Agent Technology Center (ATG)

- ATG is a university research center performing fundamental and applied research in the field of agent-based computing, multi-agent systems and agent technologies.
- There are (Jan 2009) 22 researchers and 6 PhD students working in ATG. ATG researchers work on various cutting edge research projects, have unique set of skills and broad international experience.
- Research and technology development is funded in parts by the Czech Technical University in Prague, by the Czech Government, European Commission, European and US industry and US research and defense agencies.
The main objective of ATG research is to contribute to:

- **fundamental research**: in agent-based computing and multi-agent systems
- **applied agent research**: in manufacturing, network security and defense
- **large scale prototype**: and demonstration systems development
ATG Core Competencies

- multi-agent modeling and simulations
  - scalable simulation of communities of interacting actors, e.g. air traffic, adversarial scenarios, design & manufacturing processes, car electronics
  - AGLOBE/XSIMULATION, hardware deployment in collective robotics

- multi-agent planning and coordination
  - advanced methods of planning and resource allocation and coordination
  - optimization of coordinated behavior, plan merging, repair, coordination

- multi-agent data analysis
  - distributed datamining and multi-agent learning, private knowledge confidentiality, in computer security, maritime domain awareness

- adversarial planning
  - opponent modeling, non-cooperative coordination and game playing, asymmetric conflict modeling, applied in security applications
ATG TECHNOLOGIES: SIMULATION
Build in AGLOBE Advanced, scalable and robust multi-agent simulation environment, developed under partial support of AFRL/EOARD and CERDEC/ARO.

compared to other multi-agent platforms, AGLOBE offers

» **superior performance**, low overhead, distributed load balancing
» full agent advanced **agent mobility** and computational reflection
» **environmental modeling** and scenario simulation support
» **complex visualization** environment

AGLOBE is suitable for development of large scale simulation scenarios and can be seamlessly ported to real-world deployment platforms using a standard methodology. **key functionalities:**

» Modeling and simulation  » Demo/visualization support
» Scalable experimental testing  » Hardware deployment support

Deployment in air-traffic control, distributed diagnostics, adversarial planning, design process modeling, collective underwater robotics, etc
ATG Technology: Scalable Multi-agent Simulation
ATG Technology: Scalable Multi-agent Simulation

CAR DETAILS:
Type: personal
Behavior: normal
Acceleration: 9.00
Weight: 1550.00
Current Speed: 76.56
Optimal Speed: 111.00
Maximal Speed: 220.00
Destination: 12
Strategy: AVOID OBSTACLE
ATG Technology: Scalable Multi-agent Simulation

[Image of Google Earth interface with a view of the Earth's surface.]
ATG Technology: Scalable Multi-agent Simulation
ATG TECHNOLOGIES:
PLANNING AND COORDINATION
AGENTFLY
- multi-agent model for **flight simulation** of fixed-wing aircraft
- 4D trajectory **planning algorithm**: based on AA* algorithm
- multi-layer **collision avoidance** architecture with 4 methods
- GPS system, weather model set of coordinated **information collection** planning algorithms
- external data collection and fusion (Landsat, airports, no-fly zones),
- 2D/3D advanced visualization and user interface

- Funded by the US AirForce Research Laboratory in 2006-2008
- In 2008 patent application submitted
AGENTFLY

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AGENTFLY: Noncooperative Mixed Deconfliction
AGENTFLY – industrial deployment

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- Technology take-up by US ARMY (for planning surveillance missions)
- Technology take-up by US FAA (for modeling the NAS traffic)
- Research license provisioning to BAE Systems in 2009
- Research cooperation with NASA
- SAAB/University of Linkoping deployment on helicopters

project planning:
- collaboration with Boeing
- Czech AirTraffic Navigation Services
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**AGENTFLY: Free-flight Collision Avoidance**

- **Cooperative collision** avoidance using cooperative detection, evasion maneuvers and two-way communication
  - rule-based (RBCA) – uses visual flight rules for horizontal avoidance
  - iterative peer-to-peer (IPPCA) – integrates airplane intentions in utility function
  - multi-party (MPCA) – situation-based multi-party group searching for common solution

- **Reactive collision avoidance** using two-way communication, Probability Collectives distributed optimizer with BAE Systems

- **Non-cooperative collision** avoidance based on prediction, dynamic no-flight zones-based

