Organizing Ad Hoc Agents for Human-Agent Service Matching

Wouter Pasman

W.Pasman@ewi.tudelft.nl

http://www.cg.its.tudelft.nl/~wouter/

Mobiquitous Conference

August 24-26, 2004, Boston, USA

Delft University of Technology

Introduction

Increasing number of agents:

- Home automation: light, blinds, doors, fridge, stereo, tv, coffeemachine, ...
- Web services: Travel planning, weather forecast ...
- Applications: text editors, photo editors, ...
- Communication: email, phone, web browsers, ...
- E-Commerce: payment systems, shopping assistants
- Health care: pacemaker adjustment, monitoring..
- Mobile agents: snack shop, riding shop, car agents

How does user find an agent?

A few approaches exist

- Every agent has its own special physical interface
- Browser with list/menu of agents, keyword search
- Ontology-based approaches
- Central mediator with NL interface

1. Physical Interface per Agent

Devices at home: select = handle physical interface

+ Optimal for device and average user

- Expensive, needs extra space, inflexible

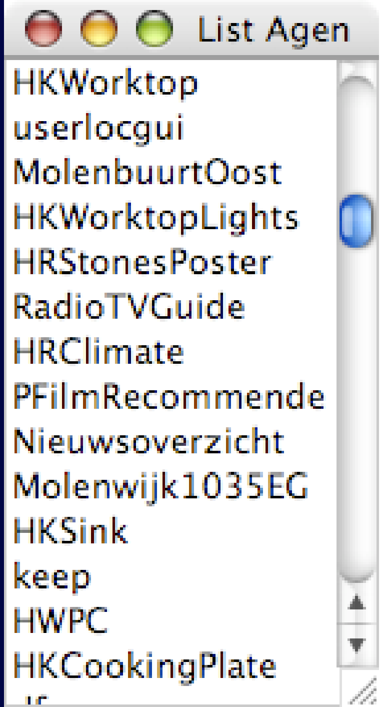
  -> Thus, suboptimal for individuals

- Many agents have no natural, nearby or human-size physical counterpart (heating, lights..)

  -> where is the interface?

- You have to know how to get what you want and where the physical device and its interface is

2. List of Agents



HKWorktop
userlocgui
MolenbuurtOost
HKWorktopLights
HRStonesPoster
RadioTVGuide
HRClimate
PFilmRecommende
Nieuwsoverzicht
Molenwijk1035EG
HKSink
keep
HWPC
HKCookingPlate

Browse list/menu of agents, keyword search

Gets unworkable when

- There are many agents
- Agents doing similar jobs but with different constraints, scope etc
- Agents are not at a fixed location
- When physical location of the agent matters
- Words in the list are not consistent (eg, Chinese, Dutch and English agents?)
- User can not determine from the words in the list which agent(s) suit his needs

3. Ontology-based approach

Two different mechanisms exist:

(1) Service discovery service: enables searching for agents delivering a certain service type

(2) Service abstraction: a resolver forwards a request to an available agent.

```
SELECT grounding(service)

FROM Cantonese

WHERE booking_date=‘02.10.2003’ AND
booking_time=‘8:00 pm’ AND
price_range=‘medium’
```

Problems for the user:

He doesn’t know and even want to know about

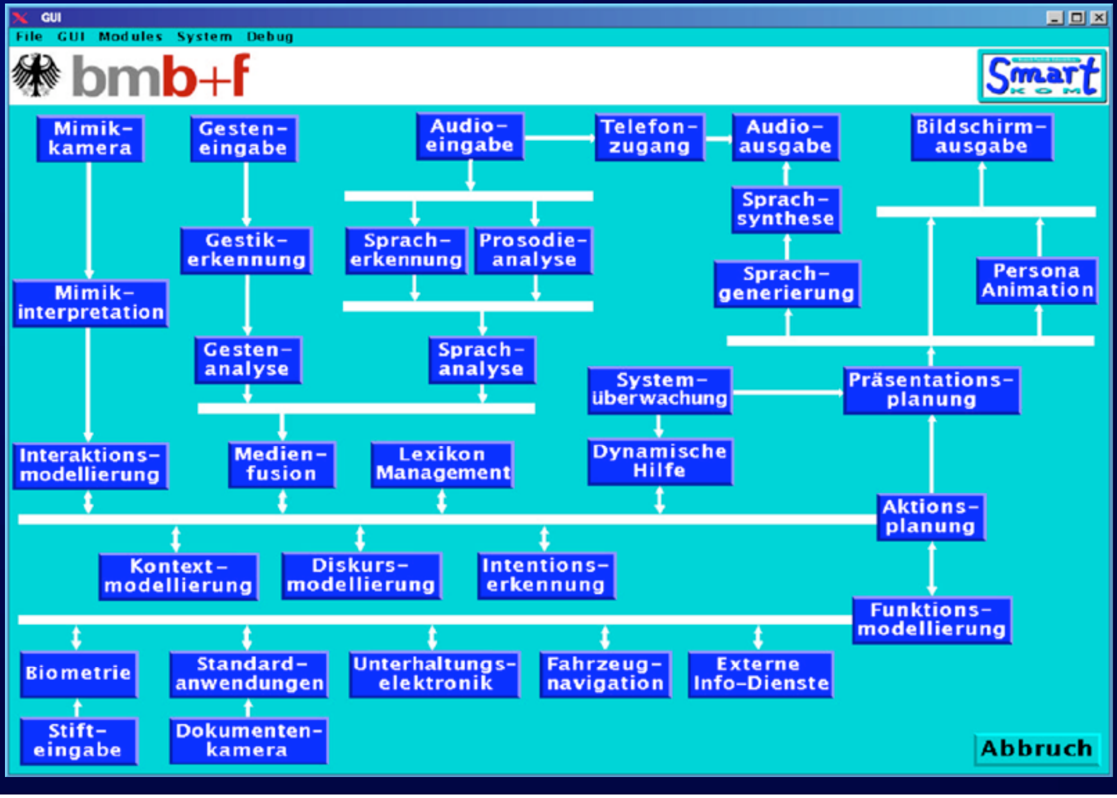
- ontologies
- service names
- programming agent-search queries
- communication protocols

