Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

//SMARTWEB

7th December 2007
SAMT, Genova, Italy

A Constraint-Based Graph Visualisation Architecture for Mobile Semantic Web Interfaces

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Agenda

- SmartWeb and Multimodal HCI
- Constraint-based RDF Visualisation
  - Semantic Navigation
  - Graph Visualisation Architecture
  - User Evaluation
- Conclusions and Outlook

Who was world champion in 1990 ?

Question Answering Functionality

SMARTWEB

- Intuitive multimodal access to a rich selection of Web-based information services.

HCI and dialogue system goals:

- Provide concise and correct **multimedia** answers in a **multimodal** way.
- Show how knowledge retrieval from ontologies and Web Services can be combined with advanced dialogical interaction, e.g., **system** clarifications.
- Provide ontology-based **integration** of verbal and non-verbal system input (fusion) and output (reaction/presentation).

The SmartWeb Consortium

Federal Ministry of Education and Research

European Media Lab

Chair for Pattern Recognition FAU Erlangen-Nuremberg

T-Systems

Ludwig-Maximilians-Universität München

UNIVERSITÄT DES SAARLANDES

SYMPALOG Speech Technologies

SIEMENS

IMS Institut für Maschinelle Sprachverarbeitung, Universität Stuttgart

LMU IPSK

AIFB

DAIMLERCHRYSLER

Fraunhofer FIRST Institut Rechnerarchitektur und Softwaretechnik

ontoprise SEMANTICS FOR THE WEB

ICSI Berkeley, USA

Funded by the German Government and Industry

Funding: 13.7 M €, Budget: 24 M €

Scientific Director: Wolfgang Wahlster

Project Duration: 2004-2007

More than 60 Researchers and Engineers

Application Scenarios

- Personal guide at the FIFA Worldcup 2006
- Answer football related and navigation related questions.

German Telekom Mobility

and Navigation Scenario

http://smartweb.dfki.de/SmartWeb_FlashDemo_eng_v09.exe

Technical Design

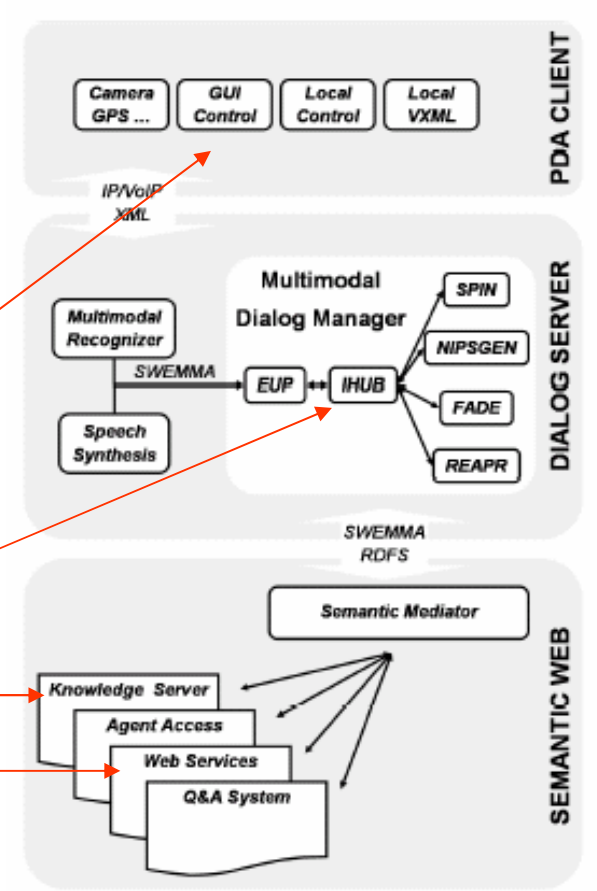
[2] http://www.smartweb-project.de/start_en.html
[3] http://www.w3.org/TR/emma
[4] http://www.w3.org/TR/speech-synthesis
[5] http://www.w3.org/TR/rdf-primer
[6] http://www.w3.org/Submission/OWL-S
[7] http://www.w3.org/TR/wsdl
[8] http://www.w3.org/TR/soap
[9] http://www.chiariglione.org/mpeg

Graphical User Interface Control

Information Hub

Knowledge Server

Web Service Access



T-Traffic info
amazon.de SMARTWEB
WM-Guide

Multimodal Interaction Guidelines

- *Multimodality*: More modalities allow for more natural communication.
- *Encapsulation:* Encapsulate user interface proper from the rest of the application.
- *Standards:* Re-use own and others resources.
- *Representation*: A common ontological knowledge base eases data flow, avoids transformations, and provide a basis for processing natural language dialogue phenomena.
  - Principles:
    - No presentation without representation
    - No interaction without representation
  - An Ontology is
    - *an explicit specification of a conceptualization* [Gruber 93].
    - (language) concepts and facts in relation to each other.

