

Extracting Ontologies from Terminological Databases

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I. 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.

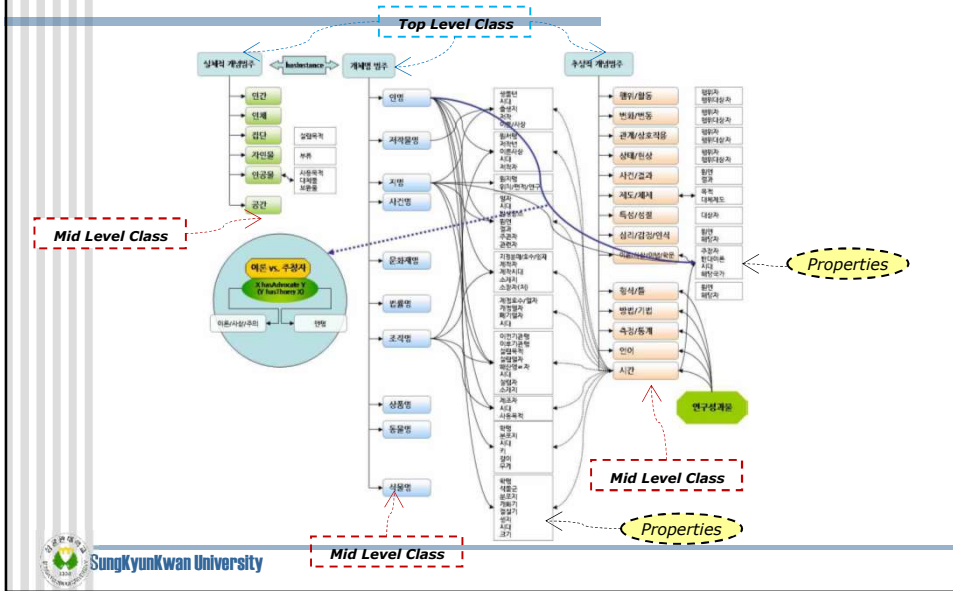


2.2 Requirements of SDBT

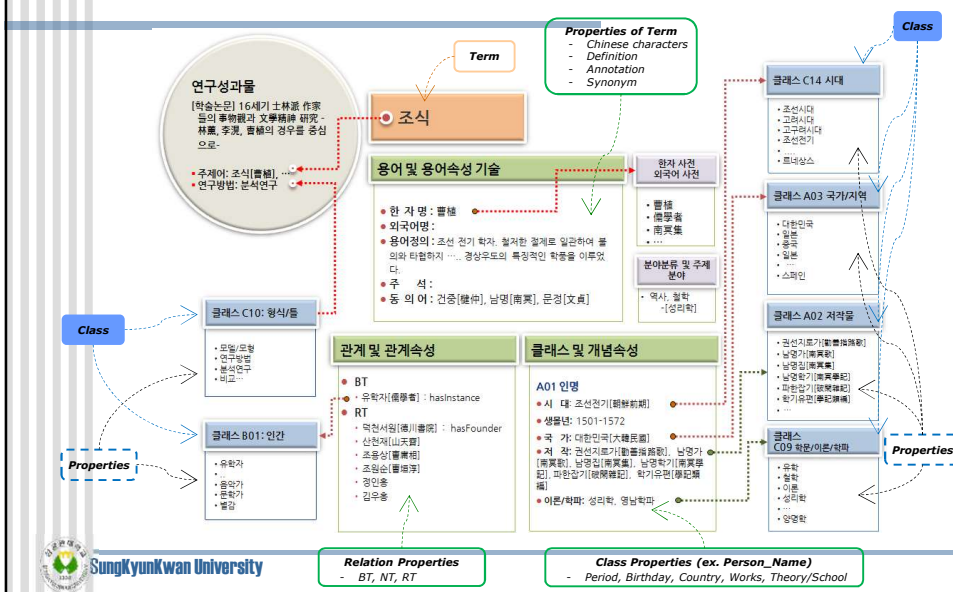
1. Taxonomy of conceptual categories
 - Hierarchical classification of conceptual categories (classes) of terms having the same properties.
2. Properties of conceptual categories
 - The conceptual category (class) is structured by properties.
 - Structured properties of a class is a metadata schema of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