Technical problems in massive adhoc agent worlds:

- Straightforward implementation is not robust and efficient enough in ad-hoc networks
- Risk of network flooding
- Excessive caching and update work at each node

4. Central NLI Interpreter

Central natural language interface interpreting all user requests and orchestrates the agents



-Not ad-hoc: new agent may offer service not fitting into the knowledge of central interpreter

-Massive central knowledge/rule planning system needed, seems unfeasible at this moment

-Natural language interpretation is not robust when all vocabularies of all agents are combined

-Central translation ignores domain knowledge available in the agents (e.g., lights that are already on)

Our Proposal

Use **Natural Language** and **Context**

to support user in finding the appropriate agent

Context: usual tasks, location, gaze direction, task, plans, goals, history and agenda; detail knowledge.

(1) Distribute NL interpretation over the agents, to improve robustness of language understanding and to enable semantic interpretation

(2) Organize agents in ad-hoc network to enable context sensitive search

Architecture

Distributed NLI

Define NLI-ontology for agents understanding NL:

(1) Interpretation AttemptInterp(String user_request)

(2) Execute(Interpretation interp)

Interpretation contains

- value [0...1] for the understanding (syntactic fit)
- value [0...1] for the executability (semantic fit)

Agent has highly restricted scope so this should be quite straightforward for each agent

Distributed Context Knowledge

Every agent knows and can communicate about its context using a RelatedAgent ontology

Context for an agent:

- Area size it covers in the real world [0...∞]
- Other agents that have some relation with this agent

Three types of relations

1 TaskRelated (SimilarTask, StepOf, HasStep)

2 LocationRelated (In, Contains)

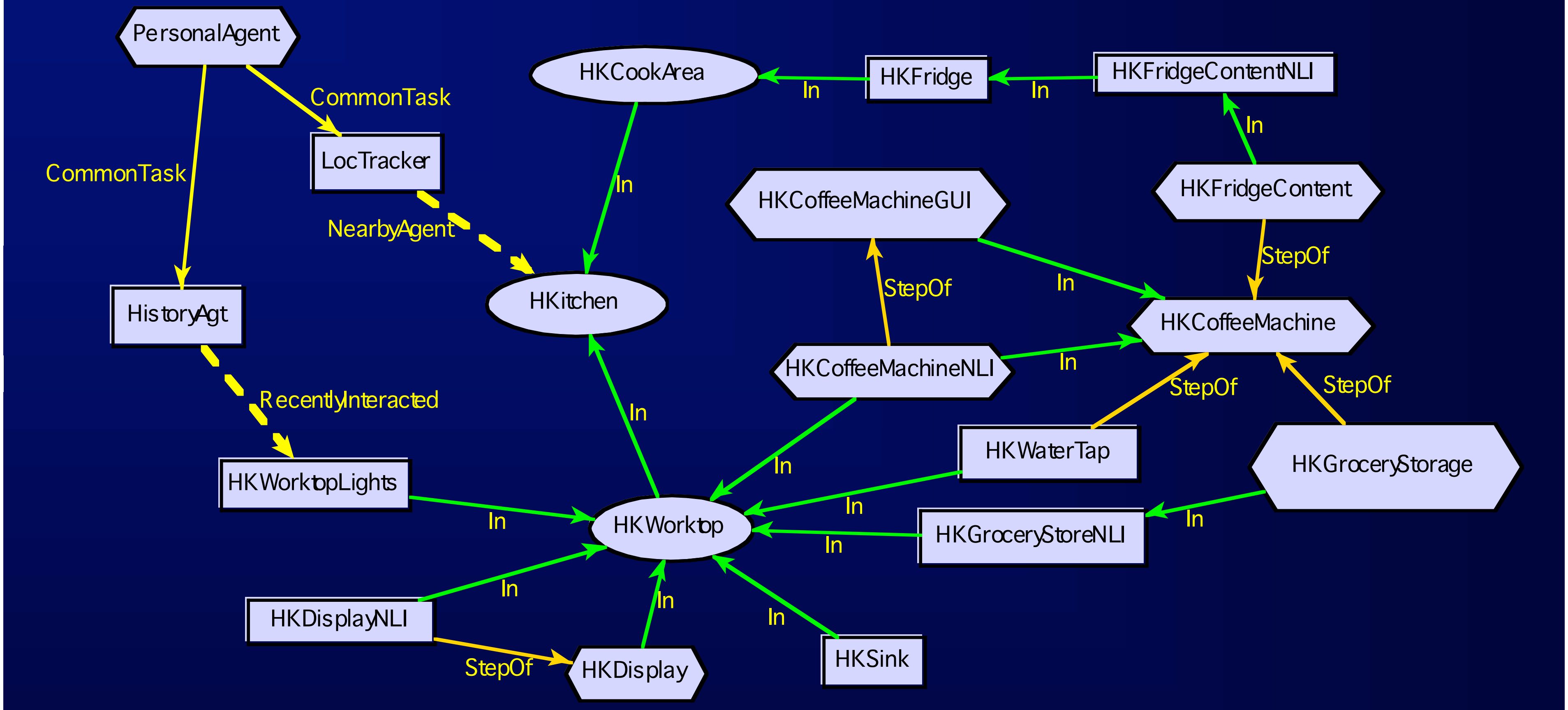
3 UserRelated (NearbyAgent, UserLooksAt, CommonTask,..)

