

Towards a MAS Product Line Engineering Approach

*Dounia Boufedji , Zahia Guessoum,
Anarosa Brandao, Tewfik Ziadi, AlchaMokhtar*

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Agenda

- Context and Motivation
- Our MAS-PL approach
- MAS analysis
- MAS implementation
- Evaluation
- Conclusion and future work

Context and Motivation

- Several application domains

- Smart grids
- Smart cities
- Simulations of complex systems
- ...

- Agent-oriented Software Engineering(AOSE)

- MAS methods and meta-models: Gaia, Ingenias, PASSI, ADELFE, ASPECS, TROPOS, Prometheus...
- MAS tools and languages: Jade, Jason, JaCaMo, Netlogo, Repast ...

Context and Motivation

- AOSE approaches are not suitable to develop similar applications (a.k.a; MAS families)
 - MAS families present similarities (i.e. commonalities) and differences (i.e. variabilities)
- Managing MAS variability in MAS families
 - key solution to capitalize MAS implementation expertise.

Context and Motivation

- Software Product Line Engineering (SPLE)
 - an interesting solution to manage MAS variability

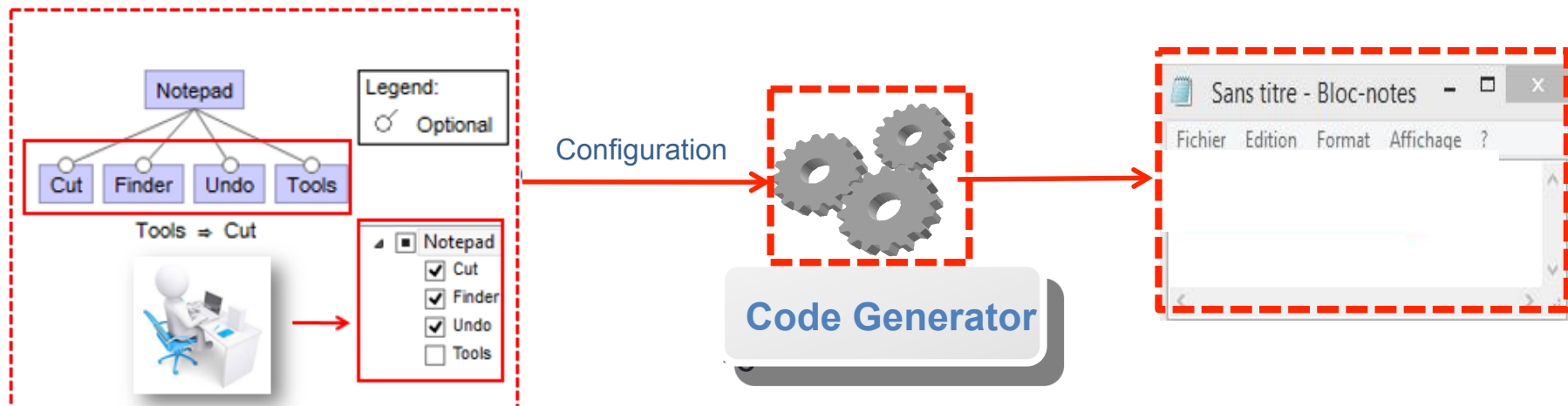
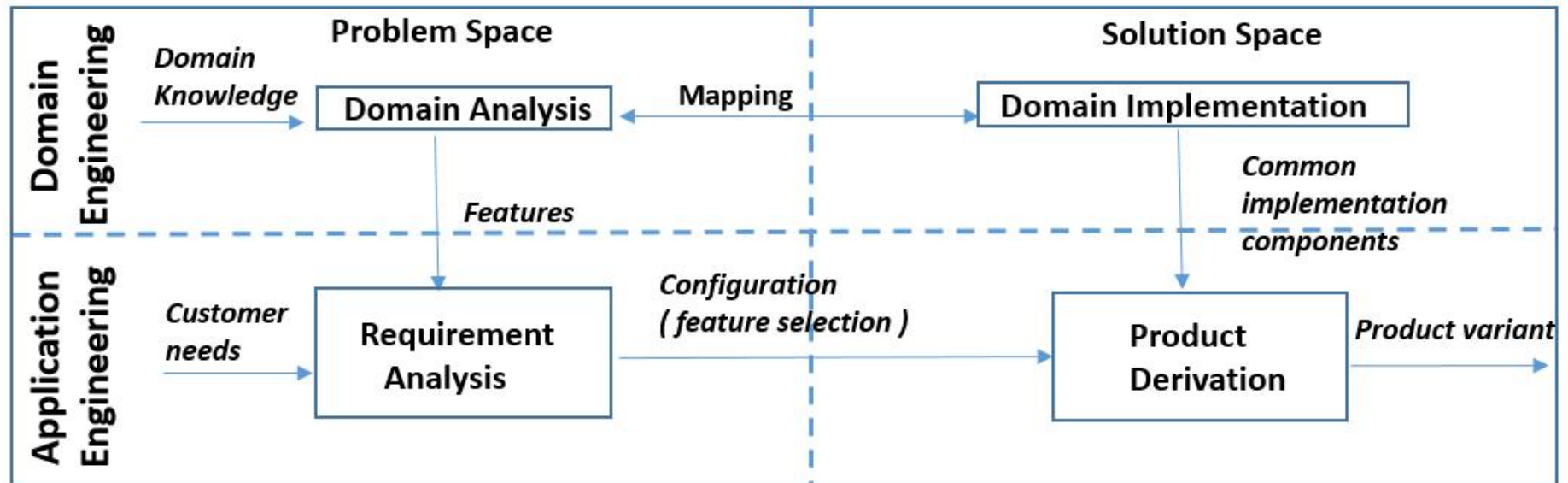
- Software product line (SPL)

set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment and that are developed from a common set of core assets in a prescribed way. It focuses on capturing commonality and variability between several software products (Clements01).

Context and Motivation

■ Software Product Line Engineering framework

[Apel et al, 2013]



Context and Motivation

■ Several MAS-PL Approaches (Peña et al, 2006, 2007; Nunes et al, 2009, 2010, 2011; Dehlinger et al, 2011; Ayala et al, 2015)

- + introduce the notion of variability for a reuse issue within a MAS family.

