Multi Agent Information Gathering from Public Sources

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Overview

- System MIA
  - MIA — An agent based search engine
  - Accessing heterogenous databases within MIA
  - MIA's logic agents
- Communication among Information Agents
  - Communication layer model
  - Message transportation problems
  - Security
  - Languages and ontologies
- Conclusions

MIA — An agent based search engine

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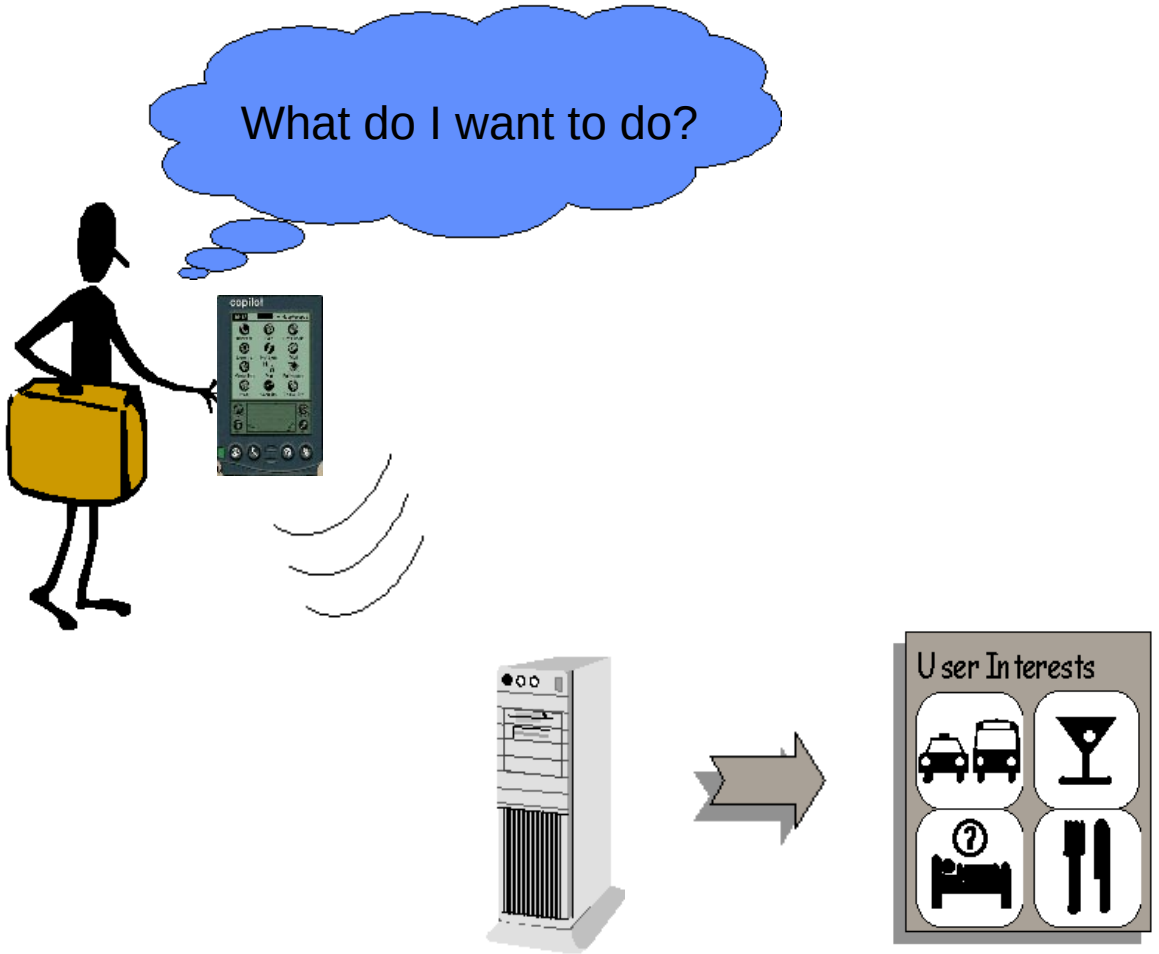
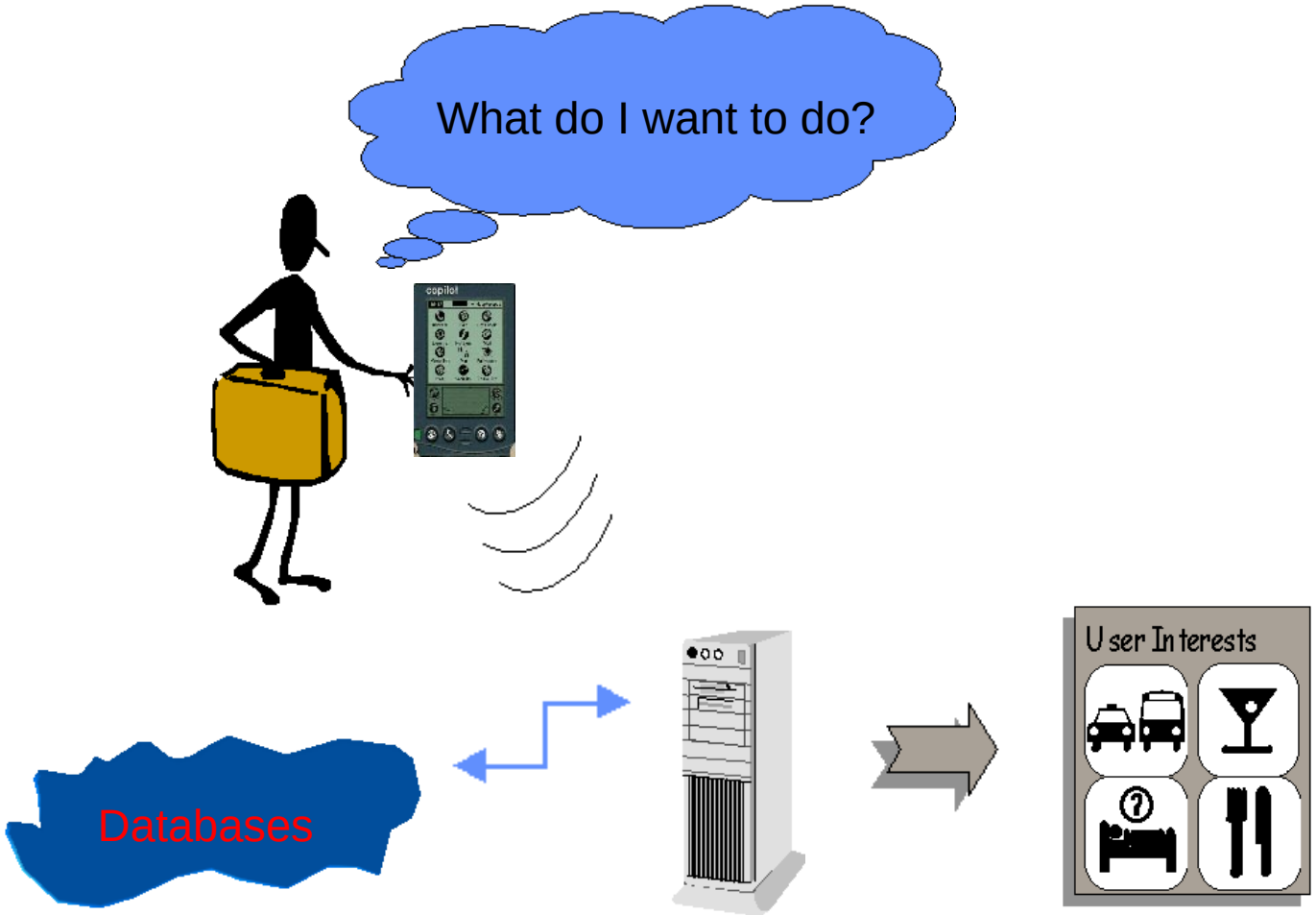


MIA — An agent based search engine



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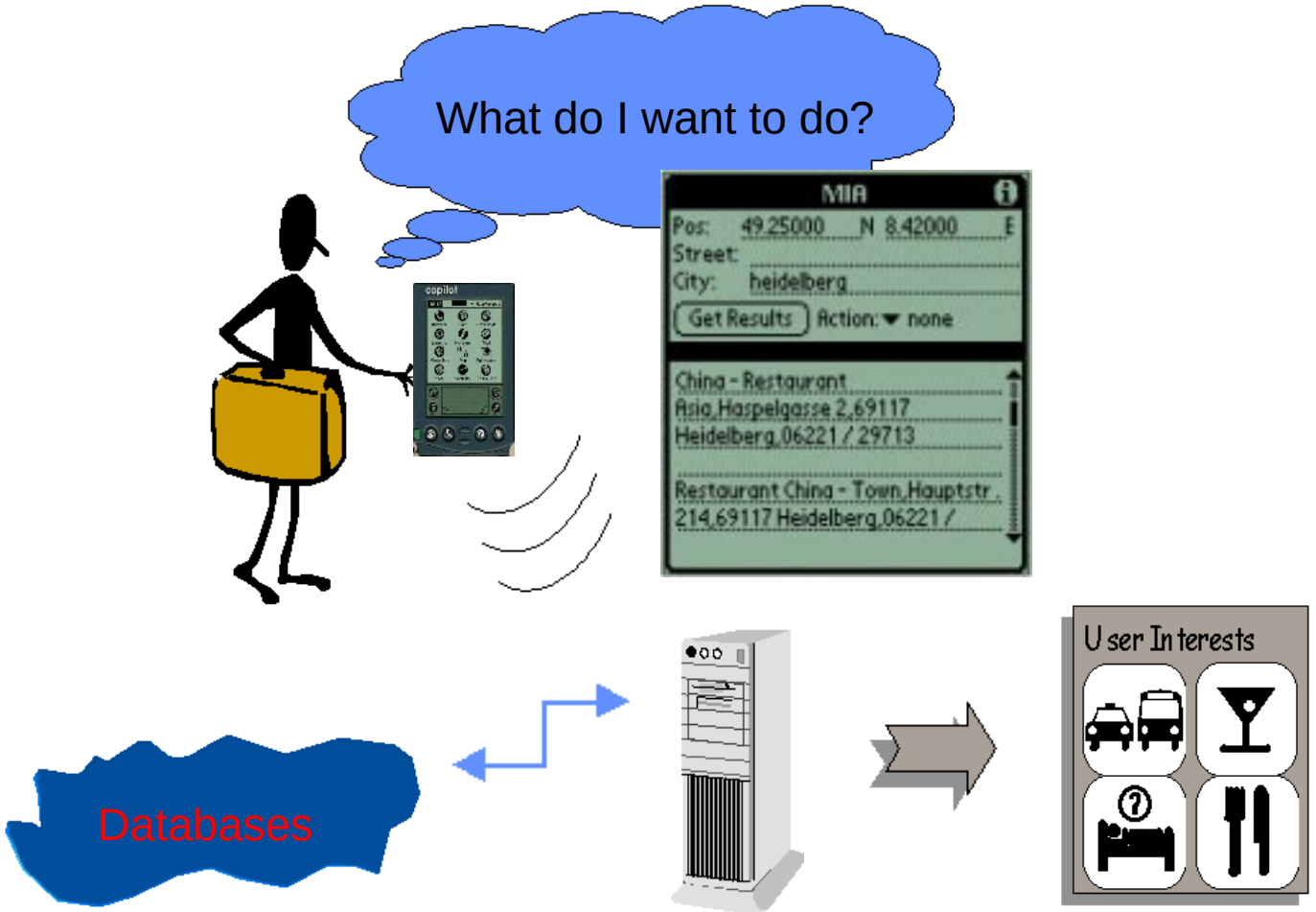

MIA Is Not An Ordinary Search Engine

- Asynchronous Interactions
- Anytime algorithm
- Takes geographical data into account
- MIA provides information, not web pages
- AI / Agent-techniques

MIA's multi agent architecture

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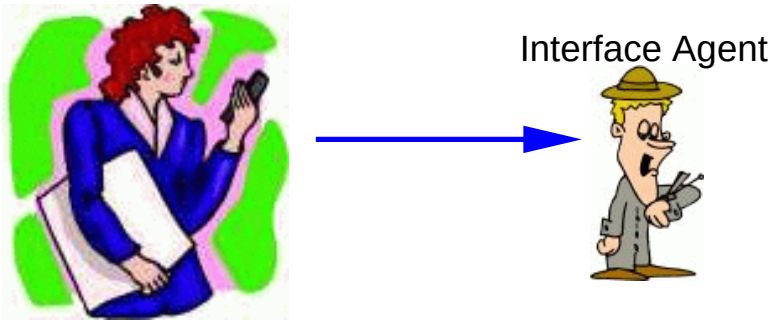