Each agent can have many relations

Each relation also has a tightness [0...1]

Agents have to be asked individually about their relations

The relations **organize** the agents

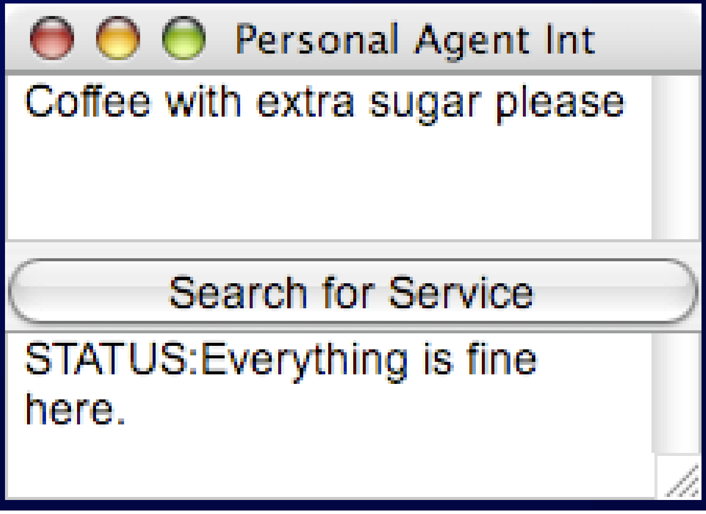


ServiceMatcher agent

Matches a user request to the available agents

Uses our architecture to do the match

Negotiates with agents until good match is found or a problem arises



Coffee with extra sugar please

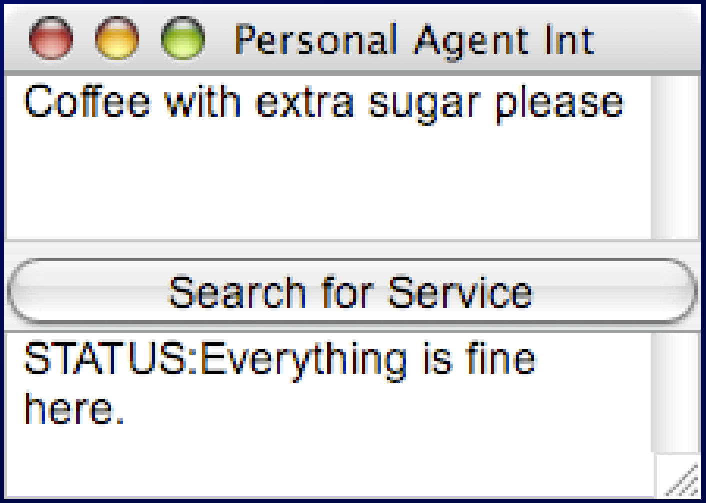
STATUS:Everything is fine here.

```
scope={PersonalAgent}
Repeat
{
   Ask interpretation(request) from agents in scope
   Wait long enough that all agents can reply
   Check #interpretations received
   {
      1 which is executable:
       activate that agent
      >1 executable:
       ask user which interpretation suits best
      many understood but no one executable
       fail: user probably asks something impossible
      0: if scope already extended 8 times
       then fail: limit of search space reached
       else scope=extend(scope)
   }
}
```

