Extending agent languages for autonomy

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Background

- BDI agent languages:
  - Useful abstraction for complex systems
  - Mostly used for single agents with static plans
  - Simple, but theoretically sound

However, lack of direct support for:
- societal cooperation
- autonomy and dynamic adaptation

*Ad hoc* implementations of techniques rather than language support
Aims

- Extend traditional agent languages with:
  - Declarative goals
  - Motivated behaviour
  - Social cooperation

- Allow development of complete multiagent systems
Contributions

- Introduction of declarative goals in AgentSpeak(L)
- Dynamic plan creation in AgentSpeak(PL)
- Motivated goal generation in AgentSpeak(MPL)
- Multiagent cooperation through plan delegation
- Normative processing
Procedural and declarative goals

**Procedural** → efficient, yet inflexible:
- Predefined encapsulated behaviours
- Designer must foresee relevant plans

**Declarative** → expressive, but not trivial:
- Desired world states
- Requires a more complex reasoning mechanism

How to link desired world states to actions?
AgentSpeak(PL)

- AgentSpeak(L) + Planning $\rightarrow$ AgentSpeak(PL)
- Declarative goals are used to determine courses of actions:
  - Desired world states and basic capabilities are specified
  - Interpreter uses planner to generate new plans
  - New plans are stored by the agent, improving it
Motivations in Meta-reasoning

Motivations

- Root cause of future-directed behaviour
- Studied by a number of other disciplines
- In our work: abstraction of meta-reasoning:
  - Goal generation
  - Representation of dynamic priorities

AgentSpeak-MPL

- AgentSpeak(L) + Motivations:
  - Standard AgentSpeak(L) language
  - External motivation specification
- Motivation model for:
  - Goal generation
  - Plan selection
- Motivation model based on mBDI
Social AgentSpeak(L)

- Much research devoted to languages for *individual* agents with static plan libraries

- Cooperative strategies implemented *ad hoc*:
  - Generally assume knowledge of others’ abilities
  - Distributed, but based on *predefined* abilities

- Planning capable agents can drop these assumptions

- Our social AgentSpeak:
  - uses dynamically discovered abilities
  - abilities are plans which agents execute on behalf of others
  - generates new (high-level) plans using these abilities
Autonomous agents operating in an open environment need regulation.

**Norms** are the mechanism of choice.

Most research focuses on the *macro* level.

We focus on the machinery in agents that

- process norms, and change the plan library
- lead to norm compliance

Norms can cause plans to be:

- suppressed in case of prohibitions
- generated anew to comply with obligations
Conclusions

- Machinery exists that can be added to agent languages
- They need to be sensibly integrated to languages
- Necessary to create a general-purpose language
Future Work

- Motivation-based norm acceptance/rejection
- Motivation-modulated planning
- Motivated intention adoption and dropping
- Integration of various notions of declarative goal in AgentSpeak
Questions?