APPROVAL SHEET

Title of Dissertation: ***BayesOWL***: A Probabilistic Framework for Uncertainty in Semantic Web

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Doctor of Philosophy, 2005

Dissertation and Abstract Approved: _____

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Z. Ding, ***BayesOWL****: A Probabilistic Framework for Uncertainty in Semantic Web*, Computer Science Doctoral Dissertation, University of Maryland, Baltimore County, December 2005.

Z. Ding, Y. Peng, and R. Pan: "***BayesOWL***: Uncertainty Modeling in Semantic Web Ontologies", book chapter to be appeared in "Soft Computing in Ontologies and Semantic Web", to be published by Springer-Verlag, in the series "Studies in Fuzziness and Soft Computing".

L. Ding, P. Kolari, Z. Ding, and S. Avancha: "Using Ontologies in the Semantic Web: A Survey", book chapter to be appeared in "Ontologies in the Context of Information Systems", to be published by Springer-Verlag, Oct. 15, 2005. (Also as UMBC Technical Report TR-CS-05-07, July 2005.)

R. Pan, Z. Ding, Y. Yu, and Y. Peng: "A Bayesian Network Approach to Ontology Mapping", to be appeared in the *Proceedings of ISWC 2005*. Galway, Ireland, Nov. 6 – Nov. 10, 2005.

Y. Peng and Z. Ding: "Modifying Bayesian Networks by Probability Constraints", in the Proceedings of UAI 2005. Edinburgh, Scotland, July 26 – July 29, 2005.

Z. Ding, Y. Peng, R. Pan, and Y. Yu: "A Bayesian Methodology towards Automatic Ontology Mapping", in the *Proceedings of First International Workshop on "Contexts and Ontologies: Theory, Practice and Applications"*, held in AAAI-05. Pittsburgh, PA, July 9, 2005.

Z. Ding, Y. Peng, and R. Pan: "A Bayesian Approach to Uncertainty Modeling in OWL Ontology", in the *Proceedings of 2004 International Conference on Advances in Intelligent Systems - Theory and Applications (AISTA2004)*. Luxembourg, Nov. 2004.

Z. Ding and Y. Peng: "A Probabilistic Extension to Ontology Language OWL", in the *Proceedings of the 37th Hawaii International Conference on System Sciences (HICSS-37)*. Big Island, Hawaii, Jan. 2004.

L. Ding, T. Finin, Y. Shi, Y. Zou, Z. Ding, and R. Pan: "Strategies and Heuristics used by the UMBCTAC Agent in the third Trading Agent Competition", in the *Workshop on "Trading Agent Design and Analysis"*, held in IJCAI-2003. Acapulco, Mexico, Aug. 2003.

L. Ding, Y. Shi, Z. Ding, R. Pan, and T. Finin: "UMBCTAC: A Balanced Bidding Agent". UMBC Technical Report TR-02-15, 2002.

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Abstract

Title of Dissertation: ***BayesOWL***: A Probabilistic Framework for Uncertainty in Semantic Web

Zhongli Ding, Doctor of Philosophy, 2005

Dissertation directed by:

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To address the difficult but important problem of modeling uncertainty in semantic web, this research takes a probabilistic approach and develops a theoretical framework, named ***BayesOWL***, that incorporates the Bayesian network (BN), a widely used graphic model for probabilistic interdependency, into the web ontology language OWL. This framework consists of three key components: 1) a representation of probabilistic constraints as OWL statements; 2) a set of structural translation rules and procedures that converts an OWL taxonomy ontology into a BN directed acyclic graph (DAG); and 3) a method ***SD-IPFP*** based on "iterative proportional fitting procedure" (IPFP) that incorporates available probability constraints into the conditional probability tables (CPTs) of the translated BN. The translated BN, which preserves the semantics of the original ontology and is consistent with all the given probability constraints, can support ontology reasoning, both within and cross ontologies, as Bayesian inferences, with more accurate and more plausible results.

SD-IPFP was further developed into ***D-IPFP***, a general approach for modifying BNs with probabilistic constraints that goes beyond ***BayesOWL***. To empirically validate this

theoretical work, both ***BayesOWL*** and variations of IPFP have been implemented and tested with example ontologies and probabilistic constraints. The tests confirmed theoretical analysis.

The major advantages of ***BayesOWL*** over existing methods are: 1) it is non-intrusive and flexible, neither OWL nor ontologies defined in OWL need to be modified and one can translate either the entire ontology or part of it into BN depending on the needs; 2) it separates the "rdfs:subClassOf" relations (or the subsumption hierarchy) from other logical relations by using L-Nodes, which makes CPTs of the translated BN smaller and easier to construct in a systematic and disciplined way, especially in a domain with rich logical relations; 3) it does not require availability of complete conditional probability distributions, pieces of probability information can be incorporated into the translated BN in a consistent fashion. One thing to emphasize is that ***BayesOWL*** can be easily extended to handle other ontology representation formalisms (syntax is not important, semantic matters), if not using OWL.

BayesOWL: A Probabilistic Framework for Uncertainty in Semantic Web

by
Zhongli Ding

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To all my family members, for supporting me and loving me all the time.