Service Matching Example

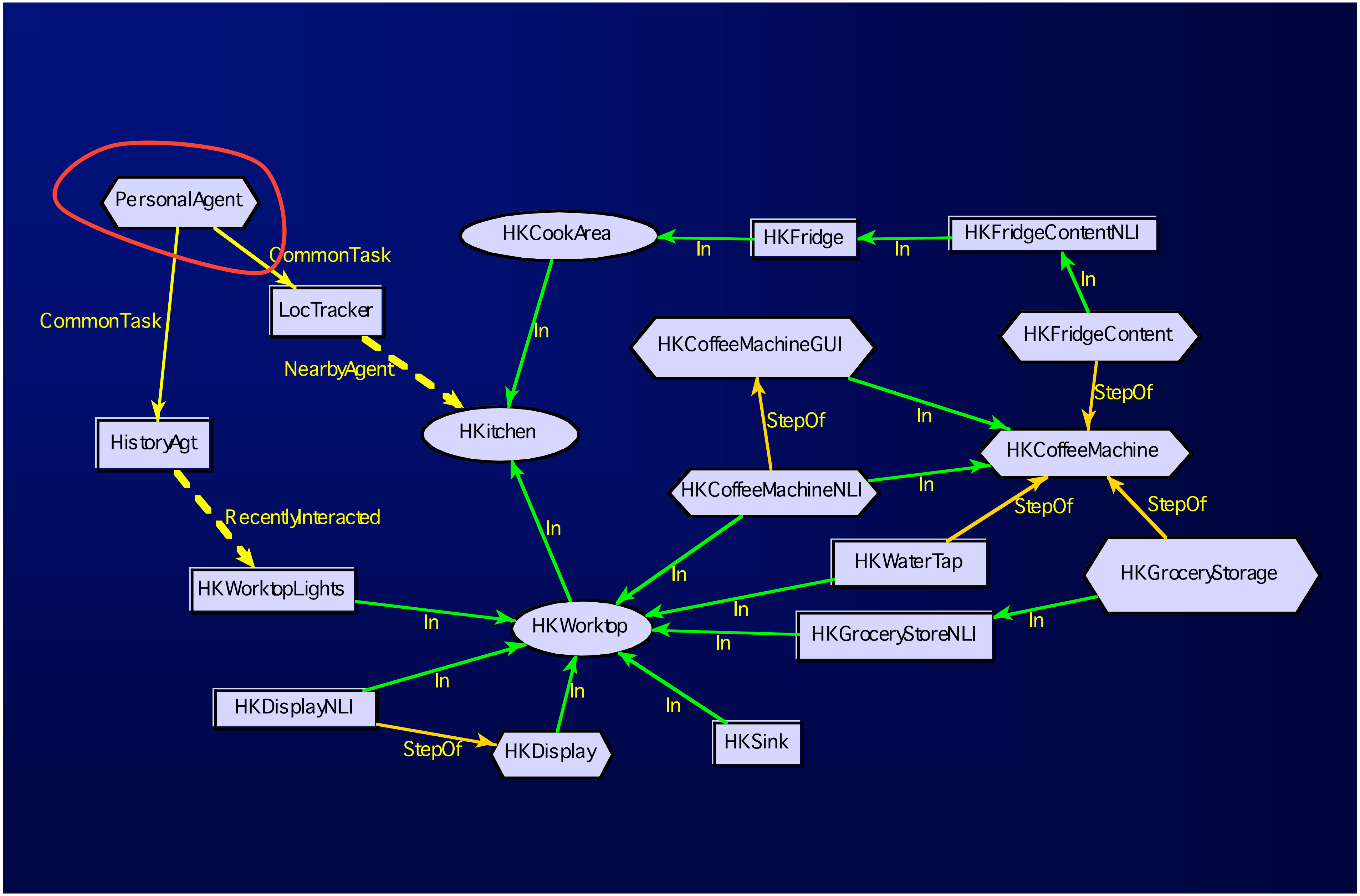
Example Use:

