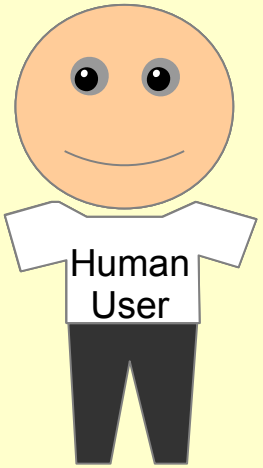
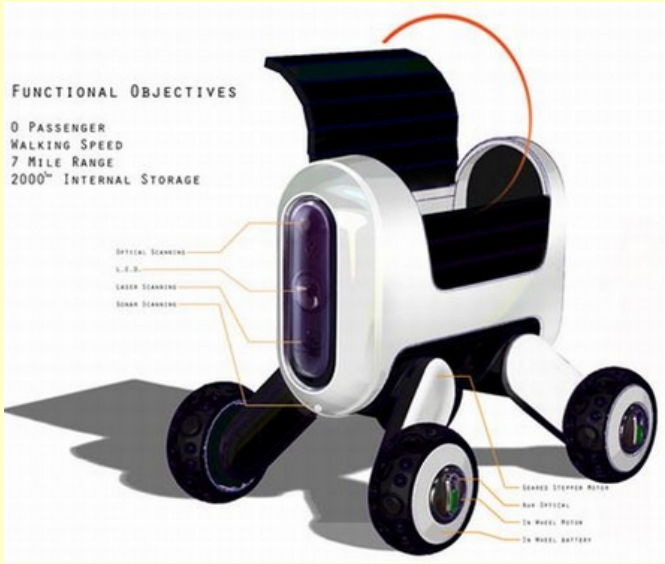
Agent Language for communication