Interactive Result Presentation

U: *"Where can I find Italian Restaurants?"*

S: Shows a map with POIs and the restaurant names + synthesis: *"Restaurants are displayed"*

U: *"... and where's an ATM?"*

S: Shows a map with POIs and ATM locations nearby + synthesis: *"ATMs are displayed"*

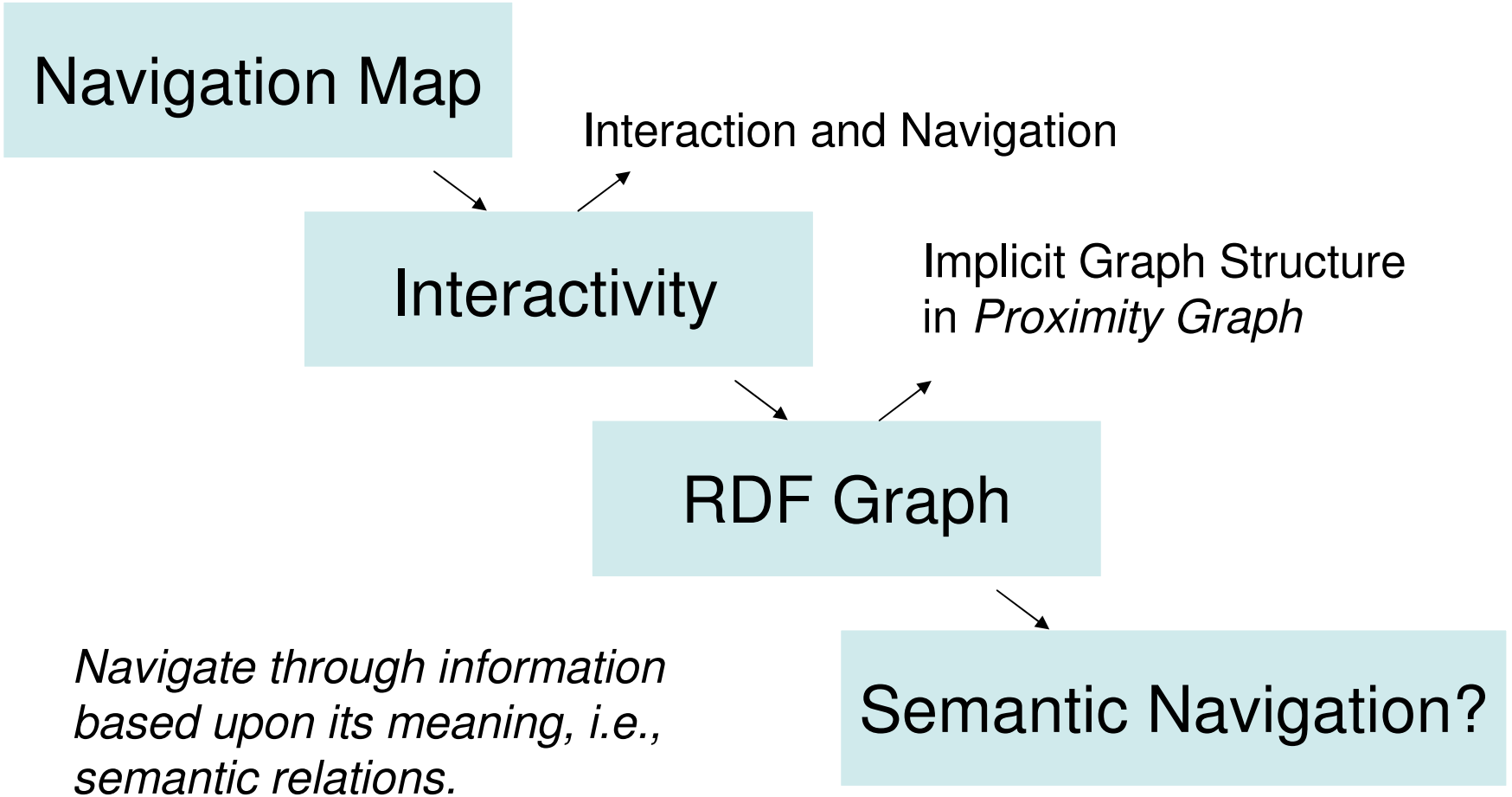
U: Pointing gesture on a suitable ATM POI[1] + synthesis: *"How can I get there from here?"*

S: Zooms into the map and shows the route + synthesis: *"To Schiller Strasse (350 m)"*

Use graphical surface to indicate narrowed dialogue context.

