**Service Modeling Language (SML)**

SML is a metamodel-based language designed for service-oriented computing. Its models, called service mograms, are focused on service-orientation similarly to UML models that are focused on object-orientation. The basic modeling style and rules of SML reflect functional composition. The simplified SML syntax is sketched below using the customized BNF style (see the *Comments* section). The SORCER [project side](http://sorcersoft.org/project/site/) contains a few hundred simple examples that allow you to learn modeling patterns along with syntax rules of SML modeling. SML models are executable by the SORCER platform when sufficiently configured.

**Signatures**

A *provider* *signature* is a service provider reference (handle) specified by a *service type*. The role of provider signatures declaring provider services is similar to constructors in object-oriented programming. An *operation signature* expending a *provider signature* is an executable provider service - *exec*(*signature*). An operation signature can be customized with the following options: signature name, signature operation name (selector), provider name, implemented types, groups, locators, data context, return result format, input and output connectors.

srvSignature ::= prvSignature | opSignature | bldrSig| **sig(**srvSignature**,** signatureOp**)**

prvSignature ::= **sig(**[name**,**] prvSpec**)**

opSignature ::= **sig(**[name**,**] opSpec, prvSpec**)**

| **sig(**prvSignature**,** selector**)** | **sig(**prvSignature**,** signatureOp**)**

bldrSig ::= **sig(**[name**,**] classSelector, classType**)**

prvSpec ::= (srvType | **type(**srvTypeName)) [**,** **types(**type+**)**] [**,** (prvId] [**,** prvDeployment]

| bldrSig | prvInstance

opSpec ::= (selector |signatureOp) [**,** srvResult]

[**,** **inConn(**mapEntry+**)**] [**,** **outConn(**mapEntry+**)**] [**,** dataContext]

srvType ::= classType | interfaceType

signatureOp := **op(**selector**,** srvArg\***)** | **op(**opSignature**)**

prvId ::= **srvName(**serviceName [**,** **locators(**locatorName+**)** ] [**,** groupName+]**)**

| **prvName(**providerName**)** |

srvResult ::= **result(**[pathName**,** ][**,** inputPaths] [**,** outputPaths] [**,** dataContext]**)**

prvDeployment ::= **deploy(**(**configuration(**configName**) |** prvImpl)**,** deployOptions**)**

prvImpl ::= **implementation(**providerClassName**),**

**classpath(**jarName\***),** **codebase(**jarName\***)**

deployOptions ::=[**, maintain(**intNumber**)**][**,** **perNode(**intNumber**)**] [, **idle(**intNumber**)**]

inputPaths ::= **inPaths(**srvPath+**)**

outputPaths ::= **outPaths(**srvPath+**)**

**Provider Services**

A *service* *provider* is an instance of local or remote concrete service specified by a signature

prvInstance ::= **prv(**srvSignature**)**

Signatures, signature entries and elementary tasks are bounded to single service providers but service mograms are bound to federations of service providers by the SORCER platform at runtime.

**Requests**

Elementary *service requests* are called *items* and *compound requests* are called *mograms*. For example, signatures, context entries, and service fidelities are items. Context models and exertions are mograms.

srvRequest ::= srvSignature | multiFi | contextEntry | srvMogram

**Multifidelities**

*Fidelity* is defined to be “the degree to which something matches or copies something else” (webster.com) or in general “adherence to fact or detail” (dictionary.com). In SML, a degree of adherence, matching, or accuracy has the same meaning, though it is acknowledged they have different meanings in some circles. Similarly, “multifidelity” in a SML perspective refers to a modeling environment with multiple fidelity levels for a given computing process, meaning there are different computing components or functions to choose from. Fidelity and cost (or similarly accuracy and time) are positively correlated; this represents a fundamental trade in modeling and design.

