Extracting Ontologies from Terminological Databases

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Contents

1. Abstract

- *A structural definition-based terminology (SDBT) defines terms on the basis of properties structured by conceptual categories (classes).*
- *When a SDBT is extracted from a relational database into RDF, inference rules can be generated for use in complex semantic search by SPARQL query.*
- *Complex SPARQL queries that leverage these rules can yield better results than simple keyword queries, reflecting the logical combination of semantically related terms.*
- *With their basis in ontologies so generated, SDBT can be used to index databases for retrieval and to mine informal big data through the application of well-defined semantic concepts.*

2. Structural Definition-Based Terminology (SDBT)

2.1 What is a SDBT?

- *A SDBT defines terms on the basis of properties that are structured by conceptual categories (classes).*
  1. *Terms are sorted by conceptual categories (classes).*
  2. *Terms are defined by properties structured by classes.*
  3. *Relationships among terms and properties are built by vocabularies.*

2.2 Requirements of SDBT

1. *Taxonomy of conceptual categories*
   - *Hierarchical classification of conceptual categories (classes) of terms having the same properties.*
2. *Properties of conceptual categories*
   - *The conceptual category (class) is structured by properties.*
   - *Structured properties of a class is a metadata schema of the class.*
3. *Vocabulary terms (VT) for relationship among terms and properties*
   - *Relationships among terms and properties are built by vocabulary terms.*

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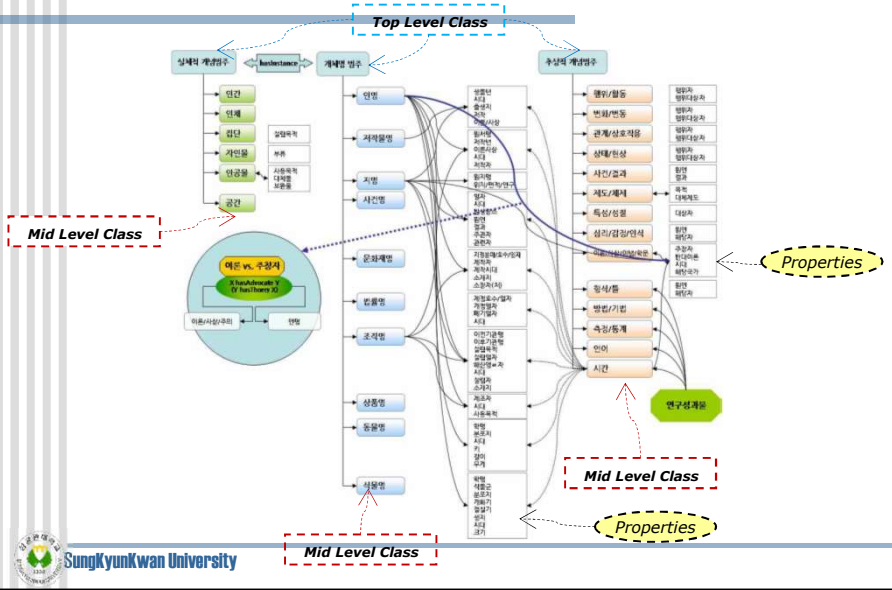
2.3 Conceptual Model of SDBT (1/2)



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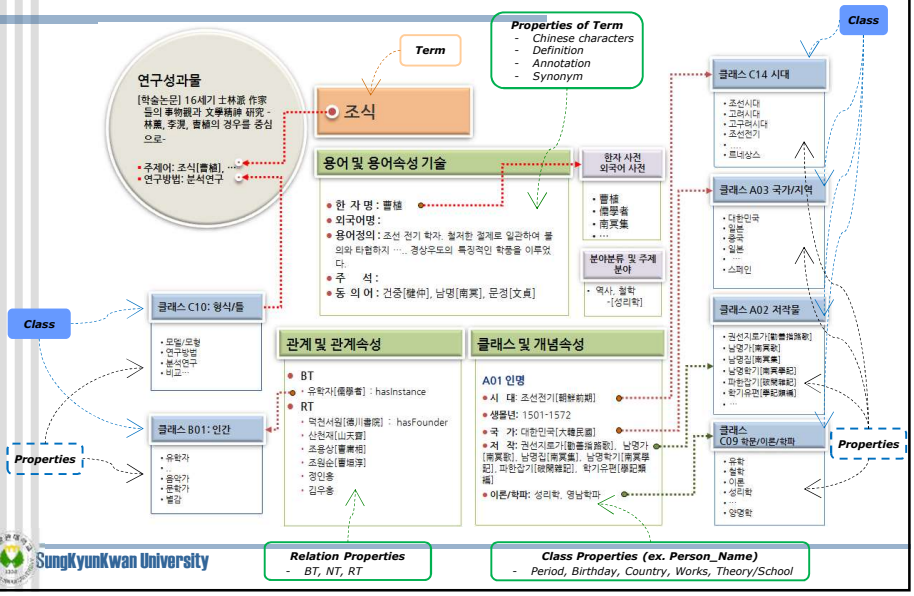
2.3 Conceptual Model of SDBT (2/2)