2.3 Conceptual Model of SDBT (1/2)



2.3 Conceptual Model of SDBT (2/2)



3. How to build a SDBT Database



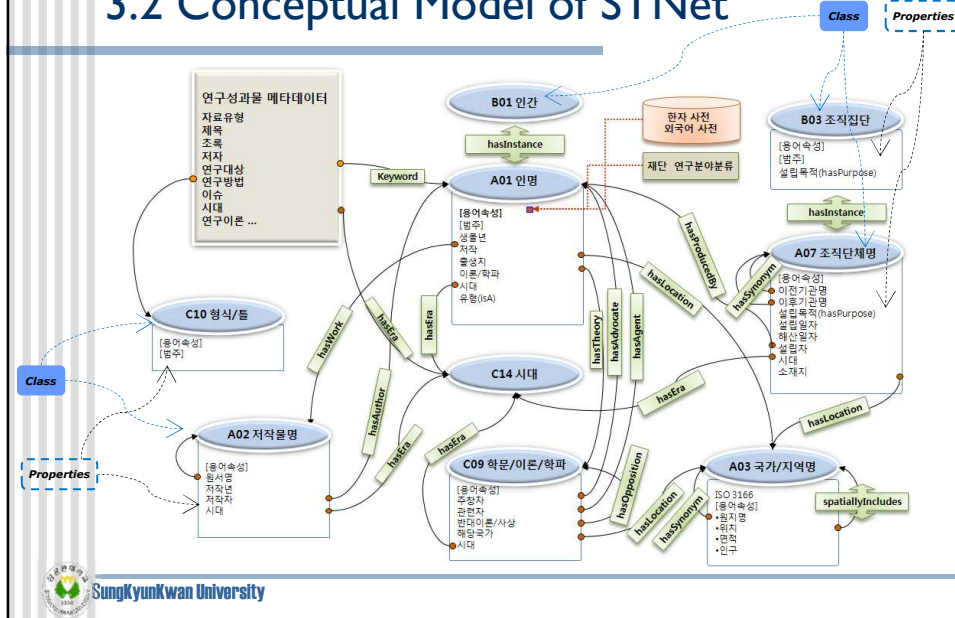
3.1 Example: STNet Project

- *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	Object type	55,236
Number of data in properties	Code type	72,839
	Text 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_Racial_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 a01-05-01_Gifted_People
			a01-05_People_with_Ability_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_Mineral	



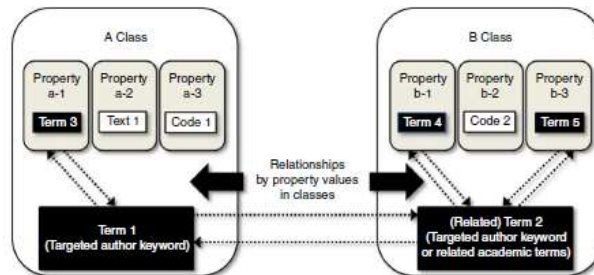
3.3 STNet Taxonomy (3/3)

E_Format /Framework	D04_Technique_Strategy	d04-02_Evaluation_Analysis d04-03_Teaching_Learning_Method d04-04_Strategy_Tactics	
	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
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
		x03-05_Cause_and_Effect	



