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بسم الله الرحمن الرحيم

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Developing Environment Tools for Collaborative Ontology Evolution

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Abstract

In an era where data is considered the new oil, the lack of meaning and well-defined data structure will lead to interoperability and usability problems. Ontologies are a representation paradigm to capture and represent the knowledge of a universe of discourse and structure it in a machine-comprehensible format. However, developing ontologies can be a time-consuming, expensive process and requires a significant investment, which is challenging to make by a single person or organization. An effective approach to tackling this problem is building ontologies collaboratively where all interested stakeholders are involved. It includes identifying the main terms and concepts by finding a consensus among stakeholders while defining a shared terminology and formalizing it for the intended domain.

The process of jointly building ontologies in distributed environments, which we refer to as collaborative ontology development, aims to accomplish shared objectives and extensive coordination of activities. Ontologies are instrumental in this process by providing formal specifications of shared semantics. In this "complex" and dynamic setting, a collaborative change process model requires more powerful engineering, argumentation, and negotiation methodologies.

In fact, the main challenge for stakeholders is to work collaboratively on a shared objective constructively and efficiently while avoiding misunderstandings, uncertainty, and ambiguity. The involved stakeholders, which may be geographically distributed, should easily express and integrate their diverse views and ideas without risking losing the original intention. Researchers have presented methodologies and platforms to allow ontology construction in various scenarios. However, there is still little understanding of and support for the evolutionary aspects of ontologies. This is particularly crucial in distributed and collaborative settings such as the Semantic Web, where ontologies naturally co-evolve with their communities of use.

Software Engineering offers many techniques and tools for teams' collaboration, teams' management, feedback management, versioning, merging, and evolving software artifacts. Many of these techniques can be reused in an ontology engineering setting. Scrum/Nexus/Spotify are Frameworks that enable iterative and incremental product development. This thesis leverages these frameworks and maps them to the collaborative, inter-organizational domain ontology building and evolution. Besides, we adopted software measurement criteria as a candidate evaluation framework for ontology quality assessment.

Another challenge exists as to how humans can see, imagine and understand the knowledge captured in different domains. The knowledge experts and teams need to analyze the quality of ontologies generated in collaborative environments quickly. They must have tools that provide them with a set of metrics and charts that let them know which parts of the ontology have problems, how to enhance some other parts, the complexity and memory consumption if we wish to traverse this ontology with the inference engine and so on. To overcome this severe problem, we adopted a set of software insights and architectural analysis techniques that significantly impact ontology building, evolution, evaluation, and review process. We visualized all the calculations of the ontology evaluation metrics described in the previous point using many interactive tools to instantly assimilate and understand a broad set of ontologies properties, problems and proposed enhancements.

Still, however, the Semantic Web is an incomplete dream to build domain ontologies on a broad scale of worldwide teams, agents, research centers and organizations. However, a homogeneous revolutionary platform as a network of Blockchains could be the solution to this. Our thesis proposed a new model to build or evolve the ontologies via worldwide consensus through the blockchain network. However, using a blockchain alone is not enough. The exact Blockchain chosen, the consensus mechanisms used, and the architecture of the voting (consensus) platform are all critical design decisions that impact system capabilities. Our thesis described architectural concerns for robust, upgradable, multi-user smart contracts used by WOL to fulfill the collaboration socio-technical requirements and all the required features to accomplish a true collaborative ontology evolution process.

Yet, there are several criteria to validate or evaluate an ontology. To do that, and as a pioneering thinking model in this research, we let each node apply its automatic or semi-automatic way of validation on the transaction. If we think about this, if each research center, company, or even an individual one, has a validation mechanism, all of these nodes will be challenged on a global scope to prove the robustness and efficiency of their automatic validation and evaluation mechanisms. We called this phenomenon "***Survival of the Fittest***." According to the Blockchain consensus algorithm(s), that transaction must be validated by 51% of the nodes or validated by quorums at the next nomination to be considered a valid transaction. Once a node gets a consensus on the transaction, the algorithm will reward this node with some reputation wealth credit. **This will steer** the research effort to enhance automatic or semi-automatic ontology validation and evaluation mechanisms. In addition, since we are rewarding the nodes or quorums by credit, the most powerful and fittest validation and evaluation techniques will survive for a longer time and will be got famous after a while.