multiFi ::= entFidelity | sigFidelity | morphFi | varFidelity | reqFidelity | fiMogram

entFidelity ::= **eFi(**[fiName**,** ]contextEntry\***)**

sigFidelity ::= **sFi(**[fiName**,** ]opSignature+**)**

morphFidelity ::= **mFi((**[fiName**,** ]srvRequest+**)**

| **mFi((**[fiName**,** ]srvMorpher**,** srvRequest+**)**

srvMorpher::= MorpherLambdaExpression

varFidelity ::= **vFi(**fiName**,** value**)** | **vFi((**[fiName**,** ]opSignature**)**

| **vFi((**[fiName**,** ][**,** srvRoutine] [**,** entGetter] [**,** entSetter]**)**

reqFidelity ::= **rFi(**[fiName**,** ] srvRequest+**)**

**Entries**

An *entry* is a functional association of a *path* and a *function body* of an underlying context model. A *path* is a function name as a sequence of attributes that define modeling namespace. A body of an entry specifies a return value of the entry. A body defining a function composition depends on paths of other entries in the model scope.

entType ::= **in** | **out** | **inout** | **db**

annotatedPath ::= **path(**pathName [**,** pathTag]**)**

srvPath ::=pathname| annotatedPath

dataEntry ::= **val(**srvPath**,** value**)** | entType**Val(**srvPath**,** value**)**

contextEntry ::= dataEntry | procEntry | srvEntry | varEntry | fiEntry

| entType**(**[name**,** ]contextEntry**)**

procEntry ::= **ent(**pathName**,** srvRoutine [**,** entModel]**)** | sigEntry | lambdaEntry

srvRoutine ::= srvEvaluator | srvInvoker

sigEntry ::= **ent**([name, ]opSignature**)**

mapEntry ::= **ent(**fromPathName**,** toPathName**)**

lambdaEntry ::= **lambda(**pathName**,** (EntryCallableLambdaExpression**)**

| ServiceLambdaExpression

| CallableLambdaExpression

| ClientLambdaExpression]

| ValueCallableLambdaExpression) [**,** srvArgs]**)**

srvEntry ::= **ent(**pathName**,** (opSignature[**,** entModel] [**,** cxtSelector]**)**

| srvRoutine| srvMogram)**)**

varEntry ::= **var(**pathName**,** (value|opSignature|varFidelity+|morphFidelity

| srvRoutine|srvEntry|varProxy)**)** | objectiveVar | constraintVar

cxtSelector ::= **selector**([componentName**,**]pathName+**)**

fiEntry ::= **ent(**pathName**,** entFidelity**)**

varProxy ::= **proxy(**pathname**,** opSignature**)**

srvInvoker ::= **invoker(**JavaExpression**,** srvArgs [**,** dataContext]**)**

| **invoker(**opSignature)| srvExertion | **inc(**srvInvoker, double | int**)**

| **methodInvoker(TODO)**

| **cmdInvoker(TODO)**

| **invoker(**[name**,**]ValueCallableLambdaExpression[**,** contextModel]**,** srvArgs**)**

|procEntry | conditionalInvoker

conditionalInvoker ::=::= **loop**(srvCondition**,** srvInvoker**)**

| **loop(**min**,** max**,** [srvCondition**,**] srvInvoker**)** | **alt(**invokeOption\***)** |invokeOption

invokeOption ::= **opt(**srvCondition**,** srvInvoker**)**

srvCondition ::= **condition(**ConditionCallableLambda**)**

| **condition(**conditionExpression**,** parameterName\***)**

srvArgs ::= **args(**argName+**)**

dependentVars ::= **vars(**dependentVarName\***)**

srvEvaluator ::= objectImplemntingEvaluation | procEntry | lambdaEvaluator

srvInvoker ::= objectImplemntingInvocation

entGetter ::= objectImplemntingGetter

entSetter ::= objectImplemntingSetter

**Mograms**

*Mograms* *are compound requests* that specify service federations. A context model is a declarative specification and an exertion is a procedural one for a dynamically bound federation of collaborating service providers.

