the direct access of these online sources (via Web API connectors or SPARQL endpoint connectors), instead of maintaining a local RDF store where the other internal data sources for dialogue processing and multimodal dialogue remain (cf. the three-tier semantic search architecture in figure 4). The Linked Data Access delivers the following additional multimedia information about Miley Cirus (based on an appropriate mapping, the access to further music-related Linked Data sources is easily conceivable).

- DBpedia:

```
associatedBand:Jonas Brothers
background:''solo\_singer''
birthdate:1992-11-23
genre:Pop rock
```

- Jamendo: is a community collection of music all freely licensed under Creative Commons licenses. This data retrieval step provides information about image, home page, and the (home) location of Miley.
- MusicBrainz: provides data about Miley and albums, e.g., names, release titles, and track lists.

Integrated Dialogue Example

We will illustrate how Linked Data are integrated in a semantic/ontology-based QA dialogue and backend access. This demonstrates a new functionality for complex QA dialogue systems, where specific information about artists and multimedia material can be retrieved from backend sources including Linked Data sources, as well as being enriched by additional results. According to the following search pattern instantiation (this representation is based on the SPARQL Inferencing Notation SPIN), QA-based dialogue can be conducted. The following XML snippet represents a (shortened) query as it occurs in our system:

```
<object type="sp#Select">
  <slot name="sp#where">
    <object type="sp#Triple">
      <slot name="sp#subject">
        <object type="sp#Resource">
          <slot name="sp#hasUri">
            yago#Miley_Cyrus
          </slot>
        </object>
      </slot>
      <slot name="sp#predicate">
        <object type="sp#Resource">
          <slot name="sp#hasUri">
            yago#created</value>
          </slot>
        </object>
      </slot>
      <slot name="sp#object">
        <object type="sp#Variable">
          <slot name="sp#varName">
            <string>work</string>
          </slot> ...
```

Note that domain specific URIs are partially represented as literals—this is due to the fact that the query is generated from an internal representation using lightweight ontologies

Figure 8: Multitouch user interface, see (Sonntag, Deru, and Bergweiler 2009).

instead of the complete domain ontologies. In the TFS/ODP framework, unresolved references (with pointers to domain ontologies and facts) are not supported.

Results are represented in a similar fashion, using a TFS variant of the SPARQL result RDF syntax. In these results, links to domain ontologies are preserved and can be used in further dialogue actions. The natural interaction character of dialogue systems is thereby applied to Linked Data sources.

The ODP rule engine may be used to modify, enrich, and contextualise all the data contained in the TFS representations. Currently, this feature is used for several transformation steps but also for enriching primary results with additional information fetched from Linked Data sources.

Further interaction possibilities are shown in the following example dialogue. The dialogue described the power of speech-based interaction in the context of one of our demonstrator systems (Comet, see (Sonntag, Deru, and Bergweiler 2009)) which aims at the design and implementation of combined mobile and touchscreen-based multimodal Web 3.0 interfaces. The dialogue example shows the meta web service access to YouTube via the GAPI; figure 8 shows the multitouch user interface of the multimodal dialogue system at the application layer. Currently, the integration of Linked Data in the system is limited to providing additional complementary information only, but we will work on the extension of the role of Linked Data in the future.

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1. **U:** The user reads a semantic web page about musicians and puts, e.g., by a pointing gesture on the screen, Miley Cirus in focus.
2. **U:** "Which songs are from her?"
3. **S:** "I will search for song information about the artist: Miley Cirus"
4. **S:** ("I will search the Internet for a suitable answer.")
5. **S: "I found some singles from 2006."** (+ display of a short supportive text in the media screen)
6. **S: "There are some videos available from YouTube."** (+ display of a media screen)

Conclusion

We described a complex AI system architecture for dialogue-based question answering. In the context of ontology-based dialogue systems, we discussed some of the main issues, i.e., "representation" and "encapsulation". A comprehensive overview of ontology-based dialogue processing and the systematic realisation of these properties can be found in (Sonntag 2010), pp.71-131. "Trust/explanation" is a further issue, which comes into account when addressing Linked Data sources. Our dialogue-based solution is to inform the user about the information sources (or easy-to understand surrogates such as "the Internet") during the dialogue. In addition, heterogeneous *textual* answer snippets or multimedia material from Linked Data sources can be displayed as an additional information on a larger presentation screen, e.g., a touchscreen. Our semantic backend system integrates multiple linked data sources to allow for an advanced multimodal QA dialogue thereby combining service composition with general semantic mediation of heterogeneous information sources. This allows us to combine data and knowledge retrieval with information and multimedia retrieval. Our impression is that data stemming from Linked Data sources should be treated as stemming from a new answer stream which we named *Remote Linked Data Source*. Future dialogue systems build upon the multimodal speech-based discourse and dialogue infrastructure. A first industrial dissemination of the Linked Data access for a radiologist is planned (Sonntag, Wennerberg, and Zillner 2010).

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