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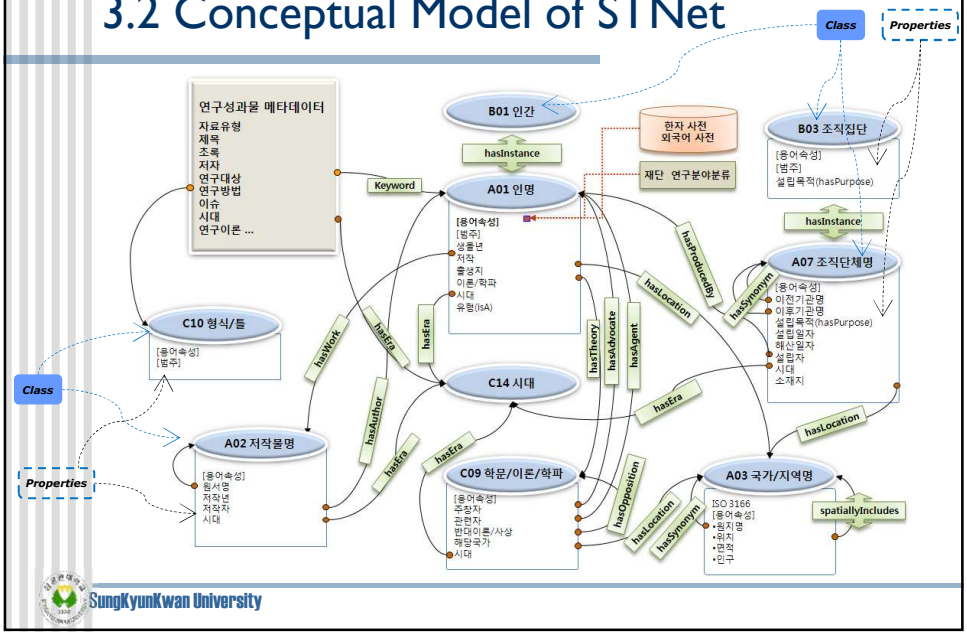
3. How to build a SDBT Database

3.1 Example: STNet Project

- *STNet project*
  - *Funded by NRF (National Research Foundation of Korea) for 3 years from Sep. 2012 to Aug. 2015 for constructing STNet database.*
- *STNet database*
  - *Constructed for keywords from journal articles in the fields of the humanities and social sciences in KCI.*
  - *There are 55,236 structural definition-based academic terms in the STNet database.*

Division	Current situation	
Number of terms		55,236
Number of data in properties	Object type	72,839
	Code type	7,251
	Text type	18,733
	Subtotal	98,823
Number of links between terms by relation predicates	Equivalent relationships	21,982
	Hierarchical relationships	66,995
	Associative relationships	120,724
	Subtotal	209,701

3.2 Conceptual Model of STNet



3.3 STNet Taxonomy (1/3)

- *STNet taxonomy consists of seven top-level classes, 27 middle level classes and 143 lower level classes.*
  - *A: Object*
  - *B: Action/Function*
  - *C: Property*
  - *D: Theory/Method*
  - *E: Format/Framework*
  - *X: General/Common*
  - *Y: Instance*
- *Lower level classes is subdivided into the first lower level and the second lower level.*
- *Each class has a code and a class name.*

3.3 STNet Taxonomy (2/3)

Appendix A. STNet Taxonomy.

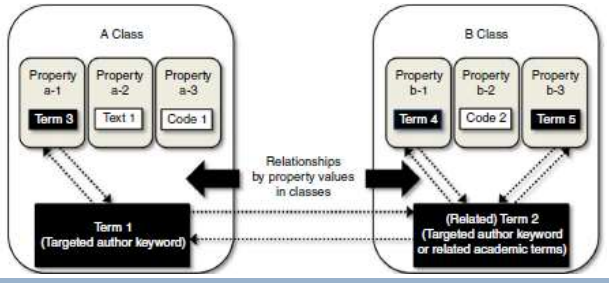
Top level classes	Mid-level classes	Lower level classes	
		1st lower level	2nd lower level
A_Object	A01_Human	a01-02_Biological_Character	a01-02-01_Gender
			a01-02-02_Age
		a01-03_Human_Relations	a01-03-01_Kinship
			a01-03-02_Personal_Relationship
		a01-04_Social_Group	a01-04-01_Ethnic_Ratial_Group
			a01-04-02_National_Groups
			a01-04-03_Residence_Situation
			a01-04-04_Social_Class
			a01-04-05_Generation
			a01-04-06_Community
			a01-04-07_Family_Name
		a01-05_ People_with_Ability_Tendency	a01-05-01_Gifted_People
			a01-05-02_ People_with_Disabilities_Illnesses
			a01-05-03_People_with_Tendency
		a01-06_Occupation_Status_Role	a01-06-01_Occupation
			a01-06-02_Status_Government_Post
			a01-06-03_Role
		a01-07_Semi-Human	
		a01-08_Physical_Body	a01-08-01_Body_Organs
			a01-08-02_Substance
			a01-08-03_Disorders_Diseases
	A02_Institution_Organization	a02-01_Administrative_Agency_Public_Institution	
		a02-02_Educational_Institution	
		a02-03_Enterprise_Company	
		a02-04_Social_Religious_Organization_Group	
	A03_Natural_Object	a03-01_Animals	
		a03-02_Plants	
		a03-03_Nature_Mineral	

