

REVE 2018

6th International Workshop on Reverse Variability Engineering



Feature Location in Model Driven Software Engineering: Industrial Experiences

Feature location is a key activity to reengineer a set of products into a Product Line. In the context of Model Driven Software Engineering, models are the cornerstone artefact where feature location must be performed. In this talk, we are going to go through the efforts performed at two industrial case studies (Induction Hobs of BSH Group, and Train Control & Management Software of CAF) to achieve feature location in models. These feature location efforts range from Information Retrieval to Machine Learning, and include the dimension of Search-based Software Engineering. Results are not perfect, but we are going to discuss if they are up to the task of Product Line Reengineering.

Hi!, I am Carlos Cetina

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Head of a young research group: svit.usj.es

Mediterranean coast of Spain, perfect weather

Zaragoza city, north of Spain, weather is not that good as in Valencia

My background is in **Model Driven Engineering** and **Software Product Lines.**

Models abstract from implementation details

Systematic reuse

Intersection: Reuse of model fragments

Before reusing model fragments, we must find them.

I am new to **SBSE**, but it is helping me to find the model fragments in industrial environments:



This is about: **Locating Model Fragments on Models**

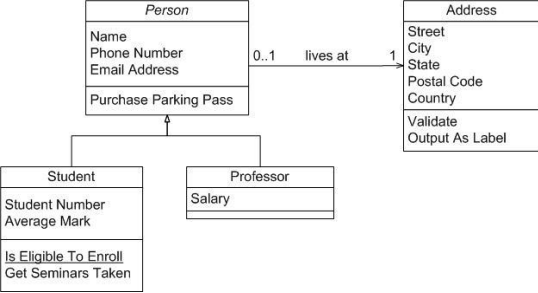
We locate model fragments to reuse them as features in other products.

Locating Model Fragments on Models

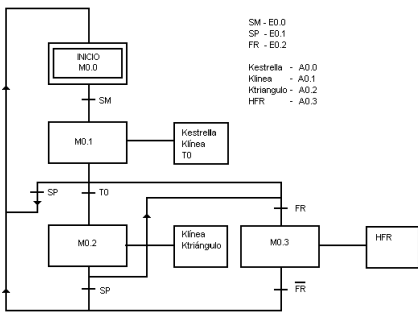
Models: abstract specification of a part of a software system.

Popular modelling languages (among others):