AGENTFLY: Iterative Peer2Peer Deconfliction
### AGENTFLY: Benchmark Tests

<table>
<thead>
<tr>
<th>Dist. ($\mu$)</th>
<th>Flights</th>
<th>Near misses</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SGTCa</td>
<td>IPPCA</td>
<td>SGTCa</td>
</tr>
<tr>
<td>4</td>
<td>2732</td>
<td>3240</td>
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</tr>
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</tr>
<tr>
<td>20</td>
<td>3860</td>
<td>4104</td>
<td>1011</td>
</tr>
<tr>
<td>const.</td>
<td>4217</td>
<td>4320</td>
<td>1847</td>
</tr>
</tbody>
</table>
Intrusion detection by network behavior analysis (NBA) – anomaly detection

» works with NetFlow data, keeps privacy of the content, open new attacks

» multiple AD methods, multiple trust models, multiple aggregation methods

» agent-based, dynamic, several layers of learning
ATG Technology: Network Security

Levels by speed:

- Up to 10 M packets ps
- Up to 10 K flows ps

Detected flows (10K fps)
Events (0-1000 per 5min)

Plans/ Attack Trees
Adaptation processes
ATG Technology: Network Security

Error rate (false positives):

300/2
58/2
15/2
5/2
ATG Technology: Network Security

Self-Management and Adaptation:

- Monitoring:
  - Self-monitoring
  - Self-evaluation
  - Defect detection

- Reflection:
  - Component generation
  - Component selection
  - Component combination
  - Component repair
business development strategy

» **Cognitive Security**: university spin-off company has been founded as a technology company
   – **CognitiveOne**: commercial product launched

» Sales channels under construction by means of partnership with HW (probes) integrator, Security provider and SW integrator

» Partnership agreement with CTU signed

» Presence in Sunnyvale, California (in PlugAndPlayTechCenter, supported by CzechInvest)
   – Technology discussion with CISCO in progress
ATG TECHNOLOGIES:
MARITIME DOMAIN AWARENESS
Can such activities be detected, predicted and (ideally) prevented (only) based on external observation of the sea traffic? How?
MDA: Data Categorization and Sources

Geographical data
- Static
  - Ports and bases
  - Transport corridors
- Dynamic
  - Weather and sea conditions
  - Daytime
  - Season

Google Earth Public domain

Incident data
- Suspicious vessels
- Attempted attack
- Hijacked vessel
- 2005-2009
- Live reports

ICC Live Piracy Reports
UNOSAT

Vessel Information
- Static
  - Vessel attributes (length, beam, ...)
  - VesselTracker
- Dynamic / Tracking
  - History of movement
  - AISLive, SailVX
- Background knowledge
  - Analysis of illegitimate traffic behavior and strategies
  - ICC, IMO, IMB, UNOSAT
MDA: Centralized Detection

**Vessel classification**
- Clustering based methods (KMeans, SVM-based)
- Hierarchical HMM
- Anomaly detection

**Behavior Prediction**
- 2D time series analysis
- Opponent modeling
- Anomaly detection

**Incident Risk mapping**
- Integration of a priori info, real-time data and outputs of classifiers and predictors
- Probabilistic approach
MDA: Monte Carlo Agent-based Simulation

World in the n-th step

Spawn and execute thousands of lightweight simulations with varied parameters

Aggregate simulation results

Incident risk map for the n-th step
MDA: AgentC Demo
MDA: Optimum Patrol Deployment

Randomization methods
- Unpredictable trajectories
- Weighted randomization
- Markov Decision process

Bayesian Stackelberg games
- Game Theory approach
  - Leader-Follower algorithms
  - Incomplete information

Robotic patrolling UAV patrolling
M.Tambe (USC) ARMOR - LAX airport IRIS – Air Marshalls

Reinforcement learning
- Bellman equation solving
- Dynamically Adaptable
R.Babuska (TU Delft) MA Reinforcement Learning
## ATG contracts with DoD and other US gov. agencies

### Air Force
- Acquaintance Models in OOTW Coalition Formation, F61775-00-WE043 (2002-03)

### ARMY
- Intelligent Software Agent Control of Combined UAV Operations for Tactical Missions (2008-2009)
- Distributed Planning and Coordination of Team-oriented Activities in a Dynamic Environment, W911NF-08-1-0041 and N62558-06-P-0353, subcontract provided to University of Edinburgh (2006-08)
- Modeling Individual, Collaborative and Adversarial Reflection, N62558-05-C-0028 (05-07)

