Generating UML Models with Inferred Types from Pharo Code

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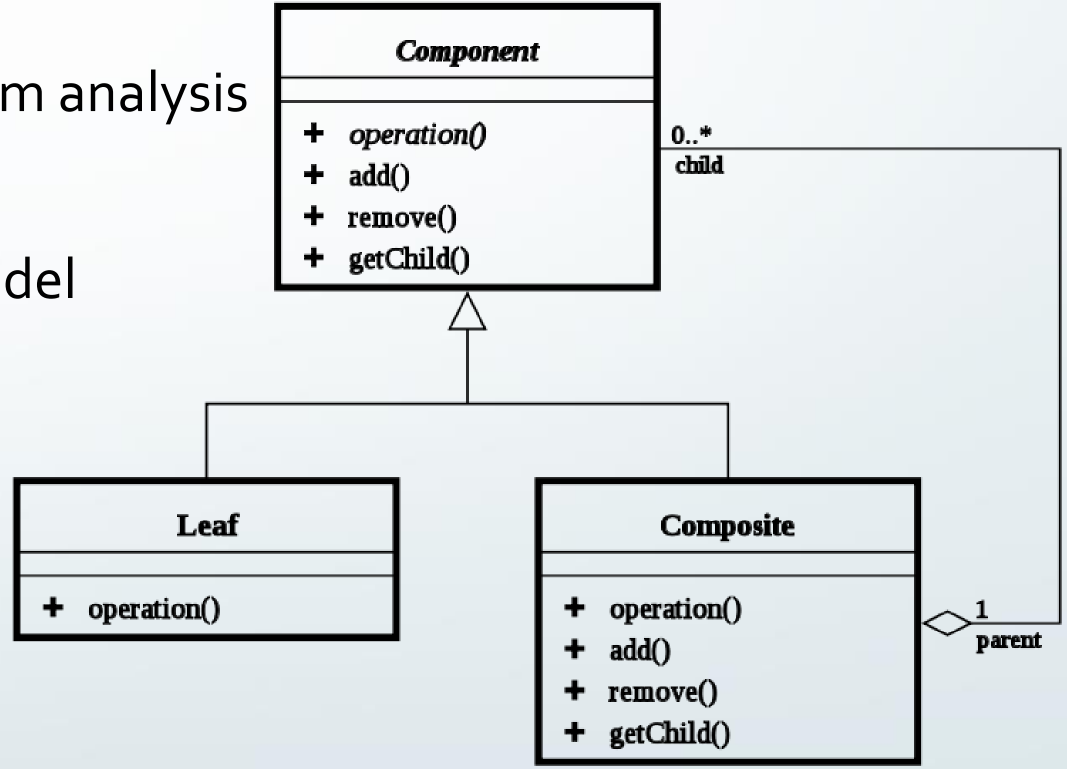
Models and diagrams

- Models and diagrams help with legacy system analysis
- Model is an abstraction of the system
- Diagram is a visual representation of the model
- Most common: UML
  - Widely used tools:
    Enterprise Architect,
    Modelio
    and many other



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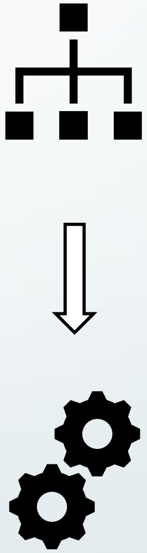
Keeping UML models up-to-date

- Updating models, generating code from model
- Updating models and code together
- Updating models based on code changes



Keeping UML models up-to-date

- Models are often outdated
- … or there are no models at all
- What to do now?

How to get UML model from code?