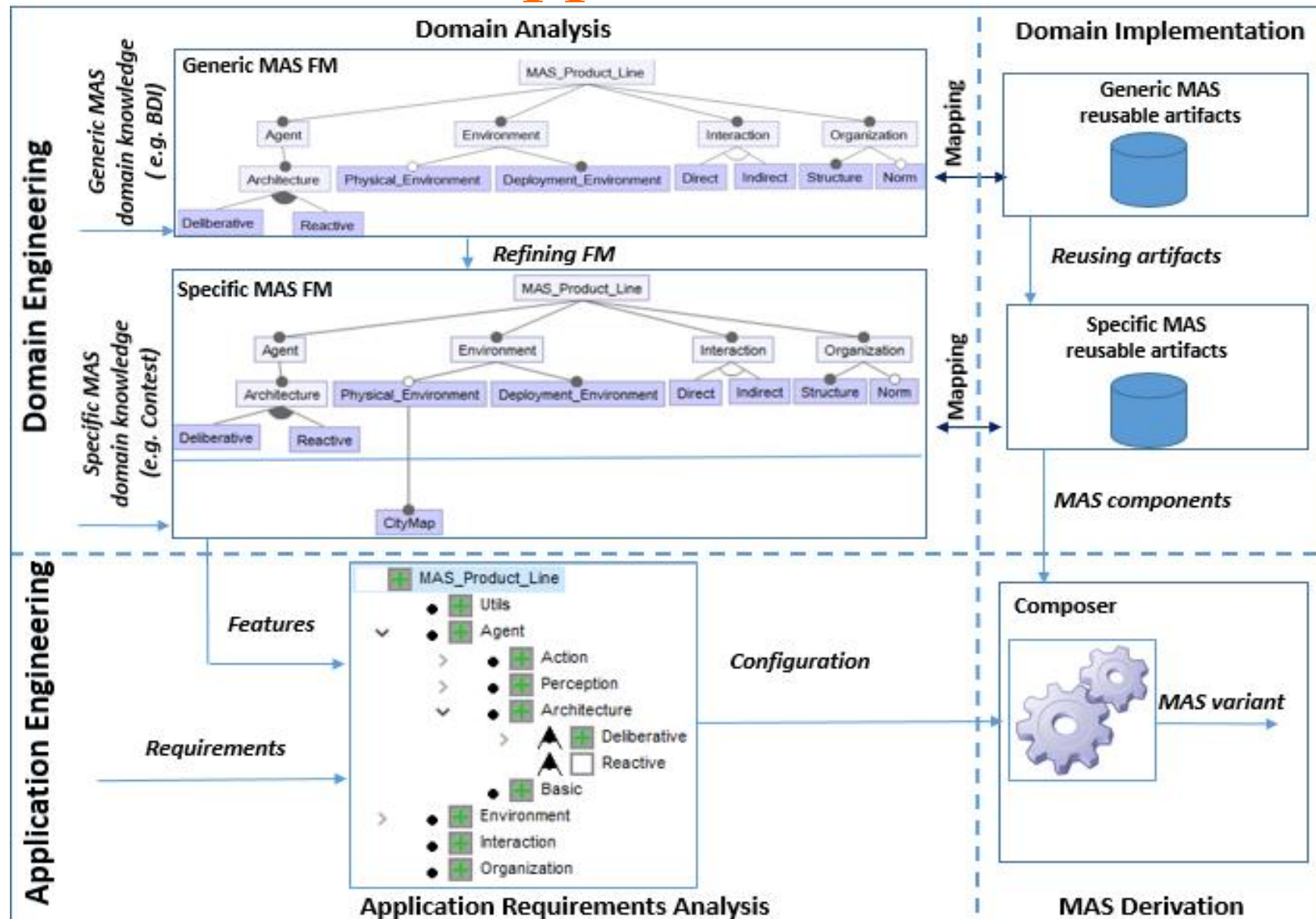
- + often built as extensions of existing methods.

- introduce complex notations to specify variability at domain engineering.