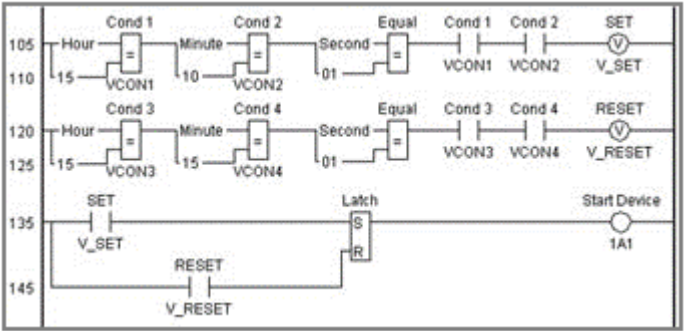
UML Class Diagram



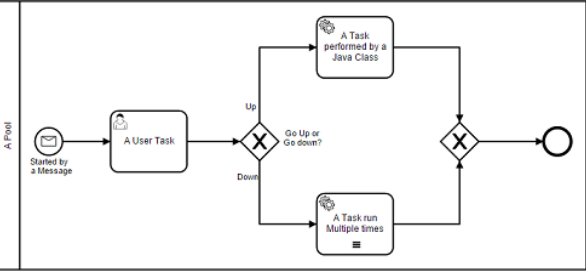
Grafcet



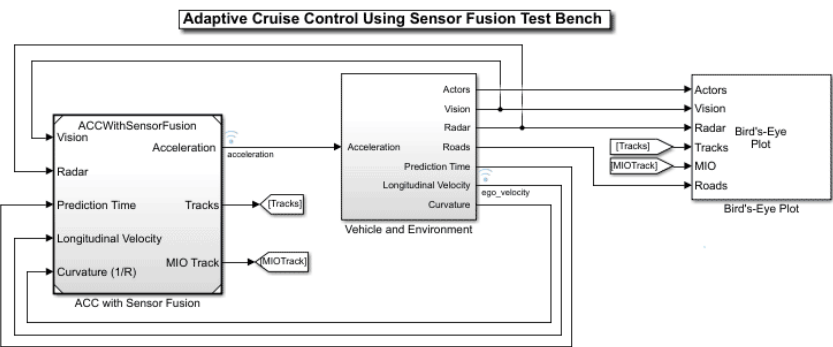
Ladder



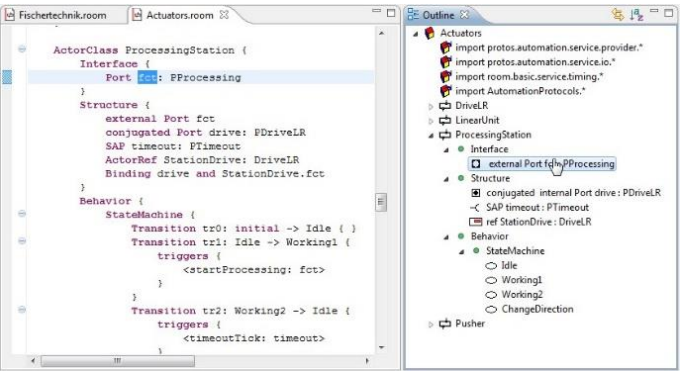
BPMN



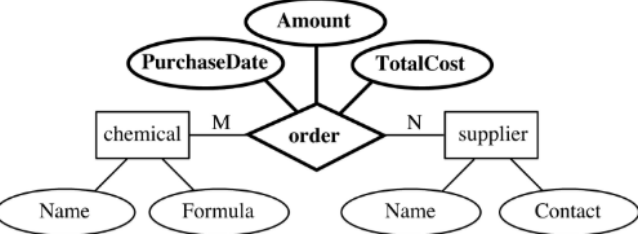
Simulink



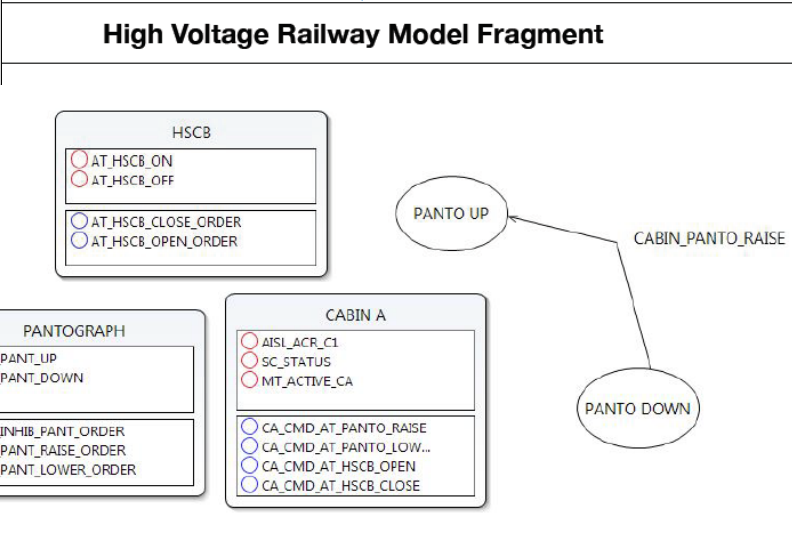
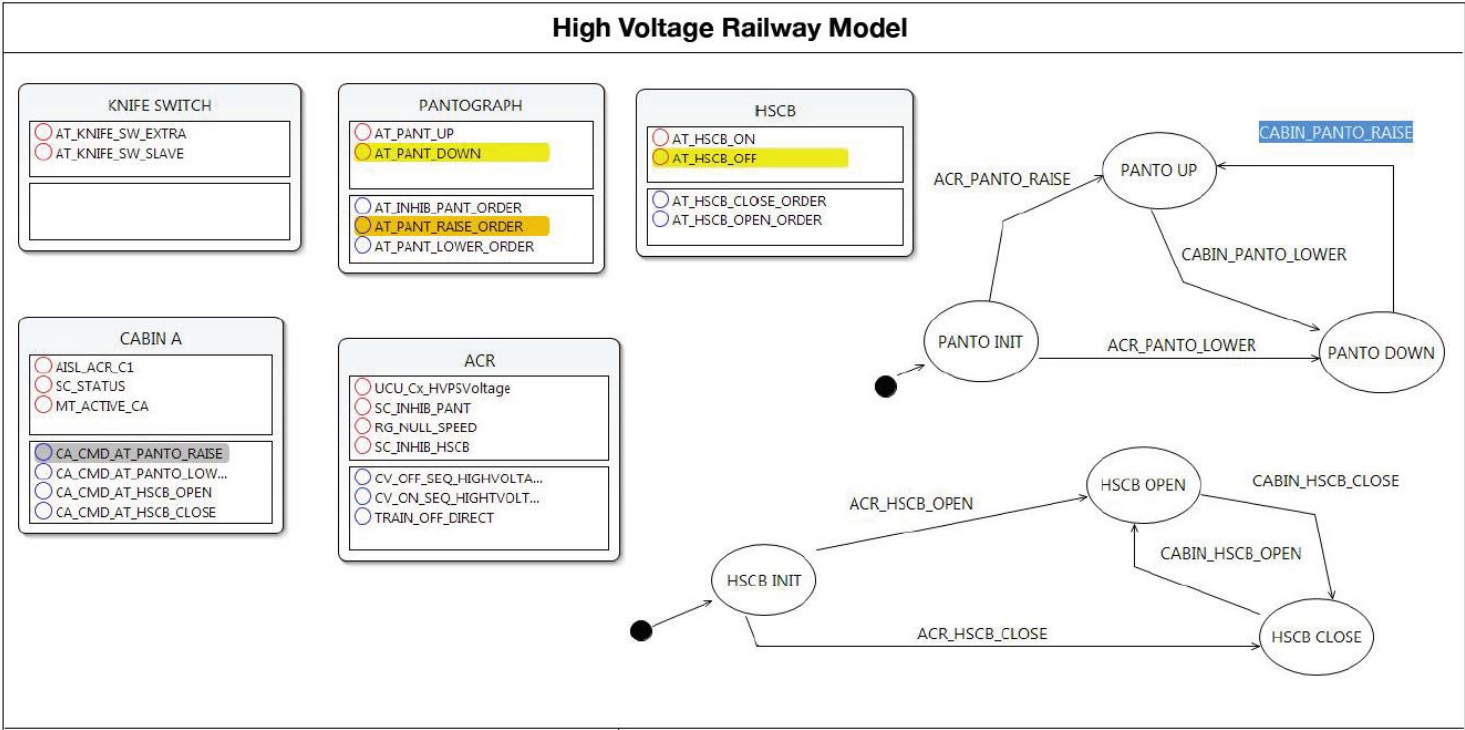
Textual modeling



Entity Relationship



Locating Model Fragments on Models



Locating Model Fragments on Models: **Industrial Experiences**

Induction Hobs of B/S/H/

(produced under the Bosch, Siemens, Balay, Neff, Gaggenau brands, among others)