Keywords: Ontology Engineering, Ontology Evolution, Cooperative, Inter-Organizational, Collaboration, Scrum, Nexus, Spotify, Agile, Metrics, KPIs, Visualizations, Blockchain, Platform, Consensus, Automatic Validation and Evaluation, Nodes, Transaction, Ledger.

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List of Publications

Published Work

1. W. Mohsen, M. Aref and K. ElBahnasy, "Software metrics for cooperative scrum based ontology analysis," 2017 2nd International Conference on Knowledge Engineering and Applications (ICKEA), London, 2017, pp. 60-70. DOI: 10.1109/ICKEA.2017.8169903

2. Wa'el Mohsen, Mostafa Aref, and Khaled ElBahnasy. 2020. Blockchain as a Platform for Collaborative Ontology Evolution. In Proceedings of the 2020 The 6th International Conference on Frontiers of Educational Technologies (ICFET 2020). Association for Computing Machinery, New York, NY, USA, 183–190. DOI:https://doi.org/10.1145/3404709.3404769

3. Wa'el Mohsen, Mostafa Aref, and Khaled ElBahnasy. 2020. Scaled Scrum Framework for Cooperative Domain Ontology Evolution. In Proceedings of the 2020 The 6th International Conference on Frontiers of Educational Technologies (ICFET 2020). Association for Computing Machinery, New York, NY, USA, 135–143. DOI:https://doi.org/10.1145/3404709.3404770

4. Wa'el Mohsen, Mostafa Aref, and Khaled ElBahnasy. 2020. Cooperative Domain Ontology Reduction Based on Power Sets. In Proceedings of the 2020 The 6th International Conference on Frontiers of Educational Technologies (ICFET 2020). Association for Computing Machinery, New York, NY, USA, 196–203. DOI:https://doi.org/10.1145/3404709.3404771.

5. Wa'el Mohsen, Mostafa Aref, and Khaled ElBahnasy. "Cooperative Domain Ontology Reduction Based on Rough Sets.", International Journal of Computer Science and Mobile Computing, Vol.9 Issue.5, May- 2020, pg. 163-174 IJCSMC.

6. Research Presentation: "*The Scrum Framework for Cooperative Ontology Evolution*" at The Thirteenth International Conference on Technology, Knowledge and Society University of Toronto, Toronto, Canada 26-28 May 2017. Presenting Author: W. Mohsen.
    - URL: https://ubi-learn.com/assets/downloads/T17-Q17FinalProgram.pdf

7. Research Presentation: "***Software metrics for cooperative scrum based ontology analysis***" at The *International Conference on Knowledge Engineering and Applications (ICKEA)*, London, 2017. Presenting Author: W. Mohsen.
    - http://toc.proceedings.com/37331webtoc.pdf

Under Review Work

1. W. Mohsen, M. Aref and K. ElBahnasy, "***Worldwide Ontology Ledger (WOL) based Stellar Consensus Protocol***," in IEEE Transactions on Knowledge and Data Engineering.
    - https://ieeexplore.ieee.org/xpl/aboutJournal.jsp?punumber=69
2. W. Mohsen, M. Aref and K. ElBahnasy, "***Worldwide Ontology Ledger (WOL) based hybrid Consensus Protocols***," in IEEE Transactions on Knowledge and Data Engineering.
    - https://ieeexplore.ieee.org/xpl/aboutJournal.jsp?punumber=69