- user in kitchen,
- Just turned on the light
- now asks the Service Matcher



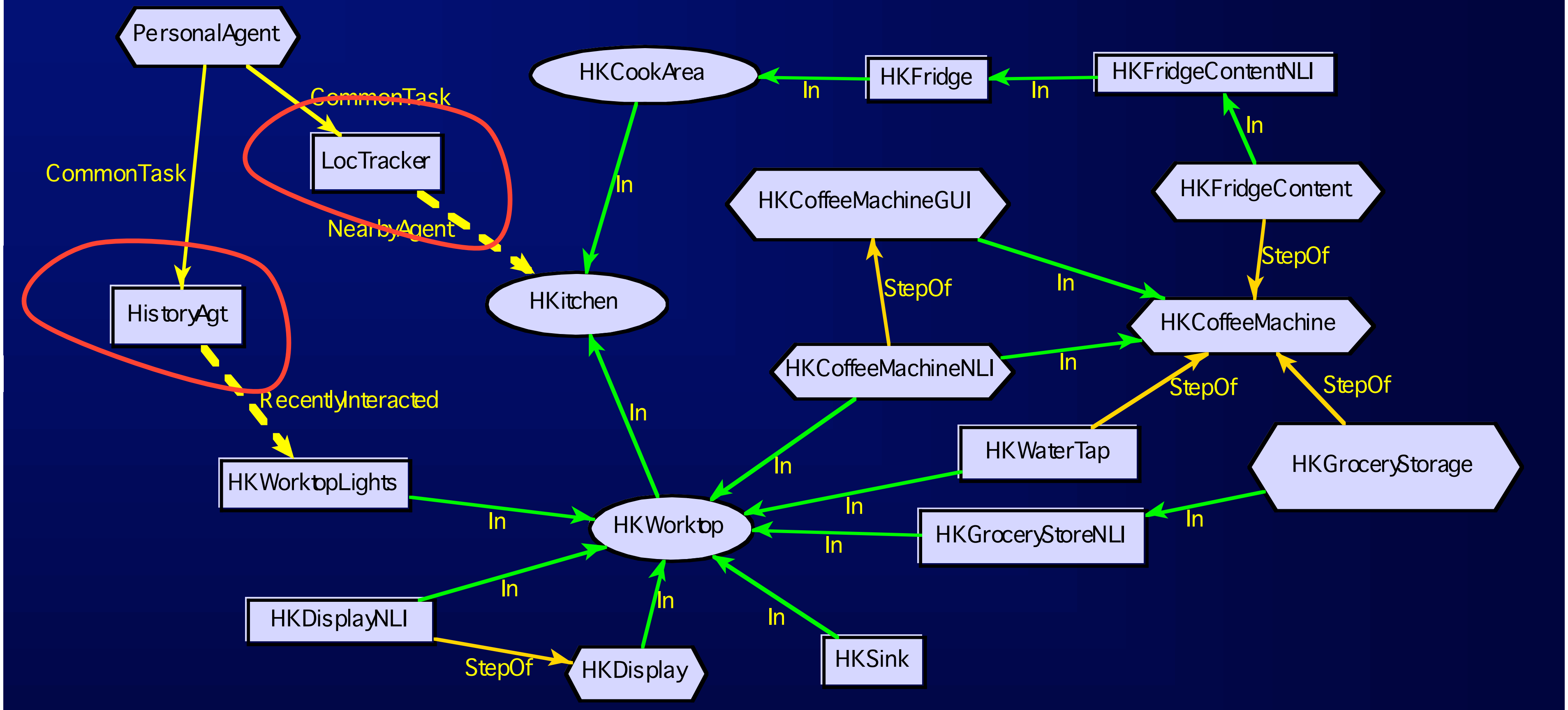
Coffee with extra sugar please

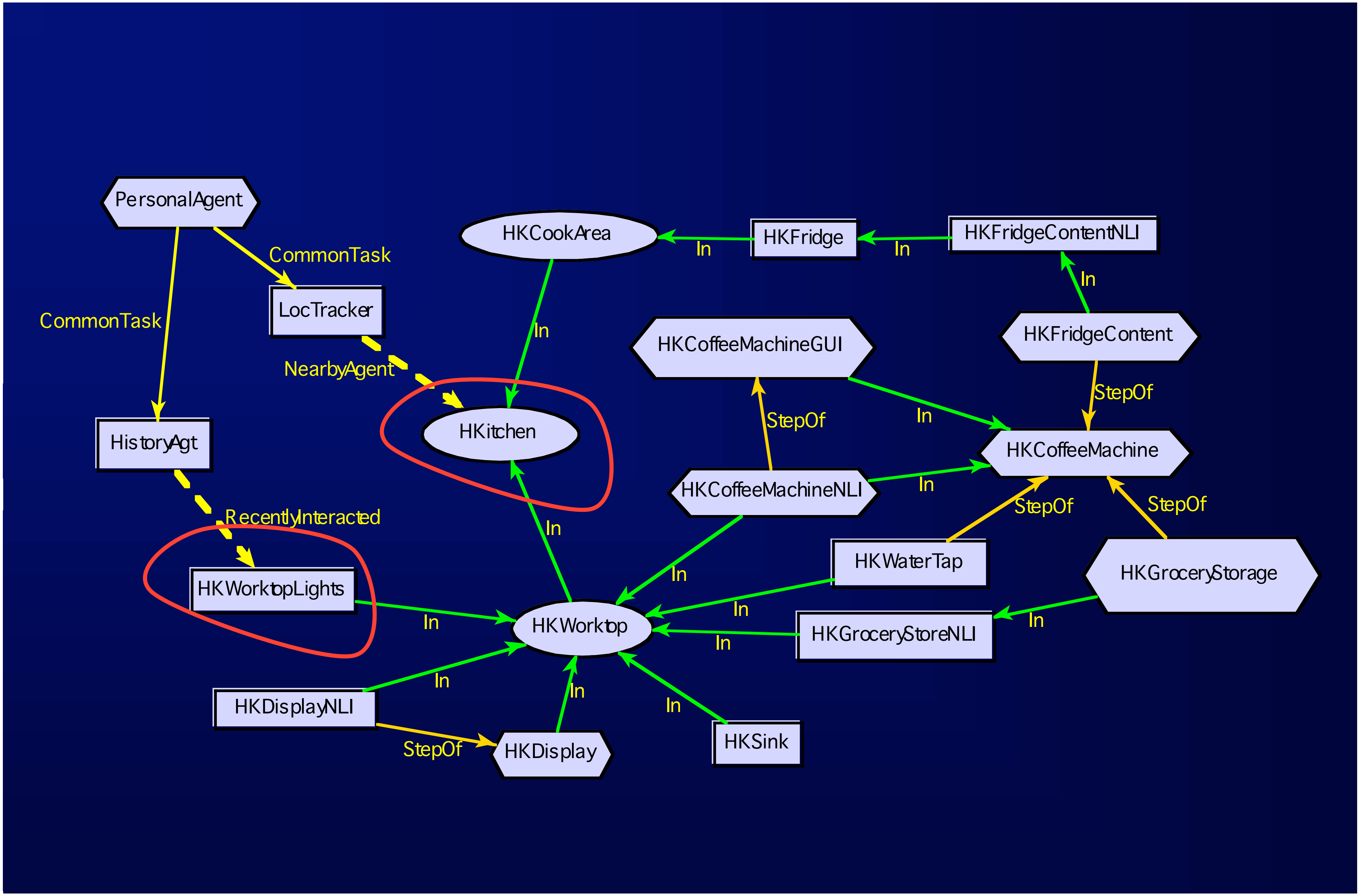
STATUS:Everything is fine here.