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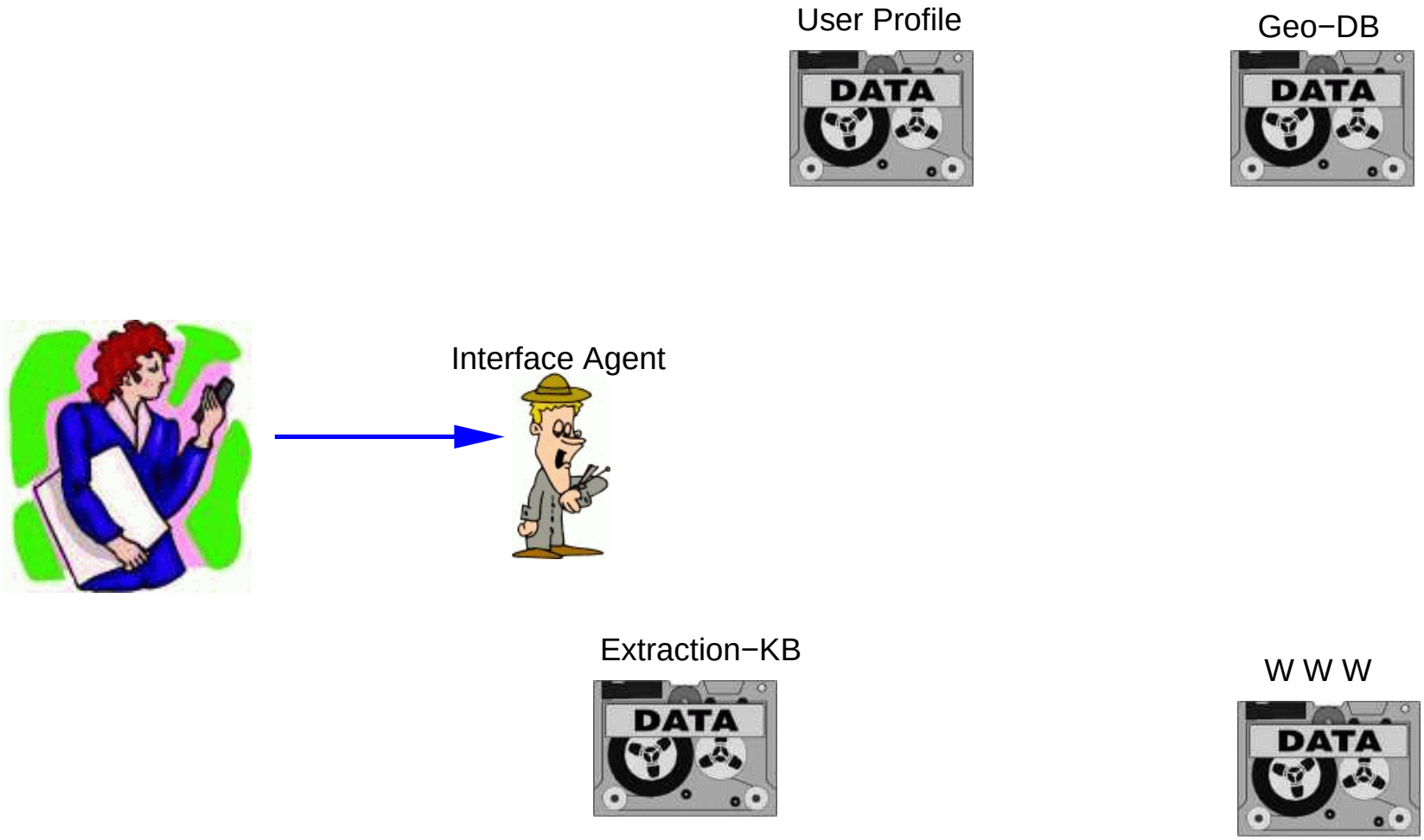

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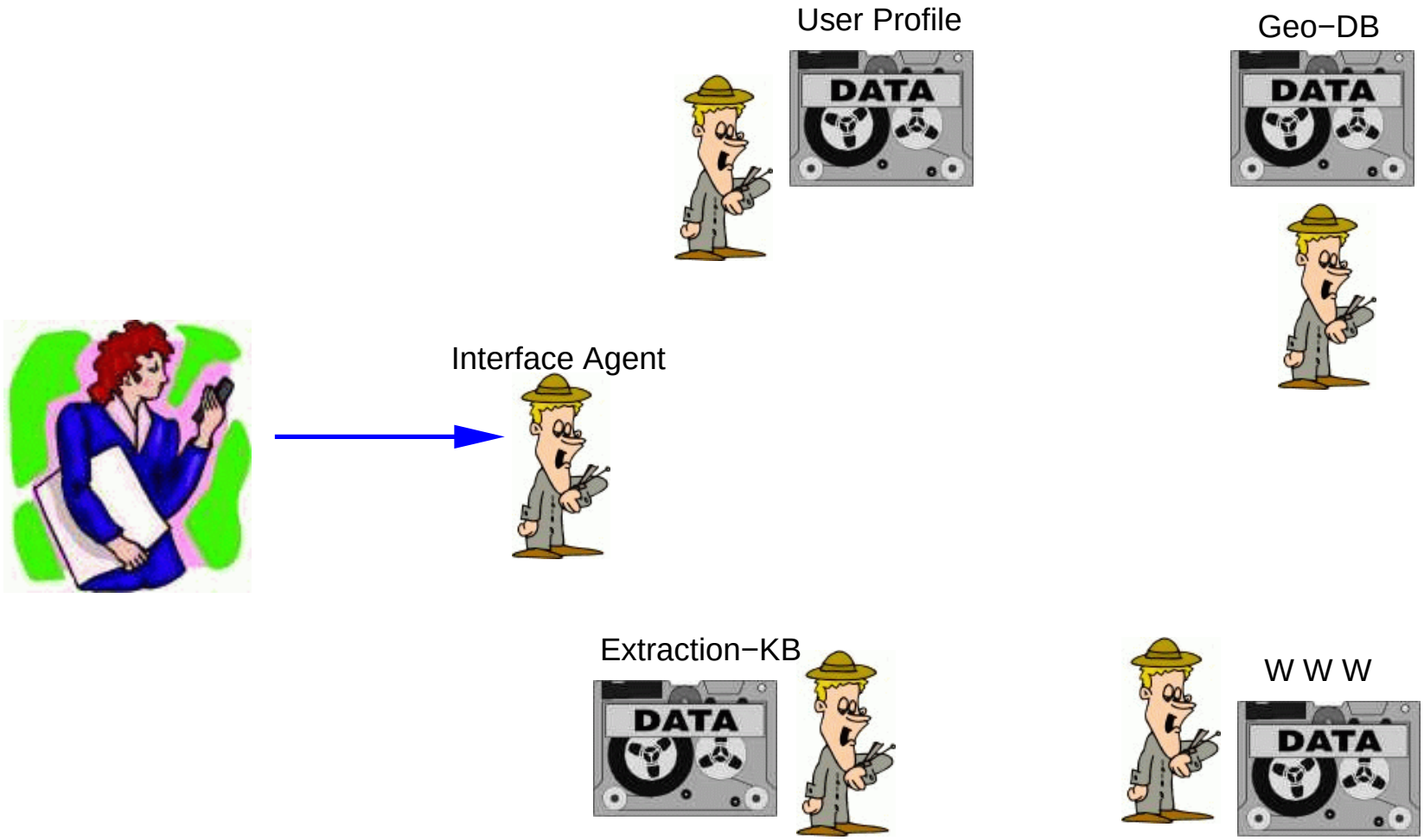

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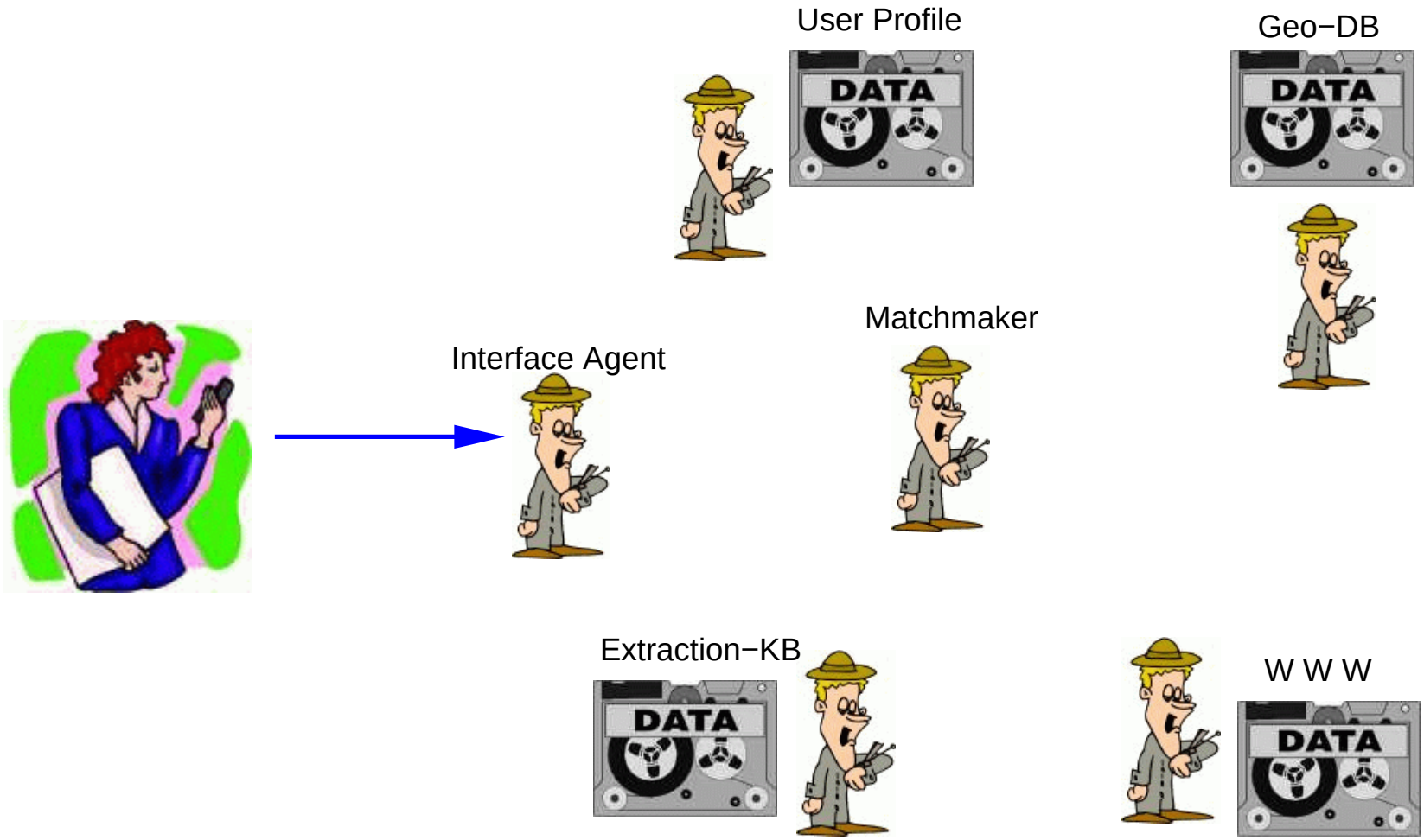