- Lots of manual work

  or

- Generating

UML related tools in Pharo

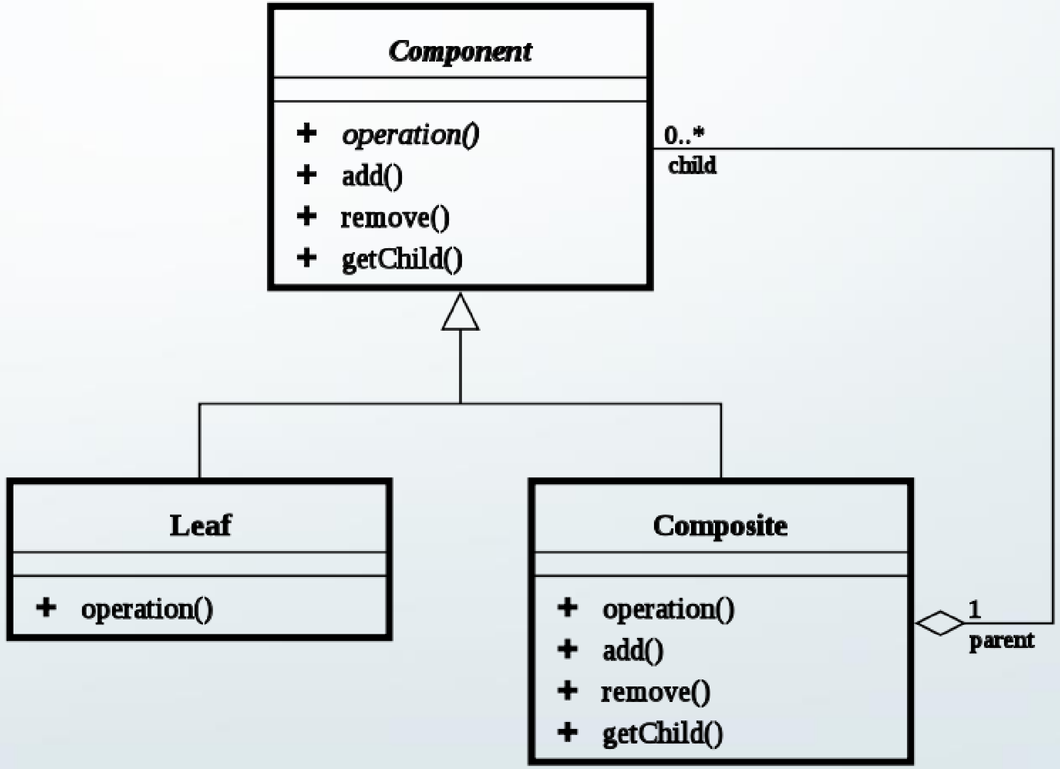
- GraphViz binding
  - generating UML class diagrams, no models, no associations
- Moose with FAMIX models
  - generating models similar to UML, uses RoelTyper to find types
- OpenPonk
  - creating UML class structure models (actual UML by specification), no generating

Need for types

Types

⇩

dependencies between classes or packages



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Type inference

- Static – analysis of the code itself / AST:
  - assignments of just-created instances
  - messages send expressions
- Real-time / dynamic – logging types of running code
  - requires running application, or thorough tests or examples

Type inference tools in Pharo

- RoelTyper – variables only, no contents of collections
- RBRefactoryTyper – variables only, includes contents of collections
- J2Inferer – variables, method parameters and return types
- Several research results regarding real-time type inference

Goal

- Long term goal: Generating UML Diagrams from Smalltalk code and using them in broadly used tools like Enterprise Architect
- For now: focusing specifically on generating structural UML models from Pharo code.
  - Models for Class diagrams

Steps towards the goal

- How to represent UML models in Pharo?
- How to generate a UML model with class structure, operations (methods), properties (variables) etc. from a Pharo code?
- How to find types of instance variables, method parameters and return types?
- How to transfer/import the generated model to Enterprise Architect?
- How could be such model used for creation of UML Diagrams with as many automation as possible?

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How to represent UML models in Pharo?

- UML metamodel for OpenPonk
  - Independent from OpenPonk
  - Generated from UML specification

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How to generate a UML class structure model?

- Moose has Pharo to FAMIX importer
  - FAMIX to UML convertor could be created
  - Advantage: reusing existing project
- Custom generator inspired by FAMIX importer
  - Advantage: independent on FAMIX and Moose, single step instead of two

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Structure generator

Includes:

- classes of the package with all details
- classes the package depends on
  - without details – customizable
  - without their dependencies

Dependencies of the package

- Superclasses
- Classes of objects used by classes in the package
  - Object assigned to an instance/shared variable
  - Object passed as an argument
  - Object returned
  - ~~Object used temporarily in a single method~~

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How to find types of instance variables, method parameters and return types?

