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Perspective:

On scalability of the Semantic Web

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Although people believe that both the Semantic Web (SW) and SW applications scale up, we have to make sure we know what they mean by 'scale up' in order to properly understand the research on the SW. It is definitely true that the data on the World Wide Web (WWW) scales up. It is also true that Linked Data scales up. How about the SW data? If it does, in what sense does it?

Let us look back at the history of knowledge bases and investigate expert systems to understand in what sense knowledge bases in expert systems did not scale up. A couple of critical issues in expert systems include the fact that it is very hard to build a very large knowledge base, and it is also hard to maintain it. So, people cannot hope to build an expert system which covers most of the tasks operated within a company. This is why people say "Expert systems do not scale up".

Note here, however, that people might miss an important factor in expert systems. That is, expert systems have very high functionality to solve real world problems faster than human experts with compatible performance. High functionality is what people want to realize because it helps them solve daily problems. So, what they long for is such an ideal system that has high functionality which covers almost all tasks in the respective domains where they work (Fig. 1). If we do not care about the functionality, it is not difficult for us to build a knowledge base that scales up because they just have to collect relevant data and build a huge database. The problem is that such a knowledge base cannot be called a knowledge base and is rarely useful for solving problems, since what people can do with it is to find relevant data, and hence it has only low functionality.

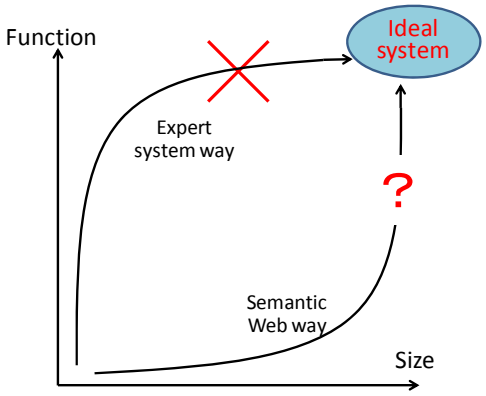

Fig. 1 Scalability of two technologies

Turning to the WWW and SW, in what sense do people believe they scale up? As far as I know, they scale up but functionality is quite low. What people can do with the WWW and SW is essentially 'information finding'. So, if we compare expert systems and WWW/SW with respect to scalability in a fair way, it would be as follows: WWW/SW scale up, but only if low functionality can be acceptable, and there is no guarantee if they scale up with reasonably high functionality. This is what I want to claim by Fig. 1. The above observation suggests that we need to pay more attention to functionality when talking about the scalability issue. More concretely, it would not make sense to claim "This and that scale up" without discussing its functionality.

Now, we discuss the implication of this. I believe it is beneficial for us to investigate what functionality we would expect in the context of WWW/SW applications. Fig. 2 is prepared for discussing this topic. In Fig. 2, functionality is replaced with computational

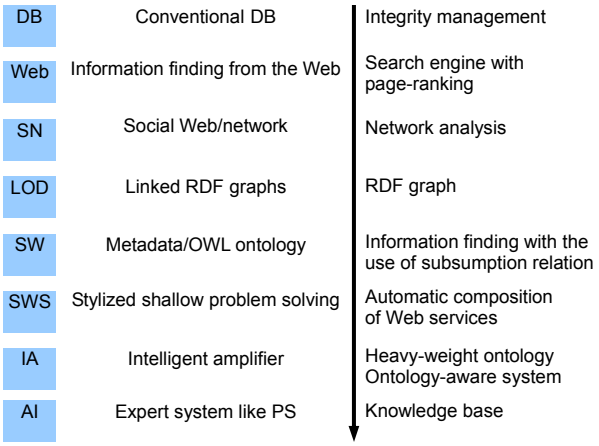

Fig. 2 Depth of the semantic level of computation
DB: database; SN: social network; LOD: Linked Open Data; SW: Semantic Web; SWS: SW Services; IA: intelligent amplifier; AI: artificial intelligence; PS: production system

semantics. Of course, they are not equivalent in general. However, high functionality usually requires deep semantics in computation/inference. They are roughly proportional. Furthermore, we can compare between depths of computational semantics more easily than between the degree of the height of functionality. Anyway, typical applications are placed along the vertical axis according to their depth of computational semantics. The shallowest application is data retrieval from databases and the deepest is the knowledge base for problem solvers like expert systems. From top to bottom, deeper applications are placed one by one. Data retrieval from a database needs little semantics but pure syntactic processes. The next shallowest one is information finding in the WWW in which we need the page-ranking algorithm which requires evaluation of the importance of Web pages by reference analysis. The next is the social Web, which requires network analysis followed by Linked Open Data (LOD), which requires a schema for retrieval of Resource Description Framework (RDF) data. The next is the SW, which requires metadata using ontology and simple reasoning in terms of subsumption relations, part-of relations, etc. Down to SW, tasks involved are still information finding, though required computational semantics is deepened step by step.

The research on Semantic Web Services (SWS) is a bit different from those explained earlier in that its function is not just information (Web services) finding but also producing a new Web service by combining Web services found, like automatic program synthesis which requires fairly high functionality. The next one requiring higher functionality than SWS is the so-called intelligent amplifier (IA) system in which I have been deeply involved. The one requiring the highest functionality is of course expert systems.

As I discussed already, we learned that expert systems do not scale up if we keep their high functionality. From the top, down to the SW, they scale up but their functionality is quite low. So, my question is what do we really want? Most SW researchers seem to believe anything that scales up is good. But, I am afraid such a criterion does not work well. I strongly believe we have to ponder on what we really want and on whether or not it is something that scales up with reasonably high functionality. If so, then we have to seriously investigate how we can pursue the two conflicting goals, scalability and high functionality, at the same time. This would open our eyes to a new research direction.

Recommended reading

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