### Navy
- Meta-reasoning and Adjustable Autonomy in Comput. MAS N00014-06-1-0232 (05-08)
- Robot coordination using PIM, subcontract awarded by Florida IHMC, US N00014-06-1-07756 (07)
- Consultation and architecture design for a shipboard chilling system - with Rockwell Automation (2004)
Industrial Collaboration

- **FAA (US):** Deployment of AGENTFLY in civilian air traffic domain
- **NASA (US):** Collaboration by means of a subcontract provided by IHMC
  - Robot coordination using PIM, subcontract awarded by IHMC (2007-2008)
  - Harry Swenson, NASA PM in ATG 2009-2010
- **BAE Systems (UK):** Deployment of the AGENTFLY multi-agent system as a test-bed for probabilistic collision avoidance strategies (2007-2008)
- **GOOGLE (CH):** Adjustable Privacy in Social Networks (Research Award in 2009)
- **ROCKWELL AUTOMATION RESEARCH CENTER in Prague (CZ):** design of agent-based reconfiguration shipboard automation for chilling system (2002)
- **DENSO Automotive, GmbH:** Agent based diagnostics in vehicle electronics directed towards facilitating graceful degradation (2005-2007)
- **CADENCE Design Systems, GmbH (D):** consultation services in design and development of an agent-based system for IC design management
Industrial Collaboration


- **MODELARNA LIAZ** (CZ), pattern manufacturing and HATZAPOULOS packaging (GR): development of ExPlanTech/ExtraPlanT multi-agent system and application towards project-driven production planning and supply chain management; co-funded by an EC project (2000-2003)


European RTD projects

- **K4Care** - Knowledge-Based HomeCare eServices for an Ageing Europe, EU 6FP-STREP Project, (contribution to the Bio-Data Processing Group)
- **Ecolead**: EU FP6 Integrated Project directed towards automated virtual enterprise creation and reconfiguration (2004-2009)
- **AgentLink III**: EU FP6 Coordinating Action in Agent Based Computing, responsibility for industrial action management (2004-2005)
- **ExPlanTech** IST project, development and take-up of production planning multi-agent system (2000-2002)
- **MPA** GROWTH project, agent-based modular planning and simulation architecture (2002-2003)
Collaboration in Research

- ATG have been in a close collaboration with leading research centers:
  - **Carnegie Melon University**, Robotics Institute, Prof. Katia Sycara,
  - **University of Southern California**, prof. Milind Tambe,
  - **Drexel University**, Department of CS, Prof. William Regli,
  - **State University of New York**, Binghamton (Prof. Victor Skormin), Florida
  - **Institute for Human and Machine Cognition** (Dr. Jeff Bradshaw),
  - **University of Edinburgh**, (prof. Austin Tate and Dr. Michael Rovatsos),
  - **University of Southampton** (Dr. Terry Payne), University of London,
  - **Kings college** (Prof. Michael Luck), University of London,
  - **Imperial College** (Dr. Allesio Lomuscio),
  - **University of Liverpool**, Agent group, (dr. Peter McBurney),
  - **Universitat Politecnica de Catalunya** (Dr. Steve Willmot), **University of Luxemburgh** (Dr. Eugen Staab) and others.
Prizes and Awards

- 2009 Google Research Award – Adjustable Privacy in Social Networks
- 2007 Engineering Academy of the CR Main Prize for AGLOBE MA technology
- 2007 CIA (Cooperative Information Agents) Workshop Best Paper Award nomine
- 2006 DARPA Award for Best Industrial and Applied Paper at AAMAS 2006
- 2005 Czech Technical University Chancellor Research Team Award to the ATG
- 2005 IEEE/WIC/ Intelligent Agent Technology Best Demo Award
- 2004 Czech Technical University Chancellor Award (3rd main prize) for excellence in industrial deployment of research results
- 2004 CIA (Cooperative Information Agents) System Innovation Award
- 2nd main prize for the X-Security package at AgentCities, Agent Technology Competition in Barcelona 2003
- Best paper award at European Symposium on System Man and Cybernetics 1998
- Siemens Dissertation Award 1998
- CTU Chancellor Award - III main prize for industrial deployment of research results CTU Chancellor Research Team Award 2005


