

BACKGROUND: SEMANTIC METRICS EVALUATION EXAMPLES



Semantic Alignment Quality Metrics: Evaluation on Interface Ontological Metamodels

Semantic Similarity Schema (SSS) Metric : : For a service SWC's interface ontology schema, say O_i , SSS metric can be interpreted and evaluated as the fraction or percentage of the number of classes (E_{QC}) of the schema O_i that are semantically *equivalent* to the classes of other SWCs interface ontology schemas compared to the total number (T_R) of the existing classes in the schema O_i . TRC may include inheritance classes (IHCL), noninheritance classes (INHCL), as well as EQV in the given schema O_i .

$$SSS = E_{QV} / T_{RC} \dots (1)$$

Where $T_{RC} = IHCL + INHCL + E_{QV}$ in (1).

Examples: (Intra-group Schema Similarity)

AR:	
☐ Case sensitive ☐ Whole words ☐ Ignore white space ☐ Regular expression	
☐ Class axioms ☒ Object properties ☐ Data properties ☐ Individuals	
- DM:ClientServerInterface EquivalentTo AR:ClientServerOperation - DM:ComponentPortGroup EquivalentTo AR:ComponentPortGroup - DM:Events EquivalentTo AR:Events - DM:PortPrototype EquivalentTo AR:PortPrototype - DM:ProvidedPortPrototype EquivalentTo AR:ProvidedPortPrototype - DM:RequiredPortPrototype EquivalentTo AR:RequiredPortPrototype - DM:SWComponentType_spec EquivalentTo AR:SwComponentType - DM:SenderReceiverInterface EquivalentTo AR:SenderComSpec - DM:TimingEvent EquivalentTo AR:TimeSynchronizationInterface - FComponentPrototype EquivalentTo AR:SwComponentType - AR:Field EquivalentTo DM:Fields - AR:SwComponentType EquivalentTo ROS:Node	Source 1
SubClassOf	- AR:AdaptiveSwcInternalBehavior - AR:ArgumentDataPrototype - AR:AutosarDataPrototype - AR:ClientServerOperation - AR:ComponentPortGroup - AR:CompositionSwComponent - AR:Events - AR:Field - AR:PPortComSpec - AR:PortInterface - AR:PortPrototype - AR:ProvidedPortPrototype - AR:RPortComSpec - AR:RequiredPortPrototype - AR:SenderComSpec - AR:SwComponentType - AR:TimeSynchronizationInterface

Total no. Of Equivalent Classes(E_{QV})= 10

Total no. Of Classes in Source 1(T_{RC})= 38

Semantic Similarity Metric (SSS) in % = $10/38 = 26\%$

**AR: AUTOSAR Adaptive Framework
SWC Interface
+
DM: Mediator SWC
Interface**

Semantic Alignment Quality Metrics: Evaluation on Interface Ontological Metamodels

- **Semantic Similarity Schema (SSS) Metric** : For a service SWC's interface ontology schema, say O_i , SSS metric can be interpreted and evaluated as the fraction or percentage of the number of classes (E_{QC}) of the schema O_i that are semantically *equivalent* to the classes of other SWCs interface ontology schemas compared to the total number (T_R) of the existing classes in the schema O_i . TRC may include inheritance classes (IHCL), noninheritance classes (INHCL), as well as EQV in the given schema O_i .

$$SSS = E_{QV} / TRC \dots (1)$$

Where $TRC = IHCL + INHCL + E_{QV}$ in (1).

- **Examples: (Inter-group Similarity)**

Total no. Of Equivalent Classes(E_{QV})= 9

Total no. Of Classes in Source 1(TRC)= 32

Semantic Similarity Metric (SSS) in % = $9/32 = 28\%$

EquivalentClasses	AR:ArgumentDataPrototype
	AR:ClientServerOperation
	AR:Field
	AR:PPortComSpec
	AR:PortPrototype
	AR:ProvidedPortPrototype
	AR:RPortComSpec
	AR:RequiredPortPrototype
	FDataNotifier
EquivalentClasses	FAttribute
	FDataNotifier
	AR:Field
	AR:PPortComSpec
	AR:RPortComSpec
	AR:PortPrototype
	AR:ArgumentDataPrototype
	AR:ClientServerOperation
	AR:ProvidedPortPrototype
	AR:RequiredPortPrototype
	+ 1 more results

Source 1-> AR:AUTOSAR
Adaptive Framework
SWC Interface
+
F: Franca Framework
SWC Interface
Source 1