Rolling stock of CAF

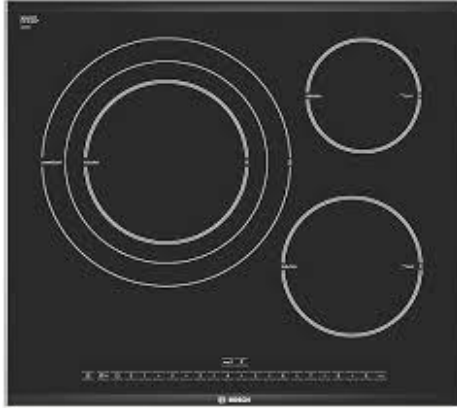
(Trains, Trams, High-speed, and Underground)



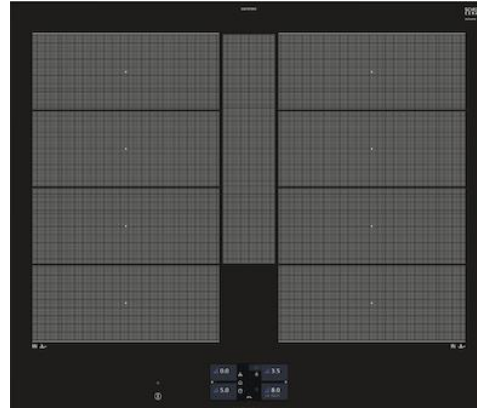
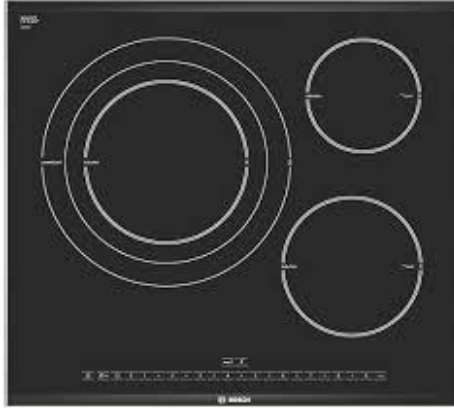
Both:

- SW development is not their main activity, but their products are intense on SW:
 - main source of new functionality,
 - and SW compensates for HW.

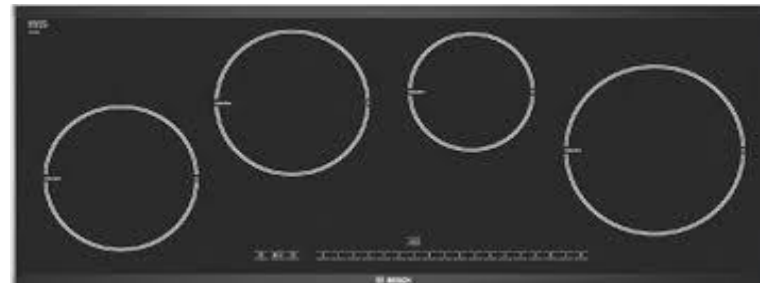
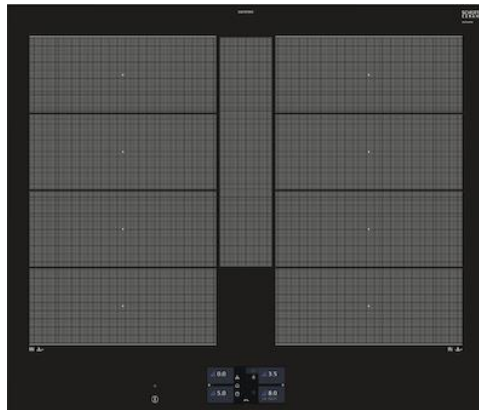
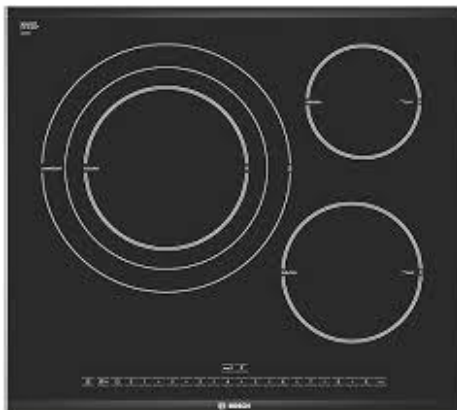
Family of products



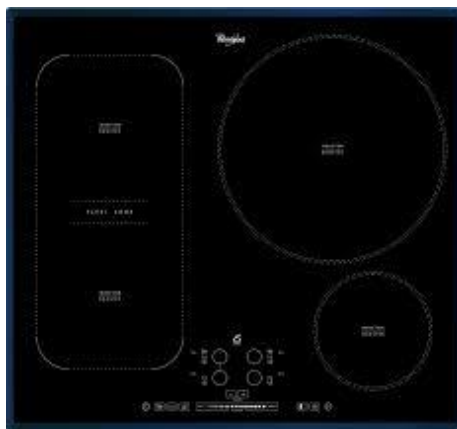
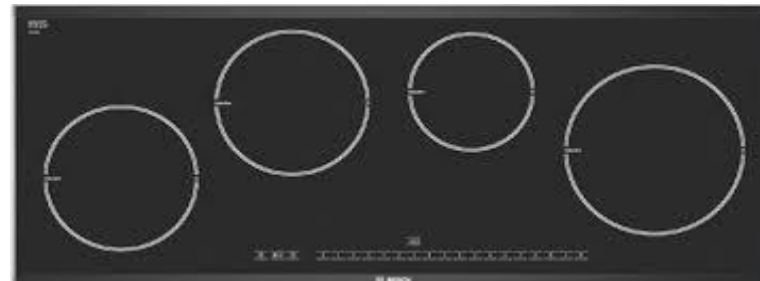
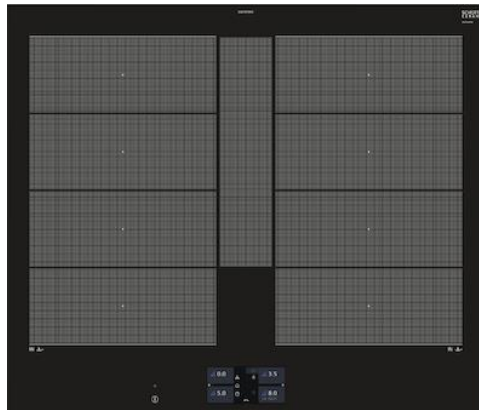
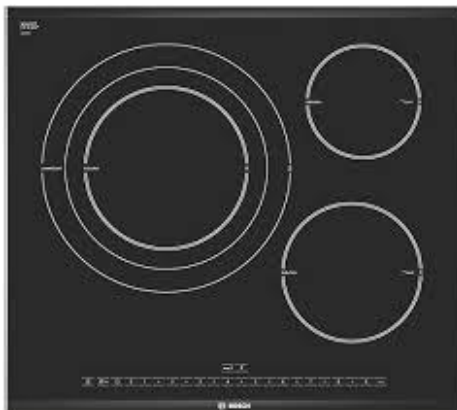
Family of products



