating without direct human control, to the new generation of intelligent motor vehicles helping drivers avoid accidents, these systems improve safety, reduce workload and lower costs, as well as reduce emissions by more efficient operation.

However, building this autonomous and intelligent capability is challenging. Although the applications vary widely, the underlying problem is the same – build a system that mimics simple rational human reasoning in rapidly changing circumstances. C-BDI has been specifically developed for this purpose: to help product designers construct their particular autonomous or intelligent application or product.

These products must also be safe and meet the safety and regulatory requirements of



Graphical representation of reasoning plans makes it easier to understand autonomous functions.

their industry, be it aerospace, oil and gas, medical, or motor vehicle. C-BDI's design

facilitates applications in meeting those requirements.

C-BDI™, The Product

C-BDI is AOS's flagship 4th generation Beliefs, Desires, Intentions (BDI) system for intelligent agents and decision-making systems. C-BDI targets demanding safety critical applications with various Safety Integrity Levels and a full DO-178B Level A certification package is planned for integration into any system's safety case.

Major Innovations in Technology & Safety

C-BDI has been engineered from the ground up to provide features that ensure stability, correctness, and ease of use:

- enhanced support for the BDI model with extended goal management to improve reasoning and reflection
- better memory management to avoid the typical problems of current BDI systems that assume infinite memory availability
- guaranteed bounded computation times by eliminating features such as dynamic memory allocation.

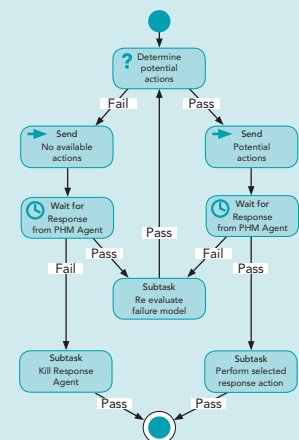
The C-BDI Runtime is written in industry standard C++ (with compliance to accepted coding standards such as JSF++ and MISRA). AOS is in close communication with regulatory authorities world-wide to ensure its products facilitate safety assurance and contribute to the overall system safety case argument for any application.

Speeds Up Product Development While Reducing Costs

C-BDI is designed so developers can ensure their applications meet the highest requirements for security, reliability, and performance. Traditional reasoning systems can crash or execute uncontrollably resulting in costly consequences such as a lost UAV or a failing car.

C-BDI enables developers of autonomous and intelligent systems to:

- quickly and easily develop and deploy their intelligent, reasoning applications;
- gain a head start because the core reasoning capability already exists;



Graphical reasoning plans are compiled directly into C-BDI executable code.

- shorten the time-to-market for their applications because developers' attention is focused on the application function;
- reduce the overall development risk as C-BDI is a proven product so designers and developers can focus on application and safety needs;
- focus on quality and innovation because designers can rely upon C-BDI as the most effective BDI model available for implementing rational reasoning.
- jumpstart product development because AOS offers an extensive array of middleware, each of which is fully integrated into the C-BDI runtime and tested to ensure that it runs seamlessly with C-BDI's advanced capabilities.



Agent Oriented Software, World Leader in Autonomous Systems Software



Crown copyright 2010. UK Ministry of Defence/BAE Systems/Rolls-Royce Taranis UCAV rolled out in July 2010. AOS's JACK provides the high autonomy capability for the vehicle.

Using C-BDI, developers can build reasoning plans graphically and compile them into C++ application code run by the C-BDI Runtime. This graphical facility provides an intuitive representation of autonomous behaviours that is easy for Subject Matter Experts to comprehend.

For industries like oil & gas, AOS also offers platforms that provide a complete environment including the C-BDI Runtime, development tools, industry-specific middleware and documentation.

C-BDI is compatible with all major development environments such as Green Hills Multi and VxWorks Workbench, as well as Visual Studio and Eclipse. C-BDI's unique approach provides guarantees for multiple safety-critical applications operating at different safety levels, and offers a universal runtime environment capable of executing

a variety of decision-making systems in the aerospace, oil & gas and medical industries, and intelligent motor vehicle applications

What's under the "bonnet"?

C-BDI's pedigree goes back 25 years to work on the philosophical concepts of rational agency developed at Stanford by Prof Michael Bratman. Introduced to the computer science world, these concepts led to the development of the Beliefs, Desires, Intentions (BDI) model of Rational Agents by Dr Anand Rao of AOS and others. The first manifestation was the Procedural Reasoning System (PRS) at SRI International, funded by NASA to explore decision-support for Space Shuttle astronauts dealing with critical decisions in space.

Over the last 20 years, AOS team members have been involved in most of the BDI-based

reasoning systems starting with PRS, then dMARS, AOS's JACK®, CoJACK™ and now C-BDI. JACK has been used in a range of applications from simulation systems for the military and decision support in the oil industry, through to Unmanned Air Vehicles applications in the US and UK. AOS's JACK also underlies the high autonomy capability of the UK Ministry of Defence/BAE Systems Taranis UCAV, due to fly in 2012. C-BDI is designed so JACK-based applications can be easily ported to the new platform.

Agent Oriented Software

Established in 1997, AOS has a world-wide presence and its customers include Statoil, Boeing, Lockheed Martin, Northrop Grumman, BAE Systems, UK Ministry of Defence, AFRL, Australian Department of Defence, Canadian Department of National Defence.



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