3.3 STNet Taxonomy (3/3)

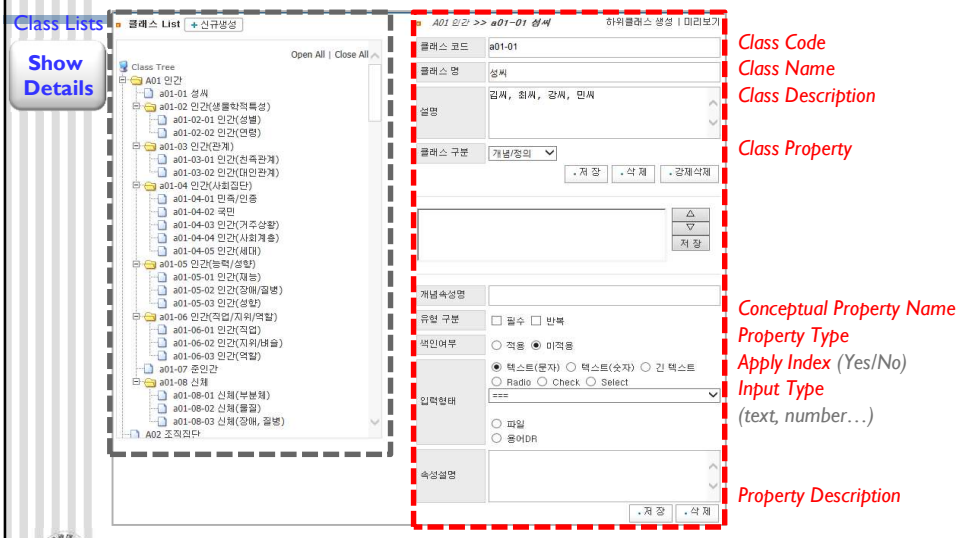
	D04_Technique_Strategy	d04-02_Evaluation_Analysis	
		d04-03_Teaching_Learning_Method	
		d04-04_Strategy_Tactics	
E_Format /Framework	E01_Form_Type_Style_Genre	e01-01_Literature_Genre	
		e01-02_Music_Genre	
		e01-03_Genre_of_Fine_Art_Design	
		e01-04_Type_of_Sports_Recreations	
		e01-05_Performing_Art	
	E02_Model_Criteria	e02-01_Model	
		e02-02_Pattern	
		e02-03_Criteria_Regulation_Qualification	
		e02-04_Standard	
		e02-05_Infrastructure_Structure_Scope	
		e02-06_Symbol_Sign	
	E03_Languages	e03-01_Language_Letter	
		e03-02_Languages_by_Countries	
	E04_Space	e04-01_Artificial_Space	
		e04-02_Ideological_Space	
		e04-03_Natural_Space	
X_General /Common	X01_Place_Name	x01-01_Name_of_Continent_Peninsula	
		x01-02_Name_of_Countries	
		x01-03_Name_of_State_City_Town_Street_Avenue	
		x01-04_Name_of_Mountains	
		x01-05_Name_of_Ocean_River_Lake	
		x01-06_Name_of_Constellation_Astronomical_Phenomena	
	X02_Period_Time	x02-01_Period	
		x02-02_Term	
		x02-03_Time	
	X03_Relationship_Interaction	x03-01_Origin_Derivation	
		x03-02_Comparison_Distinction	
		x03-03_Class_Grade_Line	
		x03-05_Cause_and_Effect	x03-05-01_Cause_Condition_Element
			x03-05-02_Result
			x03-05-03_Effect_Impact

3.4 STNet Properties

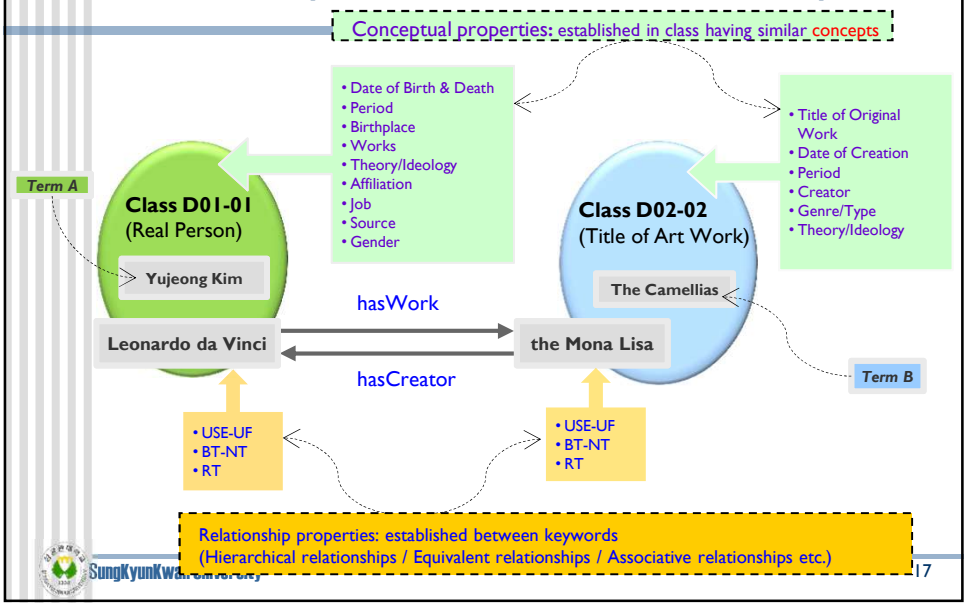
- *Each class is structured by (conceptual) properties that represent that class.*
- *Each property has a value that can be divided into "object type," "code type," or "text type."*
- *Among them, an object type value represents an input terminology in the STNet database.*



3.5 Definition by Properties in STNet



3.6 Conceptual Model of Relationships



3.7 STNet vocabulary (1/2)

- *STNet vocabulary consists 95 relation predicates (vocabulary terms: vt).*
- *STNet terms connect to the other terms that are used by property values of that class or that belong to other classes.*
- *In other words, the term that belongs to the "Title_of_Literature" class has a relationship with the values in properties of that class, such as "hasCreator" or "hasPublicationYear."*
  - *For example, The Diary of a Young Girl: Anne Frank*
    - *The term of "Title_of_Literature" class has connections with "Anne Frank" of the "has Creator" property and "1947" of the "hasPublicationYear" property.*
    - *Additionally, The Diary of a Young Girl: Anne Frank term can have an interrelationship with the "World War II" term in another "Event Name" class through a relation predicate, such as "isAffectedBy↔affects."*

3.7 STNet Vocabulary (2/2)

Appendix B. STNet Relation Predicates.