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

Class Lists
Show Details

Class Code
Class Name
Class Description

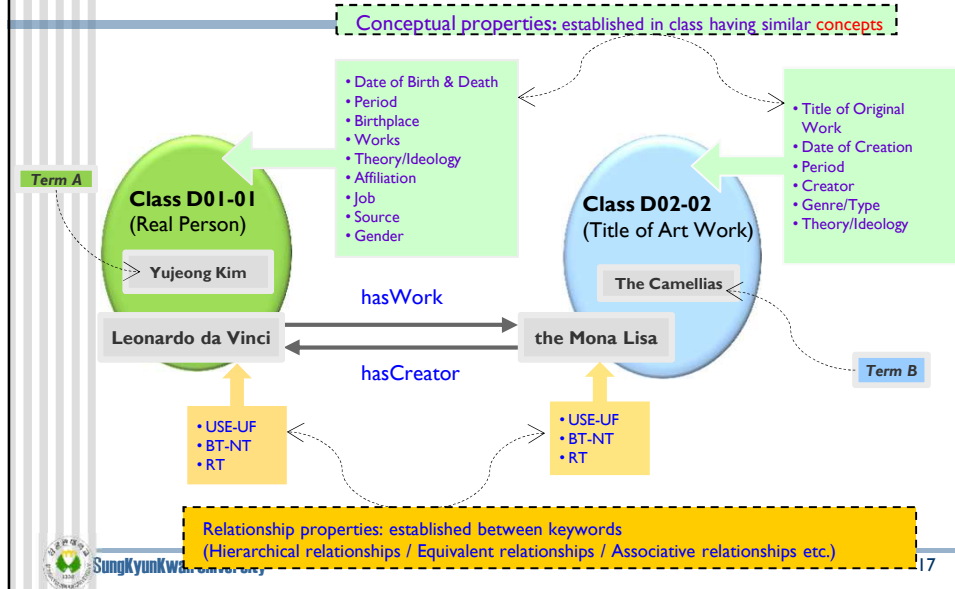
Class Property

Conceptual Property Name
Property Type
Apply Index (Yes/No)
Input Type
(text, number...)

Property Description



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
	Subordinate	NT	BT
Hierarchical Relationship	Subordinate	hasKind	isKindOf
		hasBranch	isBranchOf
		hasComponent	isComponentOf
	Whole-Part	hasMember	isMemberOf
		containsSubstance	isSubstanceOf
		hasIngredient	isIngredientOf
		spatiallyIncludes	isSpatiallyIncludedIn
Concept-Instance	hasInstance	isInstanceOf	
Conceptual	RT_X	RT_Y	
	hasIsar	isIsarOf	
	isConceptuallyRelatedTo	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	
	applies	isAppliedTo	
	hasOpposition	isOppositionOf	
	hasMeasurement	isMeasurementOf	
	manages	isManagedBy	
analyzes	isAnalyzedBy		
evaluates	isEvaluatedBy		
hasMethod	isMethodOf		
produces	isProducedBy		
Associative Relationship			
Functional			



3.8 Relationships by VT in STNet

Relationship Lists

Show Details

관계그룹	관계명	역관계명	관계속성
이종	includesSpecific	isA	종(種)
이부분	containsSubstance	isSubstanceOf	지연물부분
이부분	hasBranch	isBranchOf	분기
이부분	hasIngredient	isIngredientOf	인공물부분
이부분	spatiallyIncludes	isSpatiallyIncludedIn	공간적부분
이부분	hasMember	isMemberOf	집단조직체의 구성
이부분	hasKind	isKindOf	종류(개념적의원)
이부분	hasComponent	isComponentOf	부분-정체성유지
이부분	NT	BT	하위어
이사례	hasInstance	isInstanceOf	사례
이동위	LT	PT	이후명
이동위	PT	LT	이전명
이동위	Uf	USE	비우선어
이동위	hasSynonym	hasSynonym	동위어
이동위	Use	UF	우선어
이개념적	RT	RT	관련어
이개념적	hasForm	isForm	형태(외형)
이개념적	isForm	hasForm	형태(외형)의 대상
이개념적	isPhenomenonOf	hasPhenomenon	현상의 대상
이개념적	hasPhenomenon	isPhenomenonOf	현상
이개념적	hasIssue	isIssueIn	이슈(주제)
이개념적	isConceptOf	conceptuallyRelatedTo	개념
이개념적	conceptuallyRelatedTo	isConceptOf	개념적부분
이개념적	isIssueIn	hasIssue	이슈(주제)의 대상
이물리적	isConnectedTo	isConnectedTo	연결(부착)
이물리적	isTributaryOf	hasTributary	함류/동합 대상
이물리적	hasTributary	isTributaryOf	함류(통합)
이기능적			관용어