AR:ArgumentDataPrototype	EquivalentTo	FArgumentDataPrototype
AR:ClientServerOperation	EquivalentTo	FMethod
AR:Field	EquivalentTo	FAttribute
AR:PPortComSpec	EquivalentTo	FAskMePort
AR:PortPrototype	EquivalentTo	FPortPrototype
AR:ProvidedPortPrototype	EquivalentTo	FAskMePort
AR:RPortComSpec	EquivalentTo	FAnswerMePort
AR:RequiredPortPrototype	EquivalentTo	FAnswerMePort
FDataNotifier	EquivalentTo	AR:VariableDataPrototype
FAttribute	EquivalentTo	isTypeOf exactly 1 FAttribute
FDataNotifier	EquivalentTo	AR:VariableDataPrototype
AR:Field	EquivalentTo	FAttribute
AR:PPortComSpec	EquivalentTo	FAskMePort
AR:RPortComSpec	EquivalentTo	FAnswerMePort
AR:PortPrototype	EquivalentTo	FPortPrototype
AR:ArgumentDataPrototype	EquivalentTo	FArgumentDataPrototype
AR:ClientServerOperation	EquivalentTo	FMethod
AR:ProvidedPortPrototype	EquivalentTo	FAskMePort
AR:RequiredPortPrototype	EquivalentTo	FAnswerMePort

Semantic Alignment Quality Metrics: Evaluation on Interface Ontological Metamodels (contd.)

- Instance Relationship Richness (IRR) Metric:** IRR Metric for a service SWC's interface ontology schema, say, O_i , is defined as the percentage or ratio of the number of semantically similar or *sameAs* instances (I_{SA}) of classes of the schema O_i compared to the total number of instances of classes (TR_{Inst}) includes I_{SA} and *differentFrom* (IDF) present in the given schema pair O_i .

$$IRR = I_{SA} / TR_{Inst} \dots (2)$$

Where $TR_{Inst} = I_{SA} + IDF$ in (2).

AR: AUTOSAR Adaptive Framework
SWC Interface
+
DM: Mediator SWC
Interface

Total no. Of SameAs Instances (I_{SA}) = 5
Total no. Of instances in Source 1 (TR_{Inst}) = 15
Instance Relationship Richness (IRR) in % = $5/15 = 33,33\%$

- Examples -> Intra-Group IRR Metric:**

AdaptiveApplicationSWComponentType
AR:AdaptiveApplicationSWComponentType
AR:ClientComSpec
AR:FireandForget
AR:Getter
AR:Notifier
AR:ReceiverComSpec
AR:Request_Response
AR:SenderComSpec
AR:ServiceInterface
AR:Setter
DM:FIRE-And-FORGET
DM:Getter
DM:Notifier
DM:REQUEST-RESPONSE
DM:Setter

SameIndividual AR:FireandForget
AR:FireandForget
AR:FireandForget
AR:Getter
AR:Getter
AR:Notifier
AR:Request_Response
AR:Setter
AR:Setter

SameIndividual DM:FIRE-And-FORGET
DM:REQUEST-RESPONSE
FGetter
FSetter
AR:Getter
AR:Setter
AR:Notifier
FNORMAL_METHOD
AR:FireandForget
FREQUEST_NO_RETURN
AR:Request_Response

Source 1

AR:FireandForget SameAs DM:FIRE-And-FORGET
AR:FireandForget SameAs FREQUEST_NO_RETURN
AR:FireandForget SameAs ROS:Pub_Sub
AR:Getter SameAs DM:Getter
AR:Getter SameAs FGetter
AR:Notifier SameAs DM:Notifier
AR:Request_Response SameAs DM:REQUEST-RESPONSE
AR:Setter SameAs DM:Setter
AR:Setter SameAs FSetter

DM:FIRE-And-FORGET SameAs ROS:Pub_Sub
DM:REQUEST-RESPONSE SameAs ROS:Request_Reply
FGetter SameAs DM:Getter
FSetter SameAs DM:Setter
AR:Getter SameAs DM:Getter
AR:Setter SameAs DM:Setter
AR:Notifier SameAs DM:Notifier
FNORMAL_METHOD SameAs DM:REQUEST-RESPONSE
AR:FireandForget SameAs DM:FIRE-And-FORGET
FREQUEST_NO_RETURN SameAs DM:FIRE-And-FORGET
AR:Request_Response SameAs DM:REQUEST-RESPONSE