Classification		The Name of Relation	The Name of Inverse Relation
Equivalent Relationship	Synonym	UF	USE
	Prior & Later name	PT	LT
Hierarchical Relationship	Subordinate	NT	BT
		hasKind	isKindOf
	Whole-Part	hasBranch	isBranchOf
		hasComponent	isComponentOf
		hasMember	isMemberOf
		containsSubstance	isSubstanceOf
		hasIngredient	isIngredientOf
		spatiallyIncludes	isSpatiallyIncludedIn
	Concept-Instance	hasInstance	isInstanceOf
Associative Relationship	Conceptual	RT	
		RT_X	RT_Y
		hasIssue	isIssueIn
		isConceptualyRelatedTo	isConceptOf
		hasPhenomenon	isPhenomenonOf
		basesOn	isBaseFor
		affects	isAffectedBy
		hasProperty	isPropertyOf
		hasPurpose	isPurposeOf
		hasResult	isCausedBy
		hasSubject	isSubjectIn
		originatesFrom	isOriginOf
		hasProcess	isProcessOf
		hasPatient	hasAgent
		hasState	isStateOf
		hasDegree	isDegreeOf
		isTributaryOf	hasTributary
	Functional	applys	isAppliedTo
		hasOpposition	isOppositionOf
		hasMeasurement	isMeasurementOf
		manages	isManagedBy
		analyzes	isAnalyzedBy
		evaluates	isEvaluatedBy
		hasMethod	isMethodOf
		produces	isProducedBy

3.8 Relationships by VT in STNet

Relationship Lists

Show Details

Group of Relationships
Relationship Name(Eng)
Relationship Name(Kor)
Inverse Relationship Name
Relationship Property
Relationship Description

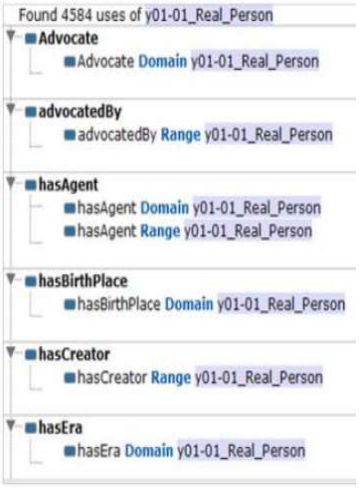
4. Extracting Ontology from SDBT Database

4.1 Setting up Ontology Classes & OWL Properties

- *Ontology classes are composed in the form of OWL-DL based on the conceptual scopes in the STNet.*
- *"ObjectType Properties" and 40 "DataType Properties" are defined by analyzing the types of relations among input terminologies in STNet.*
- *In the case of "ObjectType Property,"*
  - *We set up the "InverseOf" and "Reflexive" relations, and "Domain" and "Range" according to the structure of the properties of classes.*
  - *We also accorded "Range" such as String, DateTime, and Integer to "DataType Property" by referring values (code or text) to properties in the STNet.*

4.2 Construction of Axiom Sets

- *Applied ontology schema completed with verification of ontology structure to the STNet instance data.*
- *After verifying errors about data, constructed axiom sets about all classes in the STNet.*
- *Examples of connections with "Domain" or "Range"*
  - *When the "y01-01 Real_Person" class has connections with other related classes having property values such as "Advocate ↔advocatedBy", "hasBirthPlace ↔isBirthPlaceOf," & "hasEra ↔isActivityPeriodOf."*



4.3 Converting STNet Data into RDF

- *Convert the STNet RDB Data into RDF ontology using the D2R server.*
  - *At the start of this process, define target data and set up property values about that data.*
  - *Then, use converted scripts in D2RQ form to convert RDB data into RDF data.*
  - *Additionally, after creating the D2RQ (2016) mapping languages, check and modify the errors regarding target data through "d2rQuery," provided by the D2R Server.*

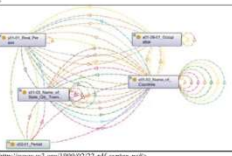
4.4 Definition of Inference Rules

- *To define generalized inference control rules for the STNet, set up inference control rules based on the types of classes and properties that contained above-average (24 or more) data after calculating the sorts and the numeral values of input data in the form of "Subject(X class) ↔ Predicate(Property) ↔ Object(Y Class)" regarding STNet data imported in the process of ontology conversion.*
- *The reason is to make efficient rules that could minimize logical errors in the process of terminology searching because one term can belong to the many classes, and the property values in X class can connect with many related Y classes.*
  - *For example, input terms in the "hasWork" property of the "Real_Person" class can belong to "Title_of_Works," "Title_of_Literature," "Monument_Name_Cultural_Asset_Name," "Performing_Arts," "Title_of_Documents," and so on.*