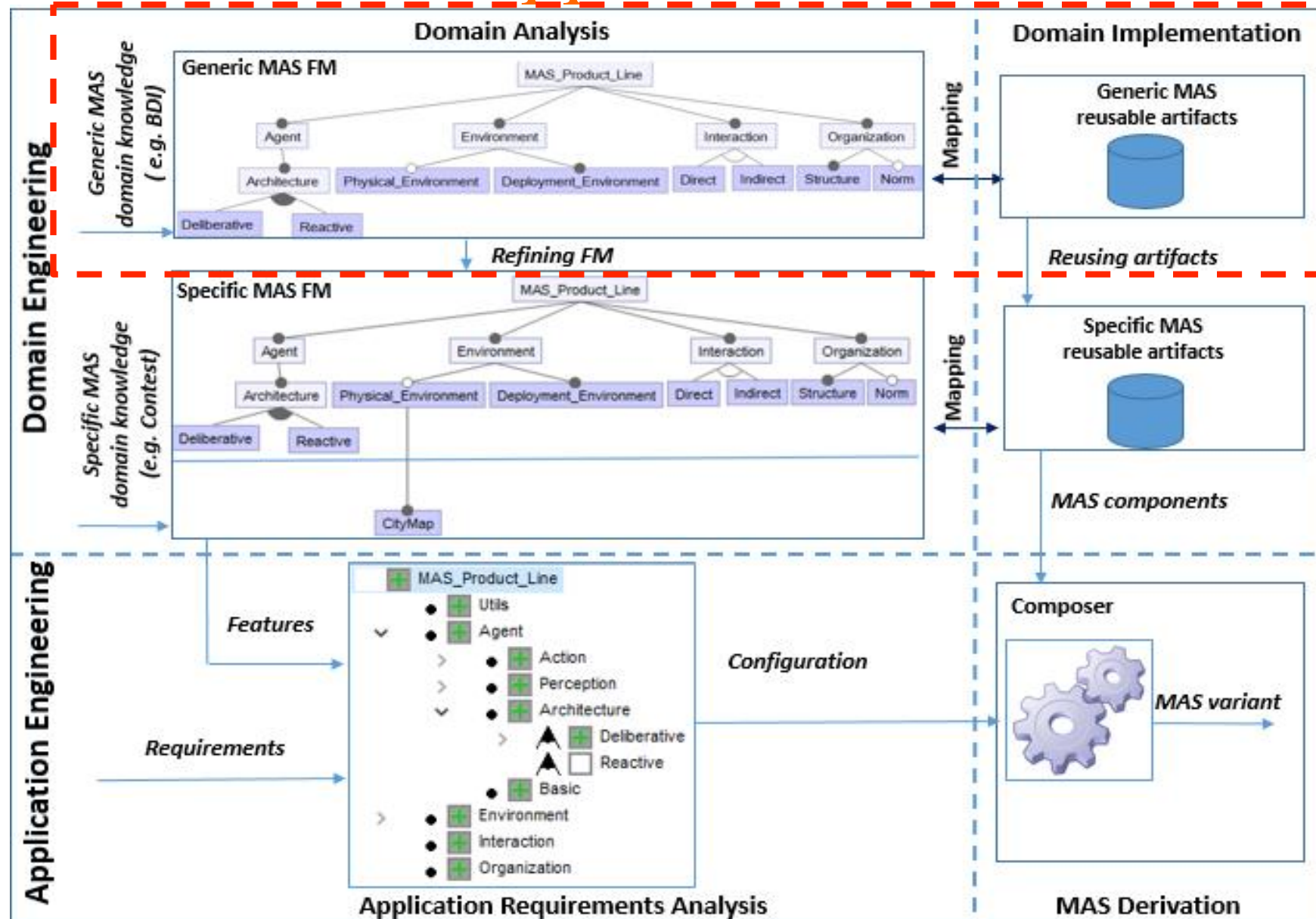
- only address an specific domain

- focus on the domain analysis

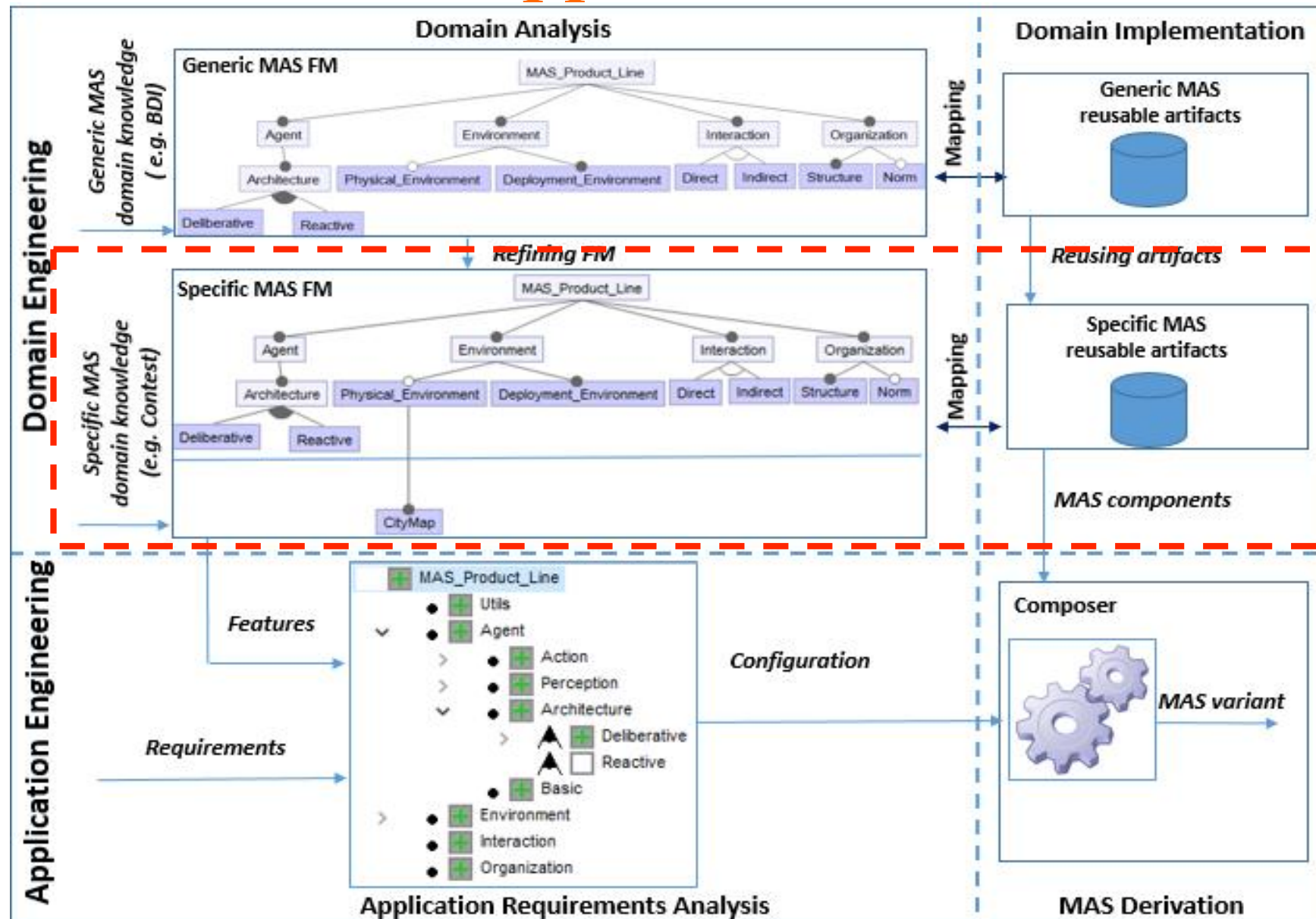
Our MAS-PL approach