- TypesManager handles finding data types

TypesManager

- In case the type is already known, return it
    - found types are persistent
- In case the type is not known, find it!

How should TypesManager find the type?

- Use any of the static type inferrers or real-time type inference?
- Try to do it automatically or just help the user (analyst)?

How should TypesManager find the type?

- Adaptors for type inferrers
  - Possibility to create custom inferrer or use any other one
- Type inferrers combinator
  - If one inferrer did not find a type, the other one might
- These return possible types
  - One, multiple ones or none

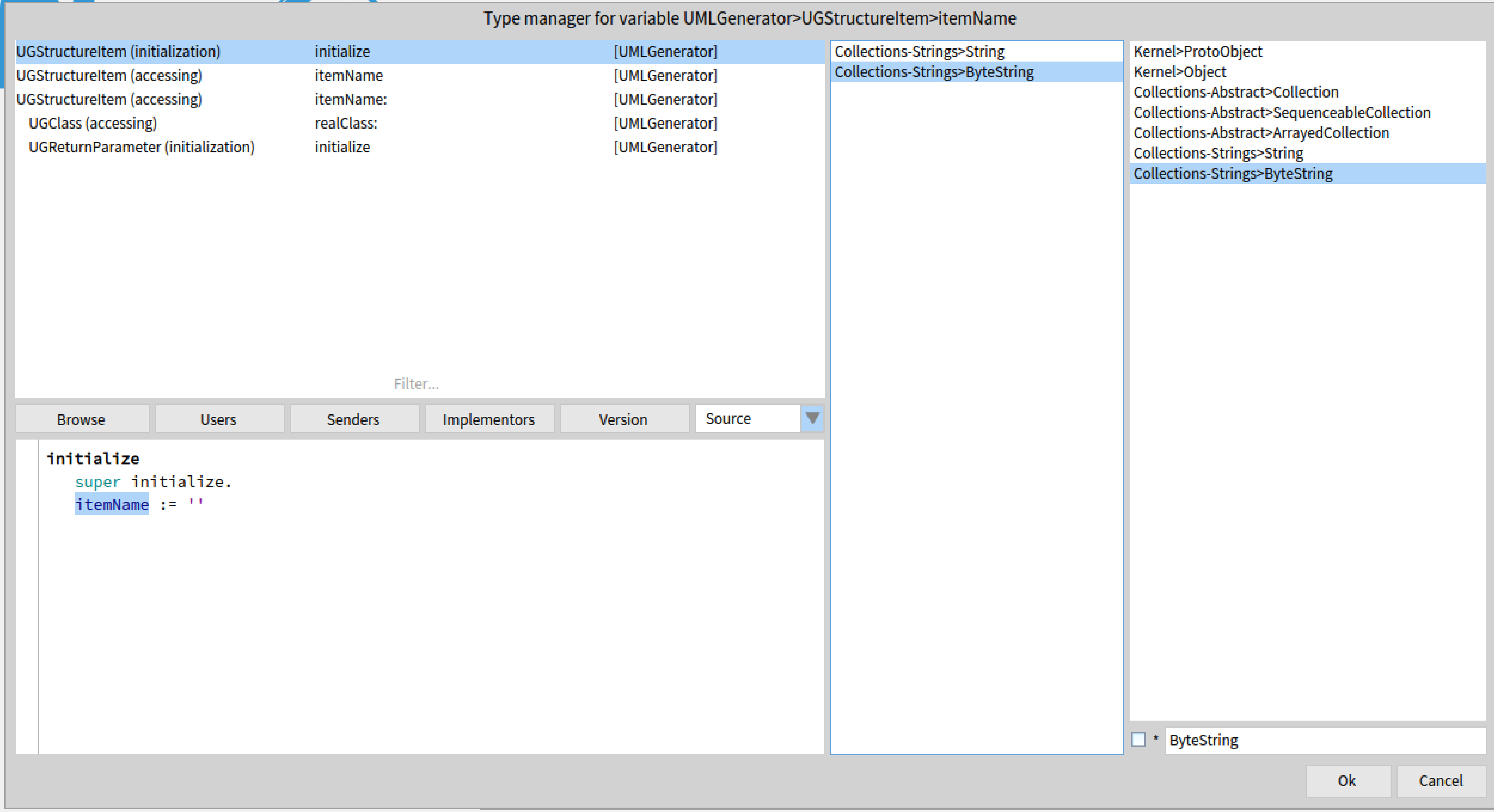
Picking one type from several options

- Semi-automatic way: provide user with as much insight as possible to make the decision
- Automatic way: Heuristics (prone to error) or picking common superclass

Semi-automatic way of picking a type

Help user by providing GUI with:

- Option to pick from classes offered by type inferrer(s),
- their superclasses
- or write any name of a class in the system
  - in case type inferrer did not find anything or offer wrong classes,
- integrated „references of the variable" GUI
  - currently just for instance variables, extendable



Type manager for variable UMLGenerator>UGStructureItem>itemName

UGStructureItem (initialization)	initialize	[UMLGenerator]
UGStructureItem (accessing)	itemName	[UMLGenerator]
UGStructureItem (accessing)	itemName:	[UMLGenerator]
UGClass (accessing)	realClass:	[UMLGenerator]
UGReturnParameter (initialization)	initialize	[UMLGenerator]

```
initialize
	super initialize.
	itemName := ''
```

Collections-Strings>String
Collections-Strings>ByteString

Kernel>ProtoObject
Kernel>Object
Collections-Abstract>Collection
Collections-Abstract>SequenceableCollection
Collections-Abstract>ArrayedCollection
Collections-Strings>String
Collections-Strings>ByteString

□ * ByteString

Automatic way of picking a type

Picking common superclass

- Discards correct type if there is also a wrong, unrelated type
- Duck typing – two classes without common superclass (except of Object) might both be correct