4.5 SPARQL Queries and Search Results

- *Extracted SPARQL query results for the very complicated search scenarios for which it was too difficult to deduce a result value via a simple keyword search.*
  - *Scenario 1:*
    - *[Real_Person] was born in [Name_Of_State_City_Town / Name_Of_Countries] with the nationality of [Name_Of_Countries] and was active in the period of [Period] as a [Occupation].*
  - *Scenario 2:*
    - *[Theory_Thought] advocated by [Real_Person] is opposed to [Theory_Thought 2] advocated by [Real_Person 2], and [Theory_Thought] is also related to [Theory_Thought 3] and [Concept_Definition]. [Concept_Definition] advocated by [Real_Person 3] is related to [Period] amd [Name_Of_ Countries].*
  - *Scenario 3:*
  - *Scenario 4:*
  - *Scenario 5:*
  - *Scenario 6:*
  - *Scenario 7:*

4.5.1 Search Result of Scenario 1

Scenario 1	[Real_Person] was born in [Name_of_State_City_Town/Name_of_Countries] with the nationality of [Name_of_Countries] and was active in the period of [Period] as a [Occupation].
Ontology Structure	

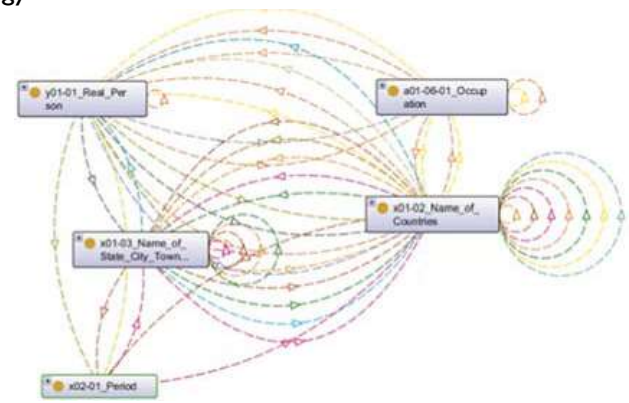
SPARQL Query	PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
	PREFIX owl: <http://www.w3.org/2002/07/owl#>
	PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
	PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
	PREFIX : <http://www.stnet.re.kr/ontology#>
	
	SELECT ?Location1 ?Nationality ?Era ?Job ?Person
	
	WHERE {
	?Location1 rdf:type :x01-03_Name_of_State_City_Town_Street_Avenue.
	?Nationality rdf:type :x01-02_Name_of_Countries.
	?Era rdf:type :x02-01_Period.
	?Person rdf:type :y01-01_Real_Person.
	?Job rdf:type :a01-06-01_Occupation.
	?Person :hasBirthPlace ?Location1.
	?Person :hasNationality ?Nationality.
	?Person :hasEra ?Era.
	?Person :hasJob ?Job.
	}

Query Results	

Scenario 1 - *Ontology Structure*

※ *Scenario 1: [Real_Person] was born in [Name_Of_State_City_Town / Name_Of_Countries] with the nationality of [Name_Of_Countries] and was active in the period of [Period] as a [Occupation].*

- *Ontology Structure:*



Scenario 1 – *SPARQL Query*

※ *Scenario 1: [Real_Person] was born in [Name_Of_State_City_Town / Name_Of_Countries] with the nationality of [Name_Of_Countries] and was active in the period of [Period] as a [Occupation].*

- ***SPARQL Query :***

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/02/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX: <http://www.stnet.re.kr/ontology#>