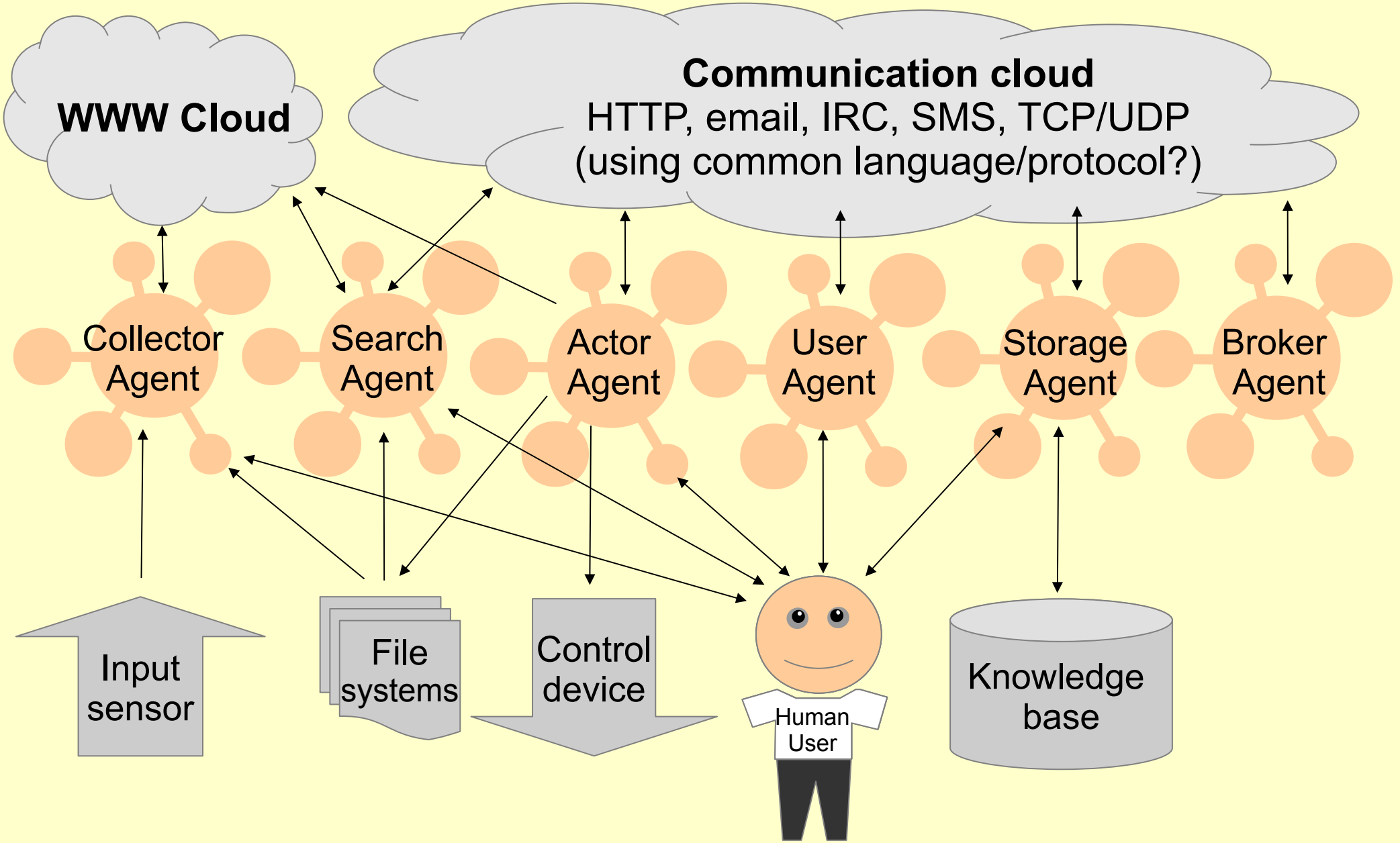
between humans and computer agents

Internet of Things – Agents everywhere