  - Example: a block might be subtituted by a symbol
- Prefers marking types as unknown/Object before picking the wrong one
- Sometimes class should be skipped to superclasses (SmallInteger -> Integer)

Smalltalk vs UML

- Representing String with multiplicity (0..*) and marking elements as unordered and unique
  - How to denote difference OrderedCollection and Array? What to do with Dictionaries?
  - String is also a collection – we prefer to represent it as String, not ordered collection of characters
- UML is based on Java-like languages
  - Static methods/variables, interfaces, no traits
  - What to do with class-side? Marking them as static or separating UML Class for String and another for String class?

Real-time type inference

- Custom implementation of real-time type inference
- Based on Metalinks – enhancing AST by custom code with types logging
  - before the AST root of the method itself => method arguments,
  - after each variable assignment node => contents of instance variables,
  - before each return node => returned types,
  - If last node is not return => returned type is self class (could be found statically).

Real-time type inference

- Cannot find types for methods not **executed** during logging & variables not assigned to
- Requires running application, well tested code, executable examples or at least very thorough use-case scenarios
  - otherwise nothing is found

Real-time type inferrer

- A command to start logging
- Manual execution of tests, examples…
- A command to stop logging and remove metalinks
- The inferrer is ready to by asked for logged types
  - Is provided to TypesManager that asks for types

Comparison of available type inferrers

- Took several packages in Pharo
- Used each type inferrer separatedly and all of them combined together
- Set automatic way of picking types
- In case of real-time type inference, executed all available tests and executable examples
- Counted items with a single found type other than Object
  - Items = instance variables, shared variables, method arguments, return types