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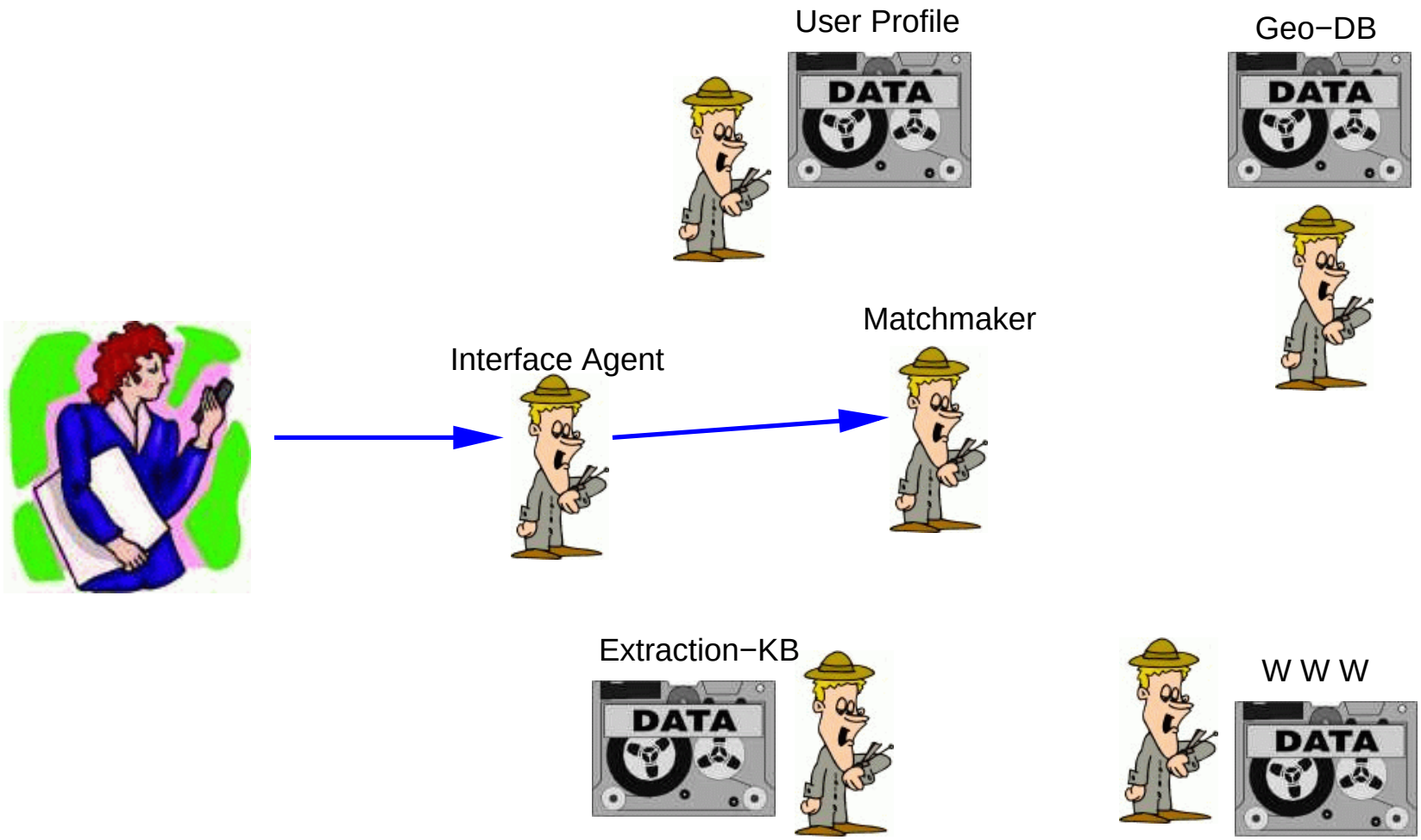

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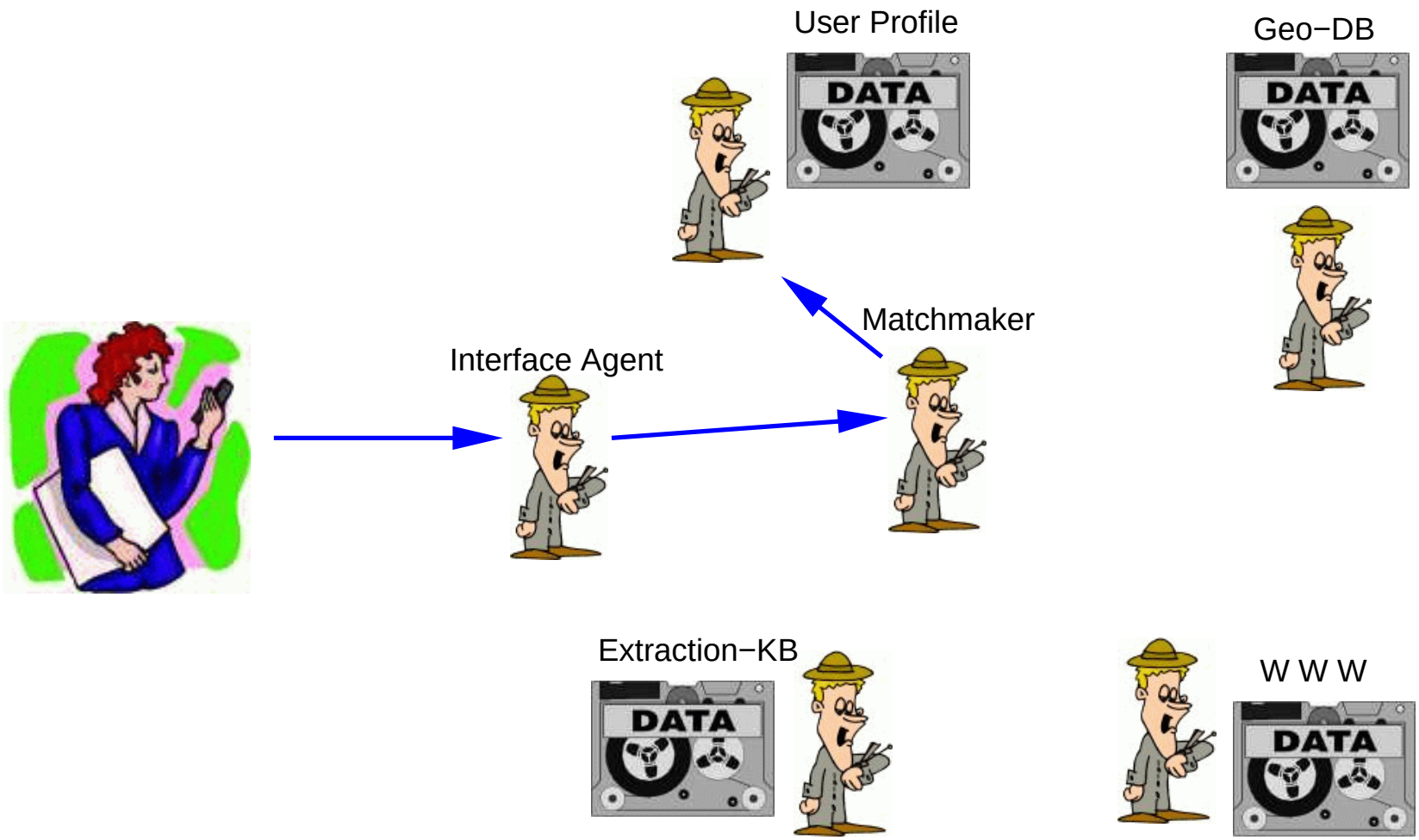

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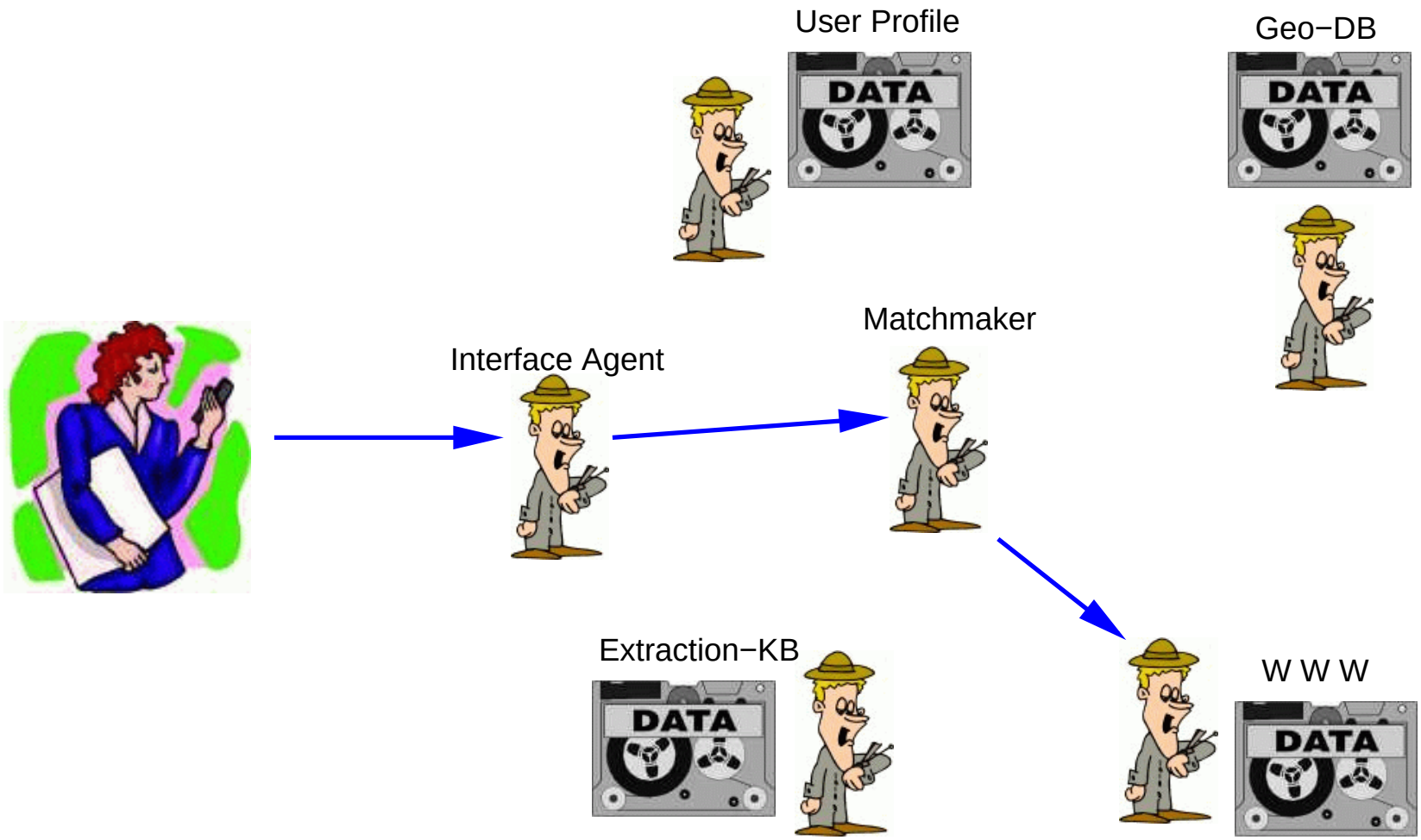

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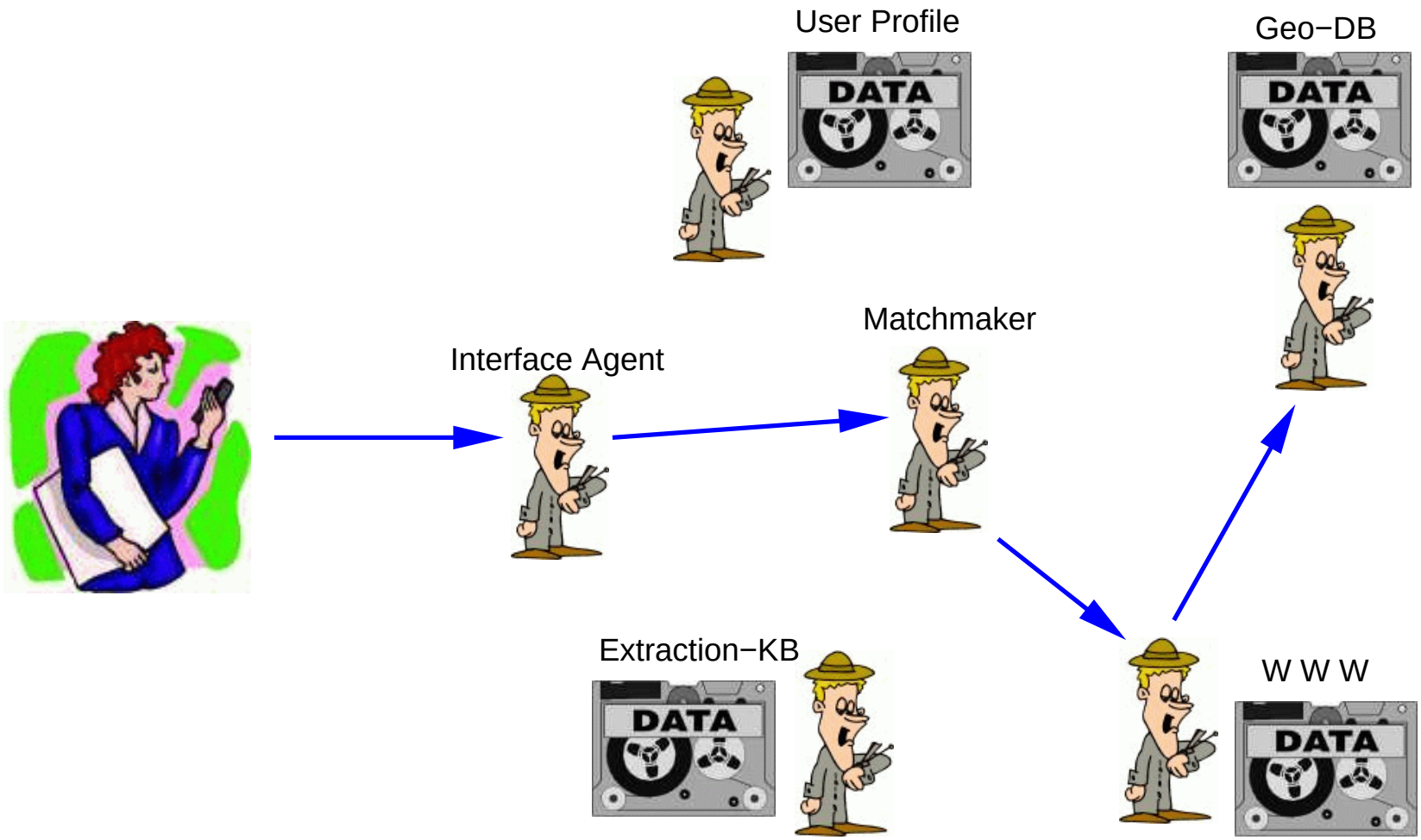