Use graphical screen transitions as system dialogue act.

Towards Semantic Navigation



Navigate through information based upon its meaning, i.e., semantic relations.

Mobile Semantic Navigation

Fisheye distortion

Automatic graph node placement

RDF Introduction

- RDF consists of two parts:
  - RDF model: a set of triples
  - RDF syntax: different serialisations, mainly XML (but not exclusively)
  - RDF Schema: definition of taxonomic vocabularies
    - simple ontology for RDF and using RDF
- Statement: "***This match (GER-SWE) has 66000 spectators***."
- Structure:
  - Resource (subject)
    - http://www.smartweb.de/WorldCup1974Match06-30_GER-SWE
  - Property (predicate / relation)
    - http://www.smartweb.de/#matchResult
  - Value (object)
    - String "66000" or Integer 66000

Proximity Graph

- **Question:** *How many yellow cards have been shown in the match Germany against Sweden*?

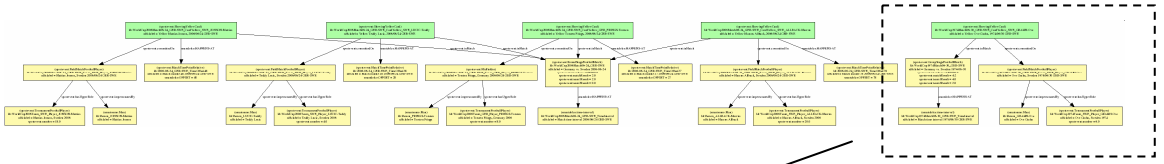
  Answer: 99 RDF triples:

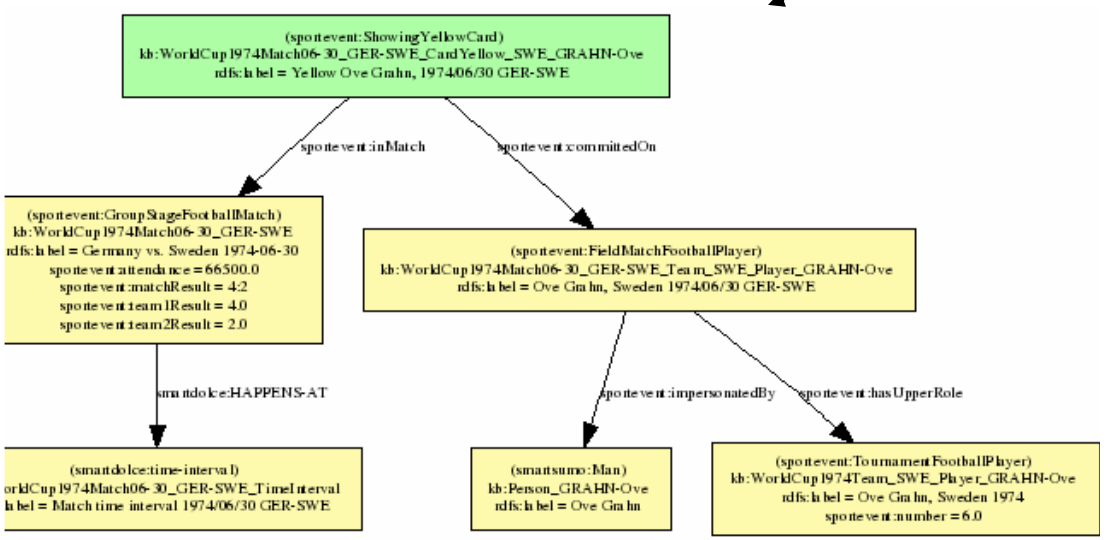
<kb:Person_GRAHN-Ove>, <rdf:type>, <smartsumo:Man>.
<kb:Person_JONSON-Mattias>, <rdf:type>, <smartsumo:Man>.
<kb:WorldCup1974Match06-30_GER-SWE>, <sportevent:matchResult>, "4:2".
<kb:WorldCup2006Match06-24_GER-SWE_CardYellow_SWE_JONSON-Mattias>, <rdf:type>, <sportevent:ShowingYellowCard>.
<kb:WorldCup2006Match06-24_GER-SWE_Team_SWE_Player_JONSON-Mattias>, <sportevent:impersonatedBy>, <kb:Person_JONSON-Mattias>.
<kb:2006-06-24_GER-SWE_TimeOffset48>, <rdf:type>, <sportevent:MatchTimePointRelative>.
<kb:WorldCup2006Match06-24_GER-SWE_CardYellow_SWE_LUCIC-Teddy>, <rdf:type>, <sportevent:ShowingYellowCard>.
<kb:Person_GRAHN-Ove>, <rdfs:label>, "Ove Grahn".
<kb:WorldCup2006Match06-24_GER-SWE_CardYellow_SWE_LUCIC-Teddy>, <rdfs:label>, "Yellow Teddy Lucic, 2006/06/24 GER-SWE".
<kb:WorldCup2006Match06-24_GER-SWE_Team_GER_Player_FRINGS-Torsten>, <rdf:type>, <sportevent:Midfielder>.
<kb:WorldCup2006Team_SWE_Player_JONSON-Mattias>, <rdf:type>, <sportevent:TournamentFootballPlayer>.
<kb:WorldCup2006Match06-24_GER-SWE>, <sportevent:attendance>, 66000.0.
<kb:WorldCup1974Match06-30_GER-SWE>, <sportevent:team2Result>, 2.0.
<kb:2006-06-24_GER-SWE_TimeOffset48>, <rdfs:label>, "Match minute 48 2006/06/24 GER-SWE".