SELECT ?Location1?Nationality ?Era ?Job ?Person

WHERE {
        ?Location1 rdf:type :x01-03_Name_of_State_City_Town_Street_Avenue.
        ?Nationality ref:type :x01-02_Name_of_Countries.
        ?Era ref:type :x02-01_Period.
        ?Person ref:type :y01-01_Real_Person.
        ?Jod rdf:type :a01-06-01_Occupation.
        ?Person :hasBirthPlace ?Location1.
        ?Person :hasNationality ?Nationality.
        ?Person :hasEra ?Era.
        ?Person :hasJob ?Job.
}
```

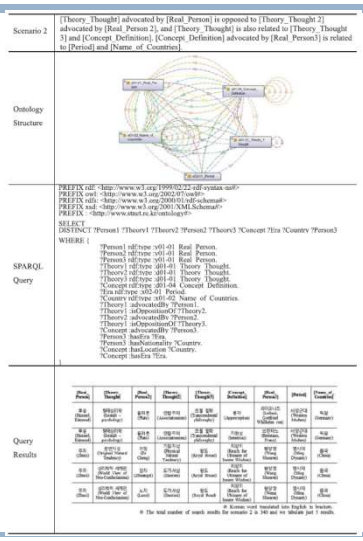

Scenario 1 – *Query Results*

※ *Scenario 1: [Real_Person] was born in [Name_Of_State_City_Town / Name_Of_Countries] with the nationality of [Name_Of_Countries] and was active in the period of [Period] as a [Occupation].*

[Name_Of_State_City_Town (Name_Of_Countries)]	[Name_Of_Countries]	[Period]	[Occupation]	[Real_Person]
경기도 (Gyeonggi-do)	대한민국 (Republic of Korea)	일제강점기 (Japanese Colonized Period)	교수 (Professor)	이선근 (Lee, Seongeun)
강원도 (Gangwon-do)	대한민국 (Republic of Korea)	일제강점기 (Japanese Colonized Period)	정치인 (Politician)	조일명 (Cho, Ilmyeong)
원산 (Wonsan-si)	북한 (North Korea)	일제강점기 (Japanese Colonized Period)	극작가 (Play Writer)	박영호 (Park, Yeongho)
성주군 (Seongju-gun)	대한민국 (Republic of Korea)	일제강점기 (Japanese Colonized Period)	정치인 (Politician)	김창숙 (Kim, Changsuk)
청양 (Cheongyang-gun)	북한 (North Korea)	일제강점기 (Japanese Colonized Period)	연극배우 (Play Actor)	황철 (Hwang, Chul)

※ Korean word translated into English in brackets.
※ 461 search results for scenario 1: just 5 results tabulated.

4.5.2 Search Result of Scenario 2



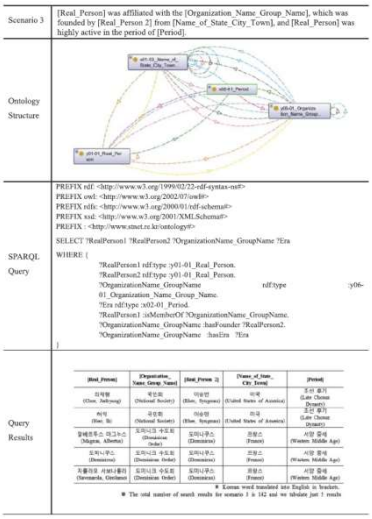
Scenario 2 – *Query Results*

※ *Scenario 2: [Theory_Thought] advocated by [Real_Person] is opposed to [Theory_Thought 2] advocated by [Real_Person 2], and [Theory_Thought] is also related to [Theory_Thought 3] and [Concept_Definition]. [Concept_Definition] advocated by [Real_Person 3] is related to [Period] and [Name Of Countries].*

[Real_Person]	[Theory_Thought]	[Real_Person2]	[Theory_Thought2]	[Theory_Thought3]	[Concept_Definition]	[Real_Person3]	[Period]	[Name_Of_Countries]
후설 (Husserl, Edmund)	형태심리학(Gestalt-psychology)	플라톤 (Plato)	연합주의 (Associationism)	초월 철학 (Transcendental philosophy)	통각 (Apperception)	라이프니즈 (Leibniz, Gottfried Whilhelm von)	서양근대 (Western Modern)	독일 (Germany)
후설 (Husserl, Edmund)	형태심리학(Gestalt-psychology)	플라톤 (Plato)	연합주의 (Associationism)	초월 철학 (Transcendental philosophy)	지향성 (Intention)	브렌타노 (Brentano, Franz)	서양근대 (Western Modern)	독일 (Germany)
주자 (Zhuxi)	본연지성 (Original Natural Tendency)	이정 (Er Cheng)	기질지성 (Physical Natural Tendency)	왕도 (Royal Road)	치양지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	명시대 (Ming Dynasty)	중국 (China)
주자 (Zhuxi)	성리학적 세계관 (World View of Neo-Confucianism)	장자 (Zhuangzi)	도가사상 (Daoism)	왕도 (Royal Road)	치양지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	명시대 (Ming Dynasty)	중국 (China)
주자 (Zhuxi)	성리학적 세계관 (World View of Neo-Confucianism)	노자 (Laozi)	도가사상 (Daoism)	왕도 (Royal Road)	치양지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	명시대 (Ming Dynasty)	중국 (China)

※ Korean word translated into English in brackets.
※ 340 search results for scenario 2: just 5 results tabulated.

4.5.3 Search Result of Scenario 3



Scenario 3	[Real_Person] was affiliated with the [Organization_Name_Group_Name], which was founded by [Real_Person 2] from [Name_of_State_City_Town], and [Real_Person] was highly active in the period of [Period].
Ontology Structure	

SPARQL Query	PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
	PREFIX owl: <http://www.w3.org/2002/07/owl#>
	PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
	PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
	PREFIX : <http://www.sinet.re.kr/ontology#>
	SELECT ?RealPerson1 ?RealPerson2 ?OrganizationName_GroupName ?Era
	WHERE {
	?RealPerson1 rdf:type :y01-01_Real_Person.
	?RealPerson2 rdf:type :y01-01_Real_Person.
	?OrganizationName_GroupName rdf:type :y06-01_Organization_Name_Group_Name.