관계그룹: [이부분] ▼

관계명: [hasComponent]

관계명(한글): [보급(조직)성유지]

역관계명: [isComponentOf]

관계속성: [보급-정체성유지]

관계설명: X가 Y의 일부로서 X는 전체에 포함되더라도 Y의 대상은 Y에서 정형성을 유지하는 관계를 말한다. 즉 열거하거나 설명할 수 있다.

[확인] [삭제]

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] and [Name_Of_Countries].
 - Scenario 3:
 - Scenario 4:
 - Scenario 5:
 - Scenario 6:
 - Scenario 7:



4.5.1 Search Result of Scenario I

Scenario I: [Real_Person] was born in [Name_of_State_City_TownName_of_Countries] with the nationality of [Name_of_Countries] and was active in the period of [Period] as a [Occupation].

Ontology Structure

```

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.mmc.sk.kr/ontology#>

SELECT ?Location ?Nationality ?Era ?Job ?Person
WHERE {
?Location rdfs:type xsd:01_Name_of_State_City_Town_Street_Avenue.
?Nationality rdfs:type xsd:02_Name_of_Countries.
?Era rdfs:type xsd:01_Period.
?Person rdfs:type y01-01_Real_Person.
?Job rdfs:type owl:01_Occupation.
?Person hasBirthPlace ?Location.
?Person hasNationality ?Nationality.
?Person hasEra ?Era.
?Person hasJob ?Job.
}
    
```

Name of Real Person	Name of State, City, Town, Street, Avenue	Nationality	Period	Occupation	Real Person
이정호	서울특별시 강남구	대한민국	1980년 1월 1일 ~ 2000년 12월 31일	소프트웨어 개발자	이정호
김민준	경기도 성남시	대한민국	1985년 3월 15일 ~ 2010년 6월 30일	데이터 분석가	김민준
박지현	충청남도 천안시	대한민국	1990년 7월 10일 ~ 2015년 9월 30일	시스템 관리자	박지현
최영준	경상남도 창원시	대한민국	1988년 11월 5일 ~ 2012년 3월 31일	네트워크 엔지니어	최영준
정민호	경기도 수원시	대한민국	1982년 4월 20일 ~ 2008년 10월 31일	프로그래머	정민호
윤지우	경기도 고양시	대한민국	1987년 8월 12일 ~ 2011년 12월 31일	시스템 운영자	윤지우
홍지우	경기도 고양시	대한민국	1987년 8월 12일 ~ 2011년 12월 31일	시스템 운영자	홍지우
이정호	서울특별시 강남구	대한민국	1980년 1월 1일 ~ 2000년 12월 31일	소프트웨어 개발자	이정호

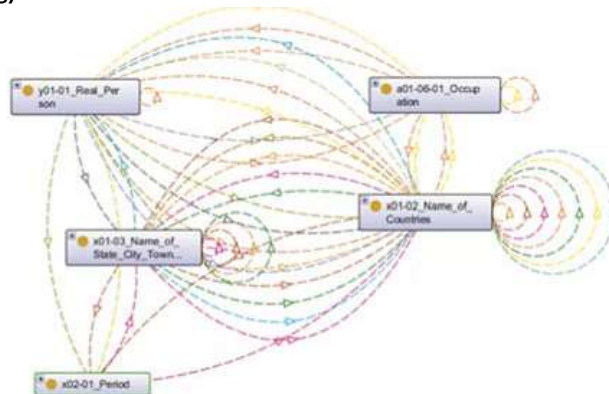
※ The max number of search results for scenario I is 80 and we displayed top 8 results.