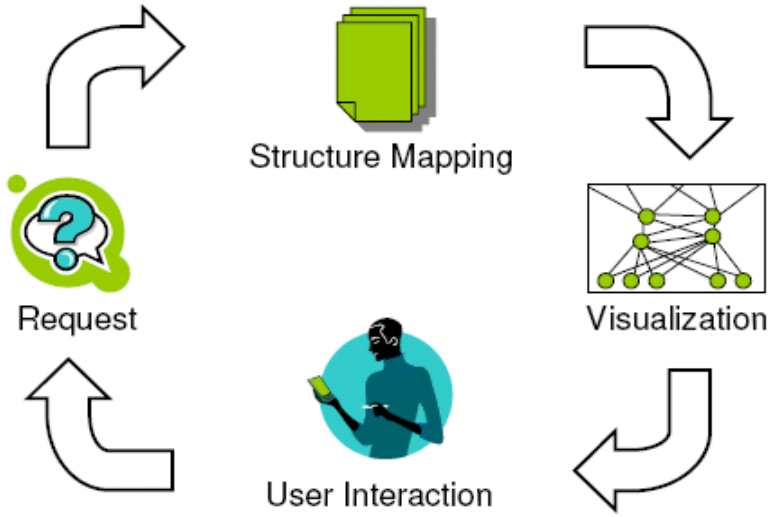
Proximity Graph Visualisation

- **Question:** *How many yellow cards have been shown in the match Germany against Sweden*?