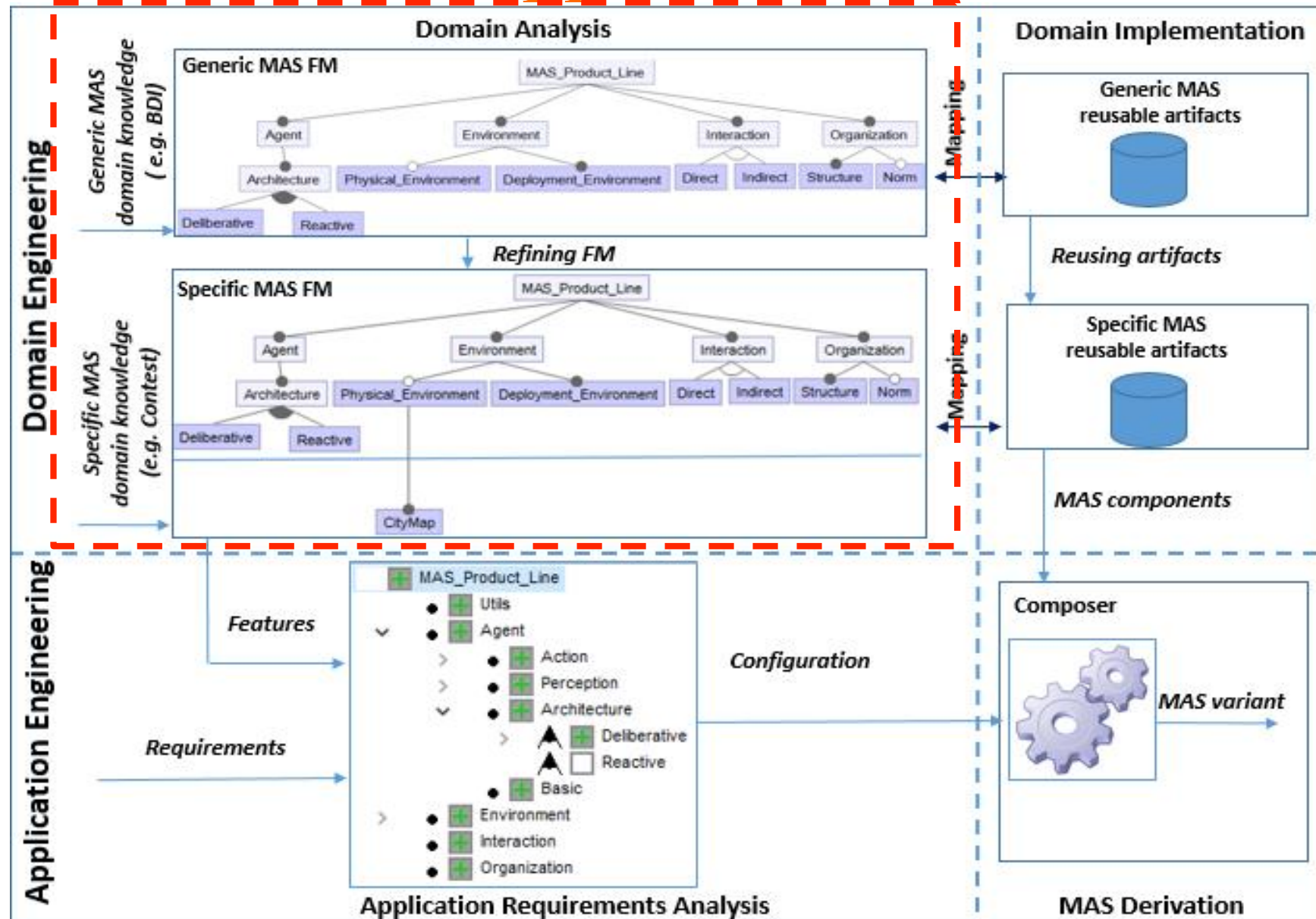
Our MAS-PL approach



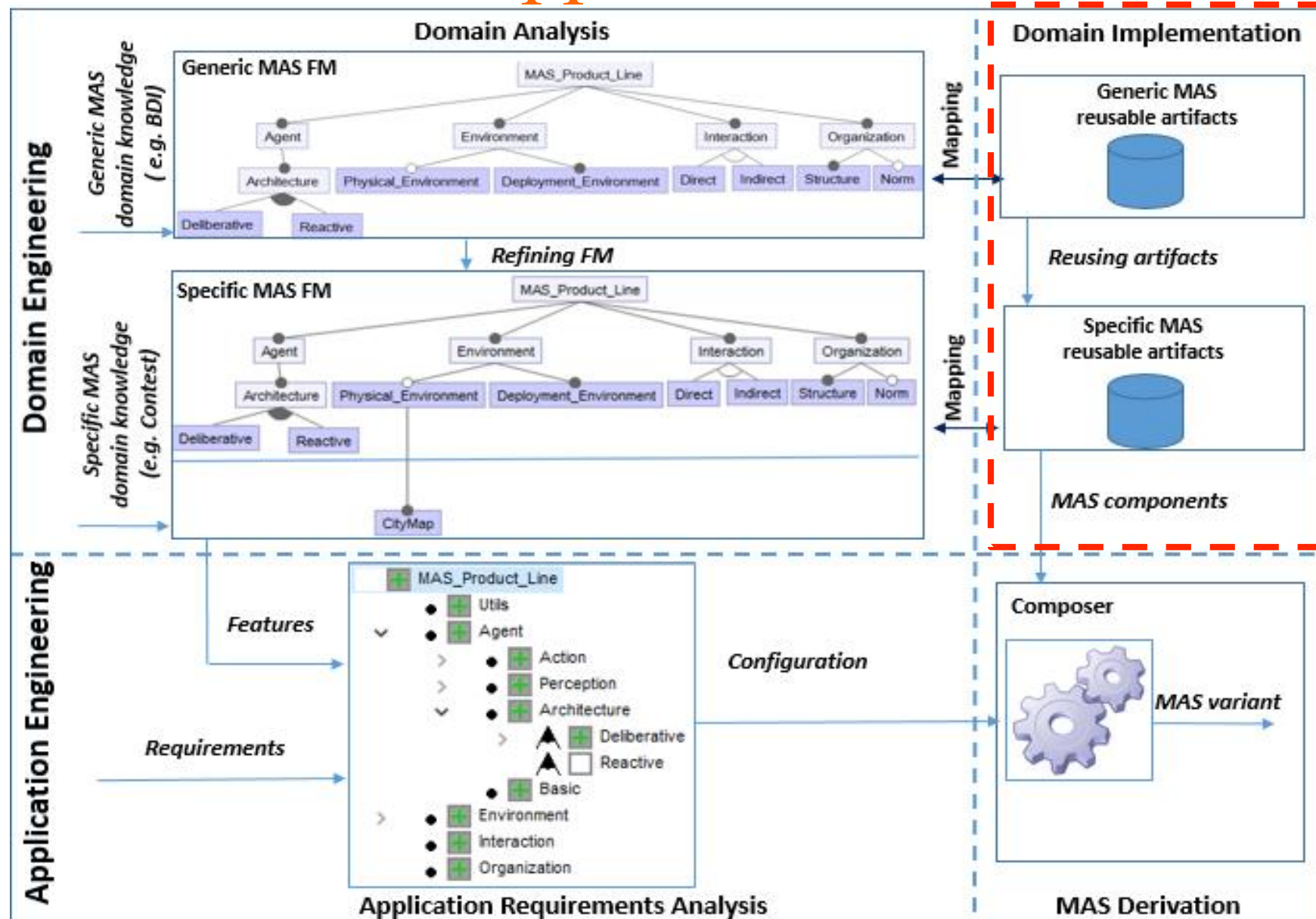
Our MAS-PL approach



Our MAS-PL approach

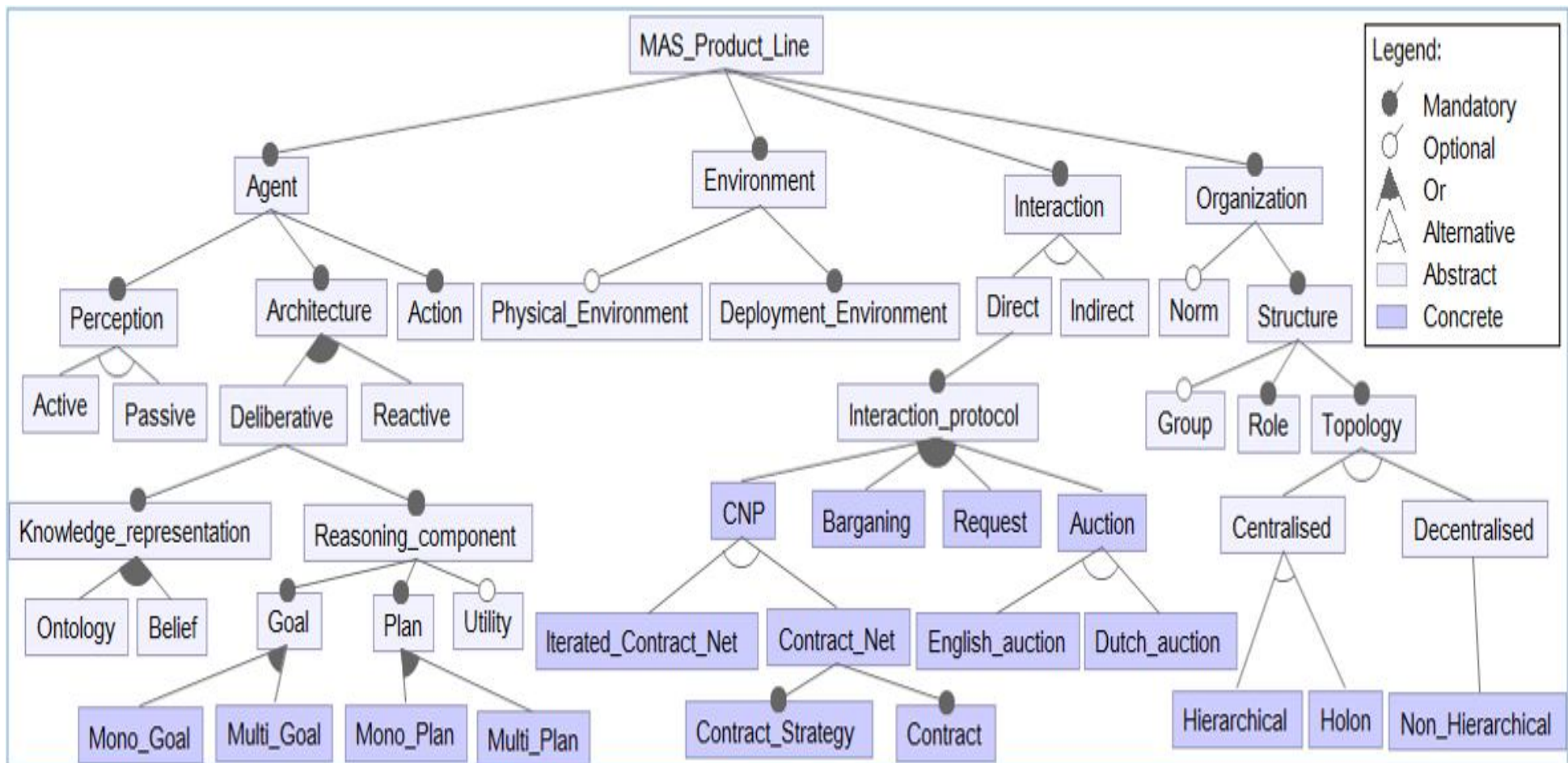