Scenario I - Ontology Structure

※ Scenario I: [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 I – SPARQL Query

※ Scenario I: [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 ?Location ?Nationality ?Era ?Job ?Person
WHERE {
    ?Location rdf:type :x01-03_Name_of_State_City_Town_Street_Avenue.
    ?Nationality rdfs:type :x01-02_Name_of_Countries.
    ?Era rdfs:type :x02-01_Period.
    ?Person rdfs:type :y01-01_Real_Person.
    ?Job rdfs:type :a01-06-01_Occupation.
    ?Person :hasBirthPlace ?Location.
    ?Person :hasNationality ?Nationality.
    ?Person :hasEra ?Era.
    ?Person :hasJob ?Job.
}
```



Scenario I – Query Results

※ Scenario I: [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)	조일형 (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 [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_Person3] is related to [Period] and [Name_of_Countries].

Ontology Structure

SPARQL Query

```

PREFIX rdt: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdfs: <http://www.w3.org/2001/XMLSchema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

SELECT DISTINCT ?Person1 ?Theory2 ?Person2 ?Theory3 ?Concept ?Era ?Country ?Period3
WHERE {
  ?Person1 rdt:type owl:Real_Person.
  ?Person2 rdt:type owl:Real_Person.
  ?Theory1 rdt:type owl:Theory_Thought.
  ?Theory2 rdt:type owl:Theory_Thought.
  ?Theory3 rdt:type owl:Theory_Thought.
  ?Concept rdt:type owl:Concept_Definition.
  ?Era rdt:type owl:Name_of_Countries.
  ?Country rdt:type owl:Name_of_Countries.
  ?Period3 rdt:type owl:Period.
  ?Theory1 owl:oppositeOf ?Theory2.
  ?Theory1 owl:relatedTo ?Theory3.
  ?Theory1 owl:relatedTo ?Concept.
  ?Theory1 owl:relatedTo ?Era.
  ?Theory1 owl:relatedTo ?Country.
  ?Theory1 owl:relatedTo ?Period3.
  ?Person1 hasKoreanName ?Country.
  ?Concept hasEra ?Era.
  ?Concept hasEra ?Era.
}
    
```

Query Results

Person	Theory	Person2	Theory2	Theory3	Concept	Person3	Period	Country
루트비히 후설	형태심리학	플라톤	연합주의	초월철학	통각	라이프니츠	서양근대	독일
루트비히 후설	형태심리학	플라톤	연합주의	초월철학	지향성	브렌타노	서양근대	독일
주자	본연지성	이칭	기질지성	왕도	치왕지	왕양명	왕시대	중국
주자	성리학적 세계관	장자	도가사상	왕도	치왕지	왕양명	왕시대	중국
주자	성리학적 세계관	노자	도가사상	왕도	치왕지	왕양명	왕시대	중국

※ The total number of search results for scenario 2 is 340 and we tabulated just 5 results.

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]
루트비히 후설 (Husserl, Edmund)	형태심리학 (Gestalt-psychology)	플라톤 (Plato)	연합주의 (Associativism)	초월철학 (Transcendental philosophy)	통각 (Apperception)	라이프니츠 (Leibniz, Gottfried Wilhelm von)	서양근대 (Western Modern)	독일 (Germany)
루트비히 후설 (Husserl, Edmund)	형태심리학 (Gestalt-psychology)	플라톤 (Plato)	연합주의 (Associativism)	초월철학 (Transcendental philosophy)	지향성 (Intention)	브렌타노 (Brentano, Franz)	서양근대 (Western Modern)	독일 (Germany)
주자 (Zhuxi)	본연지성 (Original Natural Tendency)	이칭 (Er Cheng)	기질지성 (Physical Natural Tendency)	왕도 (Royal Road)	치왕지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	왕시대 (Ming Dynasty)	중국 (China)
주자 (Zhuxi)	성리학적 세계관 (World View of Neo-Confucianism)	장자 (Zhuangzi)	도가사상 (Daoism)	왕도 (Royal Road)	치왕지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	왕시대 (Ming Dynasty)	중국 (China)
주자 (Zhuxi)	성리학적 세계관 (World View of Neo-Confucianism)	노자 (Laozi)	도가사상 (Daoism)	왕도 (Royal Road)	치왕지 (Reach the Ultimate of Innate Wisdom)	왕양명 (Wang Shouren)	왕시대 (Ming Dynasty)	중국 (China)

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 skos -<http://www.w3.org/2004/02/skos/core#>

SELECT ?RealPerson ?RealPerson2 ?OrganizationName_GroupName ?Name_of_State_City_Town ?Period
WHERE {
  ?RealPerson rdf:type rdfs:Real_Person.
  ?RealPerson2 rdf:type rdfs:Real_Person.
  ?OrganizationName_GroupName rdfs:Organization_Name_Group_Name.
  ?Name_of_State_City_Town rdfs:Name_of_State_City_Town.
  ?Period rdfs:Period.
  ?RealPerson2 rdfs:MemberOf ?OrganizationName_GroupName.
  ?OrganizationName_GroupName skos:founder ?RealPerson2.
  ?OrganizationName_GroupName skos:hasDate ?Period.
}
    
```