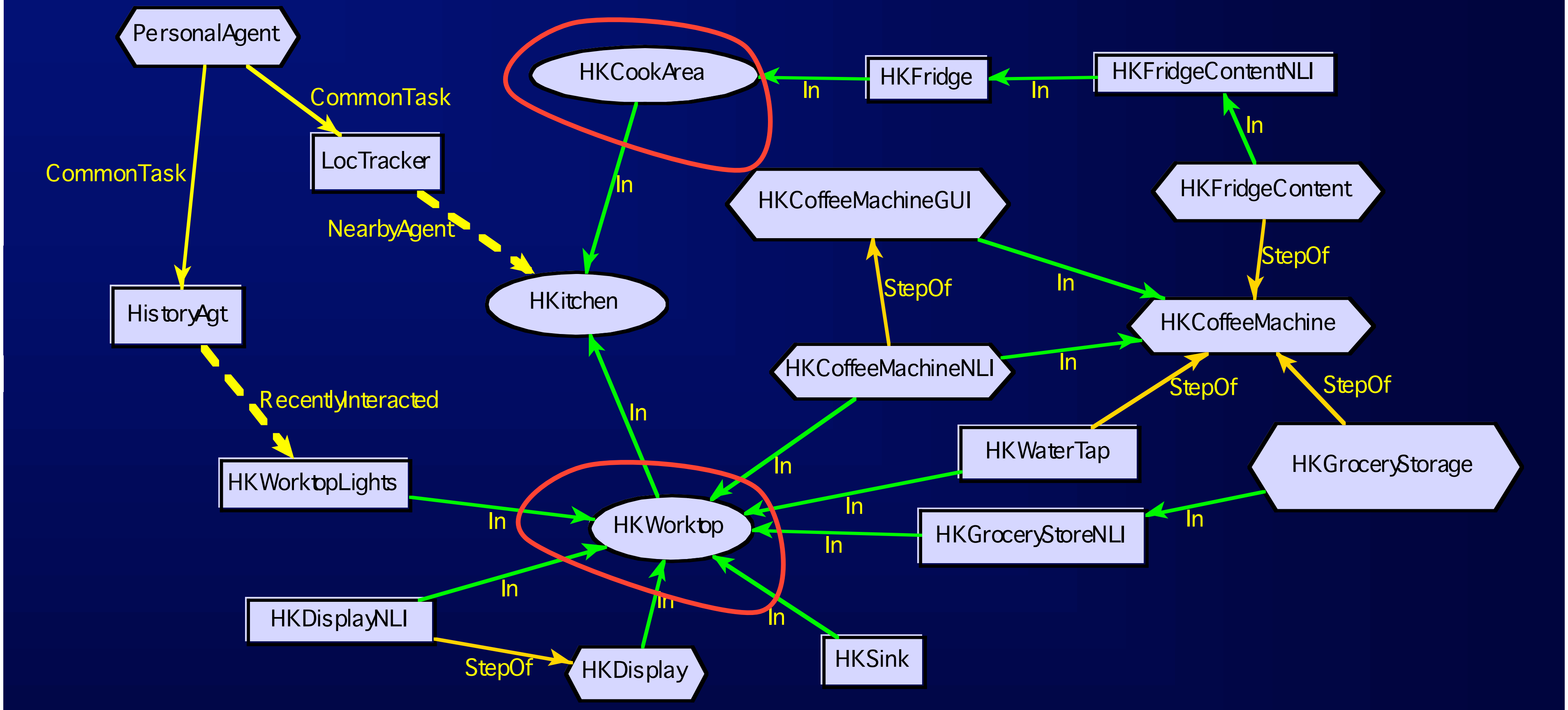
CACTUS
FREEBAND

TUDelft


PersonalAgent
CommonTask
CommonTask
LocTracker
NearbyAgent
HistoryAgt
RecentlyInteracted
HKCookArea
HKFridge
HKFridgeContentNLI
HKFridgeContent
In
In
In
In
HKKitchen
HKCoffeeMachineGUI
StepOf
In
StepOf
HKCoffeeMachine
HKCoffeeMachineNLI
In
StepOf
StepOf
HKWaterTap
HKGroceryStorage
HKWorktopLights
In
HKWorktop
In
In
In
In
HKGroceryStoreNLI
In
HKDisplayNLI
In
In
In
HKDisplay
StepOf
HKSink



PersonalAgent
CommonTask
LocTracker
CommonTask
NearbyAgent
HistoryAgt
RecentlyInteracted
HKWorktopLights
HKKitchen
HKCookArea
In
HKFridge
In
HKFridgeContentNLI
In
HKFridgeContent
StepOf
HKCoffeeMachineGUI
StepOf
In
HKCoffeeMachine
HKCoffeeMachineNLI
In
StepOf
StepOf
HKWaterTap
HKGroceryStorage
In
In
In
In
HKGroceryStoreNLI
In
HKWorktop
In
HKDisplayNLI
In
In
In
StepOf
HKDisplay
HKSink
In