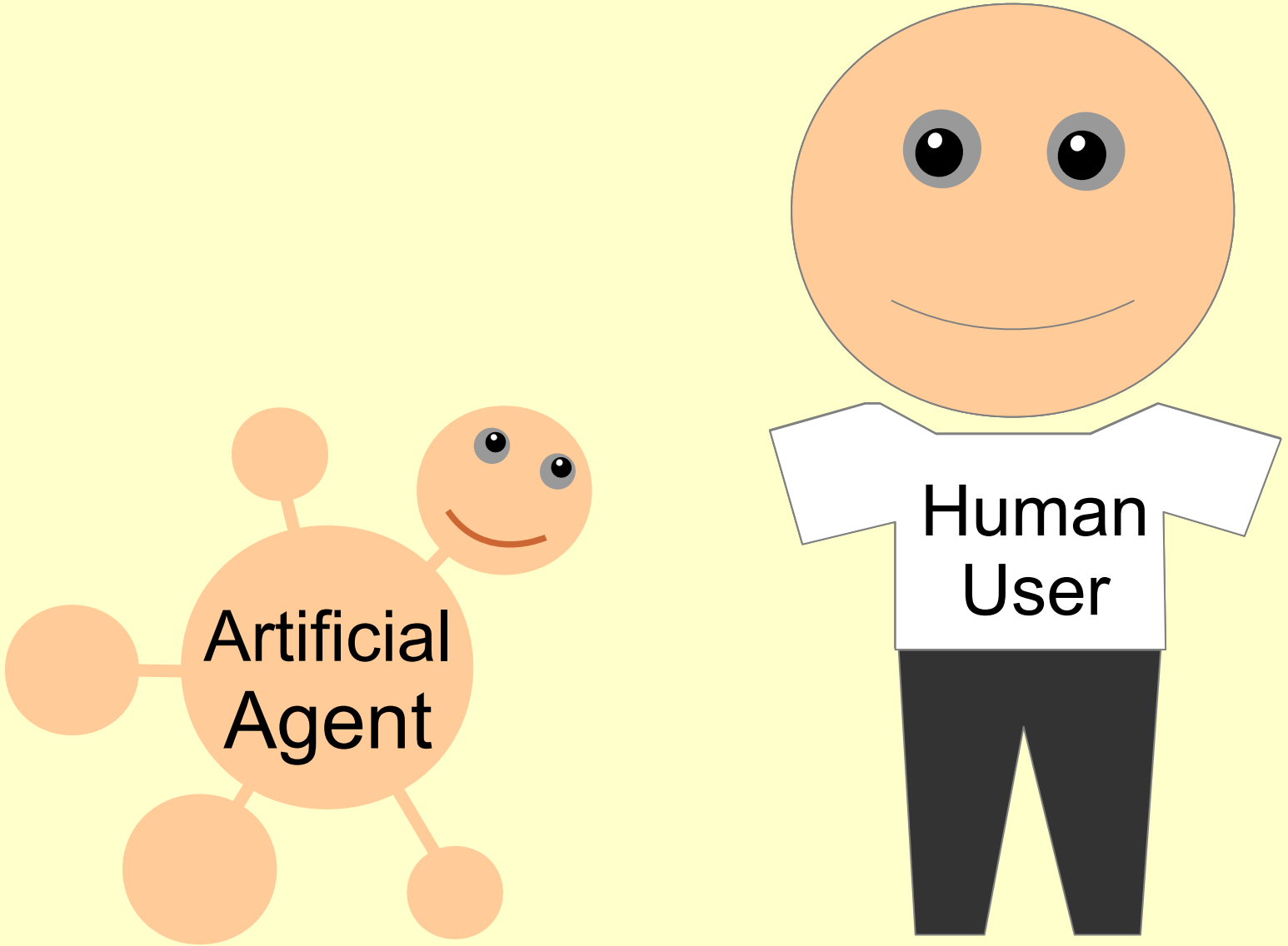




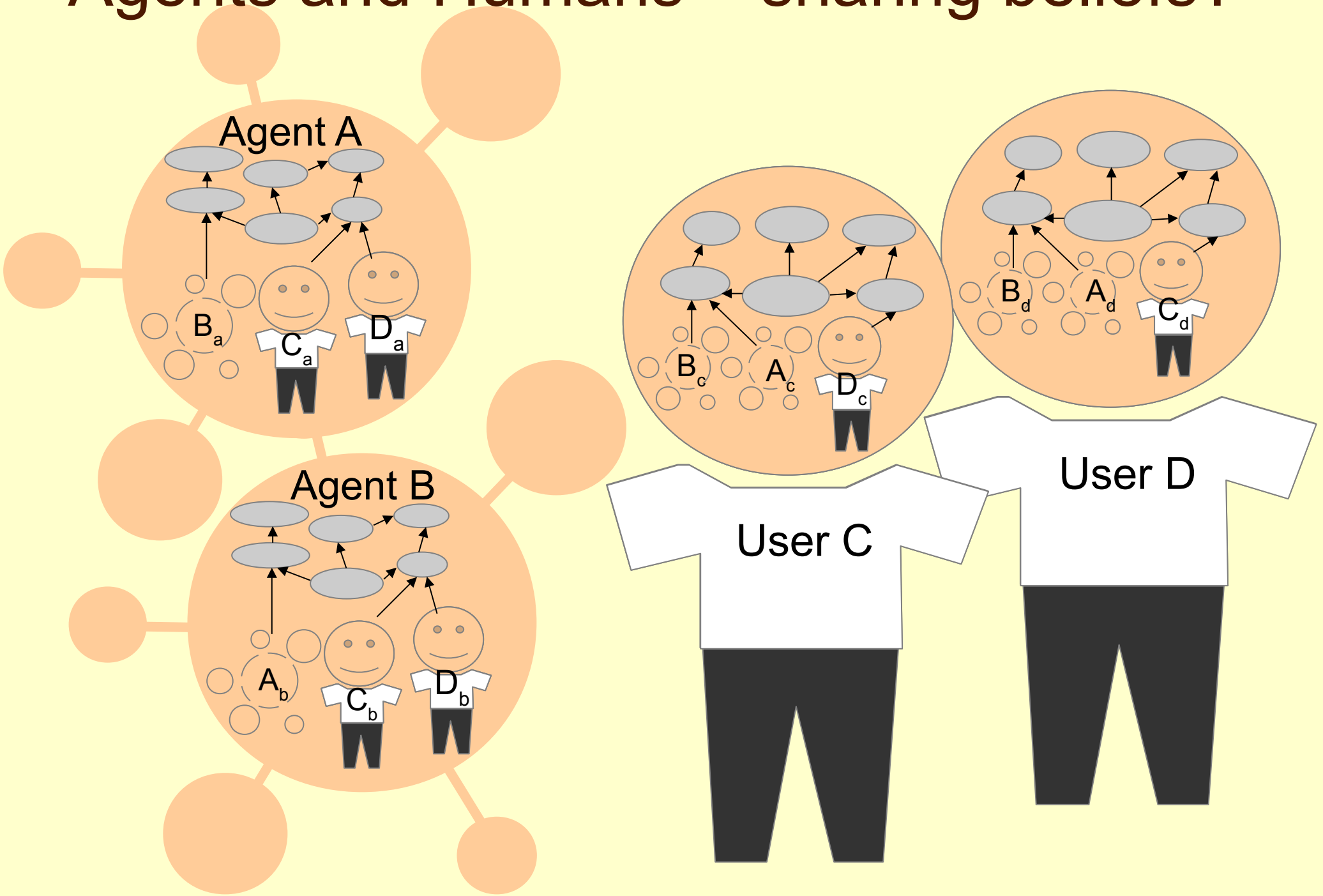