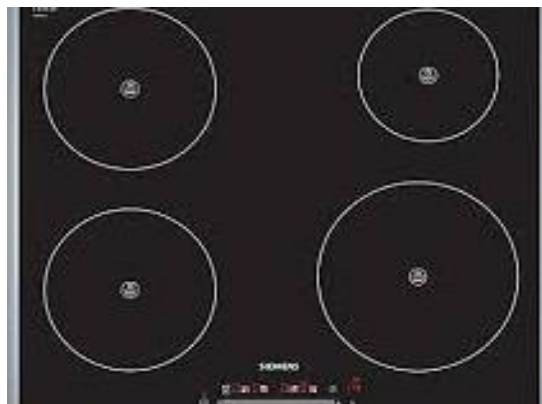
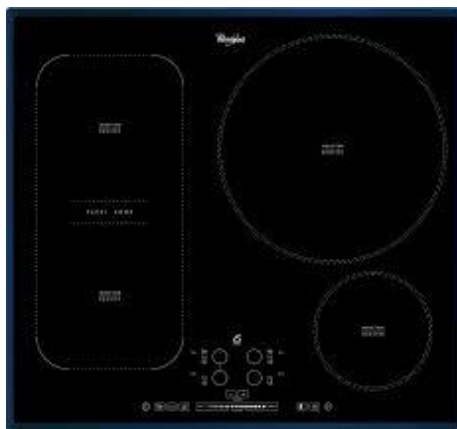
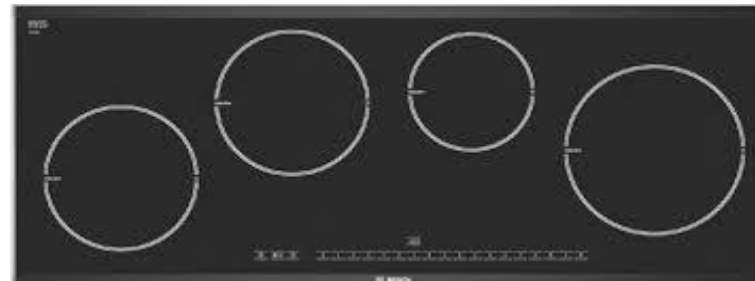
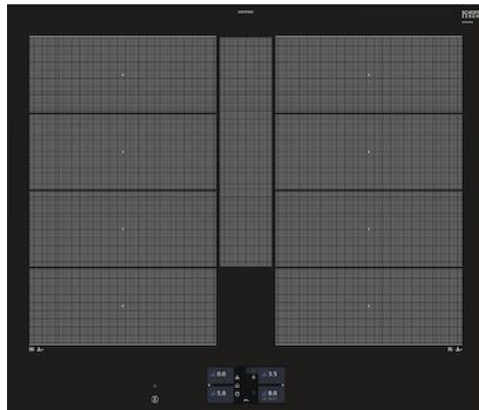
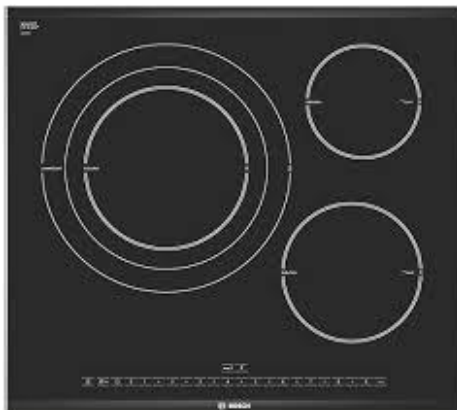
Family of products



