Good Afternoon, Colleagues

Are there any questions?
Logistics

- Programming assignment 4 - any questions?
Logistics

- Programming assignment 4 - any questions?
- Next week’s readings posted
ACL Desiderata
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible

**Content:** well-defined primitives, flexible content
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible

**Content:** well-defined primitives, flexible content

**Semantics:** unambiguous, address location and time
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible

**Content:** well-defined primitives, flexible content

**Semantics:** unambiguous, address location and time

**Implementation:** efficient, networking issues hidden, amenable to partial implementation
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible

**Content:** well-defined primitives, flexible content

**Semantics:** unambiguous, address location and time

**Implementation:** efficient, networking issues hidden, amenable to partial implementation

**Networking:** usable on top of existing protocols
ACL Desiderata

Form: simple, readable, concise, easy to parse and generate, extensible

Content: well-defined primitives, flexible content

Semantics: unambiguous, address location and time

Implementation: efficient, networking issues hidden, amenable to partial implementation

Networking: usable on top of existing protocols

Environment: interoperability with other languages
ACL Desiderata

**Form:** simple, readable, concise, easy to parse and generate, extensible

**Content:** well-defined primitives, flexible content

**Semantics:** unambiguous, address location and time

**Implementation:** efficient, networking issues hidden, amenable to partial implementation

**Networking:** usable on top of existing protocols

**Environment:** interoperability with other languages

**Reliability:** reliable, secure, authentication possible, error handling
Three-layer organization

- Content: free-form (domain-dependent)
Three-layer organization

- **Content**: free-form (domain-dependent)
- **Communication**: who is sending, etc.
Three-layer organization

- **Content**: free-form (domain-dependent)
- **Communication**: who is sending, etc.
- **Message**: performatives and fields (standard)
Three-layer organization

- **Content**: free-form (domain-dependent)

- **Communication**: who is sending, etc.

- **Message**: performatives and fields (standard)

(tell
  :sender stock-server
  :content (PRICE IBM 14)
  :receiver joe
  :in-reply-to ibm-stock
  :language LPROLOG
  :ontology NYSE-TICKS)
Three-layer organization

- Content: free-form (domain-dependent)
- Communication: who is sending, etc.
- Message: performatives and fields (standard)

(tell
  :sender stock-server
  :content (PRICE IBM 14)
  :receiver joe
  :in-reply-to ibm-stock
  :language LPROLOG
  :ontology NYSE-TICKS)
ACLs – Current Landscape

“Languages exist to serve a purpose, namely the communication between willing—and occasionally unwilling—participants”
ACLs – Current Landscape

“Languages exist to serve a purpose, namely the communication between willing—and occasionally unwilling—participants”

- There are different options
- Subtle differences
ACLs – Current Landscape

"Languages exist to serve a purpose, namely the communication between willing—and occasionally unwilling—participants"

- There are different options
- Subtle differences
- Why a standard?
  - What are the pros and cons?
ACLs – Current Landscape

“Languages exist to serve a purpose, namely the communication between willing—and occasionally unwilling—participants”

- There are different options
- Subtle differences
- Why a standard?
  - What are the pros and cons?
- How are they created?
ACLs – Current Landscape

“Languages exist to serve a purpose, namely the communication between willing—and occasionally unwilling—participants”

- There are different options
- Subtle differences
- Why a standard?
  - What are the pros and cons?
- How are they created?
- Sample FIPA applications on resources page
Soccer server communication

- What is the soccer server communication protocol?
- How does it relate?
Soccer server communication

- What is the soccer server communication protocol?
- How does it relate?
- Does an ACL make sense in the soccer server? If so, under what circumstances?
Soccer server communication

- What is the soccer server communication protocol?
- How does it relate?
- Does an ACL make sense in the soccer server? If so, under what circumstances?