Query Results

[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)
자롤라모 사보나롤라 (Savonarola, Girolamo)	도미니크 수도회 (Dominican Order)	도미니쿠스 (Dominicus)	프랑스 (France)	서양 중세 (Western Middle Age)

* The total number of search results for scenario 3 is 142 and we tabulated just 5 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)
자롤라모 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.ac.kr/ontology#>
SELECT ?RealPerson ?Era ?Literature ?Works
WHERE {
  ?RealPerson rdfs:type y01-01_ Real_Person.
  ?Literature rdfs:type y02-01_ Title_of_Literature.
  ?Works rdfs:type y02-02_ Title_of_Works.
  ?Era rdfs:type y02-01_ Period.
  ?RealPerson hasEra ?Era.
  ?RealPerson hasWork ?Literature.
  ?RealPerson hasWork ?Works.
}
    
```

Query Results

[Title of Literature]	[Real Person]	[Period]	[Theory_Thought]
주자대전경차의집보 (Jujadaejeonchaujijipbo)	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)
경제야언 (A Rustic's Words on Governance(Kyongjeayaon))	우정규 (Woo, Jungkyu)	조선 후기 (Late Chosun Dynasty)	경세제민 (Governing a Nation and Providing Relief to People)
경신철학총편 (Jeongsincheolhakdongpyeon)	전범준 (Jeon, Byunghoon)	조선 후기 (Late Chosun Dynasty)	계몽주의 (Enlightenment)
사의 (Rites of Classical Scholars(Sa Yui))	허견 (Heo, Jeon)	조선 후기 (Late Chosun Dynasty)	유가사상 (Confucian Thoughts)

* The total number of search results for scenario 4 is 49 and we tabulate just 5 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]
주자대전경차의집보 (Jujadaejeonchaujijipbo)	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)
경제야언 (A Rustic's Words on Governance(Kyongjeayaon))	우정규 (Woo, Jungkyu)	조선 후기 (Late Chosun Dynasty)	경세제민 (Governing a Nation and Providing Relief to People)
경신철학총편 (Jeongsincheolhakdongpyeon)	전범준 (Jeon, Byunghoon)	조선 후기 (Late Chosun Dynasty)	계몽주의 (Enlightenment)
사의 (Rites of Classical Scholars(Sa Yui))	허견 (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: [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].

Ontology Structure:

```

PREFIX rdf <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl <http://www.w3.org/2002/07/owl#>
PREFIX xsd <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs <http://www.w3.org/2000/01/rdf-schema#>

SELECT ?RealPerson ?OrganizationGroup ?EventName ?Title ?RealPerson2
WHERE {
  ?RealPerson rdf:type yml:01_Real_Person.
  ?RealPerson2 rdf:type yml:01_Real_Person.
  ?OrganizationGroup rdf:type yml:01_Organization_Group_Name.
  ?EventName rdf:type yml:01_Event_Name_Title_of_Agreement.
  ?Title rdf:type yml:01_Period.
  ?Name_of_Countries rdf:type yml:01_Name_of_Countries.
  ?OrganizationGroup hasFollower ?RealPerson.
  ?EventName hasParticipant ?RealPerson.
  ?Title hasLocation ?Name_of_Countries.
  ?EventName hasLocation ?Name_of_Countries.
  ?RealPerson hasLocation ?Name_of_Countries.
}
    