World of Agents – Communication cloud



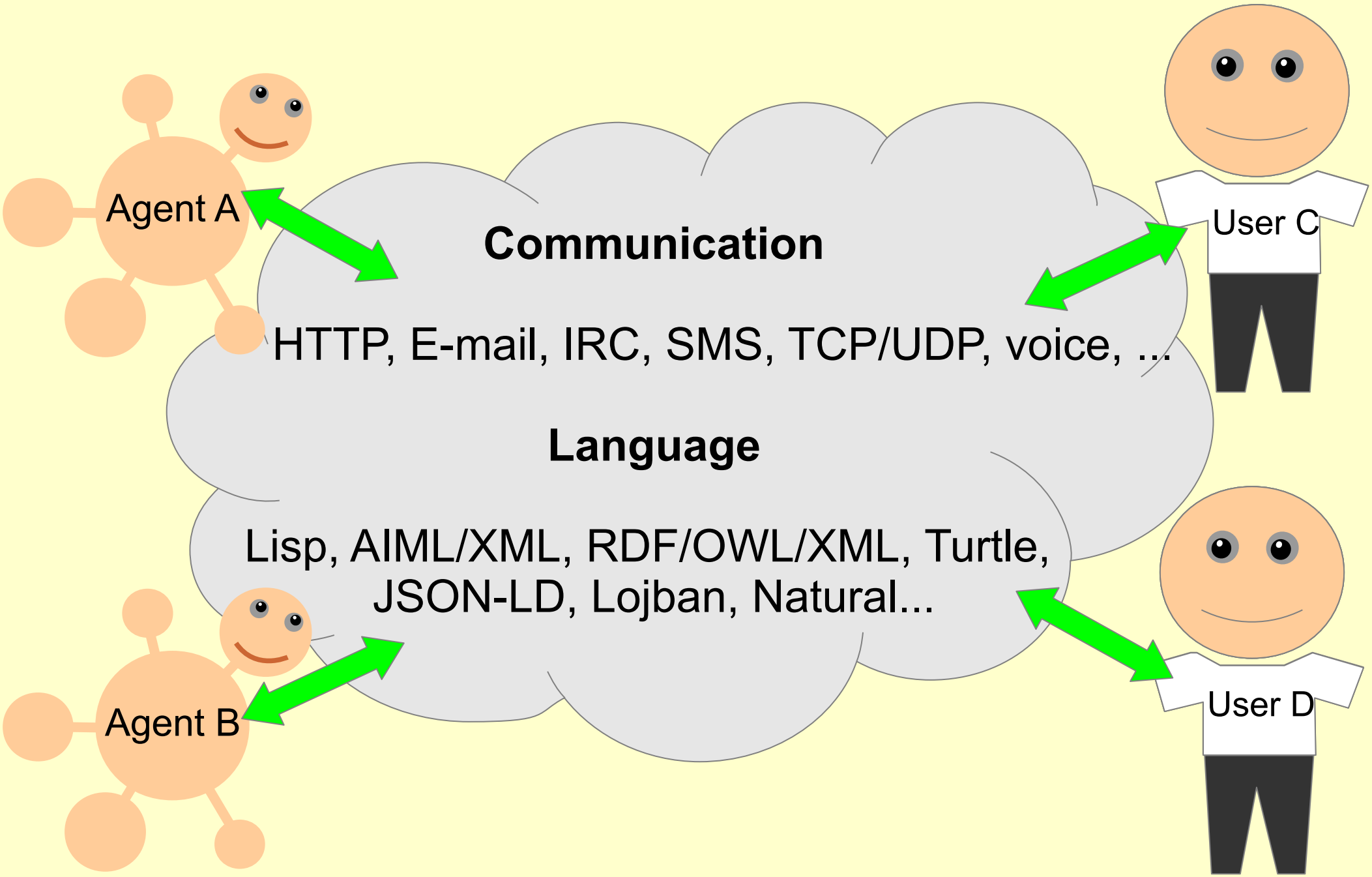
Agents and Humans – need to talk?