PersonalAgent

CommonTask

CommonTask

LocTracker

NearbyAgent

HistoryAgt

RecentlyInteracted

HKCookArea

In

HKFridge

In

HKFridgeContentNLI

In

HKFridgeContent

StepOf

HKCoffeeMachineGUI

StepOf

In

HKCoffeeMachine

HKCoffeeMachineNLI

In

StepOf

StepOf

HKKitchen

In

In

HKWaterTap

HKGroceryStorage

In

HKWorktopLights

In

HKWorktop

In

In

HKGroceryStoreNLI

In

HKDisplayNLI

In

In

In

HKSink

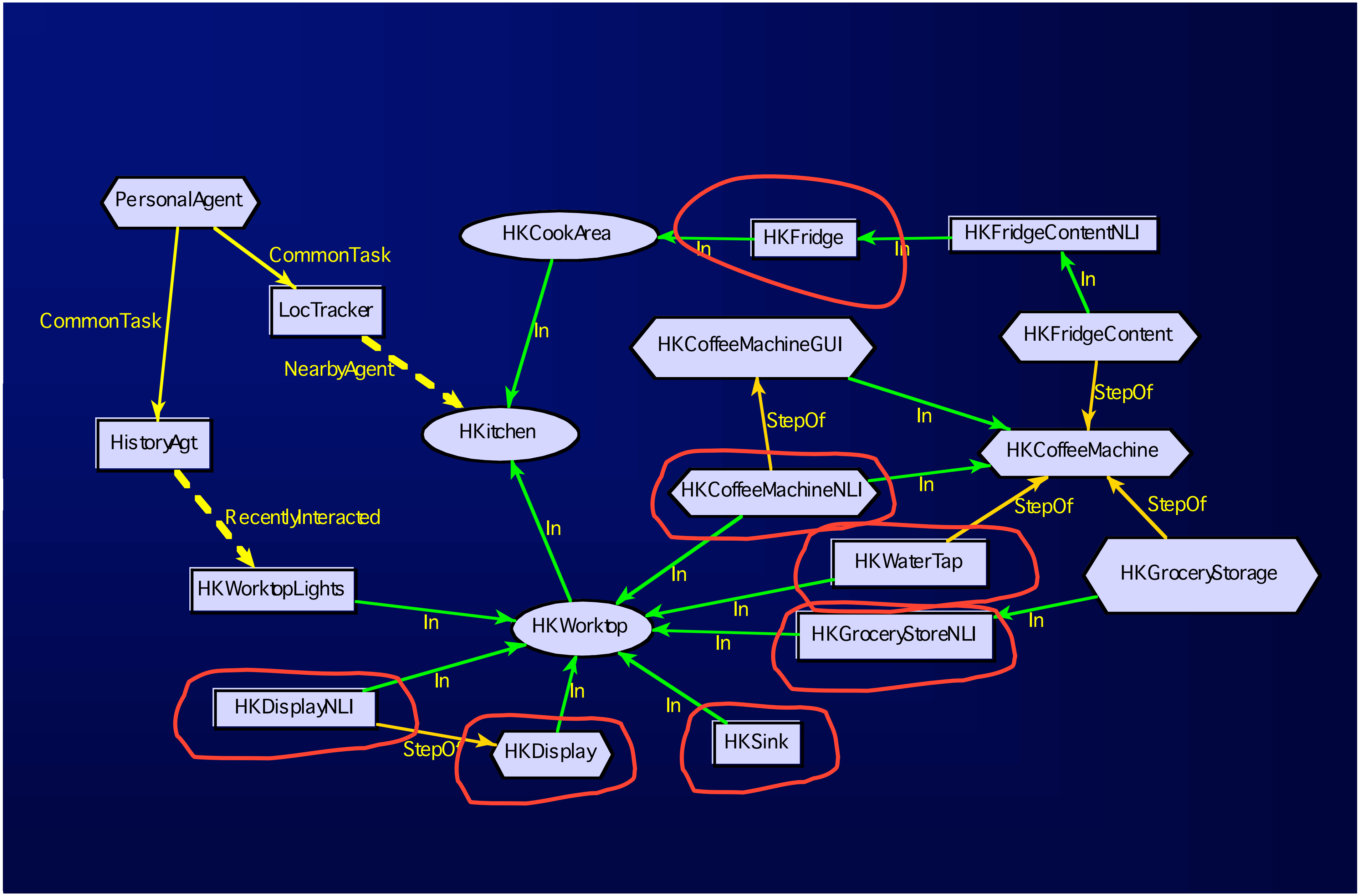
StepOf

HKDisplay

CACTUS

FREEBAND

TUDelft



PersonalAgent

HKCookArea

HKFridge

HKFridgeContentNLI

CommonTask

In

In

LocTracker

In

CommonTask

In

HKCoffeeMachineGUI

HKFridgeContent

NearbyAgent

StepOf

HistoryAgt

HKitchen

StepOf

In

HKCoffeeMachine

HKCoffeeMachineNLI

In

RecentlyInteracted

StepOf

StepOf

In

In

HKWaterTap

HKGroceryStorage

HKWorktopLights

In

HKWorktop

In

In

HKGroceryStoreNLI

In

In

HKDisplayNLI

In

In

StepOf

HKDisplay

HKSink

CACTUS

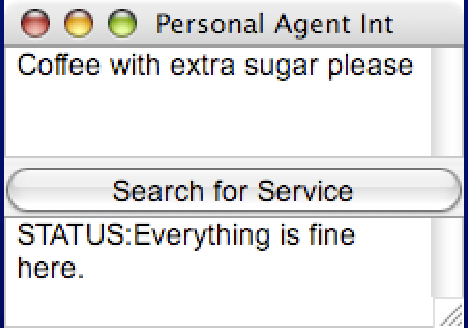
FREEBAND

TU Delft

Prototype implementation

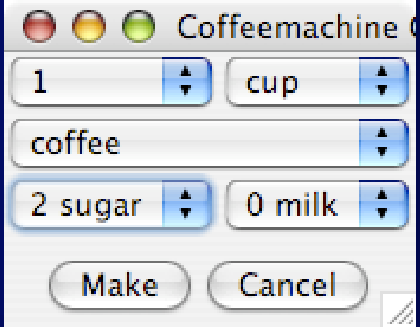
- FIPA compliant Java agents running on JADE/LEAP
- Ignore central Directory Facilitator
- Currently only coffeemachine doing full semantic interpr.
  Other agents match request with their vocabulary