contextModelType ::= **procModel** | **srvModel** | **varModel** | **model**

srvExertionType ::= **task** | **block** | **job** | conditionalExertion | **exertion**

conditionalExertionType ::= **loop** | **alt** | **opt**

srvMogramType ::= contextModelType | srvExertionType | **mogram**

**model** == **mdl**

**context** == **cxt**

**exertion** == **xrt**

**mogram** == **mog**

srvMogram ::=dataContext | contextModel | srvExertion | fiMogram

| **mogram(** (contextModelParameters | srvExertionParamters) **)**

fiMogram ::= **fiMog(**[name**,**] (morphFidelity | reqFidelity**)**

**Models**

A *model* is an aggregation of entries representing service federations as functionals. A data context is composed of entries of the dataEntry type and a context model of entries of the contextEntry type.

entModel ::= dataContext | contextModel | structuredVarModel | contextSnapshotResult

dataContext ::= **context**([name,] dataEntry+ [**,** srvResult][**,** inputPaths] [**,** outputPaths]**)**

**| tag(**dataContext**,** annotatedPath**)** | **tagAssociation(**dataContext**,** newTagAssociation**)**

contextModel ::= contextModelType **(**[name**,** ] contextEntry+

[**,** **response(**pathname+**)** [**,** srvDependency]**)**

parTypes ::= **types(**Class+**)**

parArgs ::= **args(**object+**)**

srvDependency::= **dependsOn(ent(**pathName, **paths(**pathname+**)**+**)**

**Tasks**

A task specifies an action of provider service or concatenation (batch) of provider services processing data context.

srvTask ::= **task(**[name**,**] [opSignature\* | sigFideliy\* | sigMorphFidelity]**,** [dataContext]**)**

**Exertions**

An exertion is a *task* – an elementary exertion – or a hierarchical composition of tasks and other exertions – a compound exertion. Concatenated exertions (blocks), workflow exertions (jobs) and a conditional exertions are compound exertions that are specified accordingly by signature, data context, and component mograms with optional control strategy and execution dependencies.

srvExertion ::= srvTask | compoundExertion | **exertion(**srvExertionParamters**)**

compoundExertion ::= srvJob | srvBlock | conditionalExertion

srvJob ::= **job(**[name**,**] [opSignature | sigFideliy]**,** dataContext**,** srvMogram\***,**

contextPipe\* [**,** exertionStrategy] [**,** dependency], metaFiSelector\***)**

srvBlock = **block**([name**,**] [opSignature | sigFideliy]**,** [dataContext**,**]

srvMogram\***,** metaFiSelector \***)**

conditionalExertion ::= **loop**(srvCondition**,** srvMogram**)**

| **loop(**min**,** max**,** [srvCondition**,**] srvMogram**)** | **alt(**srvOption\***)** |srvOption

srvOption ::= **opt(**srvCondition**,** srvMogram**)**

contextPipe ::= **pipe(outPoint(**srvExertion, contextPathName**),**

**inPoint(**srvExertion, contextPathName**))**

exertionStrategy ::= **strategy(**[accessType**,**] [flowType**,**] [monitorable**,**] [provisionable]**)**

flowType::= **Flow.PAR** | **Flow.SEQ**

monitorable ::= **Monitor.YES | Monitor.NO**

**Structured Var-Modeling**

Var-oriented models are structured contextModels with additional specialized aggregations of multifidelity varEntries (for example inputs, outputs, constraints, objectives vars, etc.), The structured var-models are associated with specialized modeling tasks, for example, a response, parametric, or exploration tasks. A result of executing a modeling task is, for example, a response vector for a vector of design inputs, a response table for a parametric table, and exploration context for an optimization task. When declared, a structured var-model can be more or less concrete. To be executed, to some degree an abstract model has to be configured by specifying all vars as fully declared in a model. Aggregated var-entries in structured var-models collaborate in the model accordingly to a declared type of structured modeling. Structured var-models can be used as local or remote service providers. In either case a modeling task specifies a required modeling provider with its modeling context and returns a corresponding result.