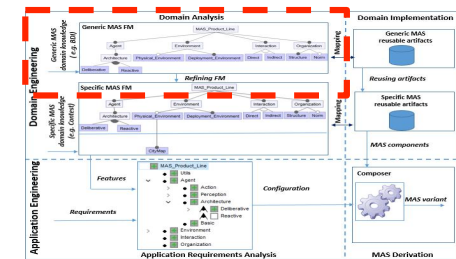


Our MAS-PL approach



MAS Analysis

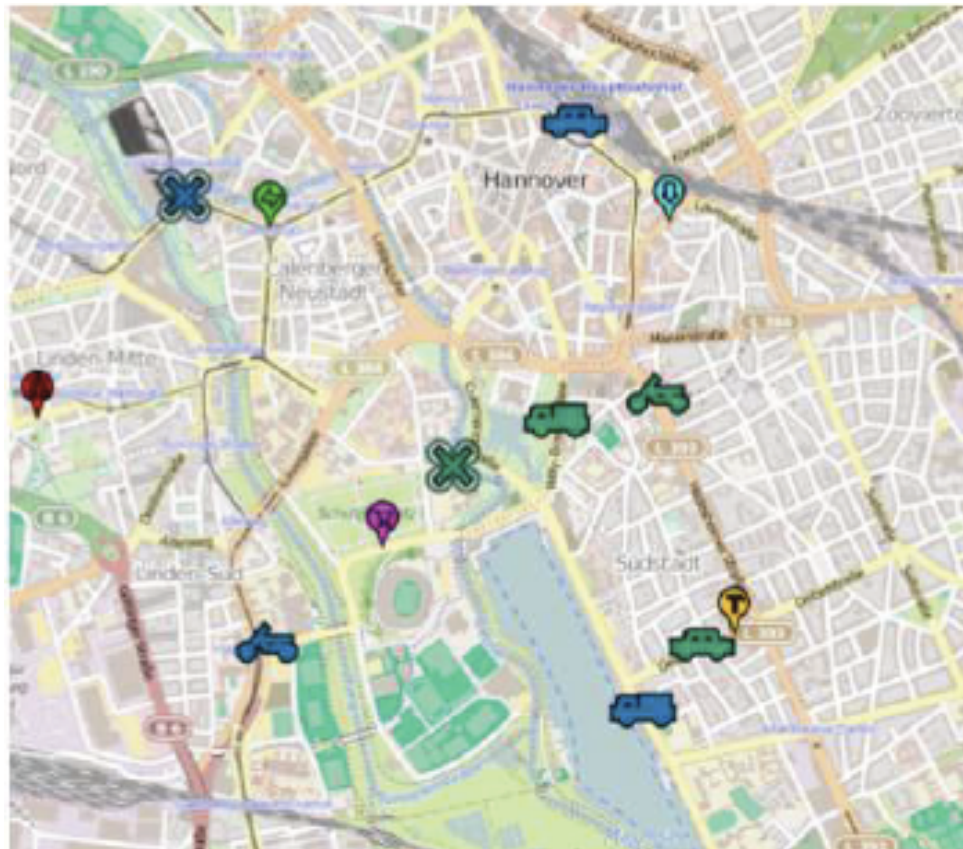
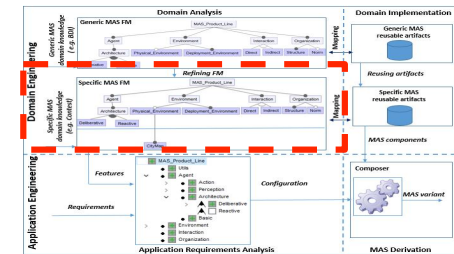
■ Generic MAS FM