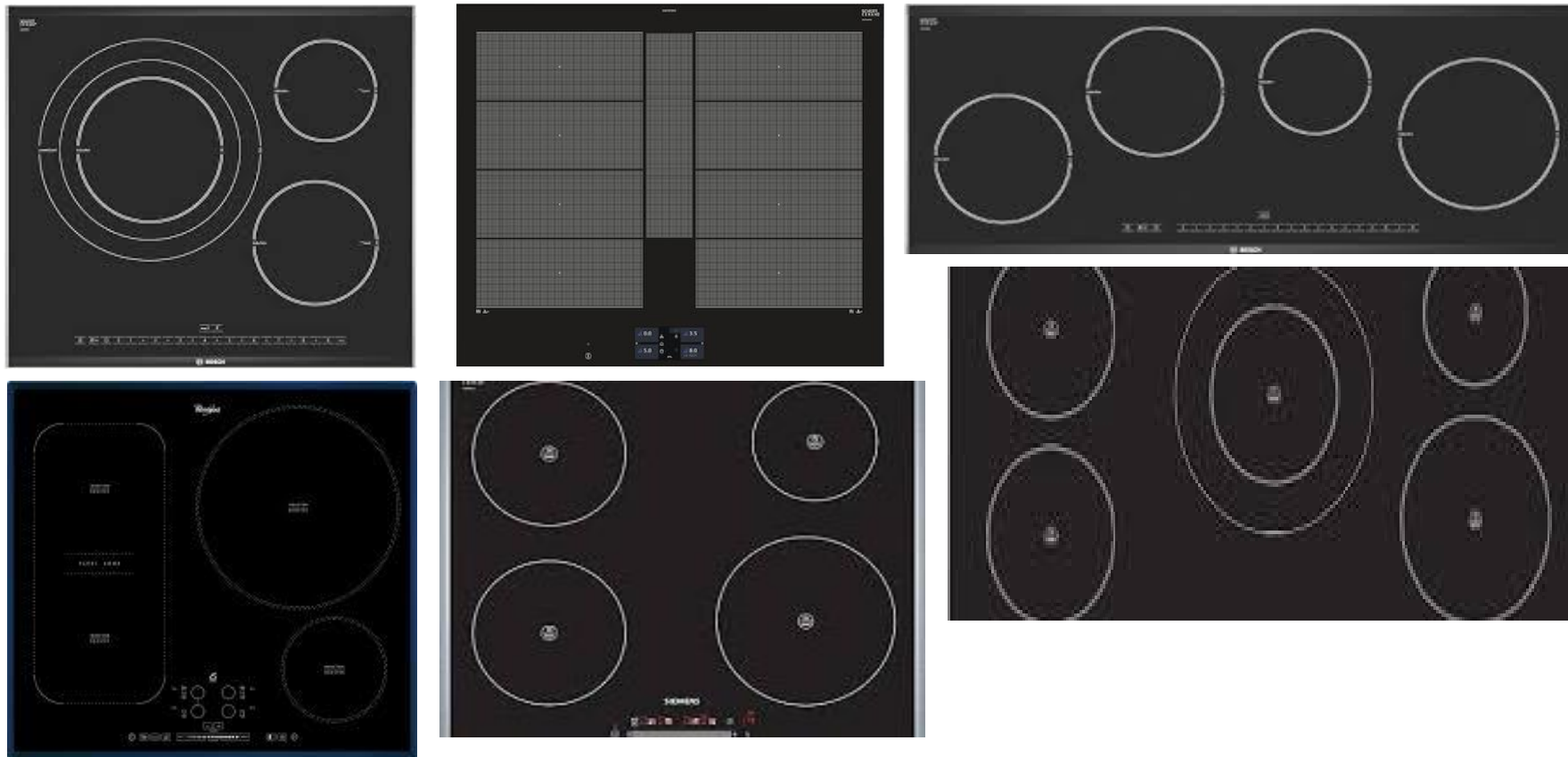
Family of products



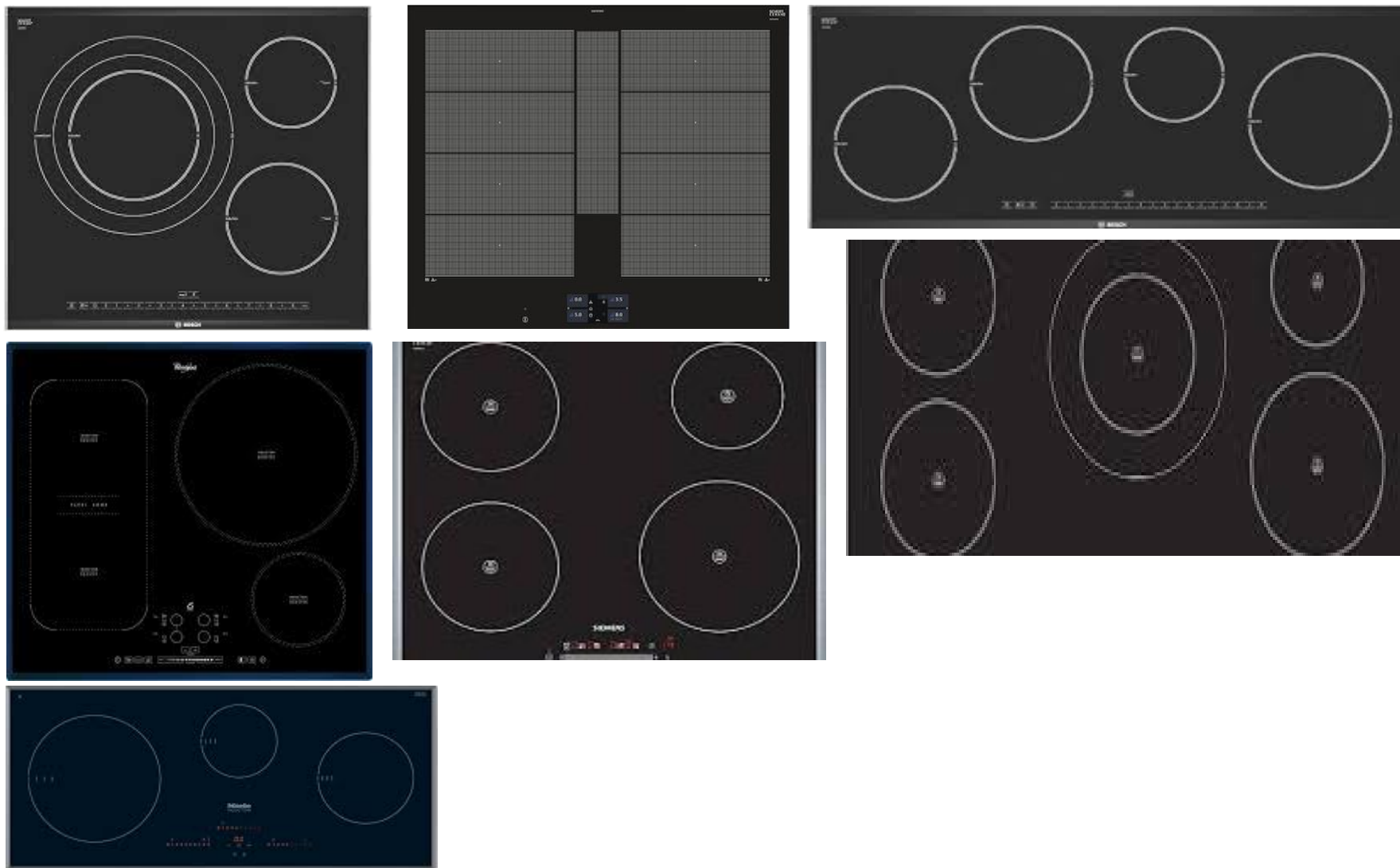
Family of products



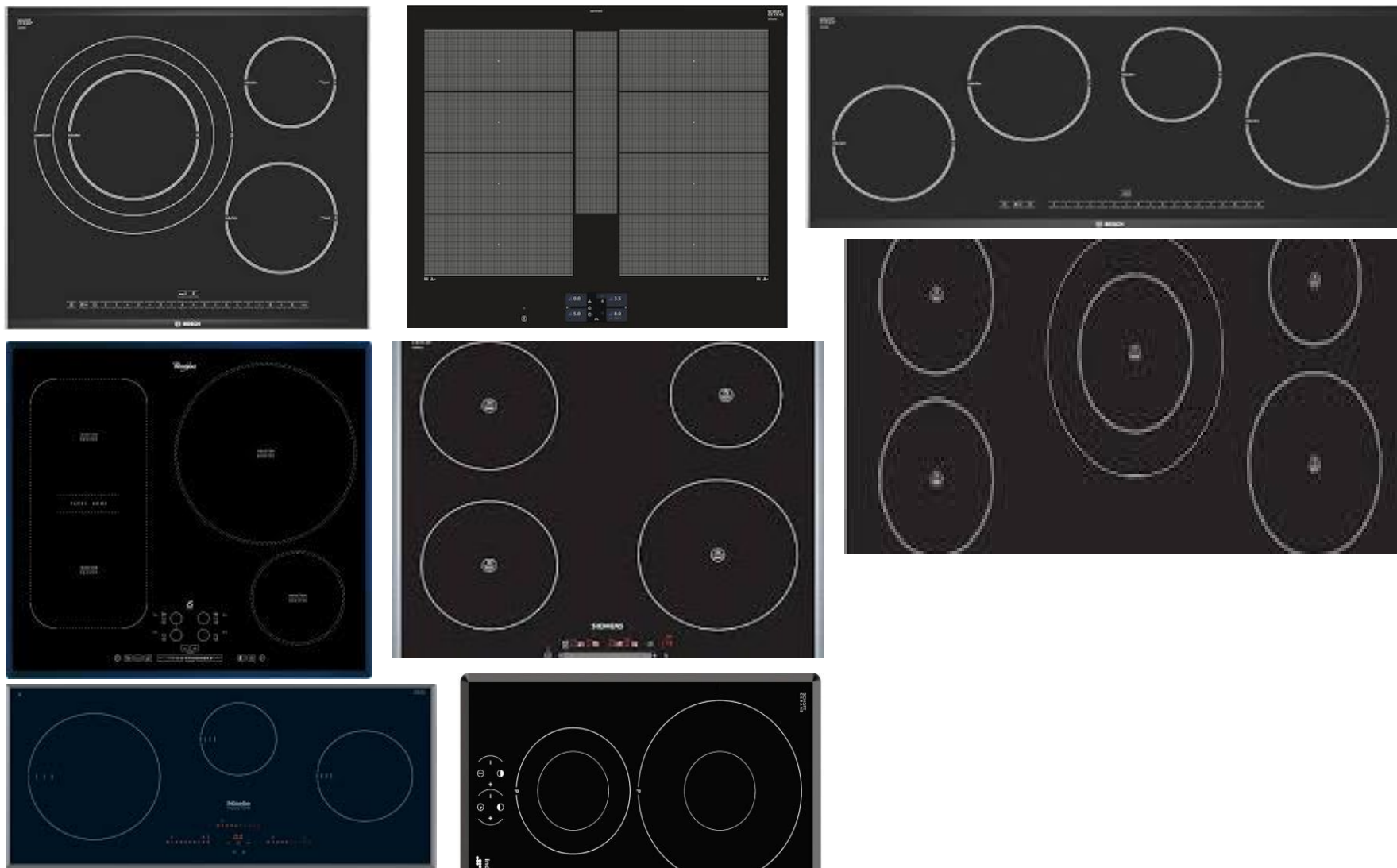
Family of products



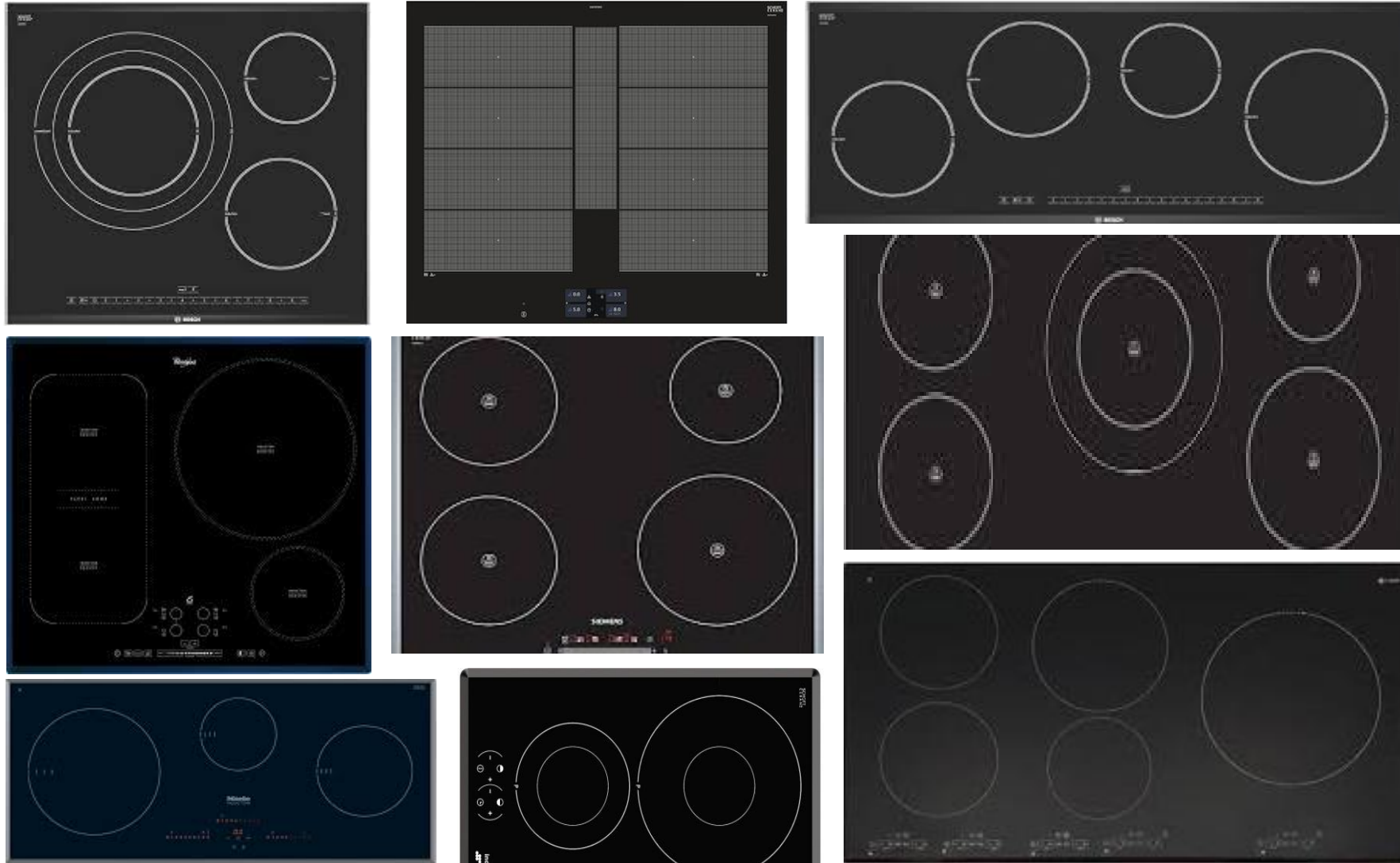
Family of products



Family of products



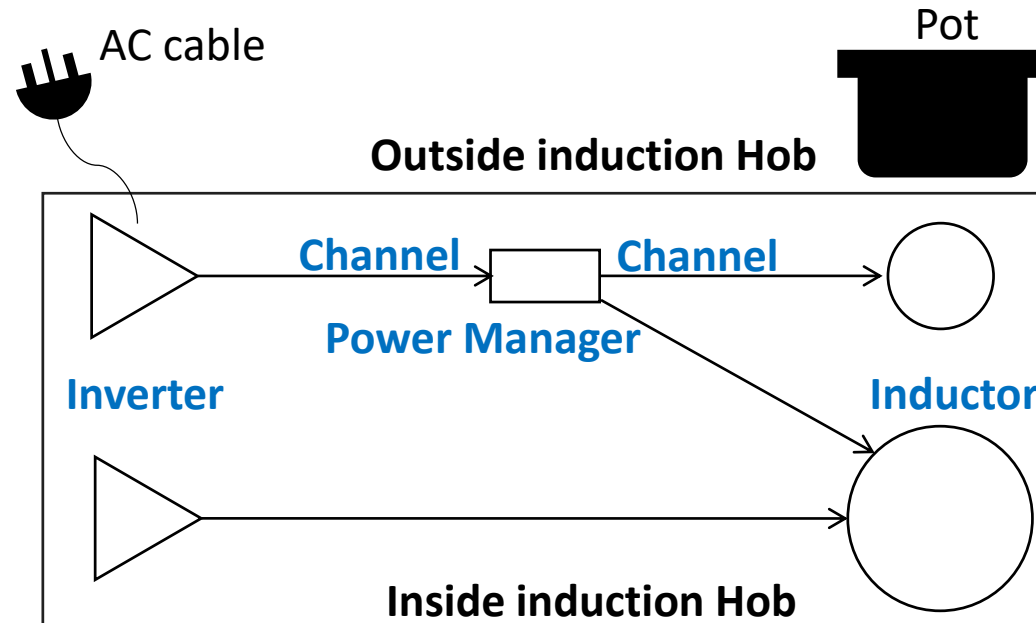
Family of products



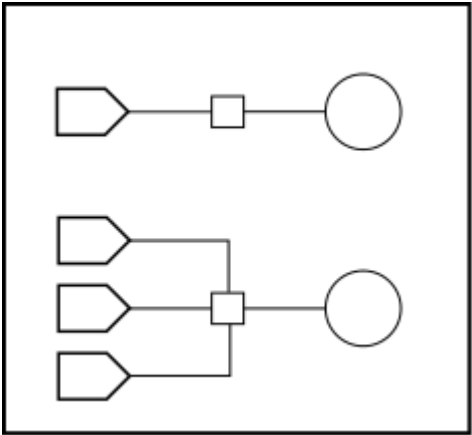
Family of products



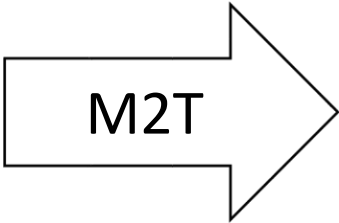
Domain Specific Language Model for Induction Hobs: IHDSL (Basic concepts)



Model Driven Engineering







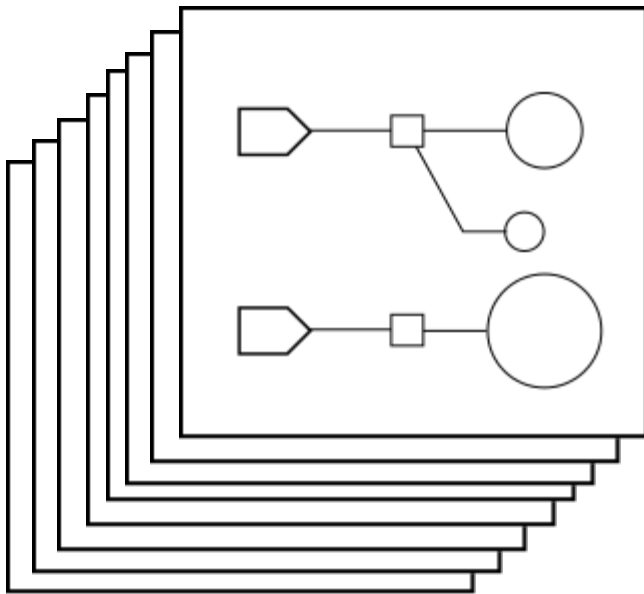