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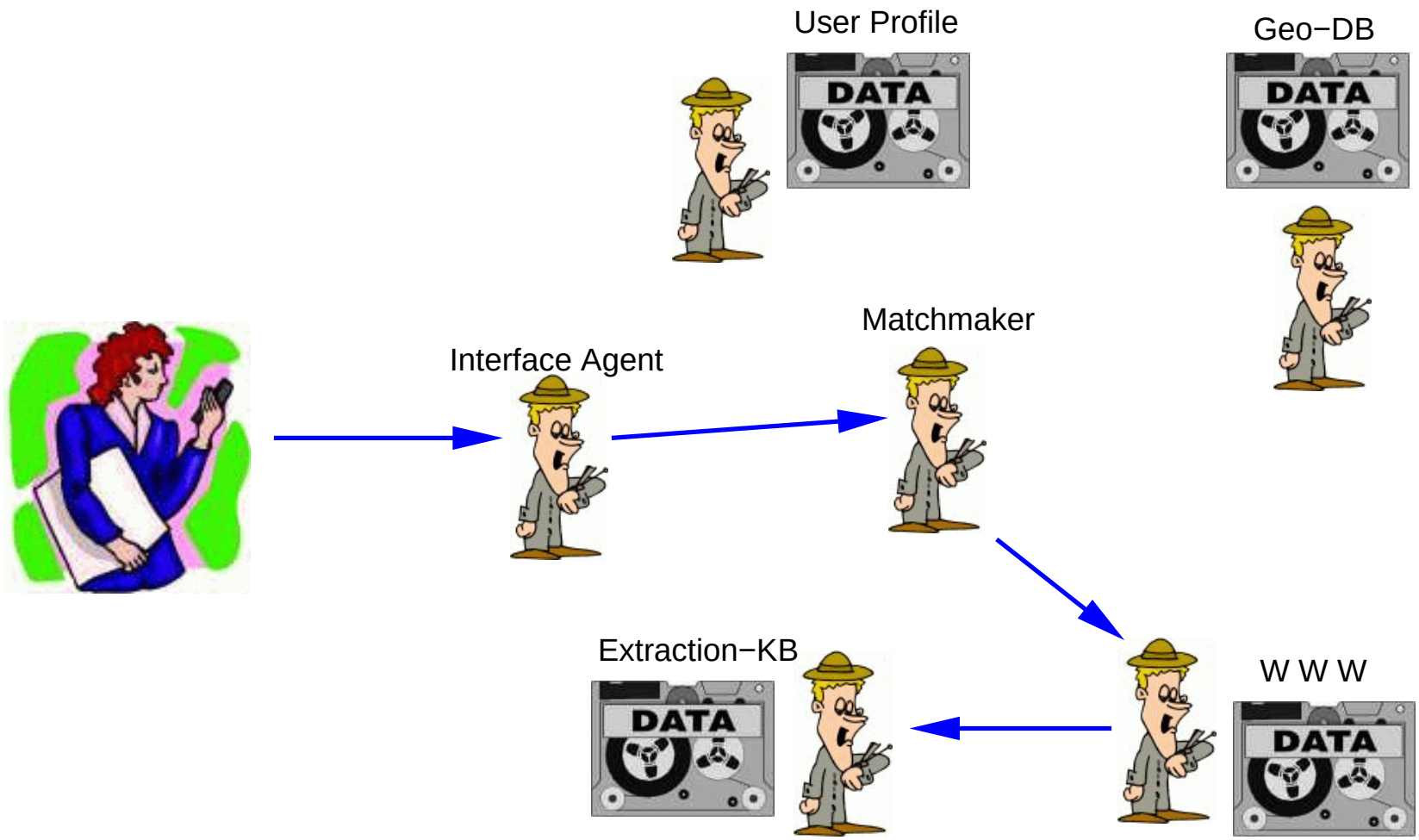


Accessing heterogenous databases

- One or more agents per database?
  - For simple databases one agent for all (GPS database)
  - For complex databases one agent per query (World Wide Web)

Accessing heterogenous databases

- MIA's task can be described as putting together information from various databases, e.g.
  - User's preferences
  - Web directories / yellow pages
  - Generic Internet search engines
  - Web Spiders
  - Geographical databases
  - Map servers
  - Ontologies
  - A priori unknown databases!

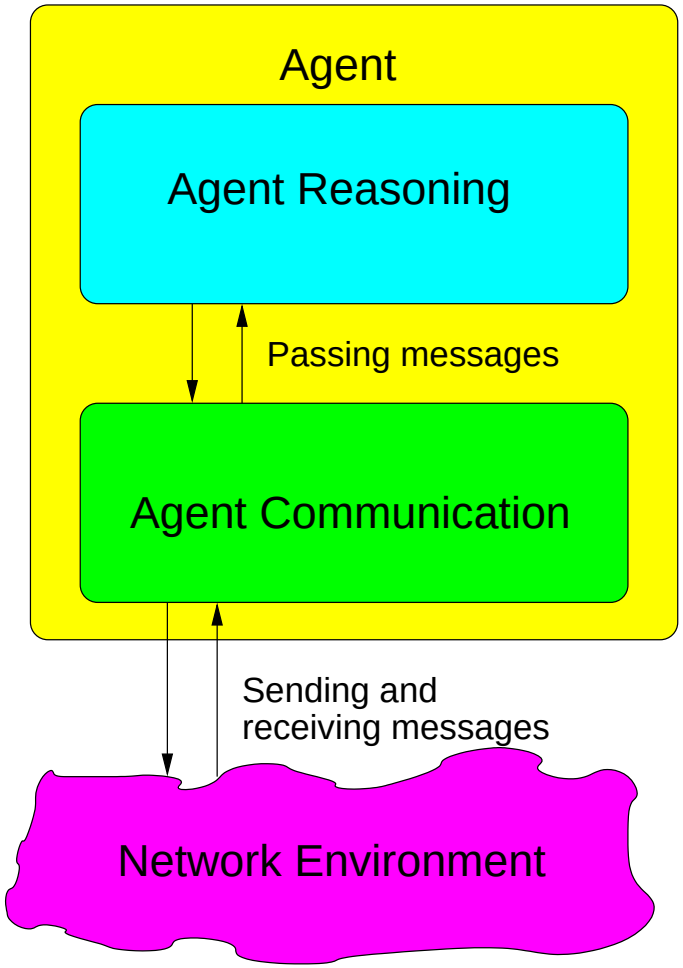
Logic agents

- *Logic agents*: Finding the right agent(s) and answering queries as construction of logical proofs.
- ```
  find(Topic, Type_of_information, Geographical_position,
       Extracted_information) :-
    query_agent(Matchmaker, 'geo_agent', Geo_agent),
    query_agent(Geo_agent, Geographical_position, [Street, City]),
    query_agent(Matchmaker, 'spider_agent', Topic, Topic_agent),
    query_agent(Topic_agent, Topic, [Street, City], Potential_answer),
    query_agent(Matchmaker, 'extraction_agent',
                Type_of_information, Extraction_agent),
    query_agent(Extraction_agent, Type_of_information,
                Potential_answer, Extracted_information).
  ```
  ```

Heterogenous agents' architecture

- Matchmaker agent as the main facilitator
- Agents who want to delegate tasks to other agents ask matchmaker agent
- Not limited to this setup: An agent can decide on its own how to solve task and which agents to contact
- Goal:
  - When a MIA agent gets introduced to an unknown information agent, it should be able to communicate with the new agent, thereby enhancing the MIA system.
  - This requires a common language!

Agent communication — Library



- Library takes care of sending, receiving and parsing of messages
- Alpha-version for Eclipse PROLOG in test right now.
- In the future, it will be available (at least) for other varieties of PROLOG as well.

Agent communication — Language

- Goal: Allow communication with alien (unknown) agents
- Use standardized communication model
- $\Longrightarrow$ KQML

Agent communication — Layers

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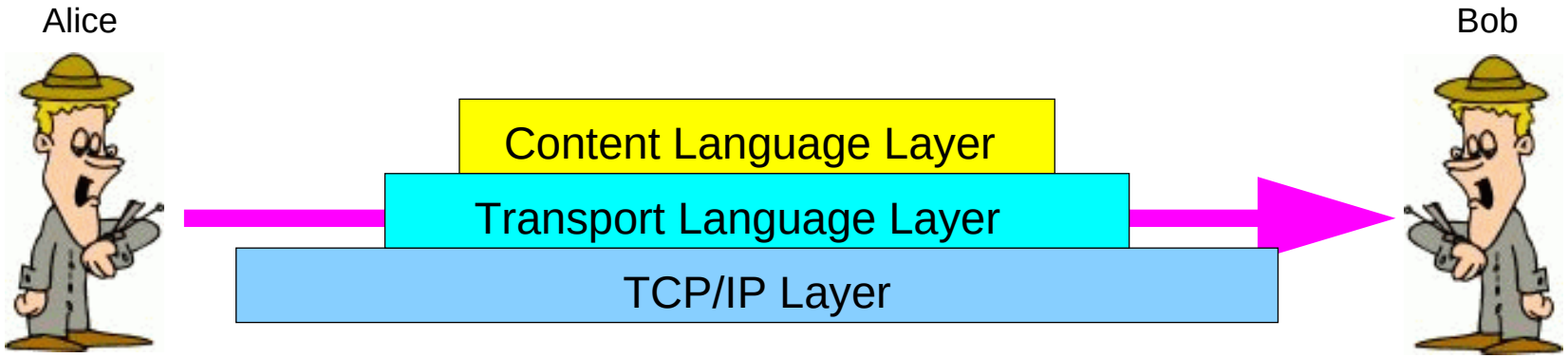

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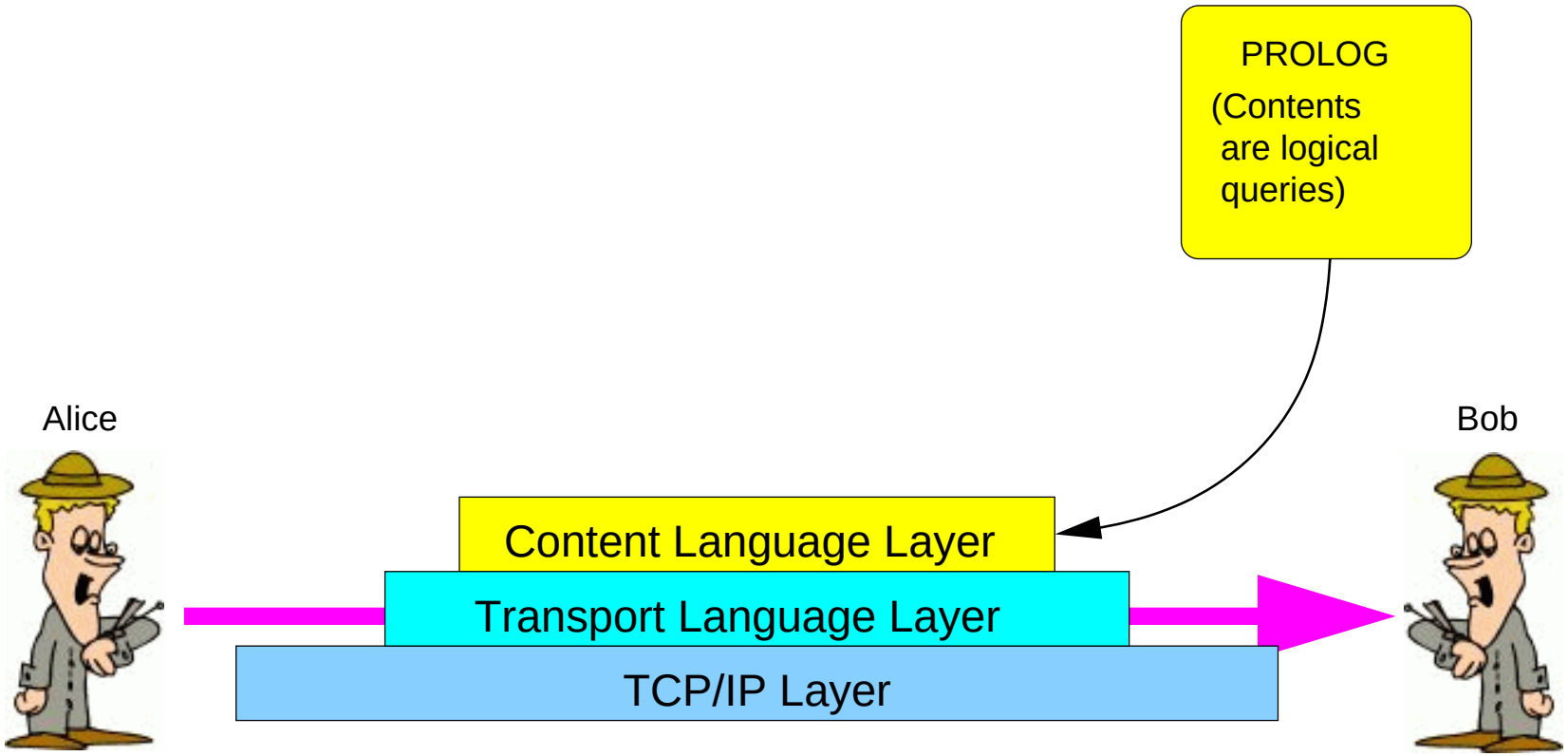
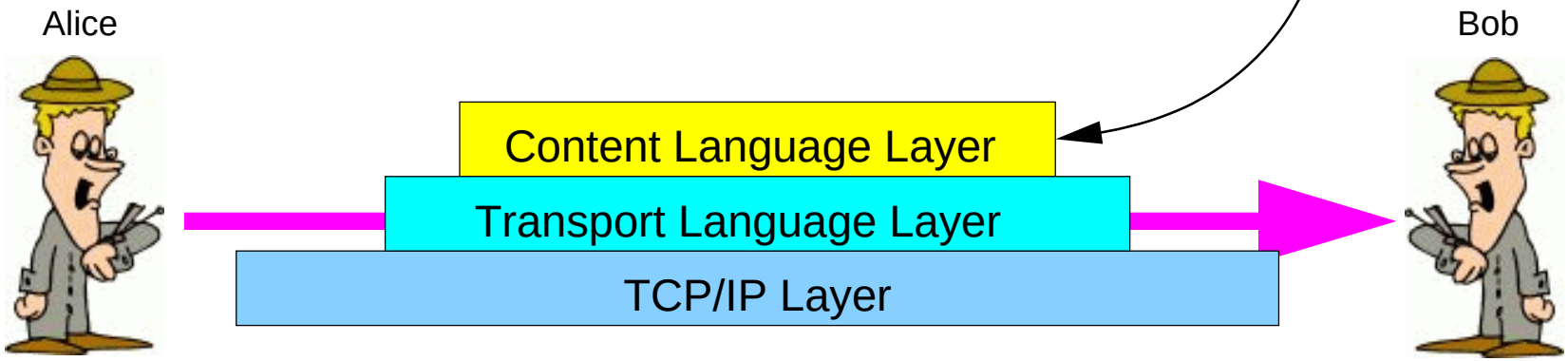


Agent communication — Layers