MAS Analysis

- Specific MAS FM

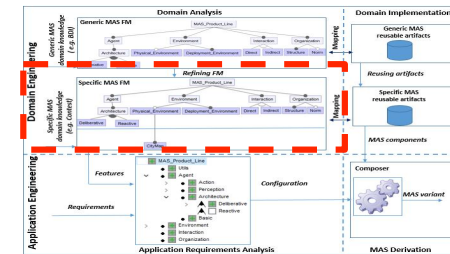
- Multiagent Programming Contest 2016: agent in the cities



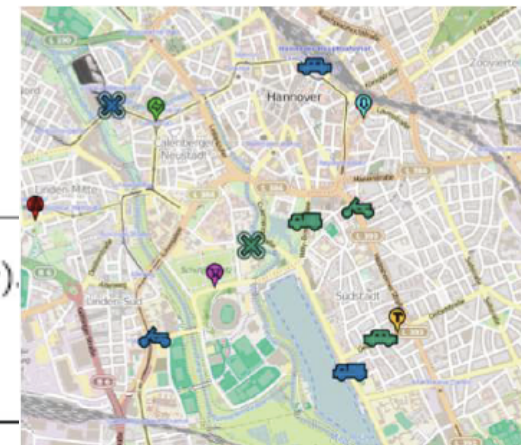
MAS Analysis

■ Specific MAS FM

■ Multiagent Programming Contest 2016: agent in the cities

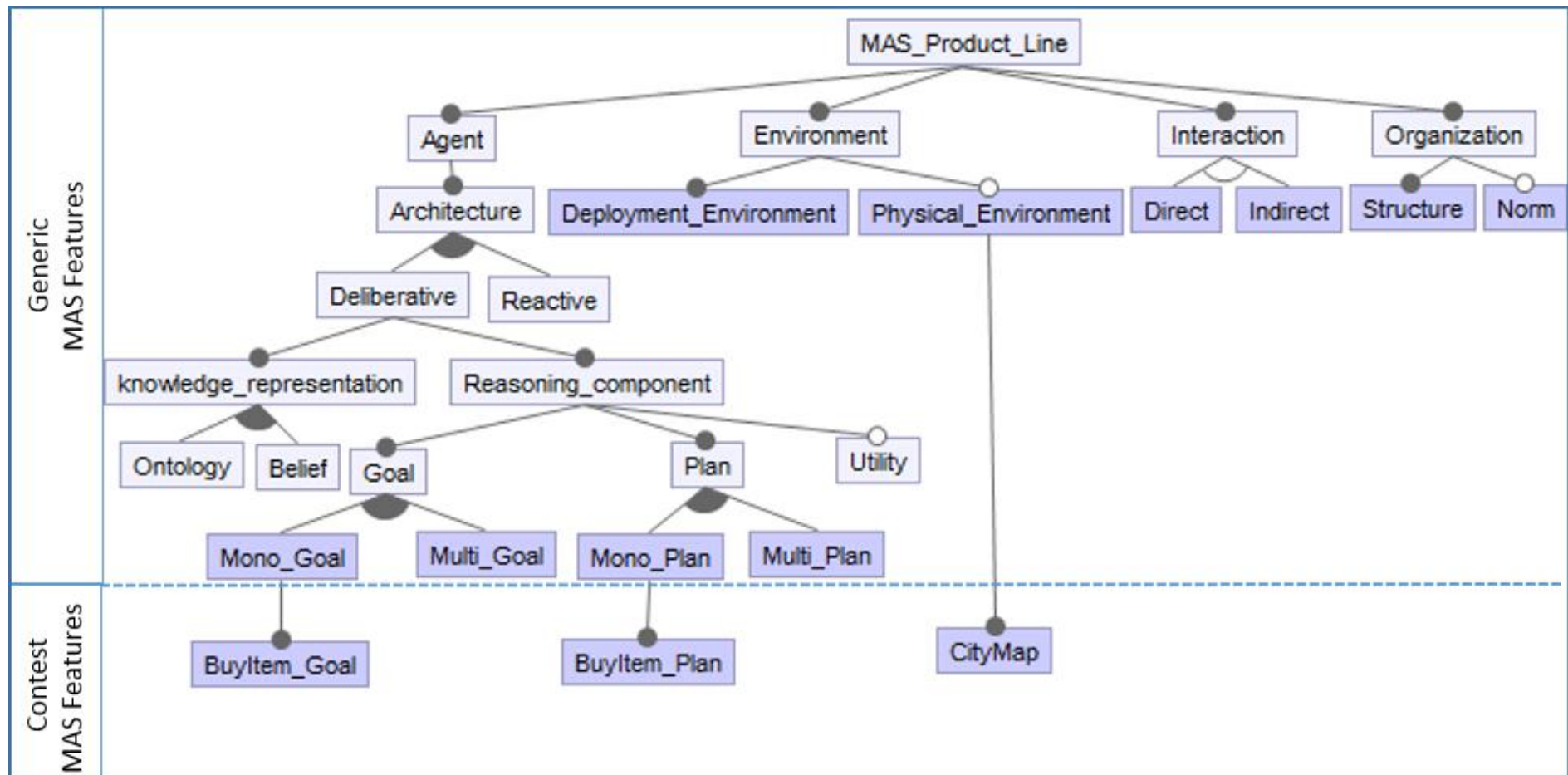
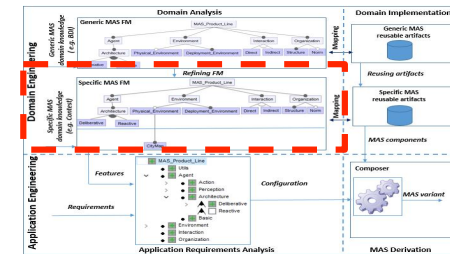


Car	Speed:	3
	Routes:	roads
	Battery capacity:	500
	Load capacity:	550
	Tools:	tool1, tool2
Drone	Speed:	5
	Routes:	air (moves in straight line from one place to another).
	Battery capacity:	250
	Load capacity:	100
	Tools:	tool1
Motorcycle	Speed:	4
	Routes:	roads
	Battery capacity:	350
	Load capacity:	300
	Tools:	tool1, tool3
Truck	Speed:	1
	Routes:	roads
	Battery capacity:	3000
	Load capacity:	1000
	Tools:	tool2, tool3