- 522 Dutch agents spanning areas in Amsterdam
  running on 16 unix machines
- Search time = distance to matching agent
  * deadlinetime per ‘round’

DEMO on tuesday: 17:00 with smaller English version



Coffee with extra sugar please

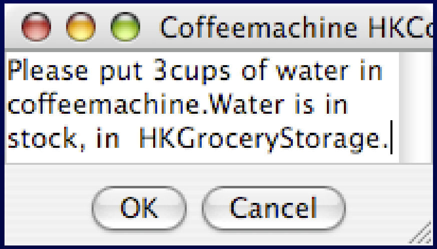
STATUS:Everything is fine here.



1 cup

coffee

2 sugar 0 milk



Please put 3cups of water in coffeemachine.Water is in stock, in HKGroceryStorage.

Robustness

- Frame-based parsing for robust NL understanding
- Semantics and actual situation used for matching
- If agents drop out, we continue with remaining agents

  Hopefully an alternative agent is available
- Agent approach promotes robustness over centralistic system

  - agents can be moved away from troublesome hardware

  - no single point of failure
- Tight deadlines on requests: avoid waiting on replies
- Internal failures cought within the agent

  -> agent survives; failure message to caller

  -> agent may correct its feasibility estimates

  BUT: caller maybe uncertain about status of request

Future Work

- WOz test of our system with real users
- Comparison of WOz study with performance of automatic servicematcher
- Other ways to support the user finding services