	?Era rdf:type :y02-01_Period.
	?RealPerson1 :isMemberOf ?OrganizationName_GroupName.
	?OrganizationName_GroupName :hasFounder ?RealPerson2.
	?OrganizationName_GroupName :hasEra ?Era
	}

Query Results	

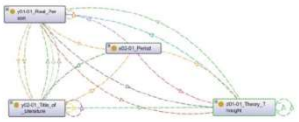
Scenario 3 – *Query Results*

※ *Scenario 3: [Real_Person] was affiliated with the [Organization_Name_Group_Name], which was founded by [Real_Person 2] from [Name_Of_State_City_Town], and [Real_Person] was highly active in the period of [Period].*

[Real_Person]	[Organization_Name_Group_Name]	[Real_Person 2]	[Name_Of_State_City_Town]	[Period]
최재형 (Choe, Jaehyung)	국민회 (National Society)	이승만 (Rhee, Syngman)	미국 (United States of America)	조선 후기 (Late Chosun Dynasty)
허익 (Heo, Ik)	국민회 (National Society)	이승만 (Rhee, Syngman)	미국 (United States of America)	조선 후기 (Late Chosun Dynasty)
알베르투스 마그누스 (Magnus, Albertus)	도미니크 수도회 (Dominican Order)	도미니쿠스 (Dominicus)	프랑스 (France)	서양 중세 (Western Middle Age)
도미니쿠스 (Dominicus)	도미니크 수도회 (Dominican Order)	도미니쿠스 (Dominicus)	프랑스 (France)	서양 중세 (Western Middle Age)
지롤라모 사보나롤라 (Savonarola, Girolamo)	도미니크 수도회 (Dominican Order)	도미니쿠스 (Dominicus)	프랑스 (France)	서양 중세 (Western Middle Age)

※ Korean word translated into English in brackets.
※ 142 search results for scenario 3: just 5 results tabulated.

4.5.4 Search Result of Scenario 4

Scenario 4	[Title_of_Literature], which was written by [Real_Person] in the [Period], reflects the [Theory_Thought].
Ontology Structure	

SPARQL Query	PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
	PREFIX owl: <http://www.w3.org/2002/07/owl#>
	PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
	PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
	PREFIX : <http://www.stnet.re.kr/ontology#>
	SELECT ?RealPerson ?Era ?Literature ?Works
	WHERE {
	?RealPerson rdf:type :y01-01_Real_Person.
	?Literature rdf:type :y02-01_Title_of_Literature.
	?Works rdf:type :y02-02_Title_of_Works.
	?Era rdf:type :x02-01_Period.
	?RealPerson :hasEra ?Era.
	?RealPerson :hasWork ?Literature.
	?RealPerson :hasWork ?Works
	}

Query Results	

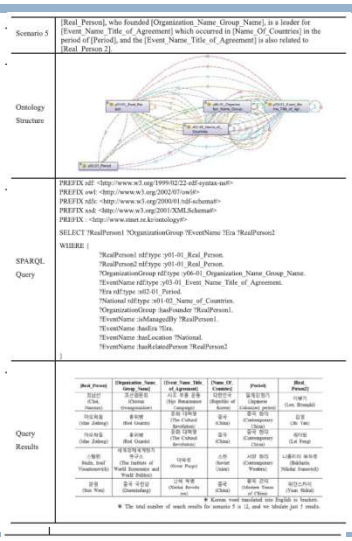
Scenario 4 – *Query Results*

※ *Scenario 4: [Title_Of_Literature], which was written by [Real_Person] in the [Period], reflects the [Theory_Thought].*

[Title Of Literature]	[Real_Person]	[Period]	[Theory_Thought]
주자대전차의집보 (Jujadaejeonchauijipbo)	*이항로 (Lee, Hangro)*	*조선 후기 (Late Chosun Dynasty)*	*조선 성리학 (Noe-Confucianism of Chosun Era)*
이륜행실도 (Iryunhaengsildo)	*이병모 (Lee, Byungmo)*	*조선 후기 (Late Chosun Dynasty)*	*유교 (Confucianism)*
경제아언 (A Rustic's Words on Governance(Kyongjeyaon))	*우정규 (Woo, Jungkyu)*	*조선 후기 (Late Chosun Dynasty)*	*경세제민 (Governing a Nation and Providing Relief to People)*
정신철학통편 (Jeongsincheolhaktongpyeon)	*전병훈 (Jeon, Byunghoon)*	*조선 후기 (Late Chosun Dynasty)*	*계몽주의 (Enlightenment)*
사의 (Rites of Classical Scholars(Sa Yui))	*허전 (Heo, Jeon)*	*조선 후기 (Late Chosun Dynasty)*	*유가사상 (Confucian Thoughts)*

※ Korean word translated into English in brackets.
※ 49 search results for scenario 4: just 5 results tabulated.

4.5.5 Search Result of Scenario 5



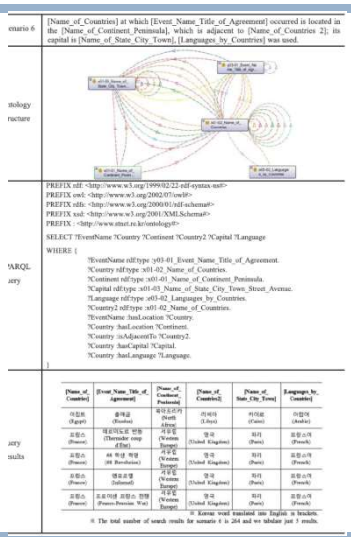
Scenario 5 – *Query Results*

※ *Scenario 5: [Real_Person], who founded [Organization_Name_Group_Name], is a leader for [Event_Name_Title_Of_Agreement] which occurred in [Name_Of_Countries] in the period of [Period], and the [Event_Name_Title_Of_Agreement] is also related to [Real_Person 2].*

[Real_Person]	[Organization_Name_Group_Name]	[Event_Name_Title_Of_Agreement]	[Name_Of_Countries]	[Period]	[Real_Person2]
최남선 (Choi, Namsun)	조선광문회 (Chosun Gwangmunhoe)	시조 부흥 운동 (Sijo Renaissance Campaign)	대한민국 (Republic of Korea)	일제강점기 (Japanese Colonized period)	이병기 (Lee, Byungki)
마오쩌둥 (Mao Zedong)	홍위병 (Red Guards)	문화 대혁명 (The Cultural Revolution)	중국 (China)	중국 현대 (Contemporary China)	김염 (Jin Yan)
마오쩌둥 (Mao Zedong)	홍위병 (Red Guards)	문화 대혁명 (The Cultural Revolution)	중국 (China)	중국 현대 (Contemporary China)	레이펑 (Lei Feng)