MAS Analysis

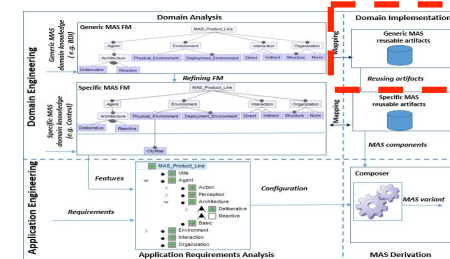
■ Specific MAS FM



MAS Implementation

■ Generic MAS FM implementation

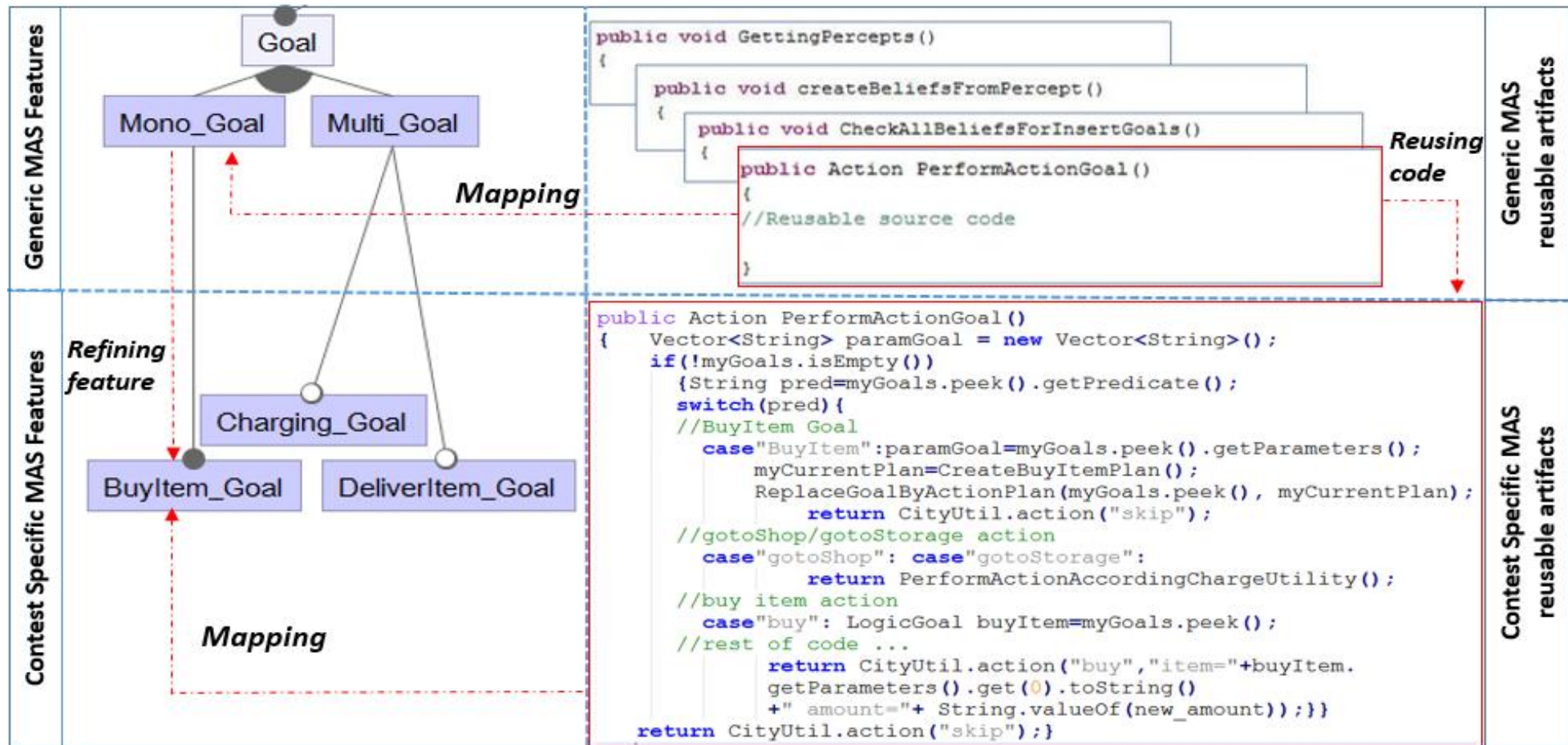
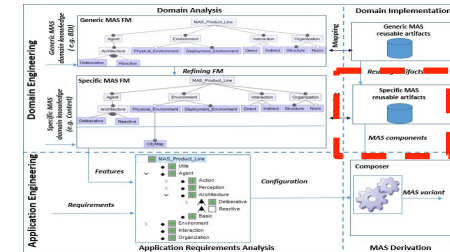
- Four types of artifacts: Agent, Interaction, Environment and Organization artefacts



Agent artifacts (ex: Java BDI packages)	Interaction artifacts (ex: Java Protocol packages)
Environment artifacts (ex: Java EIS packages)	Organization artifacts (ex: Java Structure packages)