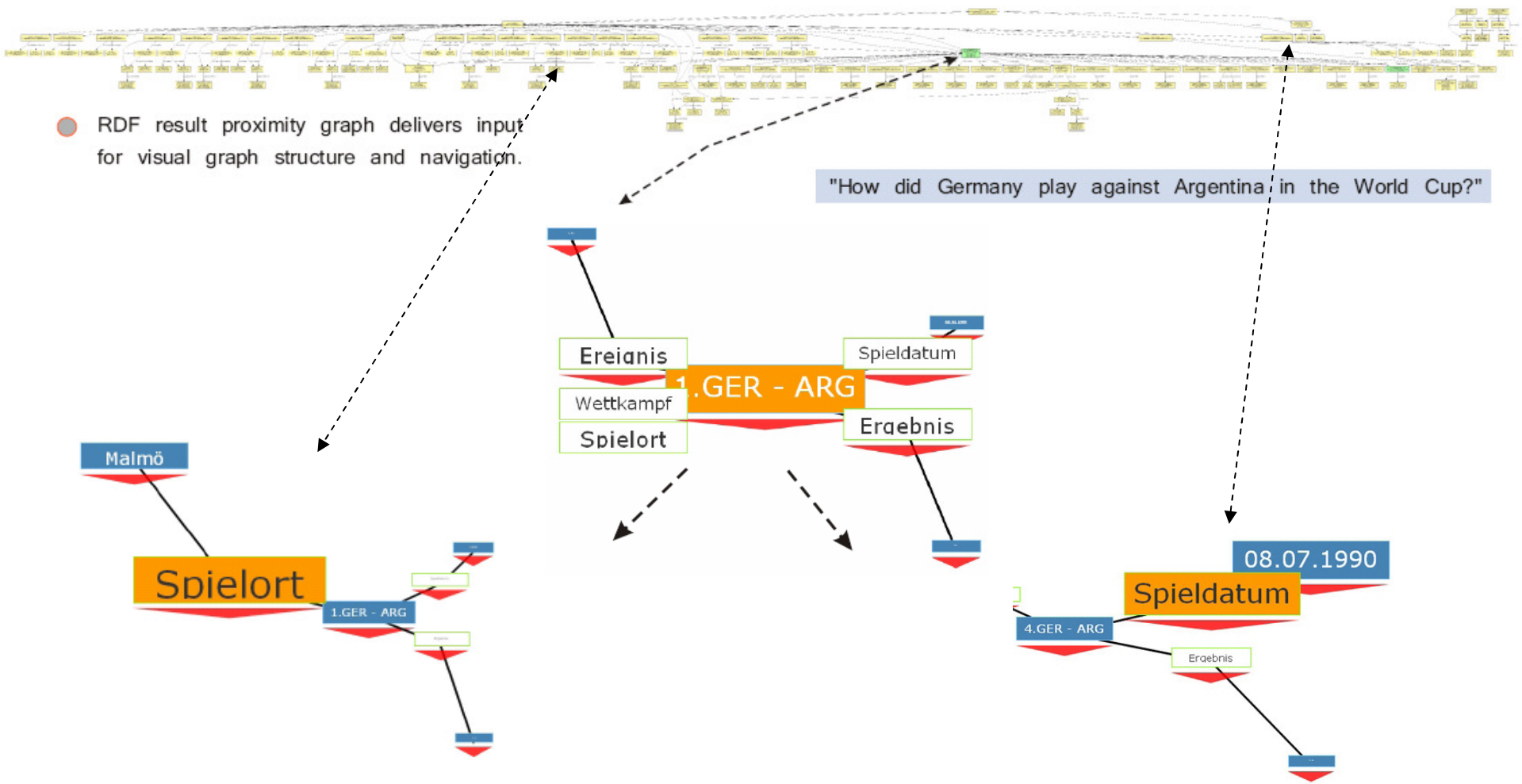
Answer:







Structure Mapping Example



Visualisation by Constraint Satisfaction

- Constraints for Graph Structure and Content
  - All vertices must be within fixed space on handheld.
  - Vertices must not overlap.
  - **Related vertices must be placed next to each other.**

- Aesthetic criteria (Soft Constraints)
  - Avoid edge crossings.
  - Keep edge length uniformly.
  - **Conform to user expectations.**

Constraint Satisfaction Problems

- CSP: set of variables and constraints on values.

  $X_1, X_2, ..., X_n$ $C_1, C_2, ..., C_m$

- CSP state and complete assignment: $\{X_i = v_i, X_j = v_j, ...\}$
- Refinement model:

  Variables are initially unconstrained; constraints are added as the computation unfolds, progressively refining the permissible values of the variables (reducing domain) until solution is found (forward checking + backtracking).

- Refinement model Java API:
  - Choco Constraint Programming System

    http://www.choco-solver.net

CSP Formulation Example

- Suitable representations for vertexes and constraints
  - Co-ordinates: (x_1, x_2) (y_1, y_2).
  - Discrete values according to fixed space on handheld (480x600)
  - Euclidian Distance Measure: $distance = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$