```
spider_result('Cologne',
              'Addresses',
              'Restaurants',
              Result).
```

PROLOG
(Contents are logical queries)



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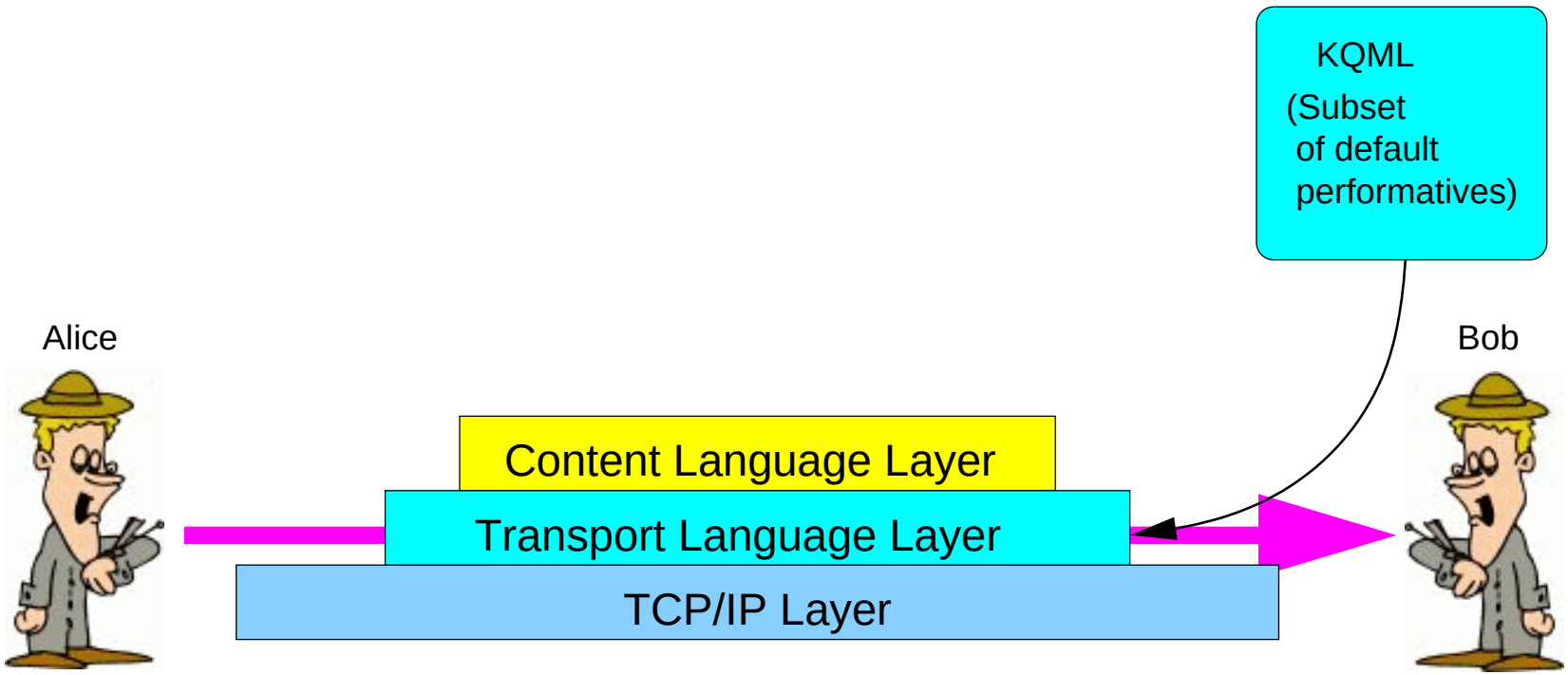

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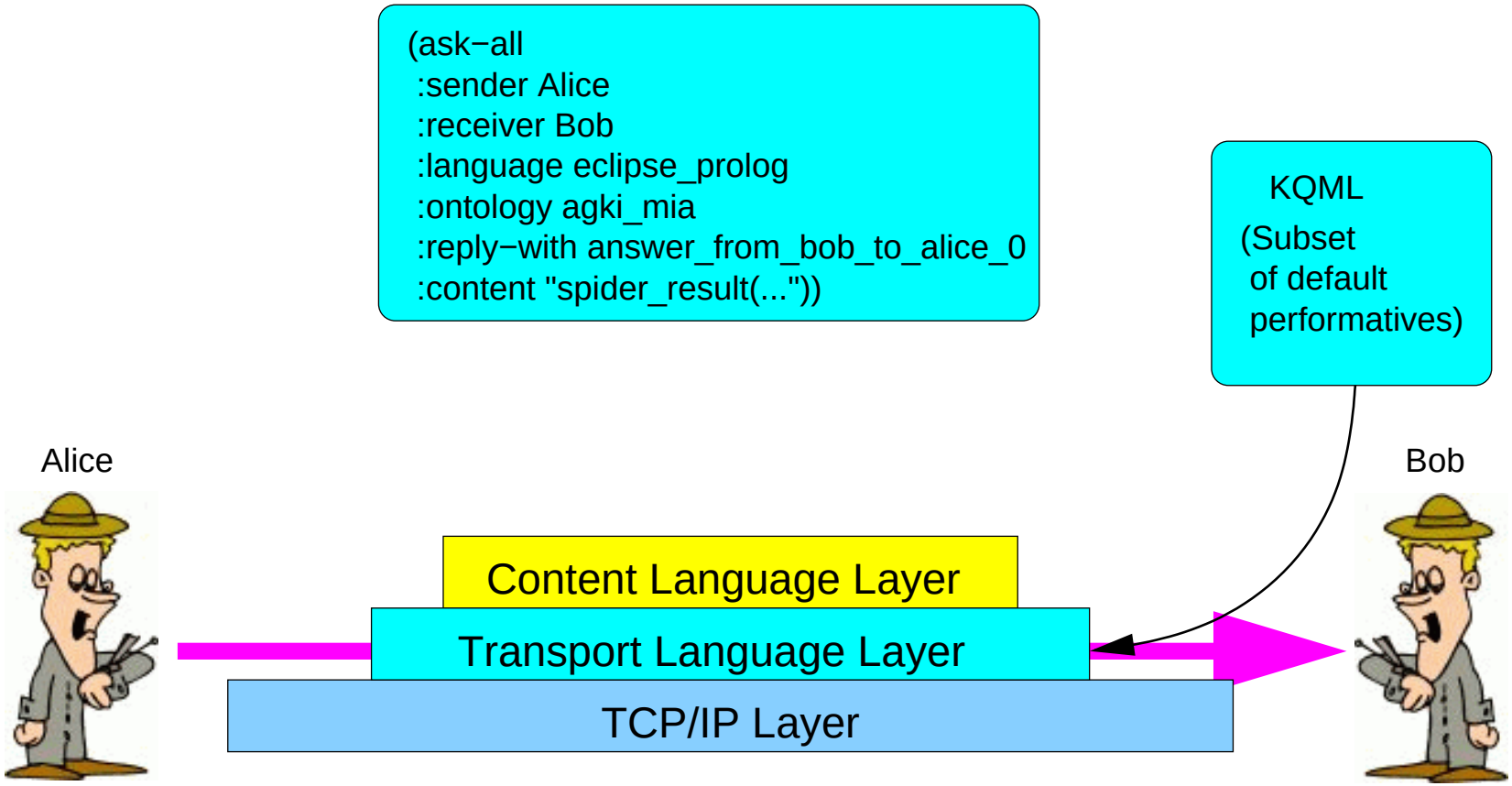

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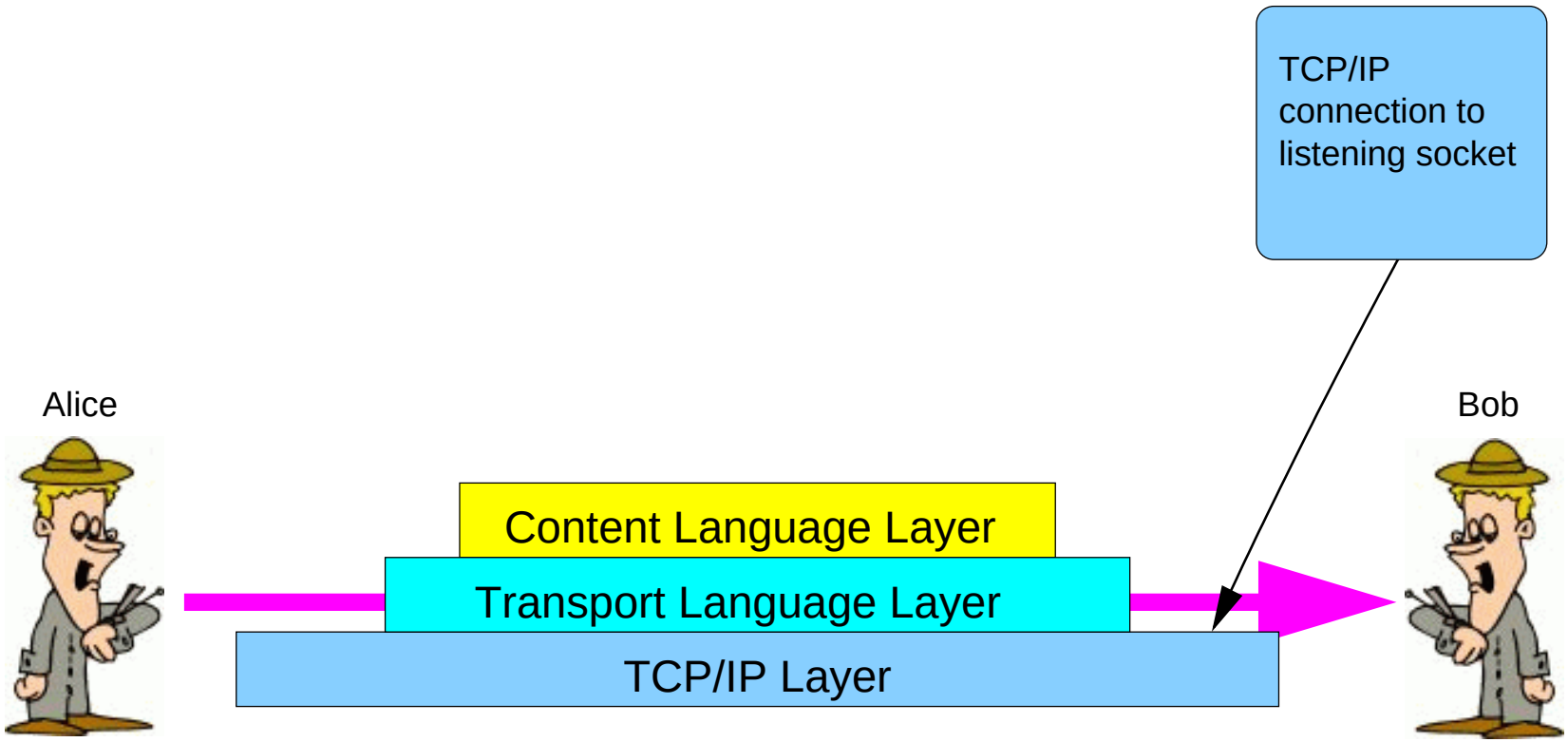

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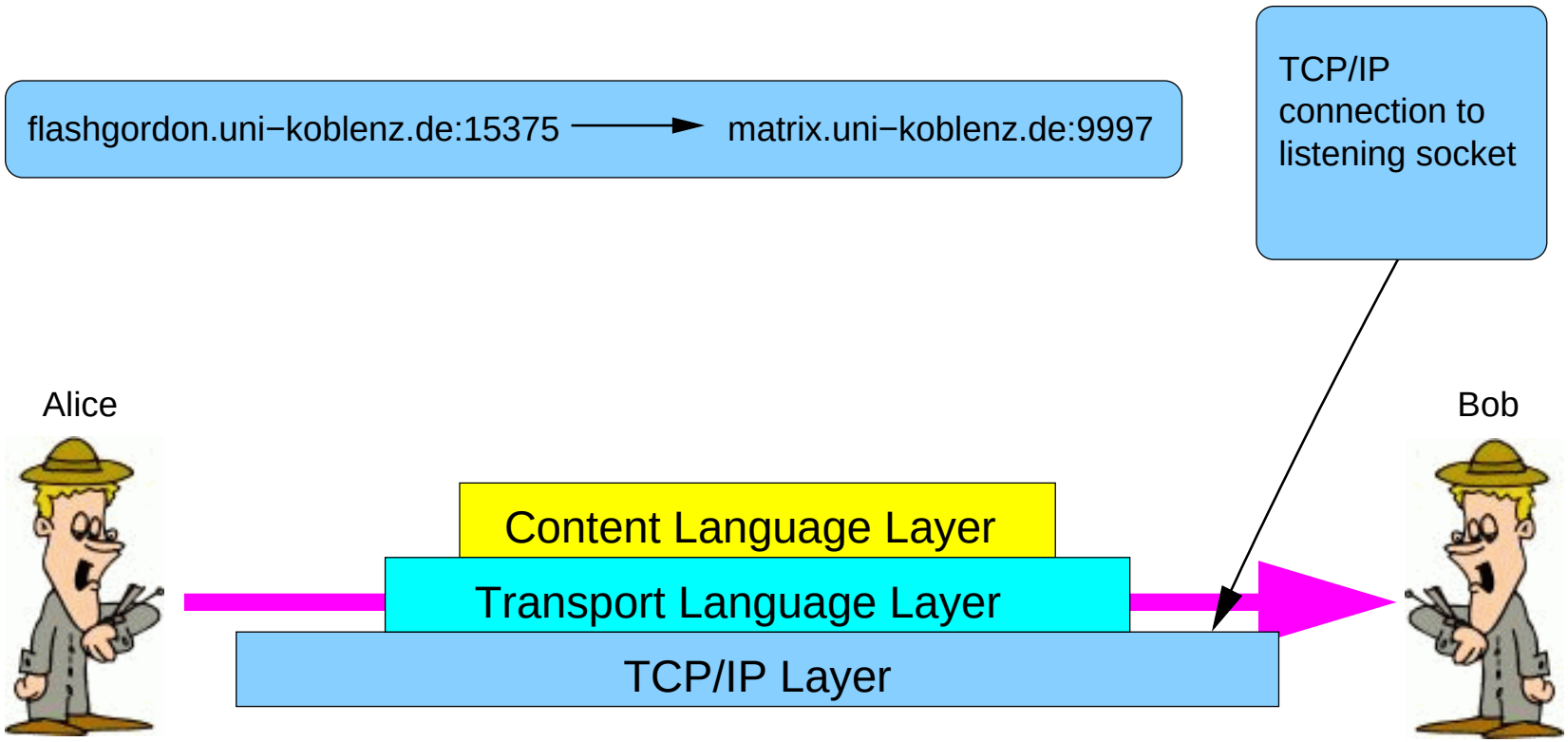
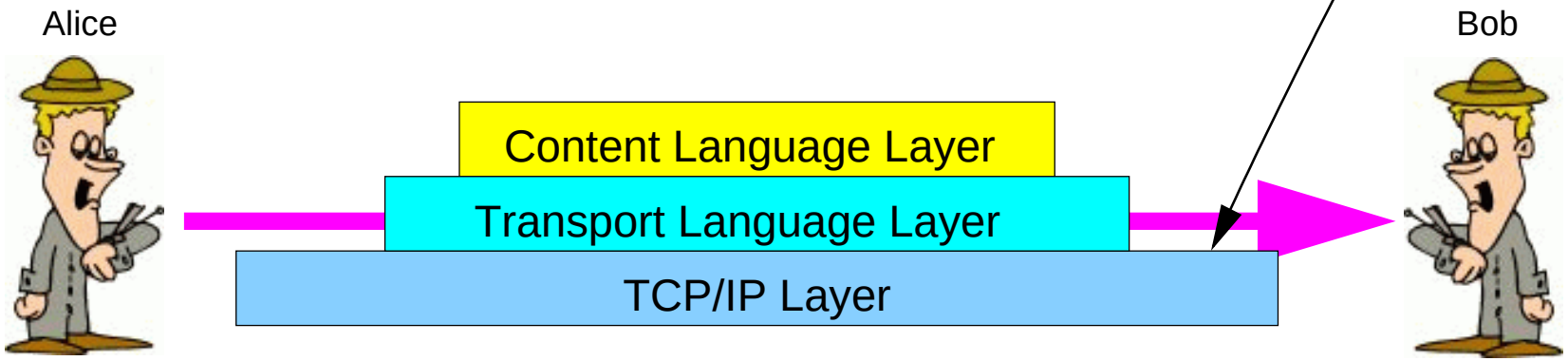


Agent communication — Layers

Problem: Sending port not identical to listening port!

flashgordon.uni−koblenz.de:15375 → matrix.uni−koblenz.de:9997

TCP/IP connection to listening socket



Agent communication problems — Transportation layer

- KQML definition not sufficient for TCP/IP communication:
- Just by receiving a message via TCP/IP, the receiving agent does not know how to contact the sender.
- Solutions:
  - Encode agent's location in its name
  - DNS-like resolver agent
  - Additional parameters in message
- No interoperability between KQML implementations!
- Violates the standard!

Agent communication — Layers

Problem: Sending port not identical to listening port!