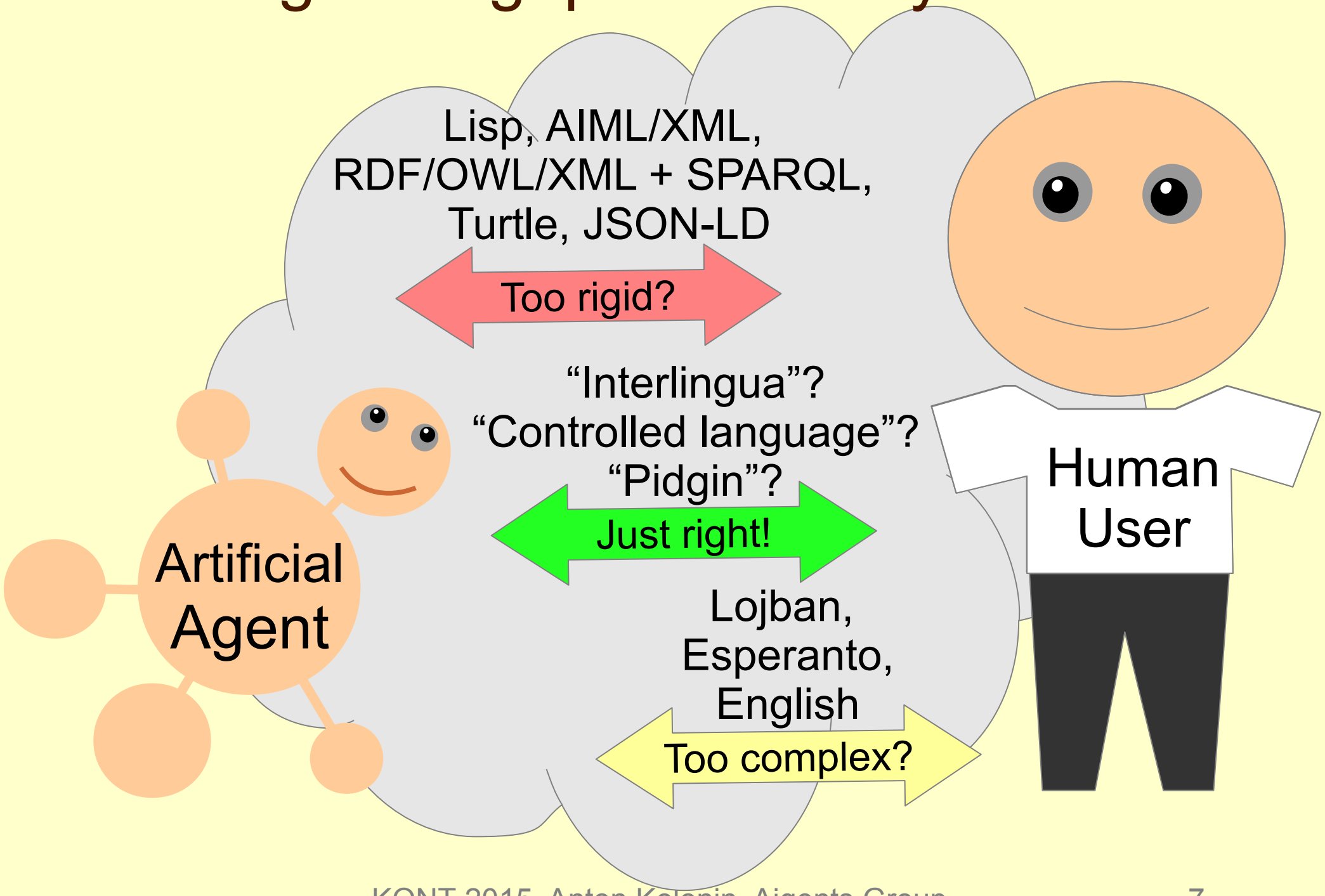
Agents and Humans – sharing beliefs?