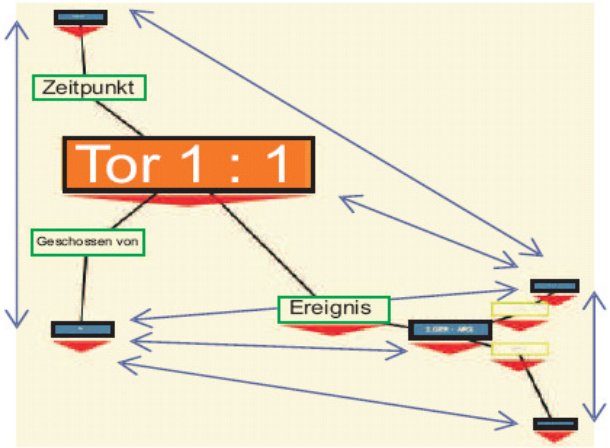
- Approximation by elementary calculation types:
  - No power/radial, no absolute values (perf. & API options)
  - Manhattan Distance (L1 Norm): $distance = |x_1 - x_2| + |y_1 - y_2|$
  - Algebraic minimisation constraint for node distance:

    $(|x_1 - x_2| > dist) \vee (|y_1 - y_2| > dist)$ reformulated to:

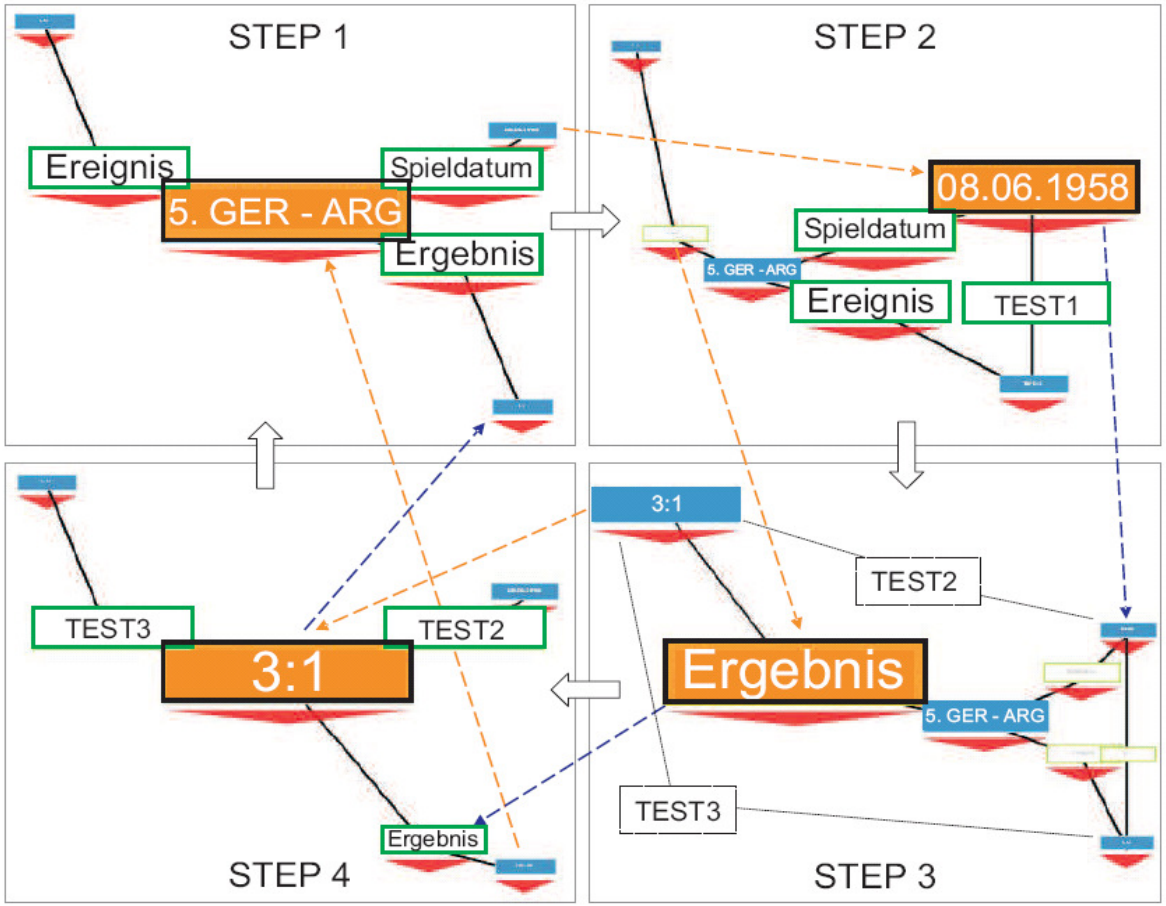
    $((x_1 - x_2) < -dist) \vee ((x_1 - x_2) > dist)$ ...