structuredVarModel ::= responseModeling | parametricModeling | optimizationModeling

| streamingParametricModeling

responseModeling ::= **responseModel(**[modelName**,** ]

[modelingInstance**,** ] baseVars+**,** varRealization\***)**

parametricModeling ::= **paramericModel(**[modelName**,** ]

[modelingInstance**,** ] baseVars+**,** varRealization\***,**

**table(**varParametricTable**,** varResponseTable**))**

streamingParametricModeling ::= **streamingParametricModel(**[modelName**,**

modelingInstance**) TODO streamer reader?**

optimizationModeling ::= **optimizationModel(**[modelName**,** ] baseVars+**,** varRealization\***,**

**objectiveVars(**objectiveVar+**), constraintVars(**constraintVar+**)** [**,** modelingInstance]**)**

modelingInstance ::= **instance(**bldrSig**)**

varType ::= **input** | **output** | **linked** | **constant**

baseVars ::= varType**Vars(**varName+**)** |varType**Vars(**varName**,** count#**)**

| varType**Vars(**varName**,** from#, to#**)** | **var(**[name**,**] srvEntry**)**

varParametricTable ::= **parametricTable(**tableURL [**,** tableSeparator]**)**

| **table(header(**varName+**)**, **row(**value+**)**+**)**

| **parametricTable(**instanceofModelTable.class**)**

varResponseTable ::= **responseTable(**tableURL [**,** tableSeparator]**)**

objectiveVar ::= **var(**varName**,** outputVarName**,** optiTarget**)**

optiTarget ::= **Target.min** | **Target.max**

constraintVar ::= **var(**varName**,** outputVarName**,** **Relation.**relationSuffix**)**

relationSuffix ::= **lt** | **lte** | **eq** | **gt** | **gte**

varRealization ::= **realization(**varName**,** **fi(**fiName**,** varComponent+**)**\***,**

**fi(**fiName**,** **differentiation(wrt(**varName+**))**\***)**

varComponent ::= **evaluator(**evaluatorName**)** | **getter(**getterName**)** | **setter(**setterName**)**

**Structured-Var Modeling Tasks**

modelingTask ::= mdlResponseTask | mdlParamericTask | mdlOptimizationTask

mdlResponseTask ::= **responseTask (outerSig(**selector, bldrSig**)**

[**,** **modelingContext(**[**inputs(**dataEntry+**),** ] [**responses(**varName\***),** ]

[**,** **result(**pathName**)**]**))**

mdlParamericTask ::= **parametricTask(outerSig(**selector**,** bldrSig**),**

**modelingContext(**varParametricTable**,** varResponseTable**,**

[**, parameters(**varName\***)**] [**, responses(**varName+**)**] [**,** **result(**pathName**)**]

[**,** parStrategy]**))**

mdlOptimizationTask ::= **optimizationTask (**explorerSignature**,** optiStrategy**,**

**modelingContext(initialDesign(**dataEntry+**)** [**,** **result(**pathName**)**]**))**

parStrategy ::= **parallel(queue(**int**),** **pool(**int**))**

optiStrategy ::= **strategy(**optiTarget**,** **dispatcherSig(**prvSignature**),**