Examples->Inter-Group IRR Metric:

AR:AdaptiveApplicationSWComponentType
 AR:ClientComSpec
 AR:FireandForget
 AR:Getter
 AR:Notifier
 AR:ReceiverComSpec
 AR:Request_Response
 AR:SenderComSpec
 AR:ServiceInterface
 AR:Setter
 FAnswerMePorttype
 FAskMePorttype
 FClientServerSpec
 FGetter
 FNORMAL_METHOD
 FNotifier
 FReceiverComSpec
 FREQUEST_NO_RETURN
 FService
 FSetter

SameIndividual

FClientServerSpec
 FGetter
 FNORMAL_METHOD
 FNORMAL_METHOD
 FNORMAL_METHOD
 FNotifier
 FREQUEST_NO_RETURN
 FREQUEST_NO_RETURN
 FReceiverComSpec
 FSetter
 AR:FireandForget
 AR:FireandForget
 AR:FireandForget
 DM:FIRE-And-FORGET
 AR:Notifier
 AR:Notifier
 AR:Getter
 AR:Setter

SameIndividual

AR:FireandForget
 AR:FireandForget
 AR:FireandForget
 AR:Getter
 AR:Getter
 AR:Notifier
 AR:Notifier
 AR:Request_Response
 AR:Setter
 AR:Setter
 FNORMAL_METHOD
 FReceiverComSpec
 FClientServerSpec

Source 1

FClientServerSpec SameAs AR:SenderComSpec
 FGetter SameAs DM:Getter
 FNORMAL_METHOD SameAs AR:Request_Response
 FNORMAL_METHOD SameAs DM:REQUEST-RESPONSE
 FNORMAL_METHOD SameAs ROS:Request_Reply
 FNotifier SameAs DM:Notifier
 FREQUEST_NO_RETURN SameAs DM:FIRE-And-FORGET
 FREQUEST_NO_RETURN SameAs ROS:Pub_Sub
 FReceiverComSpec SameAs AR:ReceiverComSpec
 FSetter SameAs DM:Setter
 AR:FireandForget SameAs DM:FIRE-And-FORGET
 AR:FireandForget SameAs FREQUEST_NO_RETURN
 AR:FireandForget SameAs ROS:Pub_Sub
 DM:FIRE-And-FORGET SameAs ROS:Pub_Sub
 AR:Notifier SameAs DM:Notifier
 AR:Notifier SameAs FNotifier
 AR:Getter SameAs FGetter
 AR:Setter SameAs FSetter

AR:FireandForget SameAs DM:FIRE-And-FORGET
 AR:FireandForget SameAs FREQUEST_NO_RETURN
 AR:FireandForget SameAs ROS:Pub_Sub
 AR:Getter SameAs DM:Getter
 AR:Getter SameAs FGetter
 AR:Notifier SameAs DM:Notifier
 AR:Notifier SameAs FNotifier
 AR:Request_Response SameAs DM:REQUEST-RESPONSE
 AR:Setter SameAs DM:Setter
 AR:Setter SameAs FSetter
 FNORMAL_METHOD SameAs AR:Request_Response
 FReceiverComSpec SameAs AR:ReceiverComSpec
 FClientServerSpec SameAs AR:SenderComSpec

Source 1->
 AR:AUTOSAR
 Adaptive Framework
 SWC Interface
 +
 F: Franca Framework
 SWC Interface

Total no. Of SameAs Instances (ISA)= 7
 Total no. Of Classes in Source 1(TRInst)= 20
 Instance Relationship Richness (IRR) in % = $7/20 = 35\%$

Inter-Group CIC Metric

- Class Instance Connectivity (CIC) Metric:** *CIC* metric for a service SWC's interface ontology schema, say, O_i , is defined as the ratio or percentage of the number of *sameAs* instances of semantically *equivalent* classes (E_{QC}) of the schema O_i compared to the total number of semantically *equivalent* classes (TR_Q) that are present in the interface ontology schema O_i .
- The *CIC* metric for an ontology schema pair O_i , fundamentally represents the proportion of class *equivalence* relationships that are being utilized by the classes' instances O_i at instance level to create *sameAs* semantic relationships.
- Value evaluated for *CIC* metric also indicates class to class connectivity and ensures the data in the knowledgebase represents most of the knowledge in the schema.

$$CIC = EQ_c / TR_Q \dots (3)$$

Where $EQ_c \propto (sameAs \text{ REL } (O_i))$ in (3).