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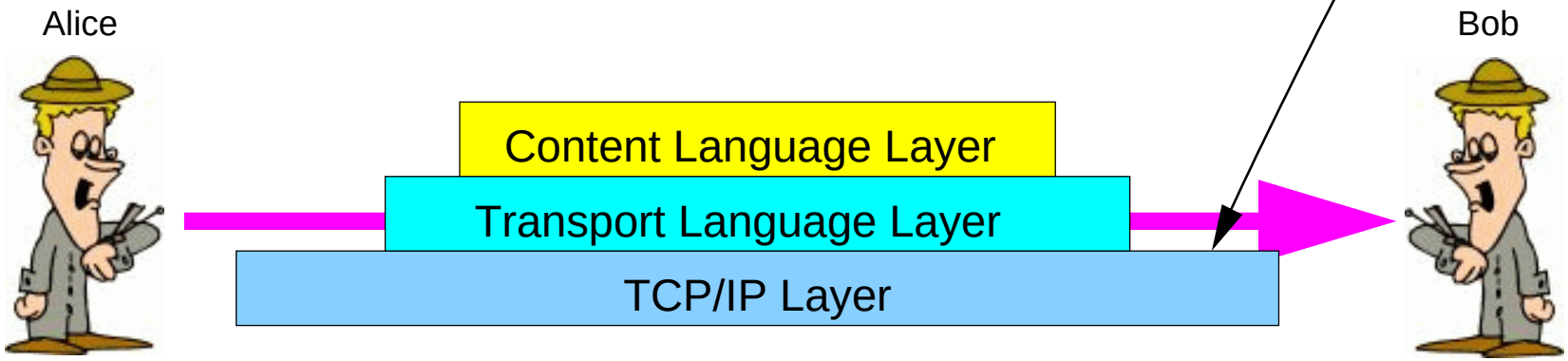
TCP/IP connection to listening socket

Solution: Add layer between KQML and TCP/IP



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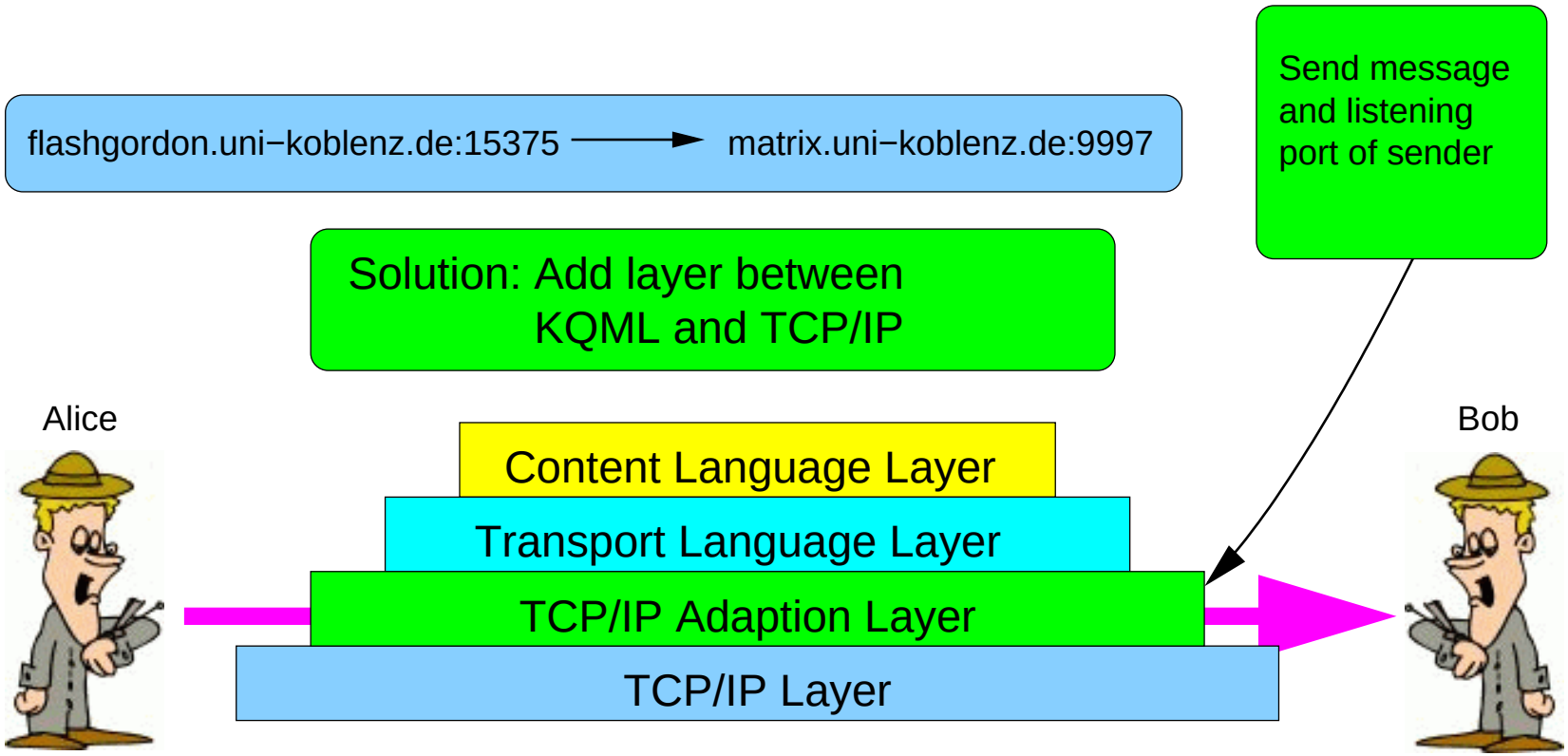

Agent communication — Layers

flashgordon.uni−koblenz.de 10000 (ask−all :sender Alice :receiver Bob ...

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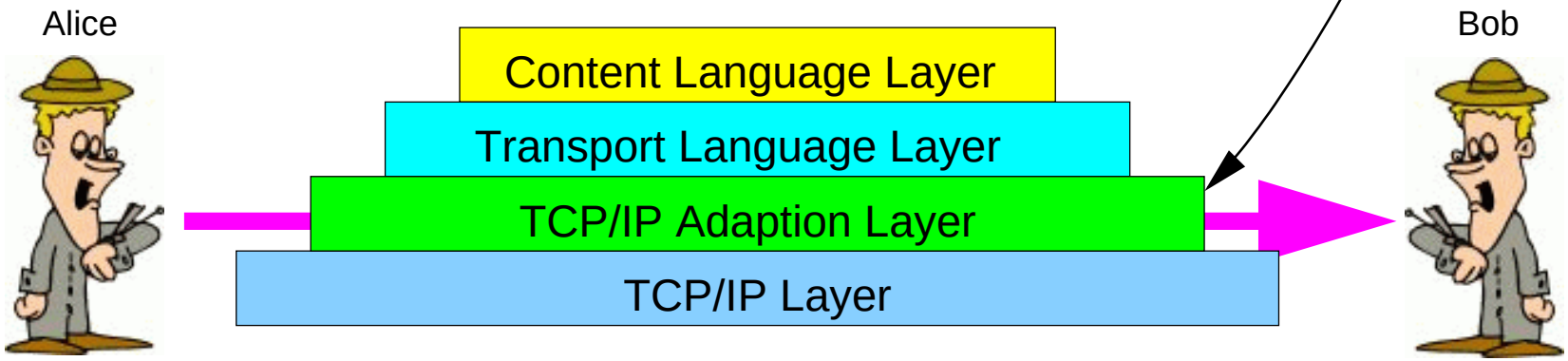
Send message and listening port of sender

Solution: Add layer between KQML and TCP/IP



Agent communication

- In order to communicate, the agents must agree not only on a communication protocol, but also on a common language and ontology for the messages's content
- Right now, we use (Eclipse-)PROLOG as the language, and a simple, implicit ontology.

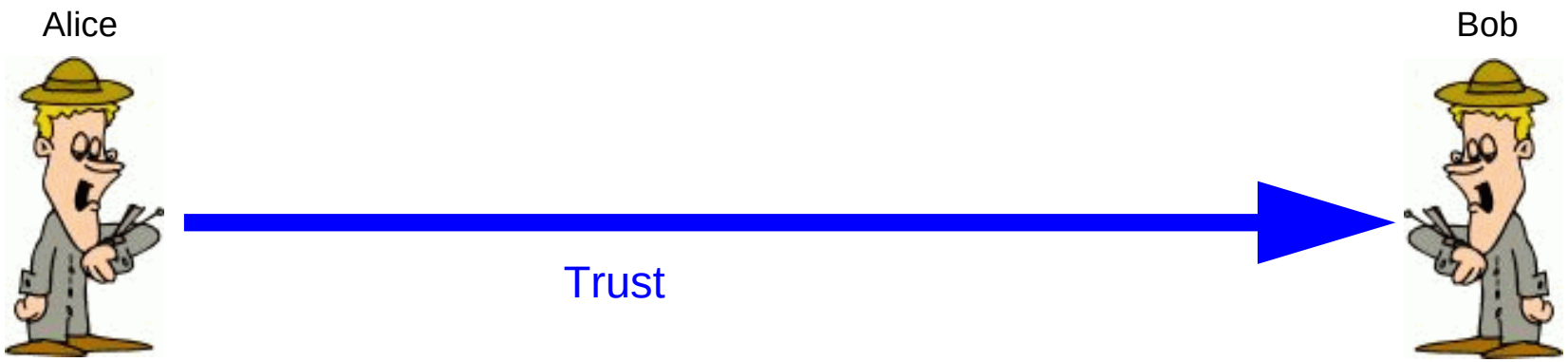
Critique of KQML

- Performatives and content are not clearly distinguished.
- Examples:
  - `(ask-all :content "agent_results(X)")` $\equiv$
    `(ask-one :content "findall(Y, agent_result(Y), X)"`
  - `(achieve :content "foo(bar)"` $\equiv$
    `(ask-if :content "foo(bar)")`
  - `(insert :content "foo(bar)")` $\equiv$
    `(ask-if :content "asserta(foo(bar))")`
- $\Rightarrow$ Security!