**modelSig(**prvSignature**),** **optimizerSig(**prvSignature**))**

explorerSignature ::= opSignature

**Accessing Values and Getting Results**

contextValueResult ::= **value(**dataContext, pathName | outputPaths**)**

| **valueAt(**dataContext, index**)**

| **valueAt(**dataContext, pathTag**)** | **valuesAt(**dataContext, pathTag**)**

| **get(**contextModel, pathName)

srvValueResult ::= **exec(**srvRequest**,** arg\***)** |

| **eval(**contextEntry, srvArg\***)** | **eval(**entModel, pathName, srvArg \***)**

| **eval (**srvExertion, srvArg\***)** | **returnValue(**srvMogram**)**

srvMogramResult ::= **exert(**srvMogram, srvArg\***)**

dataContextResult ::= **response(**entModel, srvArg\***)**

| **result(**entModel [, pathName]**)** | **context(**srvMogram**)**

| **upcontext(**compoundExertion**)**

srvExertionResult ::= **get(**srvExertion, componentPathName**)**

srvEntryResult ::= **getEntry(**dataContext, pathName**) | getEntry(**contextModel, pathName**)**

structuredVarModelResult ::= **setInputs(**structuredVarModel**,** dataContext**)**

contextSnapshotResult ::= **snapshot(**srvExertion**)**

| **snapshot(**structuredVarModel [**,** varInfo +]**)** | **snapshot(**prvSignature [**,** varInfo +]**)**

| **evalSnapshot (**structuredVarModel [**,** varInfo +]**)**

| **evalSnapshot (**prvSignature [**,** varInfo +]**)**

varInformation ::= **varInfo(**varsType, varName\***)**

varsType ::= **INPUTS** | **CONSTANTS** | **INVARIANTS** | **DESIGN** | **PARAMETERS**

| **ALL\_OUTPUTS** | **OUTPUTS** | **RESPONSES** | **LINKED** | **OBJECTIVES**

| **CONSTRAINTS** | **WATCHABLE** | **ALL** | **NONE** | **NULL** |

srvArg ::= instanceofArg.class | dataEntry | srvMogram | fiSelector | metaFiSelector

| cxtSelector | inputPaths | outputPaths |srvResult | opSignature | accessType

| provsionable | fiList

fiSelector ::= **fi(**pathName, fiName**)**

metaFiSelector ::= **fi(**fiName**,** fiSelector+**)**

fiList ::= fis((fiSelector | fiList)+])

accessType ::= **Access.PUSH** | **Access.PULL**

provisionable ::= **Provision.YES** | **Provision.NO**

**Comments**

* Not all parts of SML language implementation are available as open source
* The simplified BNF notation is used to enhance functional composition notation for SO metamodeling with type-based arguments. That means that in most cases the order or function arguments does not matter and number of arguments depends on the context used.
* Each rule is of the form nonterminal ::= metaexpression. Other metasymbols are: | for alternation, brackets [ … ] for options, parenthesis ( ... ) for grouping, postfix + for 1 or more occurrence, postfix \* for 0 or more occurrences, and ; for the rule termination unless the line delimiter indicates termination. For simplicity, postfix \* and + includes the terminal separator **,** for each function argument. The equivalence == is for aliasing and abbreviations. Note the dual use of parenthesis as BNF metasymbols and SML terminal symbols in bold.
* Terminals appear in bold and non-terminals in plain;
* Non-terminals name, \*Name, annotation, and selector are of String type
* srvType is a class or interface type (\*.class)
* value is an instance of Object, instanceofClassName.class in an object of ClassName type
* \*LambdaExpression is a Java 8 lambda expression for the functional interface named by a prefix to “LambdaExpression”
* conditionExpression is a Groovy style closure with parameterNames as paths in its block context (scope)
* **loop** min times, then while condition is true, loop (max - min) times.
* (UML semantics of the loop operator)
* in netlets
  + classpath specification examples
  + @Load('org.sorcer:sml:jar:${sorcer.version}')
  + @Load(group='org.sorcer', module='sml', version='${sorcer.version}')
  + codebase specification examples
  + @Codebase('org.sorcer:sml:jar:dl:${sorcer.version}')
  + @Codebase(group='org.sorcer', module='sml', version='${sorcer.version}', classifier='dl')
* *Tell me and I forget. Show me and I remember. Involve me and I understand.* Get involved - the SORCER project website: <http://sorcersoft.org/project/site/>