```

Query Results:

Real_Person	Organization_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)	이범기 (Lee, Byungki)
마오쩌둥 (Mao Zedong)	홍위병 (Red Guards)	문화 대혁명 (The Cultural Revolution)	중국 (China)	중국 현대 (Contemporary China)	김영 (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)

* The total number of search results for scenario 5 is 12, and we tabulate just 5 results.

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)	이범기 (Lee, Byungki)
마오쩌둥 (Mao Zedong)	홍위병 (Red Guards)	문화 대혁명 (The Cultural Revolution)	중국 (China)	중국 현대 (Contemporary China)	김영 (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: [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.

```

PREFIX owl <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 sk <http://www.semantic.kookmin.ac.kr/>

SELECT ?eventName ?country ?continent ?country2 ?capital ?language
WHERE {
  ?eventName rdfs:type sk:01-01_Event_Name_Title_of_Agreement ;
  ?country rdfs:type owl:02_Name_of_Countries ;
  ?continent rdfs:type owl:04_Name_of_Continent_Peninsula ;
  ?capital rdfs:type owl:05_Name_of_State_City_Town ;
  ?language rdfs:type owl:06_Languages_by_Countries ;
  ?eventName owl:location ?country ;
  ?country owl:location ?continent ;
  ?country owl:adjacentTo ?country2 ;
  ?country owl:capital ?capital ;
  ?country owl:language ?language .
}
    
```

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)	88 학생 혁명 (88 Revolution)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)
프랑스 (France)	앵포르벨 (Infornel)	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)

※ The total number of search results for scenario 6 is 264 and we tabulate just 5 results.



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)	88 학생 혁명 (88 Revolution)	서유럽 (Western Europe)	영국 (United Kingdom)	파리 (Paris)	프랑스어 (French)
프랑스 (France)	앵포르벨 (Infornel)	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 6 [Name_of_Country] 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], [Language by_Countries] was used.

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.man.ia.ki.ac.kr/ontology#>

SELECT ?EventName ?Country ?Continent ?Country2 ?Capital ?Language
WHERE {
  ?EventName rdfs:type rdfs:lit ?Event_Name_Title_of_Agreement.
  ?Country rdfs:type rdfs:lit ?Name_of_Countries.
  ?Continent rdfs:type rdfs:lit ?Name_of_Continent_Peninsula.
  ?Capital rdfs:type rdfs:lit ?Name_of_State_City_Town_Street_Avenue.
  ?Language rdfs:type rdfs:lit ?Languages_by_Countries.
  ?Country2 rdfs:type rdfs:lit ?Name_of_Countries.
  ?Continent rdfs:location ?Country.
  ?Country rdfs:location ?Continent.
  ?Country rdfs:adjacentTo ?Country2.
  ?Country rdfs:capital ?Capital.
  ?Country rdfs:language ?Language.
}
    
```

Query Results

[Name_of_Country]	[Event_Name_Title_of_Agreement]	[Name_of_Country]	[Name_of_Country]	[Name_of_Continent Peninsula]	[Language by_Countries]
조선국 (Chosun)	세종실록 (Sejong Sillok)	조선국 (Chosun)	조선국 (Chosun)	아시아 (Asia)	한글 (Hangeul)
조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	아시아 (Asia)	한글 (Hangeul)
조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	아시아 (Asia)	한글 (Hangeul)
조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	아시아 (Asia)	한글 (Hangeul)
조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	조선국 (Chosun)	아시아 (Asia)	한글 (Hangeul)

* The total number of search results for scenario 6 is 264 and we tabulate just 5 results.



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)	경림사지오층석탑 (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 !!