Soft Constraints and Limits

- No edge crossings, uniform edge length works.
- We can avoid inconsistent layouts by reducing the number of active instances, but sometimes no CSP solution exists.
- Smooth transitions between consecutive displays are hard to implement.



Handling of Inconsistencies



User Evaluation

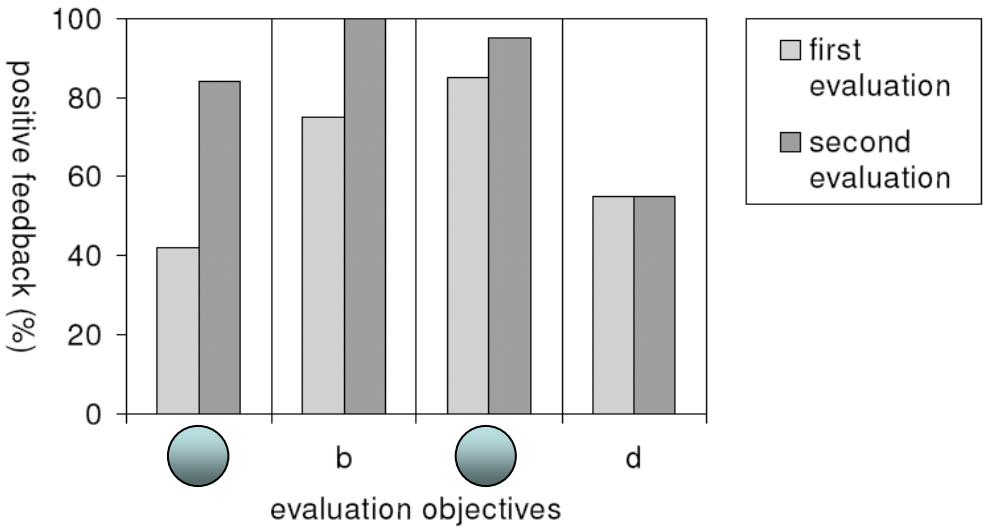
- Twenty users, two evaluation phases, four evaluation objectives.