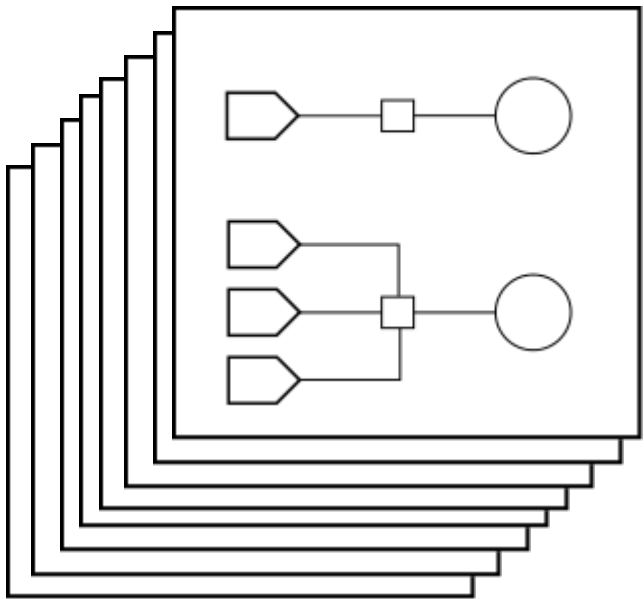
IHDSL Model



```
base64.cc
31 void base64_encode(const uint8_t * data, size_t len, char * dst)
32 {
33     size_t src_idx = 0;
34     size_t dst_idx = 0;
35     for (; (src_idx + 2) < len; src_idx += 3, dst_idx += 4)
36     {
37         uint8_t s0 = data[src_idx];
38         uint8_t s1 = data[src_idx + 1];
39         uint8_t s2 = data[src_idx + 2];
40
41         dst[dst_idx + 0] = charset[(s0 & 0xfc) >> 2];
42         dst[dst_idx + 1] = charset[((s0 & 0x03) << 4) | ((s1 & 0xf0) >> 4)];