Comparison of available type inferrers

Package name	Total	RoelTyper	RBRefactoryT.	Real-time	Combined
Zinc-HTTP	2369	76 (3,2 %)	88 (3,7 %)	1565 (66,1 %)	1584 (66,9 %)
Athens-Cairo	1146	34 (3,0 %)	31 (2,7 %)	298 (43,5 %)	513 (44,8 %)
GT-Playground	264	3 (1,1 %)	5 (1,9 %)	58 (22,0 %)	60 (22,7 %)
Ombu	430	21 (4,9 %)	26 (6,0 %)	255 (59,3 %)	263 (61,2 %)
OSWindow-Core	1675	57 (3,4 %)	50 (3,0 %)	64 (3,8 %)	125 (7,5 %)
Tool-Diff	559	34 (6,1 %)	29 (5,2 %)	0 (0,0 %)	34 (6,1 %)
Traits	1823	14 (0,8 %)	13 (0,7 %)	17 (0,9 %)	30 (1,6 %)

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How to transfer/import the generated model to Enterprise Architect?

- Standardized XMI format for representing UML models
  - based on XML
- UML Metamodel for OpenPonk comes with XMI exporter
- Most modelling tools come with XMI import capabilities

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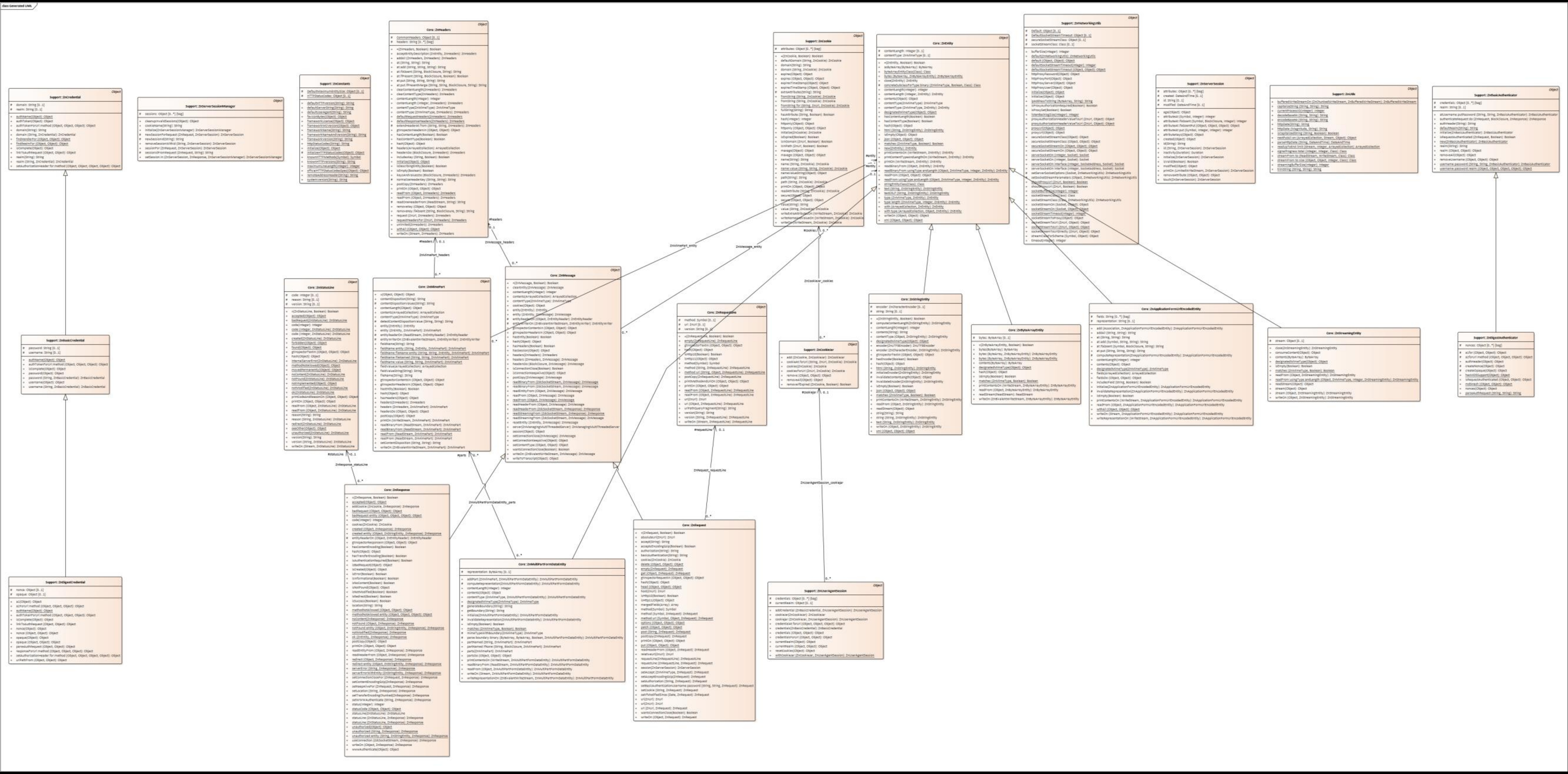
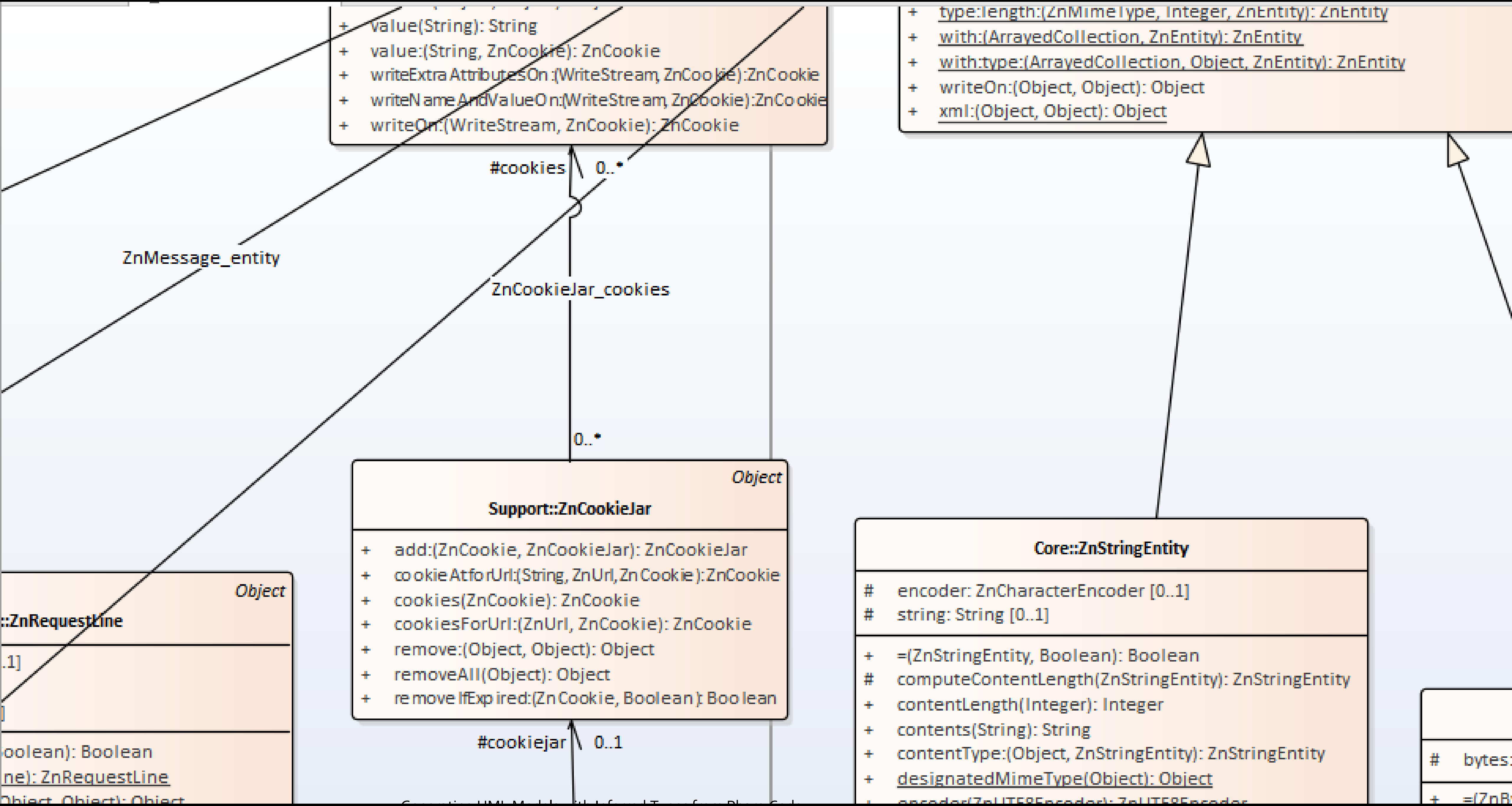
How could be such model used for creation of UML Class Diagrams with as many automation as possible?