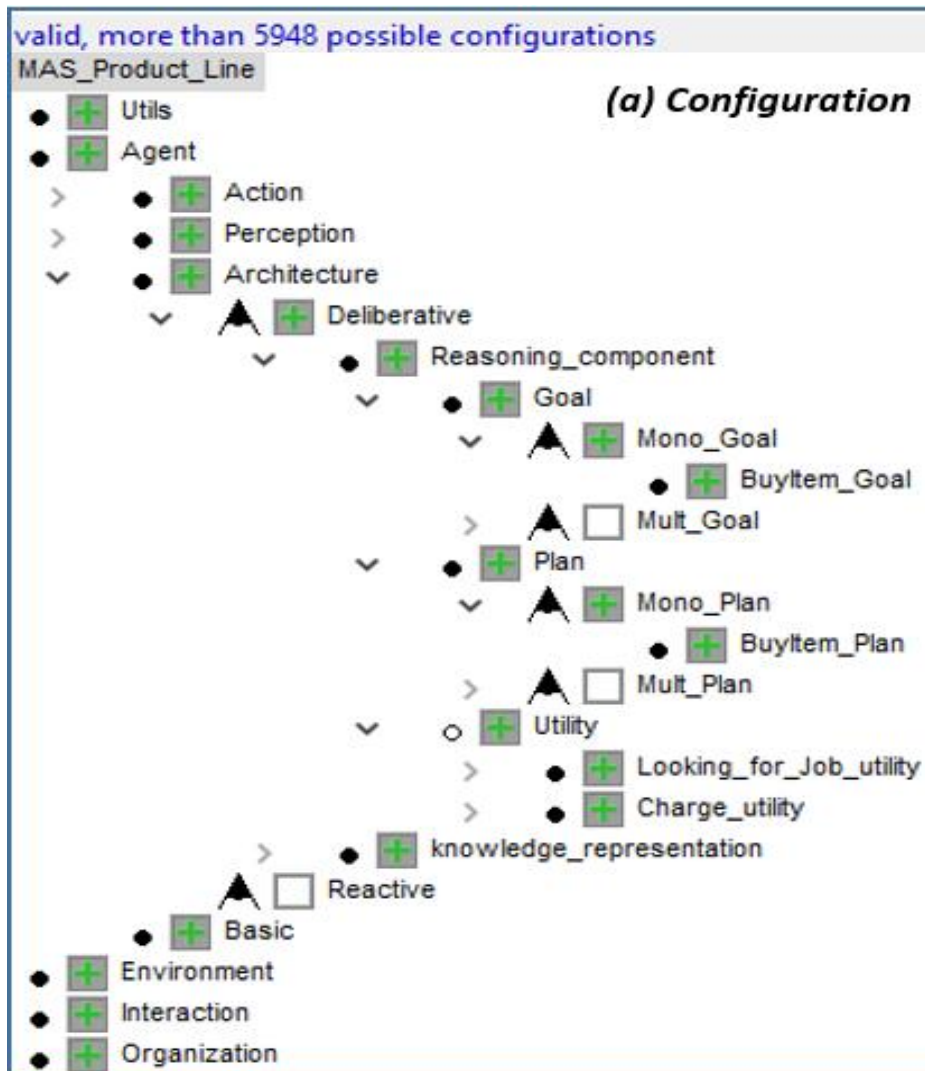
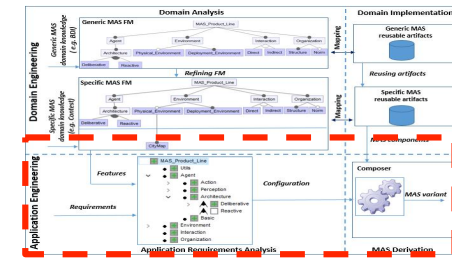
MAS Implementation

■ Specific MAS FM implementation



MAS Implementation

■ Application engineering



(b) Set of literals (propositional expression)

GoTo
Buy
Shops_Percept
PricedJob_Percept
Mono_Goal
BuyItem_Goal
Mono_Plan
BuyItem_Plan
Utility
Priced_Job
Composed_Job
No_Charge_Utility
knowledge_representation
Shops_Belief
Job_Belief
Car
Basic
City_Map

(c) Agent Contest Variant

MAS_Product_Line

- > JRE System Library
- > Referenced Librarie
- ▼ src/conf1
 - > massim.javaagents
 - ▼ massim.javaagents.agents
 - > AgentMinimaliste.java
 - > massim.javaagents.agents.util.map
 - > myenv.Environment.Vehicle

Evaluation

		MAS-PL Features																Metrics			
		Generic MAS features				Contest MAS features															
	F1	F2	F3	F4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13				
Contest Agent Variants	Mono_Goal																				
	Multi_Goal																				
	Mono_Plan																				
	Multi_Plan																				
	BuyItem_Goal																				
	Charging_Goal																				
	CallBreakDownService_Goal																				
	Item_Plan																				
	Charging_Plan																				
	CallBreakDownService_Plan																				
	No_Charge_Utility																				
BreakDown_Utility																					
ClosestStationFromDestination																					
ClosestStationFromStartingPosition																					
ClosestStationWhenHalfEmpty																					
Car																					
Truck																					
																		Total selected features	Lines of code	Number of methods	
CAV1	x		x		x			x			x					x		6	1506	120	
CAV2	x		x		x			x			x						x	6	1565	120	
CAV3		x		x	x		x	x		x		x				x		8	1523	108	
CAV4		x		x	x		x	x		x		x					x	8	1654	127	
CAV5		x		x	x	x		x	x				x			x		8	1760	130	
CAV6		x		x	x	x		x	x				x				x	8	1799	133	
CAV7		x		x	x	x		x	x					x		x		8	1850	133	
CAV8		x		x	x	x		x	x					x			x	8	1821	130	
CAV9		x		x	x	x		x	x						x	x		8	1815	133	
CAV10		x		x	x	x		x	x						x		x	8	1860	133	

Evaluation

Saved development
effort: 354 lines of code

MAS-PL Features																						
	Generic MAS features				Contest MAS features													Metrics				
	F1	F2	F3	F4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13					
Contest Agent Variants	Mono_Goal	Multi_Goal	Mono_Plan	Multi_Plan	BuyItem_Goal	Charging_Goal	CallBreakDownService_Goal	Item_Plan	Charging_Plan	CallBreakDownService_Plan	No_Charge_Utility	BreakDown_Utility	ClosestStationFromDestination	ClosestStationFromStartingPosition	ClosestStationWhenHalfEmpty	Car	Truck	Total selected features	Lines of code	Number of methods		
	CAV1	x		x		x		x			x					x		6	1506	120		
	CAV2	x		x		x		x			x						x	6	1565	120		
	CAV3		x		x	x	x	x		x		x				x		8	1523	108		
	CAV4		x		x	x		x	x		x		x				x	8	1654	127		
	CAV5		x		x	x	x		x	x				x			x		8	1760	130	
	CAV6		x		x	x	x		x	x				x			x		8	1799	133	
	CAV7		x		x	x	x		x	x					x		x		8	1850	133	
	CAV8		x		x	x	x		x	x					x			x		8	1821	130
	CAV9		x		x	x	x		x	x						x	x			8	1815	133
	CAV10		x		x	x	x		x	x						x		x		8	1860	133

Evaluation

Saved development
effort: 21 methods

		MAS-PL Features																	Metrics		
		Generic MAS features				Contest MAS features															
	F1	F2	F3	F4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13				
Contest Agent Variants	Mono_Goal																				
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ClosestStationFromStartingPosition																					
ClosestStationWhenHalfEmpty																					
Car																					
Truck																					

Conclusion and Future Work

- A New MAS-PL approach

- facilitates the reuse in MAS engineering
- facilitates the development of MAS families
- Is based on Feature Composition (Feature House)

- Several examples

- Book trading with jade
- Multiagent Programming Contest

Conclusion and Future Work

- Extend the Generic MAS FM
 - Refine the Organizational features
- Refine the Interactional features
 - Enrich the set of reusable artifacts with reusable components extracted from multi-agent frameworks (JaCAMO, JADE .etc)
 - Experiment other specific application domains