An example protocol
Joint Intentions – Setting

How agents **form and disband** teams
Joint Intentions – Setting

How agents form and disband teams

- Agents in dynamic multiagent world
- Neither complete nor correct beliefs
  - Positive introspection: know own beliefs
- Changeable goals, fallible actions
- Don’t know others’ beliefs/goals
Starting Point – Individuals

Persistent goal: relative to $q$ to achieve $p$
Starting Point – Individuals

**Persistent goal**: relative to $q$ to achieve $p$

- $p$ false, but desired true
- $p$ will keep being desired unless:
Starting Point – Individuals

**Persistent goal:** relative to \( q \) to achieve \( p \)

- \( p \) false, but desired true
- \( p \) will keep being desired unless:
  - \( p \) true
  - \( p \) impossible
  - \( q \) false
Starting Point – Individuals

**Persistent goal:** relative to \( q \) to achieve \( p \)

- \( p \) false, but desired true
- \( p \) will keep being desired unless:
  - \( p \) true
  - \( p \) impossible
  - \( q \) false

**Intention:** persistent goal, belief throughout that it’s being done
Starting Point – Individuals

**Persistent goal:** relative to $q$ to achieve $p$

- $p$ false, but desired true
- $p$ will keep being desired unless:
  - $p$ true
  - $p$ impossible
  - $q$ false

**Intention:** persistent goal, belief throughout that it’s being done

- What’s the role of $q$?
Starting Point – Individuals

**Persistent goal:** relative to $q$ to achieve $p$

- $p$ false, but desired true
- $p$ will keep being desired unless:
  - $p$ true
  - $p$ impossible
  - $q$ false

**Intention:** persistent goal, belief throughout that it’s being done

- What’s the role of $q$?
- What’s the difference between goal, intention?
2 proposals for teams

Joint commitment not just intention where agent is team
2 proposals for teams

Joint commitment not just intention where agent is team

**Weak:** Joint intention $\equiv$ mutually known intention: each intend to do their part of collective action
2 proposals for teams

Joint commitment not just intention where agent is team

Weak: Joint intention ≡ mutually known intention: each intend to do their part of collective action

Strong: Same, except mutual knowledge persists until mutually known that activity is over
2 proposals for teams

Joint commitment not just intention where agent is team

**Weak:** Joint intention $\equiv$ mutually known intention: each intend to do their part of collective action

**Strong:** Same, except mutual knowledge persists until mutually known that activity is over

Why too weak and too strong?
Joint Commitment

Weak achievement goal (WAG): relative to $q$ with respect to a team to achieve $p$
Joint Commitment

Weak achievement goal (WAG): relative to $q$ with respect to a team to achieve $p$

- Individually wants $p$
Joint Commitment

Weak achievement goal (WAG): relative to \( q \) with respect to a team to achieve \( p \)

- Individually wants \( p \)
  OR
- Believes \( p \) true, impossible, or irrelevant, AND has a goal of team knowing it.

4 cases
Joint Commitment

Joint Persistent Goal (JPG): relative to $q$ to achieve $p$

- mutually believe $p$ false, but mutually know all desire $p$ true
- mutually believe that each have WAG $p$ until
  - mutually believe $p$ true
  - mutually believe $p$ impossible
  - mutually believe $q$ false
Joint Commitment

Joint Persistent Goal (JPG): relative to $q$ to achieve $p$

- mutually believe $p$ false, but mutually know all desire $p$ true
- mutually believe that each have WAG $p$ until
  - mutually believe $p$ true
  - mutually believe $p$ impossible
  - mutually believe $q$ false

Intention: joint persistent goal, mutual belief throughout that it’s being done
Joint Commitment

Joint Persistent Goal (JPG): relative to $q$ to achieve $p$

- mutually believe $p$ false, but mutually know all desire $p$ true
- mutually believe that each have WAG $p$ until
  - mutually believe $p$ true
  - mutually believe $p$ impossible
  - mutually believe $q$ false

Intention: joint persistent goal, mutual belief throughout that it’s being done

- Intend own action, committed to others’
Joint Commitment

Joint Persistent Goal (JPG): relative to $q$ to achieve $p$

- mutually believe $p$ false, but mutually know all desire $p$ true
- mutually believe that each have WAG $p$ until
  - mutually believe $p$ true
  - mutually believe $p$ impossible
  - mutually believe $q$ false

Intention: joint persistent goal, mutual belief throughout that it’s being done

- Intend own action, committed to others’
- Overhead: automatic goal to communicate status
Establishing JPGs

- Communication (basis for KQML)
- Observation (requires co-presence)
Establishing JPGs

- Communication (basis for KQML)
- Observation (requires co-presence)
- Any other way?
Locution: What is said (physical)
Locution: What is said (physical)

Illocution: What is meant
Locution: What is said (physical)