Mixed environment – multiple languages?



Linguistic gap – best way to fill?



Communication principles

- Sharing **belief system or domain ontology** as structured knowledge about communication subject matter
- Being able for **adaptive behavior** – experiential self-learning and extending communication interfaces in course of interaction with environment and other agents
- Using “open” (not a hardcoded protocol) **extensible linguistic interface** (“**interlingua**” or “**controlled language**”) based on dynamic ontology

Extensible linguistic interface

- **Asynchronous and symmetric** communication protocol
- **"Open" structure of a language** based on common "foundation ontology"
- **Partial and probabilistic comprehension** of information out of scope of shared "foundation ontology"
- **Human-friendly** communication language

Agent Language - “pidgin” example

A: My is appliance, agent, thermostat, device.
A: My has shape, color, voltage.
A: My has location.
A: My shape rectangular, color white, voltage 220, location kitchen.
A: My has temperature, humidity, CO2, feeling.
A: Temperature, humidity, CO2 is number.
A: Feeling is good or bad.
H: What your feeling, temperature, humidity?
A: My feeling good, temperature 20, humidity 72.

A: Моя это прибор, агент, термостат, устройство.
A: Моя иметь форма, цвет, питание.
A: Моя иметь место.
A: Моя форма прямоугольный, цвет белый, питание 220, место кухня.
A: Моя иметь температура, влажность, CO2, самочувствие.
A: Температура, влажность, CO2 это число.
A: Самочувствие это хорошо или плохо.
H: Как твоя самочувствие, температура, влажность?
A: Моя самочувствие хорошо, температура 20, влажность 72.

Agent Language – as labeled ontology

Common domain-specific ontology for “controlled interlingua”