- TODO ☺
- We can generate one large diagram of the whole package or tag
  - Might be too large with unimportant auxiliary classes
- How to split the model into several class diagrams?
- For now, Enterprise Architect offers quite quick way to select all classes in any package/tag and *(quite good)* auto-layouting


class Generated UML
Support::ZnCredential
Support::ZnServerSessionManager
Support::ZnConstants
Core::ZnHeaders
Support::ZnCookie
Core::ZnEntity
Support::ZnNetworkingUtils
Support::ZnServerSession
Support::ZnUtils
Support::ZnBasicAuthenticator
Core::ZnStatusLine
Core::ZnMimePart
Core::ZnMessage
Core::ZnRequestLine
Support::ZnCookieJar
Core::ZnStringEntity
Core::ZnByteArrayEntity
Core::ZnApplicationFormUrlEncodedEntity
Core::ZnStreamingEntity
Support::ZnDigestAuthenticator
Support::ZnBasicCredential
Support::ZnDigestCredential
Core::ZnResponse
Core::ZnMultiPartFormDataEntity
Core::ZnRequest
Support::ZnUserAgentSession
ZnMimePart_headers
ZnMessage_headers
ZnMimePart_entity
ZnMessage_entity
ZnCookieJar_cookies
ZnResponse_statusLine
ZnMultiPartFormDataEntity_parts
ZnRequest_requestLine
ZnUserAgentSession_cookieJar
Object



+ value(String): String
+ value:(String, ZnCookie): ZnCookie
+ writeExtraAttributesOn:(WriteStream, ZnCookie):ZnCookie
+ writeNameAndValueOn:(WriteStream, ZnCookie):ZnCookie
+ writeOn:(WriteStream, ZnCookie): ZnCookie

+ type:length:(ZnMimeType, Integer, ZnEntity): ZnEntity
+ with:(ArrayedCollection, ZnEntity): ZnEntity
+ with:type:(ArrayedCollection, Object, ZnEntity): ZnEntity
+ writeOn:(Object, Object): Object
+ xml:(Object, Object): Object

Object

Support::ZnCookieJar

+ add:(ZnCookie, ZnCookieJar): ZnCookieJar
+ cookieAtforUrl:(String, ZnUrl, ZnCookie):ZnCookie
+ cookies(ZnCookie): ZnCookie
+ cookiesForUrl:(ZnUrl, ZnCookie): ZnCookie
+ remove:(Object, Object): Object
+ removeAll(Object): Object
+ removeIfExpired:(ZnCookie, Boolean): Boolean

Object

::ZnRequestLine

.1]

]

oolean): Boolean
ne): ZnRequestLine
Object, Object): Object

Core::ZnStringEntity

encoder: ZnCharacterEncoder [0..1]
string: String [0..1]

+ =(ZnStringEntity, Boolean): Boolean
# computeContentLength(ZnStringEntity): ZnStringEntity
+ contentLength(Integer): Integer
+ contents(String): String
+ contentType:(Object, ZnStringEntity): ZnStringEntity
+ designatedMimeType(Object): Object

bytes:
+ =(ZnB

Future work

- Generating diagrams from models
- Generating models for sequence diagrams
- Improving current type inference tools
- Improving several important aspects of current solution
- Trying the solution on large commercial project

Thank you

Questions?

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The presented research was sponsored by Tomcat® computer GmbH.