Interacting with alien agents — Security

- In Prolog, it is hard to limit the interface
- Example:
  - `(ask-if :content "asserta(foo(bar))")`
- How to deal with agents serving malicious data? ("Spam agent" redirect queries for cinemas, cultural events, etc.)
- Authentification / Limited access
  - MIT-Magic-Cookies
  - Public-Key Encryption
  - Problem: How to deal with unknown agents?

Web of Trust



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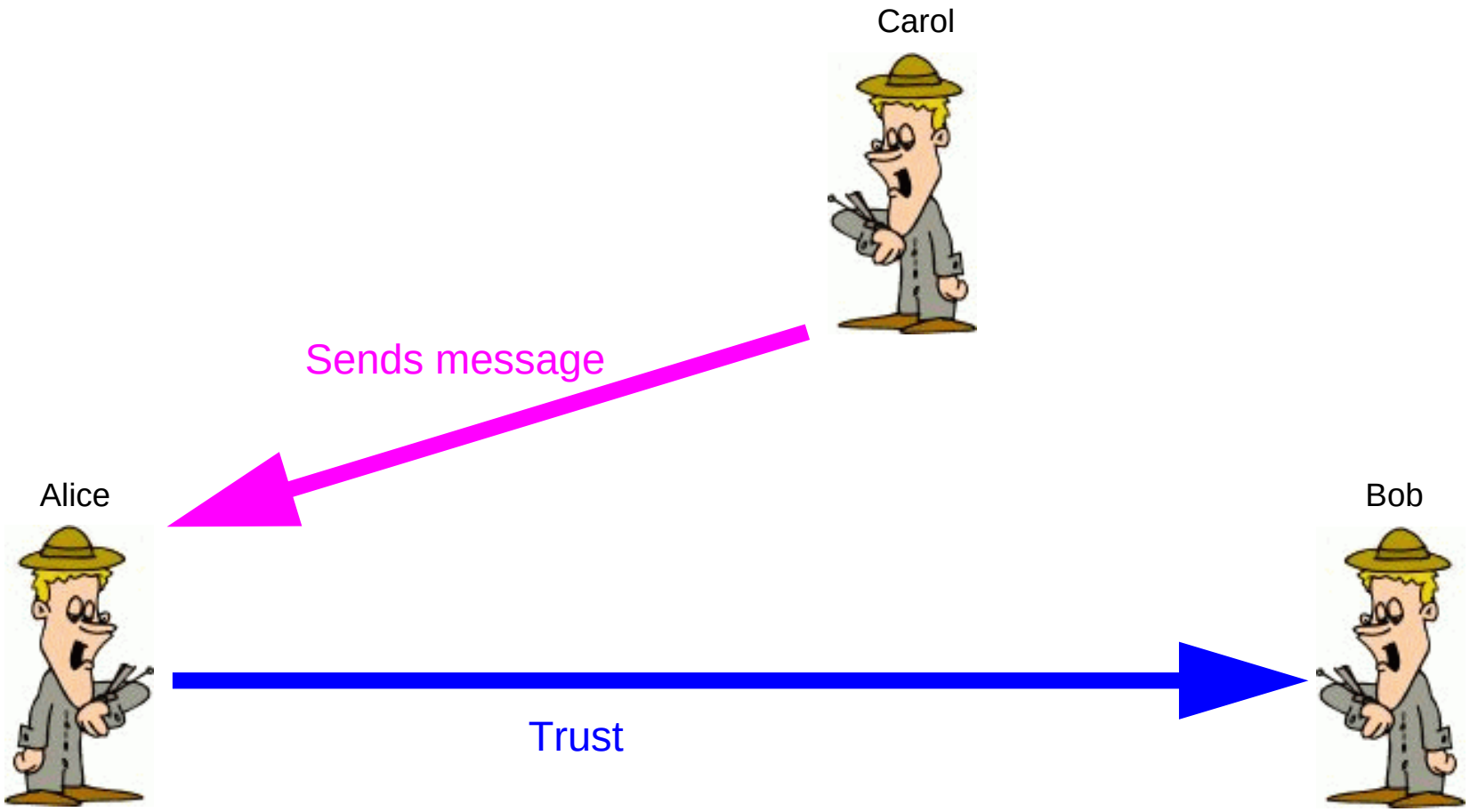

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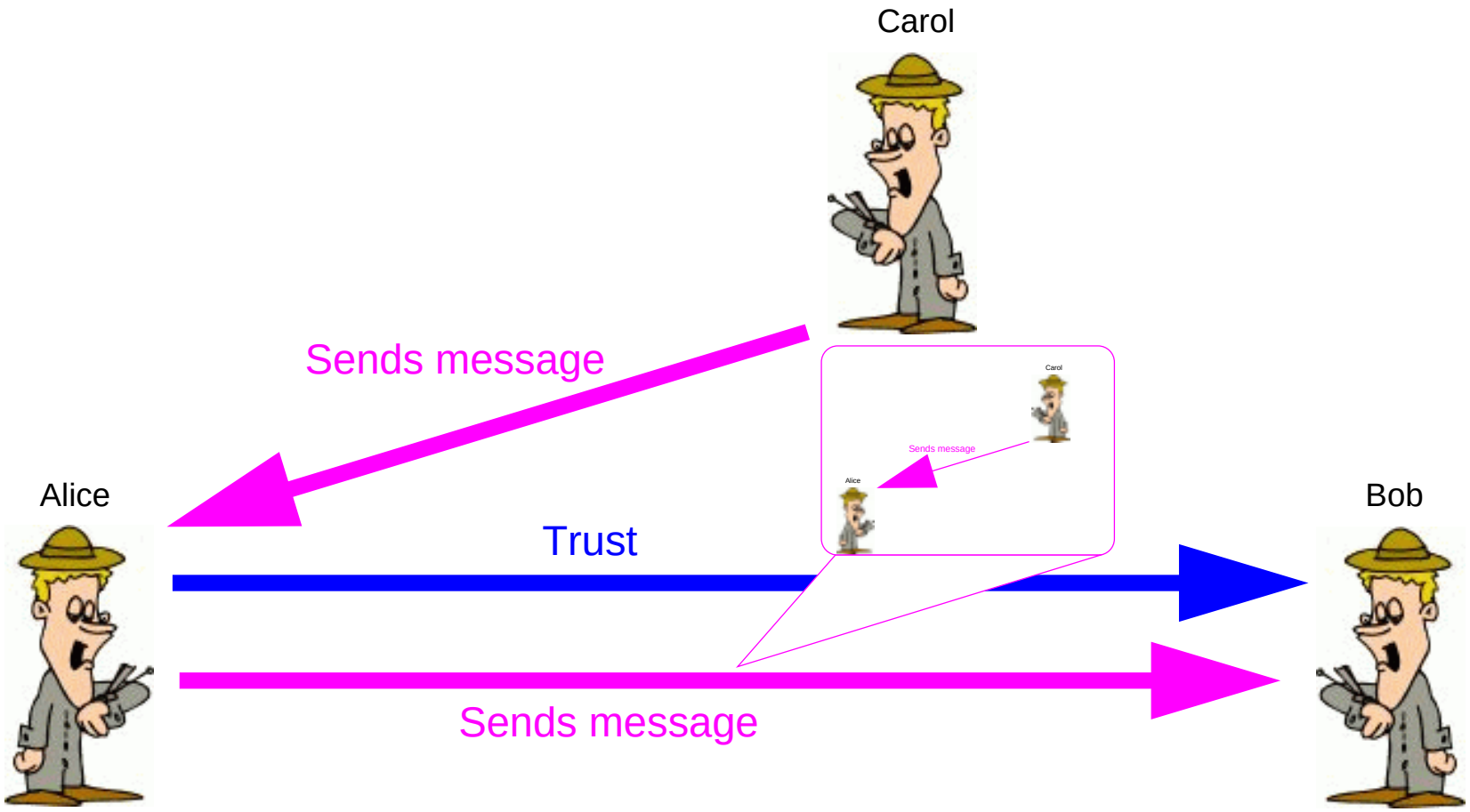

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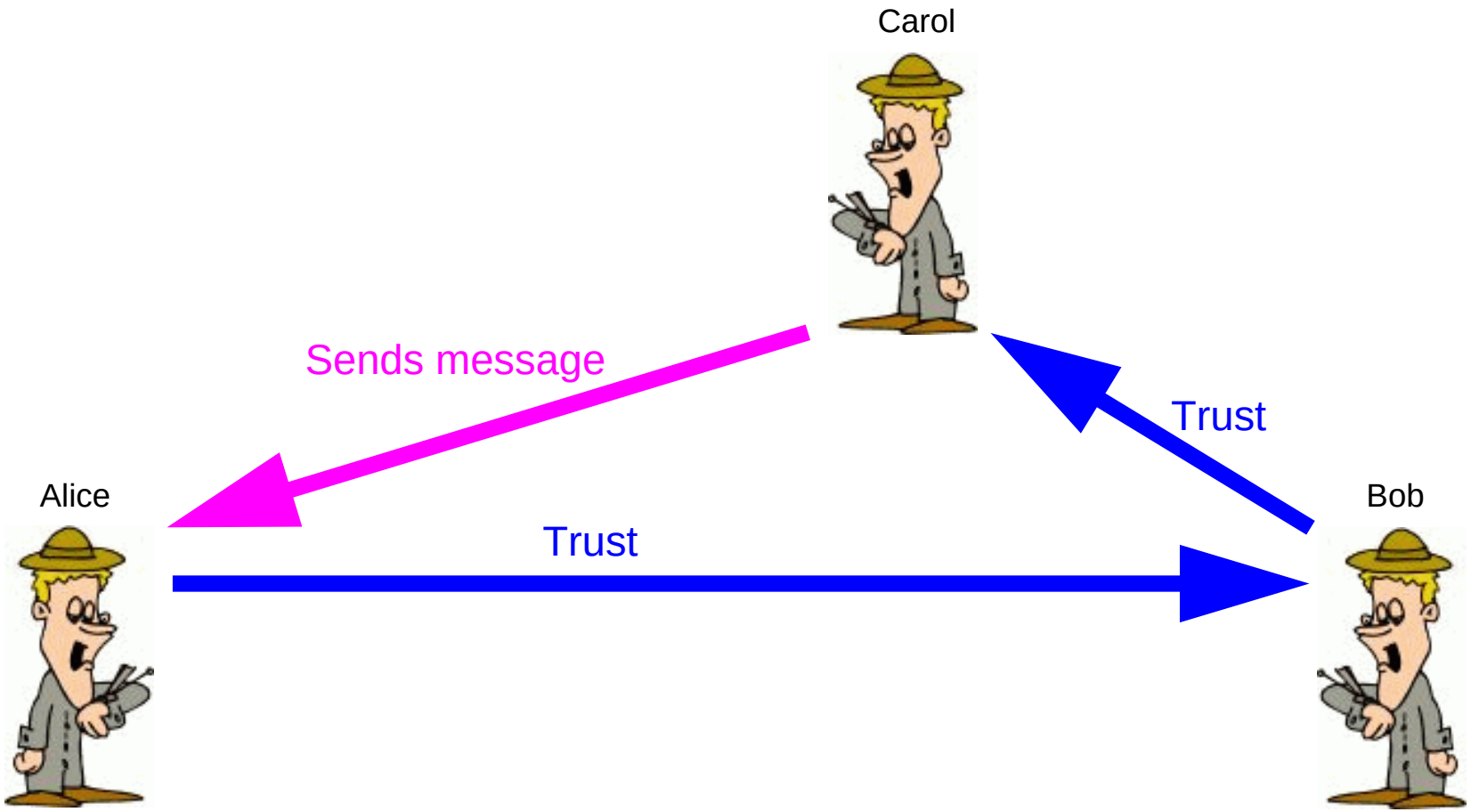

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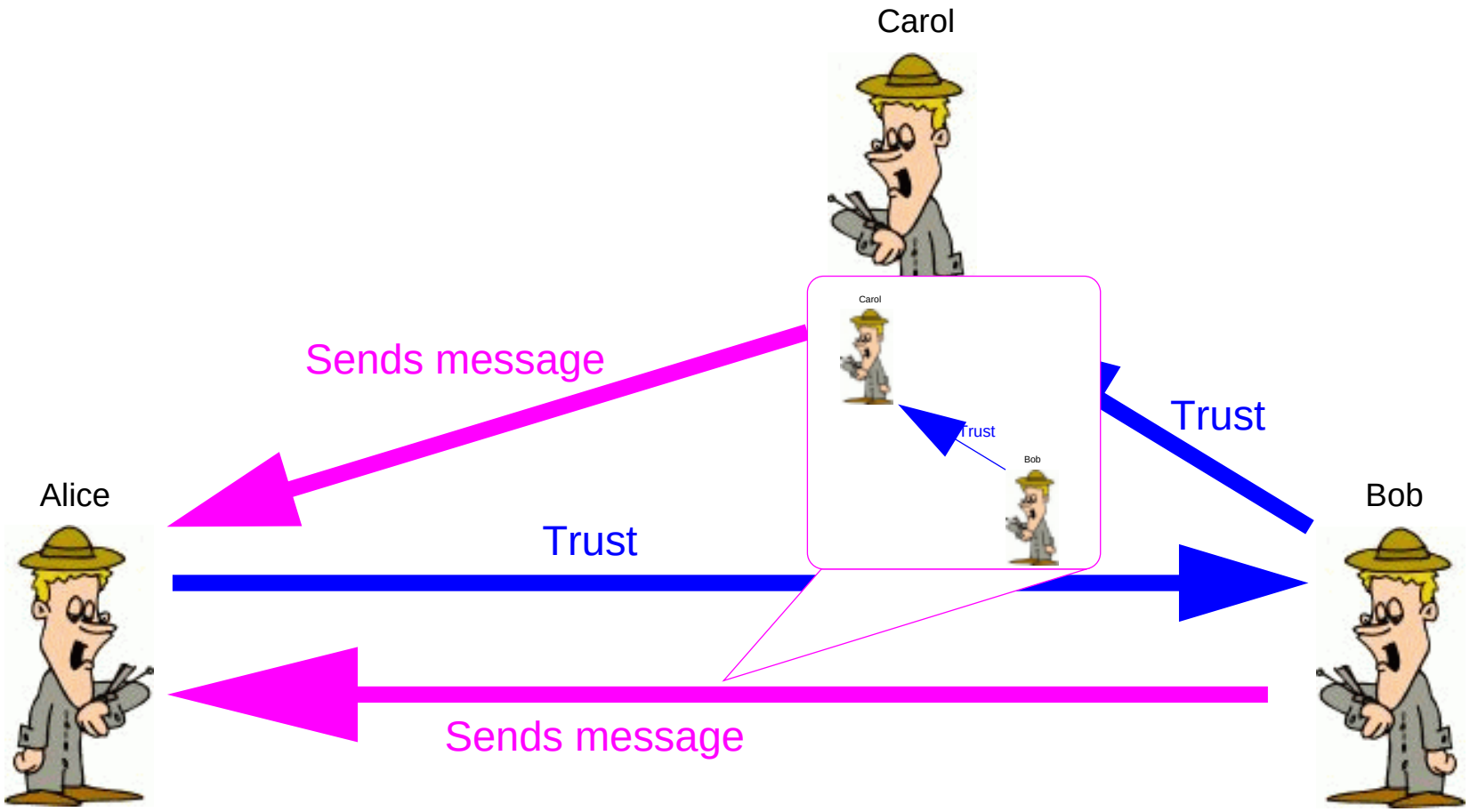
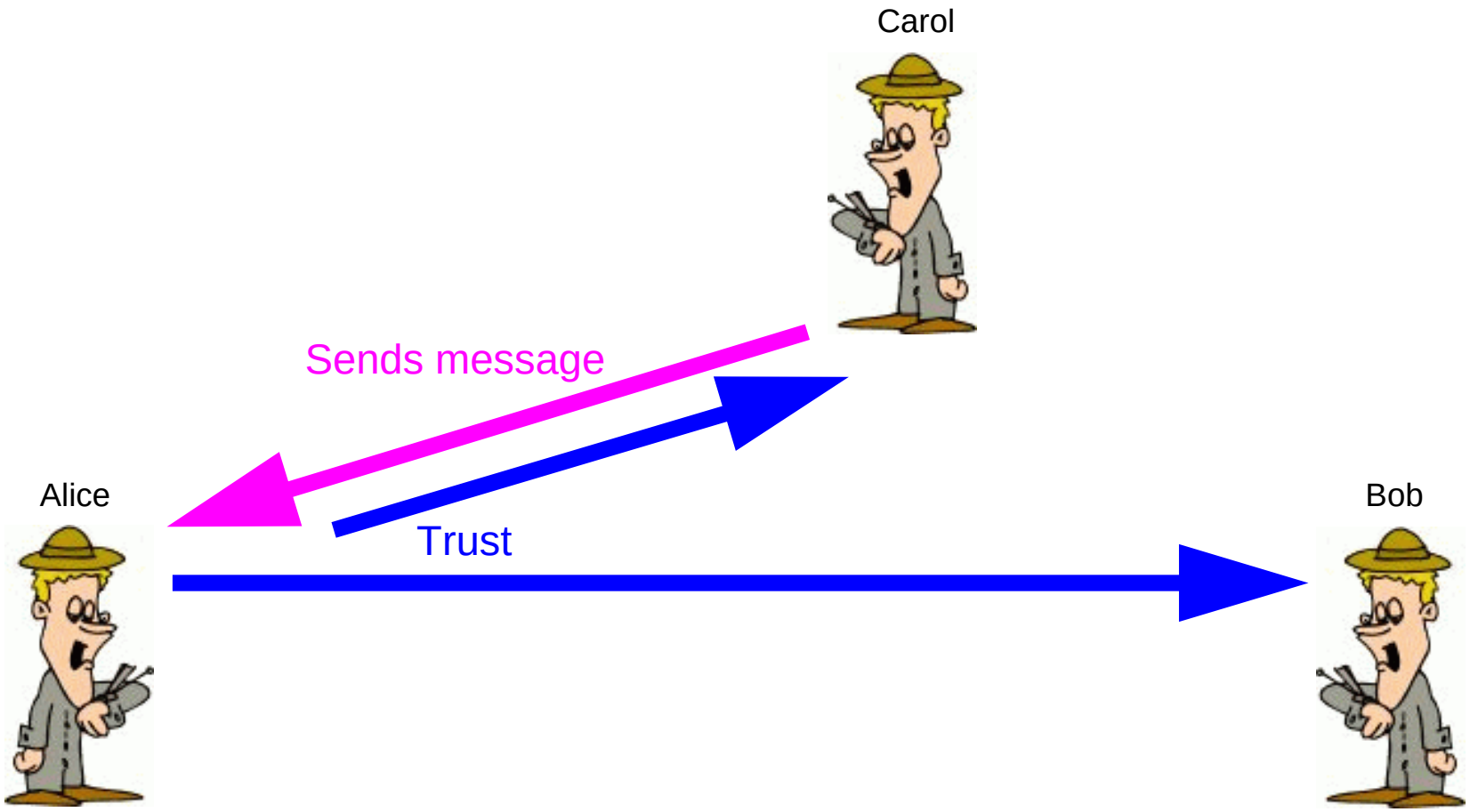

Carol
Carol
Trust
Bob
Sends message
Trust
Alice
Trust
Bob
Sends message

Web of Trust



Agent communication — Language

- KQML is independent of language
- For flexibility, support for multiple language is desirable.
- Beside PROLOG (used right now), we intend to support KIF
- Since KIF = first order predicate logic plus extentions, it can easy be transfer to PROLOG.

Agent communication — Ontology

- So far, MIA uses a simple implicit ontology.
- Lack of generic ontologies
- In order to share knowledge with alien agents, different ontologies should be understood.
- Problem to speak multiple languages (Uschold 2001)
  - Different ontology languages are based on different paradigms (description logic, first order logic, frame-based, . . .)
  - It is not always possible to translate between languages. E.g. (Hayes, 96) shows that representations of time as points and as intervals are incompatible.

Agent communication - Ontology (2)

- Solutions:
  - Ontology negotiation (Bailin/Truszkowski, 2001)
  - Abstract Ontology Representation (Willmott, Constantinescu, Calisti, 2001)
  - Generic formalization of ontologies (Ontolingua)
  - "Big" ontologies (http://ontotext.com)

Conclusions — Information agents

- In order to build generic information agents there are unsolved problems on all levels of communication:
  - Transportation: KQML is not sufficient to interconnect agents on TCP/IP based networks.
  - Little experience with content languages use between alien agents.
  - Lack of common ontologies.
  - Little experience in dealing with malicious agents

Contact

http://www.uni-koblenz.de/ bthomas/MIA_HTML/
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