> Semantic Web Use Cases and Case Studies

Case Study: Composing a Safer Drug Regimen for each Patient with Semantic Web Technologies

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General Description

Drug safety is on America's mind, and their computers. According to Harris Interactive, a subsidiary of Harris Polls, 100 Million Americans visit healthcare web sites multiple times each month searching for drug side effect and interaction information, yet say their needs are largely unmet. But they're not paranoid; over 200 thousand deaths each year result from adverse drug events, while three-quarters of those deaths are believed avoidable if only existing knowledge could be effectively applied. The barrier is complexity on an astronomical scale: to identify a safer drug regimen for the typical senior requires searching through a space of indicated regimens that, by comparison, outnumbers the web pages Google searches 1,000 to 1. Plus, a single criterion is insufficient to guide the selection of a safer regimen; one drug presents a lower incidence of bladder inflammation but a higher risk of bleeding from the digestive tract; another drug reduces the risk of abdominal bleeding but presents a higher risk of bladder inflammation. Other factors, including effectiveness of therapy for a given condition, patient-friendly features, such as infrequent dosing and small pill size, and the fact that most people over the age of 40 are on multi-drug regimens, all greatly compound these trade-offs. Given this complexity it's surprising that the loss of life is not even higher.

PharmaSURVEYOR enables the navigation of this complex space and identifies the best trade-offs for each patient. The PharmaSURVEY shown in Figure 1 provides two safety optimized profiles, each of which provides better options for the patient.

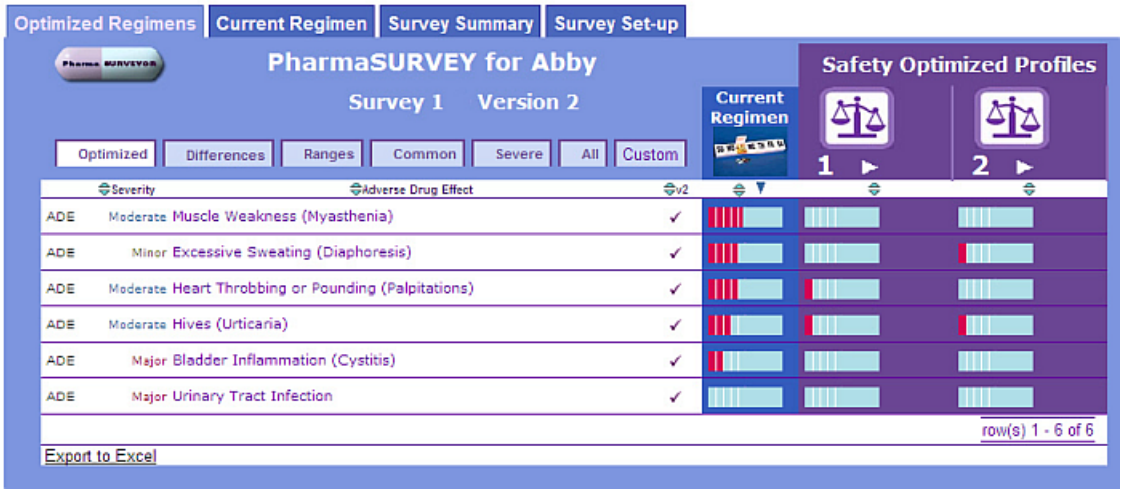

Figure 1: PharmaSURVEYOR provides safety optimized profiles—each of which contains multiple drug regimens—treatment options optimized with respect to the patient's safety concerns

Both profiles significantly improve upon the safety of her current drug regimen with respect to her safety concerns, either eliminating the risk of an adverse drug event, e.g., muscle weakness, or minimizing the risk where it can't be eliminated, e.g., hives. However the patient and her physician face a choice: is it more important to eliminate the risk of moderate heart palpitations or eliminate the risk of minor excessive sweating, as this is an unavoidable trade-off in treating her conditions. Note also that the patient may have an undiagnosed primary condition: she reports a major urinary tract infection but data obtained from FDA approved randomize clinical drug trials suggests her current drug regimen poses no risk for such an infection as an adverse event.

A Semantic Web ontology to specify medical conditions

To enable a patient's drug regimen to be entered along with the conditions being treated we are developing an ontology of medical conditions, and signs and symptoms that is patient-friendly both in its terminology and in how its terms and concepts are organized and accessed. The Semantic Web languages RDF and OWL provide a standardized, interoperable form for this ontology, enabling its collaborative development, maintenance and access from multiple, diverse applications. While mappings to SNOMED and other existing medical vocabularies are planned, the new ontology will go beyond a mere taxonomy, providing lateral as well as hierarchical relationships, with access to granular conditions via multiple classifications.

Represent evolving data structures with Semantic Web triples

To identify a safer drug regimen from the vast number of indicated regimens is not a mere "search" problem, as one needs to discover the respective trade-offs between the different options, which are unknown at the outset. A technical consequence of this lack of *a priori* knowledge is that programming objects of

fixed type, and database relations with a static schema, simply do not work; they must evolve. The Semantic Web enables continuous type/schema evolution as drug regimens are tuned and safety concerns revealed, which is why we embraced this technical approach.

Unify Semantic Web ontologies with relational data

Relational databases are the de facto standard for data management, form processing and report generation. The underlying technology of PharmaSURVEYOR enables seamless bi-directional movement between database relations, relational views and Semantic Web ontologies managed as triples, thus achieving the best of both worlds – the scalability and pervasiveness of relational with the expressivity, agility and inference of the Semantic Web.

Enable data sharing with Semantic Web ontologies

We are building a community of collaborating patients, physicians, pharmacists, Pharma, researchers and payers. It is therefore crucial that data be made available in a form that is both *accessible* and *meaningful* across these diverse sub-communities. Semantic Web technologies satisfy both of these requirements; XML serializations of RDF(S) and OWL using web-centric resource identifiers enable shared access, and the formal semantics of these ontology languages enable shared meaning.

Benefits of using Semantic Web technologies

- Web access to resources enabled by URI-based naming
- Non-ambiguous inference via OWL's formal semantics
- Dynamic schema evolution enabled by Semantic Web triple format
- Facile knowledge exchange via RDF(S) and OWL
- Numerous choices for the management of Semantic Web knowledge

Conclusion

As Ted Codd, the father of the relational model said, the quest to represent the meaning of data is never-ending. Semantic Web technologies have advanced this quest dramatically. Using the Semantic Web, we now have the power to greatly improve the safety of drug treatments, providing benefit to all members of the community, including patients and their family members, physicians, pharmacists, Pharma, payers and drug discovery researchers.