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### Use Case: Using Semantic Web and Proof Technologies to Reduce Errors in Radiological Procedure Orders

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*Helen Chen and Jos de Roo, Agfa Healthcare*

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#### General Description

The obvious benefits of radiological procedures often come with harmful side effects and high costs. Common misuse of radiology includes investigations that are unnecessary or too frequently, investigations that result in little or no impact on patient management, and wrong investigations. In each case, the patient may be subjected unnecessarily to irradiation and scarce medical resources are wasted.

Clinical guidelines and referral criteria have been established to assist clinicians in determining the appropriate radiological procedures for specific clinical circumstances. For this very purpose, "The Radiation Protection 118 – Referral Guideline for Imaging"<sup>1</sup> is published by the European Union and a series of Appropriateness Criteria<sup>2</sup> are published by American College of Radiology.

Significant effort has been devoted to representing such guidelines and protocols in a machine-executable and interoperable format<sup>3</sup>. However, the adaptation of these frameworks has not moved beyond their development community. This is because the high cost of translating the text-based guidelines to a machine-executable format and the requirement for a proprietary guideline execution engine have hindered the wider adaptation of existing computerized guideline systems, and the reusability of computerized medical knowledge. Furthermore, the latency of updating guidelines to reflect new modalities and radiology protocols reduces the usability and credibility of the published guidelines and protocols.

Semantic web technology provides an open, standards-based, computer-interpretable and executable framework on which the clinical guidelines and protocols can be published. In such an environment, we do not assume all knowledge needed for clinical decision support systems are contained in one proprietary repository, and in a non-standardized format. Instead, we envisage a web of connected knowledge bases; with each piece representing a type of knowledge that is developed and maintained by appropriate bodies. Figure 1 illustrates the key pieces of knowledge needed for a radiological order entry system. Elements of general clinical knowledge are shown in the upper section of the diagram, and the localization rules are shown in the lower section of the diagram.

We use Resource Description Framework (RDF)<sup>4</sup> and Web Ontology Language (OWL)<sup>5</sup> to transform the Appropriateness Criteria<sup>2</sup> into a machine-readable medical knowledge base using ontologies. The ontology (radGuideline) we use associates clinical problems with preferred investigations, and captures in rules the recommendations and comments that contain the imperative wisdom of the medical community. RadGuideline enables the reuse of existing medical knowledge by linking this specialized information with other medical ontologies such as SNOMED CT<sup>6</sup>, ACR Codea<sup>7</sup> and some OBO ontologies<sup>8</sup>, which enables a standard description of clinical problems and the patient condition.

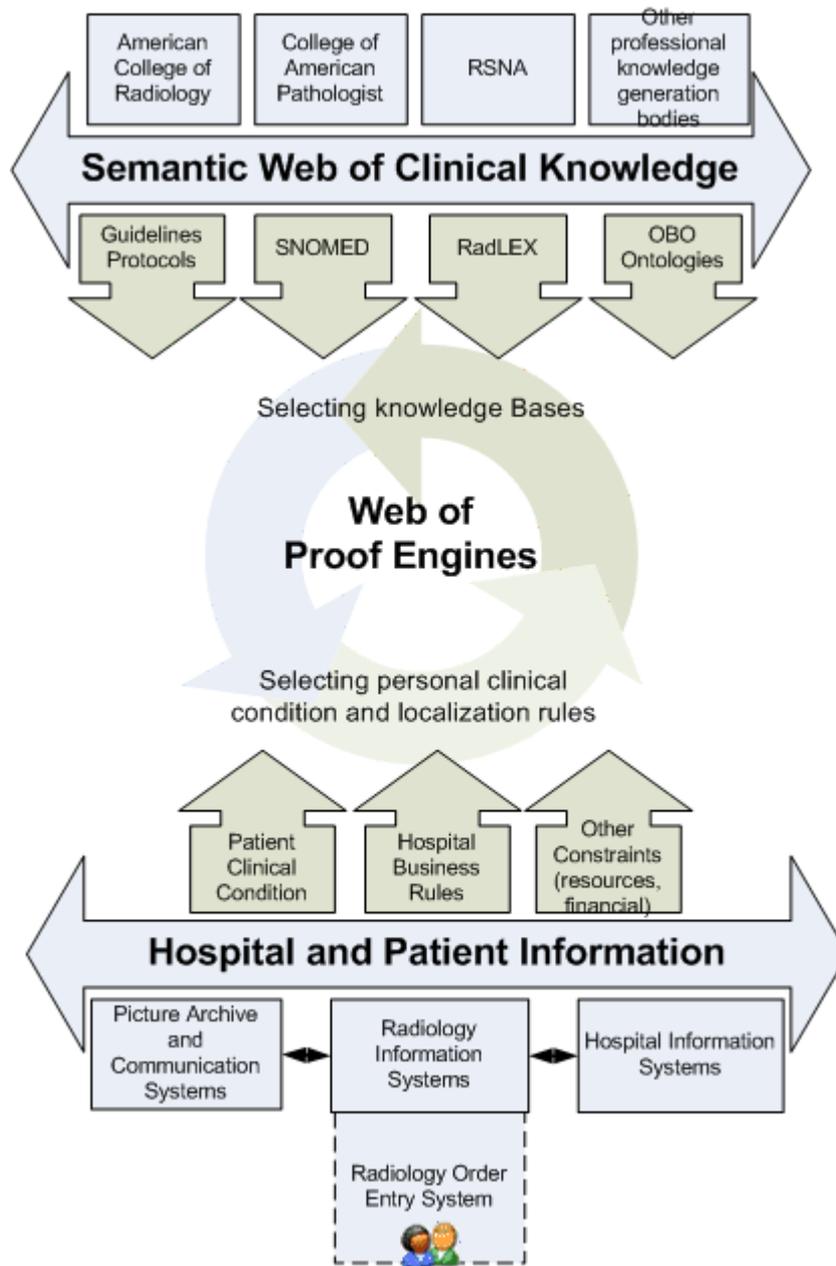


Figure 1: Web of Knowledge for Radiology Order Entry System

Semantic web rule engines such as CWM<sup>9</sup> and Euler<sup>10</sup> are able to generate recommendations for radiology orders and proofs based on the given patient conditions (medical history and physical condition) and a set of rules derived from the Referral Guidelines<sup>1</sup> or Appropriateness Criteria<sup>2</sup>.

The true potential of this approach is its ability to integrate cross-domain knowledge and data seamlessly on explicit and unambiguous terms expressed in ontologies. The explanations generated by proof engines provide evidence to clinicians for a decision. The approach can even provide alternative solution. The final decision is still in the hands of a clinician, but making such key information and evidence readily available is extremely important when there are such large volumes of data to consider. This approach can help to prevent medical errors that are caused by physicians overlooking vital facts.

### Key Benefits of Using Semantic Web Technology

- Supports a natural separation of general medical knowledge captured in the Appropriateness Criteria (guidelines), and the adaptation rules that denote local and execution context. This separation allows knowledge bases to be developed

and validated by professional bodies. These knowledge bases end up having better credibility and are easier to keep up to date.

- A standards-based, application neutral platform, for expressing and connecting to the existing corpus of knowledge.
- Ease the burden of developing and maintaining a “complete” knowledge base by one medical organization or vendor.
- Ability to trace the provenance of facts and rules used in medical decision-making, and providing explanation and proof. This is very important in the healthcare domain.

## References

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