Based on total number of *sameAs* instances of semantically Equivalent classes of ontology schemas,

Class Instance Connectivity Metric (CIC) for Source 3, $(EQ_c / TR_Q) = 6 / 9 = 66.67 \%$

Examples->CIC Inter-group:

EquivalentClasses	Source 3
AR:Field	AR:Field EquivalentTo ROS:Parameter
AR:Publish	AR:Publish EquivalentTo ROS:Data_Publisher
AR:Subscribe	AR:Subscribe EquivalentTo ROS:Data_Subscriber
AR:SwComponentType	AR:SwComponentType EquivalentTo ROS:Node
AR:ClientServerOperation	AR:ClientServerOperation EquivalentTo ROS:Service
AR:ClientServerOperation	AR:ClientServerOperation EquivalentTo ROS:ServiceClient
AR:ClientServerOperation	AR:ClientServerOperation EquivalentTo ROS:ServiceServer
AR:VariableDataPrototype	AR:VariableDataPrototype EquivalentTo ROS:Topic
AR:CompositionSwComponent	AR:CompositionSwComponent EquivalentTo ROS:Master_Node
SameIndividual	Source 3
AR:FireandForget	AR:FireandForget SameAs DM:FIRE-And-FORGET
AR:FireandForget	AR:FireandForget SameAs FREQUEST_NO_RETURN
AR:FireandForget	AR:FireandForget SameAs ROS:FireAndForget
AR:Getter	AR:Getter SameAs DM:Getter
AR:Getter	AR:Getter SameAs FGetter
AR:Notifier	AR:Notifier SameAs DM:Notifier
AR:Notifier	AR:Notifier SameAs FNotifier
AR:Notifier	AR:Notifier SameAs ROS:Pub_Sub
AR:Request_Response	AR:Request_Response SameAs DM:REQUEST-RESPONSE
AR:Request_Response	AR:Request_Response SameAs ROS:Request_Reply
AR:Setter	AR:Setter SameAs DM:Setter
AR:Setter	AR:Setter SameAs FSetter
FNORMAL_METHOD	FNORMAL_METHOD SameAs AR:Request_Response
FReceiverComSpec	FReceiverComSpec SameAs AR:ReceiverComSpec
FClientServerSpec	FClientServerSpec SameAs AR:SenderComSpec

Total no. Of Equivalent Classes (TR_Q) = 9
Total no. Of SameAs Instances (E_{QC}) = 6

► Examples->CIC Intra-group:

Source 2	
EquivalentClasses	- FArgumentDataPrototype - FComponentPrototype - FCompositionComponentPrototype - FMethod - FMethod - FMethod - FMethod - FPortPrototype
	- FArgumentDataPrototype EquivalentTo ROS:Parameter - FComponentPrototype EquivalentTo ROS:Node - FCompositionComponentPrototype EquivalentTo ROS:Master_Node - FMethod EquivalentTo ROS:Service - FMethod EquivalentTo ROS:ServiceClient - FMethod EquivalentTo ROS:ServiceServer - FPortPrototype EquivalentTo ROS:Topic
SameIndividual	- FNotifier - AR:Notifier - DM:Notifier - FAskMePorttype - FNORMAL_METHOD - AR:FireandForget - FAnswerMePorttype - DM:FIRE-And-FORGET - FREQUEST_NO_RETURN - AR:Request_Response - DM:REQUEST-RESPONSE
	- FNotifier SameAs ROS:Pub_Sub - AR:Notifier SameAs ROS:Pub_Sub - DM:Notifier SameAs ROS:Pub_Sub - FAskMePorttype SameAs ROS:Pub_Sub - FNORMAL_METHOD SameAs ROS:Request_Reply - AR:FireandForget SameAs ROS:FireAndForget - FAnswerMePorttype SameAs ROS:Pub_Sub - DM:FIRE-And-FORGET SameAs ROS:FireAndForget - FREQUEST_NO_RETURN SameAs ROS:FireAndForget - AR:Request_Response SameAs ROS:Request_Reply - DM:REQUEST-RESPONSE SameAs ROS:Request_Reply

Total no. Of Equivalent Classes (TR_Q)= 7
Total no. Of SameAs Instances (E_{QC})= 5

Based on total number of sameAs instances of semantically Equivalent classes of ontology schemas,
Class Instance Connectivity Metric (CIC) for Source 2, $(E_{QC} / TR_Q) = 5/7 = 71.4 \%$