$thermostat_13 $property $humidity $isa $number

моя иметь влажность это число

Russian name space

$name

my has humidity is number

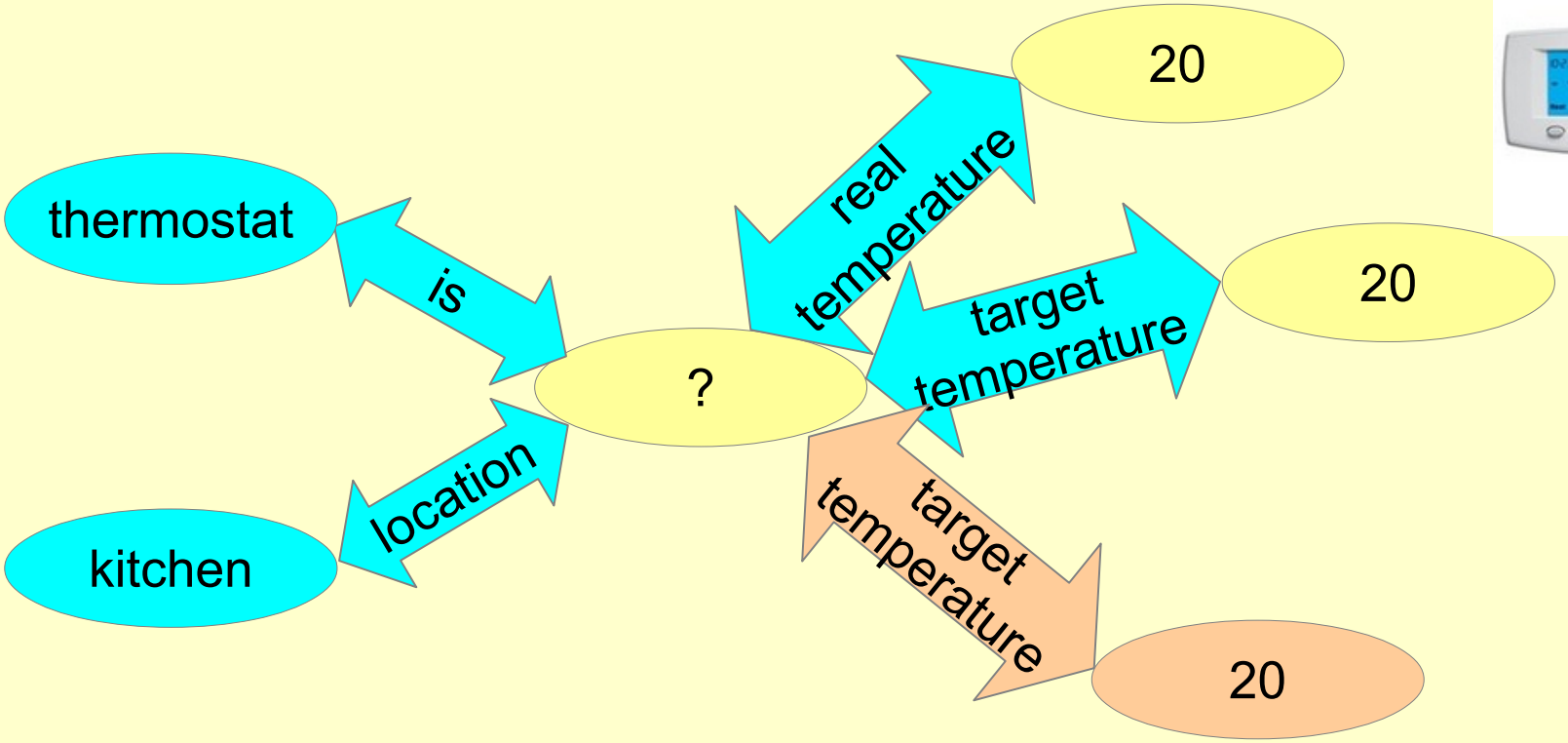
English name space

Agent Language – graph manipulation

Interrogation:
What is thermostat, location kitchen real temperature, target temperature?

Declaration:
Is thermostat, location kitchen real temperature 30, target temperature 25.

Direction:
Is thermostat, location kitchen target temperature 20!



Agent Language - EBNF

```
<message> := ( <statement> | <acknowledgement> )*
<acknowledgement> := ( 'ok' | ('true' | 'yes' | <number>) | ('no' | 'false' | 0) ) '.'
<statement> := <interrogation> | <confirmation> | <declaration> | <direction>
<interrogation> := 'what' ? <expression> '?'        (* “open” incomplete graph *)
<confirmation> := 'if' ? <expression-set> '?'       (* “closed” complete graph  *)
<declaration> := ( <expression-set> ) '.'           (* “closed” complete graph *)
<direction> := 'do' ? <expression-set> '!'          (* “closed” complete graph *)
<expression> := <term> (' ' <term>)*                (* separated by spaces *)
<expression-set> := <all-set> | <any-set> | <seq-set>      (* different kinds of sets *)
<term> := <negation>? ( <anonymous>? | <self> | <peer> | <id> | <name> | <value> | <qualifier> )
<qualifier> := <expression> | <expression-set>
<any-set> := <or-list> | ( '{' <or-list> '}' )
<all-set> := <and-list> | ( '(' <and-list>  ')' )
<seq-set> := <next-list> | ( '[' <next-list> ']' )
<or-list> := <expression> ( (',' | 'or' ) <expression> )*
<and-list> := <expression> ( (',' | 'and' ) <expression> )*
<then-list> := <expression> ( (',' | 'next' ) <expression> )*
<negation> := 'not' | 'no' | '~'
<anonymous> := ('there' ('is'|'are')) | 'any' | 'anything' ?
<self> := 'my'|'i'|'we'|'our'
<peer> := 'your'|'you'
<value> := <number> | <date> | <time> | <string>
```