Contents

List of Abbreviations

Acronym	Full Definition
ADIT-LN	Average Depth of Inheritance Tree of Leaf Nodes
AFRC	Fanout Of Root Class
AI	Artificial Intelligence
AKA	As Known As
ALM	Application Lifecycle Management
AR	Attribute Richness
ASCM	Architectural Software Component Model
AVAI	Average Value of Axiom Inconsistencies
BFT	Byzantine Fault-Tolerant
BPEL	Business Process Execution Language
CB	Continuously Building
CBO	Coupling Between Object Classes
CD	Continuous Delivery
CDL	Change Definition Language
CI	Continuous Integration
CID	Class in Degree
COD	Class Out-Degree
COH	Cohesion. No. Of Separate Connected Components in The Instances
Connectivity	No. Of Relationships Between Instances
CR	Class Richness
CVA	Close Vocabulary Assumption
CyclC	Cyclomatic Complexity
DApp	Decentralized Application
DAO	Decentralized Autonomous Organization
DAS	Data Access Service
DaSM	Dependency and Structure Modeling
DCP	Distributed Consensus Protocol
DILIGENT	DIstributed, Loosely controlled and evolvInG Engineering processes of oNTologies
DIT	Depth of Inheritance
DL	Description Logic
DSM	Design Structure Matrix
DTO	Data Transfer Object

DTs	Decision Table
EC	Evolutionary Computation
EOG	Entropy of Graph
ESB	Enterprise Service Bus
FBA	Federated Byzantine Agreement
FL	Fuzzy Logic
GEA	Governance Enterprise Architecture
GKSB	Government Knowledge Service Bus
HIT	Inheritance Tree
HTML	Hyper Text Markup Language
HTTP	HyperText Transfer Protocol
IBIS	Issues as elements of information systems
IDE	Integrated Development Environment
Imp	Importance
IOO	Inter-Organizational Ontology
IRC	Inheritance Richness
IRS	Inheritance Richness of The Schema
IS	Information System
ITF	Identity Trust Fabric
JSON	JavaScript Object Notation
KPI	Key Performance Indicators
LCO	Lower Common Ontology
LCOM	Lack of Cohesion of Methods
MoJ	Ministry of Justice
MoL	Ministry of Labor
NEC	Number of External Classes
NIC	National Information Center
NMIS	No. Of Minimal Inconsistent Subsets
Noc	No. Of Classes
NoF	Number of Fanout
NoL	No. Of Leaf Classes
NoP	No. Of Properties
NoOP	No. Of Ontology Partitions
NoRC	No. Of Root Classes
NOR	Number of Roots
OAF	Ontology Abstraction Framework

OE	Ontology Evolution
OLM	Ontology Lifecycle Management
OO	Organizational Ontology
OTBASS	**O**ntology **T**echnology-**B**ased **A**gile **S**caled **S**crum
OVA	Open Vocabulary Assumption
OVN	Open Vote Network
OWL	Web Ontology Language
PBFT	Practical Byzantine Fault Tolerance
PoA	Proof-of-Authority
PoB	Proof-of-Burn
PoET	Proof-Of-Elapsed-Time
PoS	Proof-of-Stake
PoVR	Proof-Of-Validation-Reputation
PoW	Proof-of-Work
PR	Probabilistic Reasoning
PSM	Problem-Solving Matrix
P2P	Peer-To-Peer Network
QLDB	Quantum Ledger Database
R2ML	REWERSE Rule Markup Language
RDF	Resource Description Framework
REC	Reference to External Classes
RFC	Response to Class
RFU	Rule Finding Uniqueness
RIF	Rule Interchange Format
RKB	Refined Knowledge Base
RR	Relationship Richness
RST	Rough Set Theory
SC	Sum of The Number of Subclasses
SCA	Service Component Architecture
SCC	Separate Connected Components
SCP	Stellar Consensus Protocol
SDO	Service Data Object
SOV	Size of Vocabulary
SWRL	Semantic Web Rule Language
TFS	Team Foundation Server
UCO	Upper Common Ontology