스탈린 (Stalin, Iosif Vissarionovich)	세계경제세계정치 연구소 (The Institute of World Economics and World Politics)	대숙청 (Great Purge)	소련 (Soviet Union)	서양 현대 (Contemporary Western)	니콜라이 부하린 (Bukharin, Nikolai Ivanovich)
쑨원 (Sun Wen)	중국 국민당 (Guomindang)	신해 혁명 (Xinhai Revolution)	중국 (China)	중국 근대 (Modern Times of China)	위안스카이 (Yuan Shikai)

※ Korean word translated into English in brackets.
※ 12 search results for scenario 5: just 5 results tabulated.

4.5.6 Search Result of Scenario 6



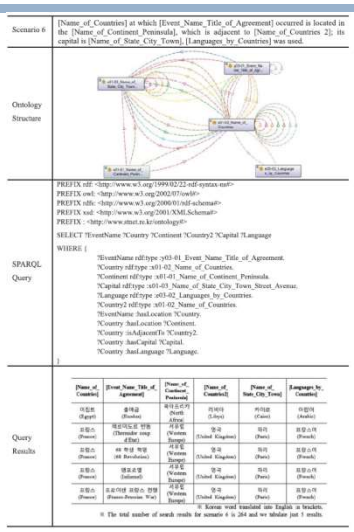
Scenario 6 – *Query Results*

※ *Scenario 6: [Name_Of_Countries] at which [Event_Name_Title_Of_Agreement] occurred is located in the [Name_Of_Continent_Peninsula], which is adjacent to [Name_Of_Countries 2]; its capital is [Name_Of_State_City_Town], [Languages_By_Countries] was used.*

[Name_Of_Countries]	[Event_Name_Title_Of_Agreement]	[Name_Of_Continent_Peninsula]	[Name_Of_Countries2]	[Name_Of_State_City_Town]	[Languages_By_Countries]
이집트 (Egypt)	출애굽 (Exodus)	북아프리카 (North Africa)	리비아 (Libya)	카이로 (Cairo)	아랍어 (Arabic)
프랑스 (France)	테르미도르 반동 (Thermidor coup d' État)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)
프랑스 (France)	68 학생 혁명 (68 Revolution)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)
프랑스 (France)	앵포르멜 (Informel)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)
프랑스 (France)	프로이센 프랑스 전쟁 (Franco-Prussian War)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)

※ Korean word translated into English in brackets.
※ 264 search results for scenario 6: just 5 results tabulated.

4.5.7 Search Result of Scenario 7



Scenario 7 – *Query Results*

※ *Scenario 7: The most famous thing in this [Name_Of_State_City_Town] is the [Monument_Name_Cultural_Asset_Name] that represents the genre of [Buildings_Facilities], which was produced in the period of [Period].*

[Name_Of_State_City_Town]	[Monument_Name_Cultural_Asset_Name]	[Buildings_Facilities]	[Period]
고양 (Goyang-si)	*서삼릉 (Seosamneung Royal Tombs)*	*왕릉 (Royal Tomb)*	*조선시대 (Period of Chosun Dynasty)*
구리 (Guri-si)	*동구릉 (Donggureung Royal Tombs)*	*왕릉 (Royal Tomb)*	*조선시대 (Period of Chosun Dynasty)*
공주 (Gongju-si)	*무령왕릉 석수 (Stone Image of an Animal in the Royal Tomb of King Muryeong)*	*석수 (Stone Image of an Animal)*	*백제시대 (Period of Baekje Kingdom)*
충청남도 (Chungcheongnam-do)	*정림사지오층석탑 (Five storied Stone Pagoda of Jeongnimsa Temple Site)*	*석탑 (Stone Pagoda)*	*백제시대 (Period of Baekje Kingdom)*
익산 (Iksan-si)	*미륵사지 석탑 (Stone Pagoda of Mireuksa Temple Site)*	*석탑 (Stone Pagoda)*	*백제시대 (Period of Baekje Kingdom)*

※ Korean word translated into English in brackets.
※ 84 search results for scenario 7: just 5 results tabulated.

5. Resume

5.1 Resume (1/2): SDBT

1) *A SDBT defines terms on the basis of properties structured by conceptual categories (classes).*
   - ① *The property structure of a conceptual category (class) is the metadata schema of the terms which fall into the class.*
   - ② *Thus all terms are defined according to the metadata schema of the class a term belongs.*

2) *SDBT employs taxonomy of the conceptual categories (classes) of terms having the same properties.*

3) *SDBT employs vocabulary term (vt) to establish relations between term and properties, among properties, and among terms.*

5.2 Resume (2/2): SDBT Database & Ontology

1) *For Semantic Search*
   - ① *A semantic search is possible by converting SDBT data into RDF ontology and definition of inference rules.*
   - ② *The SDBT-based ontology can be efficiently utilized for semantic retrieval.*
   - ③ *The SDBT-based ontology is a new methodology for supporting information retrieval within a specific domain using expanded queries.*

2) *For Text Analysis*
   - ① *SDBT can be used to mine topics from text or informal big data through applying well-defined semantic concepts to SDBT ontologies.*
   - ② *Using SDBT ontologies, the relationships among topics or core words could be presented.*

Thank you for your attention !!