That is all!
There rest is done by means of domain-specific ontology and providing national-specific name space

Agent Language - comparisons

English
What is your feeling?
If your feeling is good?
Your feeling is good.
Have your feeling good!

Agent Language
Your feeling?
Your feeling good?
Your feeling good.
Your feeling good!

Russian (with tonal modulation)
Твое ощущение? (rising tone)
Твое ощущение хорошее? (rising tone)
Твое ощущение хорошее. (neutral tone)
Твое ощущение хорошее! (lowering tone)

Agent Language - written
I (can (eat, sleep), want (dance, sing)).
I {can (eat, sleep), want (dance, sing)}.
I (can {eat, sleep}, want {dance, sing}).
You [eat (rice, meat), drink {juice, water}]!

Agent Language - spoken
I can eat and sleep and want dance and sing.
I can eat and sleep or want dance and sing.
I can eat or sleep and want dance or sing.
You eat rice and meat next drink juice or water!

Agent Language
A C (D,E).
A (C D, F G).
A (C (D,E), F (G,H)).
(A,B) C D.
(A,B) (C (D,E), F (G,H)).

Term logic
A C D. A C E.
A C D. A F G.
A C D. A C E. A F G. A F H.
A C D. B C D.
A C D. A C E. B C D. B C E. A F G. A F H. B F G. B F H.

Turtle
A C D,E.
A C D; F G.
A C D,E; F G,H.

Agent Language - extensions

For one example, declarative and directive expressions can be turned into conditional trees in an action graph (representing decision trees or applicable rule sets or executable programs depending on the case) with use of qualifiers and expressions involving predicates such as “then” and “else” recursively enclosed, like in the following example (note, preceding clue keyword “if” would turn the declaration of the algorithm into confirmation regarding the existence of such algorithm).

Your CO2_inside > CO2_outside then
T_inside > 19 then
Your Ventilation State Opened, Fan Speed High
else
Messaging message text “Alert!” to owner@localhost.home
else
Your Fan Speed Off,
Your Ventilation State Closed.

For another example, the notion of “time” and “location” can be expressed in terms of other predicates existing in the ontology of an agent specialized to handle them, as in the following example.

Your time 14:00 being not good, CO2_inside 410, Ventilation State Closed.

My location city Moscow, latitude 55N, longitude 37E weather T_outside -7, HUM_outside 95%.

Agent Language - conclusion

The **language seems compact enough for transmission and visual comprehension**, easy to read and write for average human (not possessing the special computer knowledge) and easy to parse into semantic graph operations for computer program.

The **ambiguity can be resolved**:

- In written form, with **use of clue keywords and braces and parentheses**.
- In spoken form, there may be a need for **ontology-based disambiguation** techniques so that only expressions valid in terms of current ontology are accepted by the parsing process using the underlying ontology while building the parse tree.

Having an ontology implemented for computer agents operating in any practical domain and supplying the ontology with human-friendly labels in some human language (like in the examples above), **plain translation of the labels to another language immediately makes agent speaking one more human language** about the same domain. Moreover, agents speaking to humans in their own languages would easily understand other agents speaking alien languages as long as label translation mapping table is present.

Many sub-languages can be developed for different practical domains involving intelligent computer agents, so the same communication engine can be re-purposed being overloaded with domain-specific ontologies and vocabularies.

Agents operating in different domains can co-operate if their knowledge rely on the same foundation ontology (say one employing basic predicates like then/else, being, possessing, feeling and doing) so their individual intelligence acquired by means of interactions with humans can be enriched in the course of cross-learning from peer agents.

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Thank you for your attention!