Illocution: What is meant

Perlocution: Intended effects
Locution: What is said (physical)

Illocution: What is meant

Perlocution: Intended effects

Example: “Please close the window.”
“Capabilities for teamwork cannot be patched on, but must be designed in from the start.” (Grosz, 1996)
“Capabilities for teamwork cannot be patched on, but must be designed in from the start.” (Grosz, 1996)

• Agree or disagree?
STEAM

- An implementation/extension of joint intentions

- Goals
  - Anticipate teamwork failures
  - Flexibility and re-use
STEAM

• An implementation/extension of joint intentions

• Goals
  – Anticipate teamwork failures
  – Flexibility and re-use

• Joint intentions doesn’t do it all, though
STEAM

• An implementation/extension of joint intentions

• Goals
  – Anticipate teamwork failures
  – Flexibility and re-use

• Joint intentions doesn’t do it all, though
  – Coherence: all use same plan, commitment protocols
  – Communication cost — decision theoretic
  – Replanning — role dependencies
Team Operators

- Have preconditions, effects, termination rules
- Automatically establish joint intentions
Team Operators

• Have preconditions, effects, termination rules

• Automatically establish joint intentions

• To establish, “all team members must simultaneously select” a team operator to establish a joint intention

• Agents maintain “team state:” model of team’s mutual beliefs
Domains

- **Attack:**
  - Fly to holding point
  - Send out scouts
  - Shoot at enemy

- **Transport:**
  - Escorts protect transports

- **RoboCup**
Observed Problems

- Commander returns to home alone after failing, others stayed
Observed Problems

- Commander returns to home alone after failing, others stayed
- Scout never returned, others got into infinite loop
Observed Problems

- Commander returns to home alone after failing, others stayed
- Scout never returned, others got into infinite loop
- One got orders first and went ahead alone
Observed Problems

- Commander returns to home alone after failing, others stayed
- Scout never returned, others got into infinite loop
- One got orders first and went ahead alone
- All out of ammunition, but failed to realize unachievable
Observed Problems

- Commander returns to home alone after failing, others stayed
- Scout never returned, others got into infinite loop
- One got orders first and went ahead alone
- All out of ammunition, but failed to realize unachievable

Solved generally with STEAM
Evaluation

- Used in 3 domains with different characteristics
Evaluation

- Used in 3 domains with different characteristics
- STEAM rules can be re-used
- Flexibility: solves initial problems, can deal with small changes to environment
Evaluation

• Used in 3 domains with different characteristics

• STEAM rules can be re-used

• Flexibility: solves initial problems, can deal with small changes to environment

• Communication efficiency

• Encoding and modification effort
CYC – Doug Lenat

- Attempt to program common sense
• Attempt to program common sense

• > 1 million rules
  – “Trees are usually outdoors.”
  – “Once people die they stop buying things.”
  – “Glasses of liquid should be carried rightside-up.”
• Attempt to program common sense

• > 1 million rules
  – “Trees are usually outdoors.”
  – “Once people die they stop buying things.”
  – “Glasses of liquid should be carried rightside-up.”

• Ongoing effort since 1984
CYC – Doug Lenat

- Attempt to program common sense

- > 1 million rules
  - “Trees are usually outdoors.”
  - “Once people die they stop buying things.”
  - “Glasses of liquid should be carried rightside-up.”

- Ongoing effort since 1984

- Potential applications?
CYC – Doug Lenat

- Attempt to program common sense
- > 1 million rules
  - “Trees are usually outdoors.”
  - “Once people die they stop buying things.”
  - “Glasses of liquid should be carried rightside-up.”
- Ongoing effort since 1984
- Potential applications?
  - Some listed on their web site
  - Question answering, retrieval of captioned information, machine translation, speech recognition, semantic data mining, ...
Pursuit Activity

Group 1: homogeneous, non-communicating

Group 2: homogeneous, communicating

Group 3: heterogeneous, non-communicating

Group 4: heterogeneous, communicating
Student-led Discussion

- David Terei: Sort yourselves by age
Student-led Discussion

- David Terei: Sort yourselves by age

- No verbal or written language is allowed.

- Any form of gesturing is OK, except for “skywriting” or writing with one’s finger.

- Other ways of conveying characters are ok.

- All other forms of communication are allowed, be creative.