(a): *Graph Interaction possibilities easy to understand*

(b): *It is possible to extract information from structure and labels.*

(c): *One gets the difference between a relation node and an instance node.*

(d): *User realises the dependencies between active instances. (Filtering)*

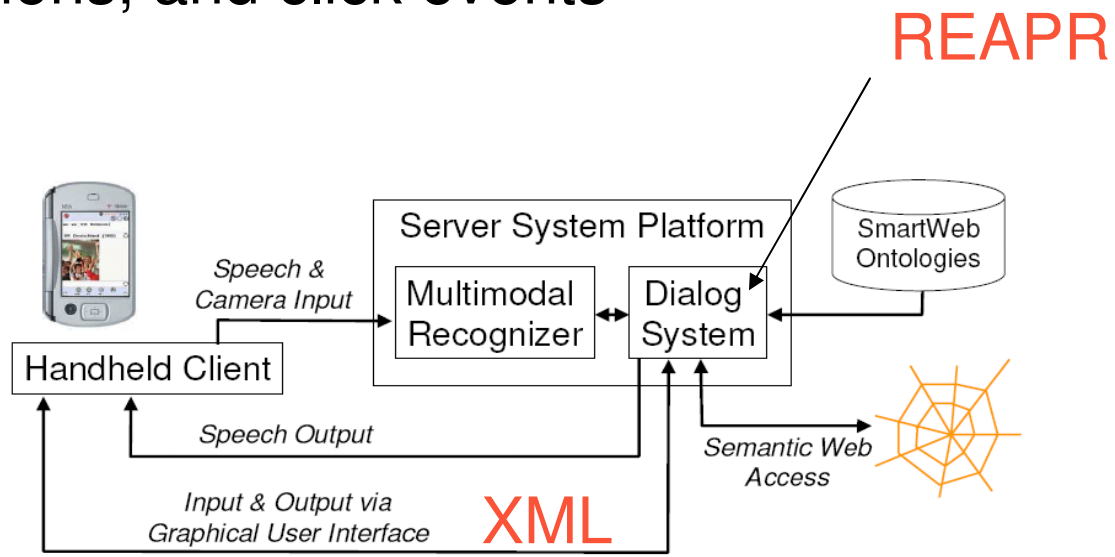


85% describe the interaction possibilities as easy to understand

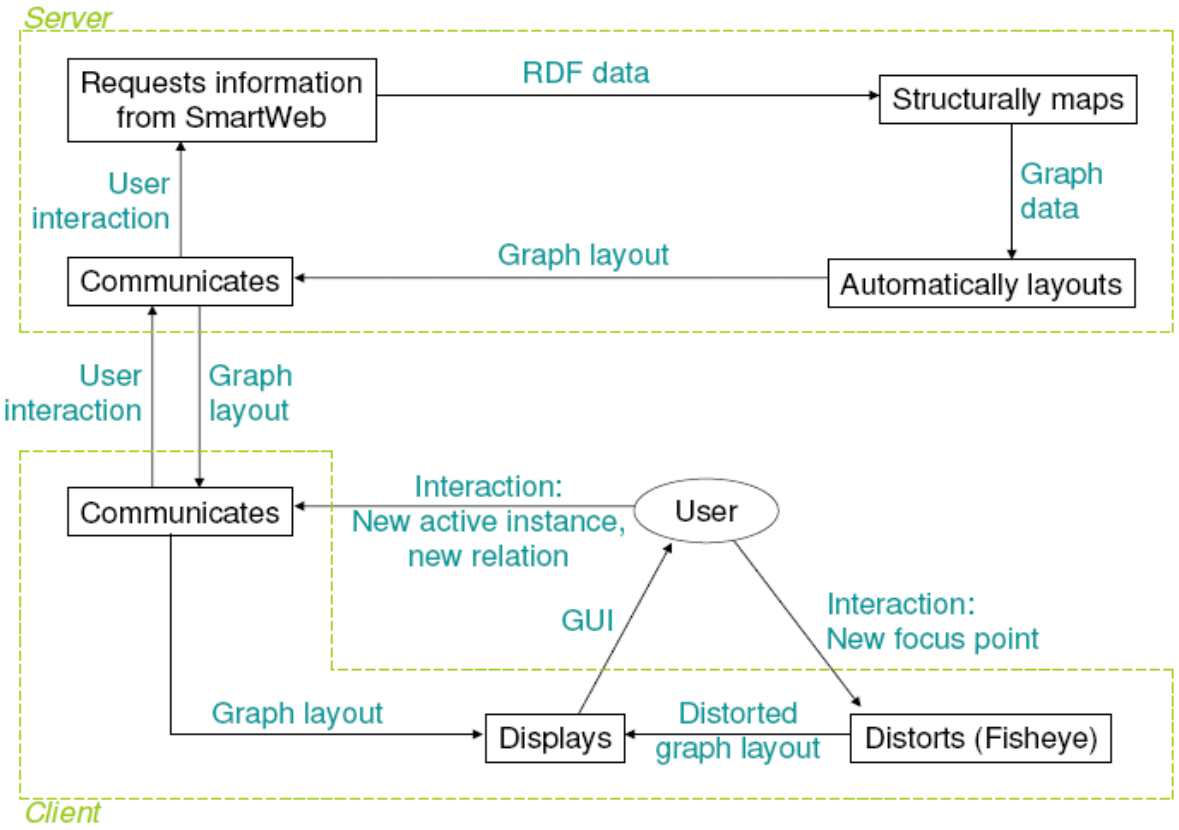
95% easily understand the difference between instance and relation nodes

Dialogue System Integration

- Semantic Navigation is embedded into a Reaction and Presentation component (REAPR).
- REAPR is a dialogue server module.
- Server Communication via XML for graph structure, node positions, and click events



Integration Architecture



Conlusions

- SmartWeb provides a useful distributed architecture for CSP based graph visualisation.
- The evaluation suggests that a user gets a more precise understanding of a presented QA + Navigation result in its whole complexity.

Directions

- Symmetric Multimodal Interaction for Semantic Graphs (Speech & Navigation).
  - Editing via concurrent pen and voice
- Information Filtering by User Personalisation
  - Logging click events + navigation events “tells a story”:
    - of individual exploration of knowledge space
    - group interests (-> *collaborative filtering*)

  -> **Individualised Information Presentation:**
    - **(Semantic) Information Design**
    - **(Semantic) Presentation Design**
    - **(Semantic) Interaction Design**

-Individual Semantic Desktop
-Different “conceptual” areas
-Desktop Information Interlinkage (based on RDF - OWL)
-**Multiple Focussed Natural Language and Multimedia Presentations**

-Where are suitable (RDF/OWL) APIs for information fusion, ontology mapping (access layer), and multimedia presentation generation (interaction layer)?

Please help!