43         dst[dst_idx + 2] = charset[((s1 & 0x0f) << 2) | (s2 & 0xc0) >> 6];
44         dst[dst_idx + 3] = charset[(s2 & 0x3f)];
45     }
46
47     if (src_idx < len)
48     {
49         uint8_t s0 = data[src_idx];
50         uint8_t s1 = (src_idx + 1 < len) ? data[src_idx + 1] : 0;
51
52         dst[dst_idx++] = charset[(s0 & 0xfc) >> 2];
53         dst[dst_idx++] = charset[((s0 & 0x03) << 4) | ((s1 & 0xf0) >> 4)];
54         if (src_idx + 1 < len)
55             dst[dst_idx++] = charset[((s1 & 0x0f) << 2)];
56     }
57 }
```

Induction Hob firmware

IHDSL syntax	
 Inverter	 Inductors
 Channels	 Power manager



Starting point: **variability is not formalized.**

Goal: Locating Features (Model Fragments) on Models

Locating Features (Model Fragments) on Models

The good, the bad

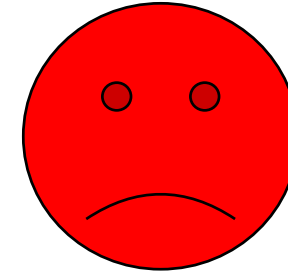


Less noise:

Models are less bound to the underlying implementation details and are much closer to the problem domain.

Metamodel helps:

Metamodel of DSL encode domain knowledge. Inductor in IHDSL as oppose to Class in UML or in Java grammar.



From code to models

IR techniques and models?

Intuition: as text documents.

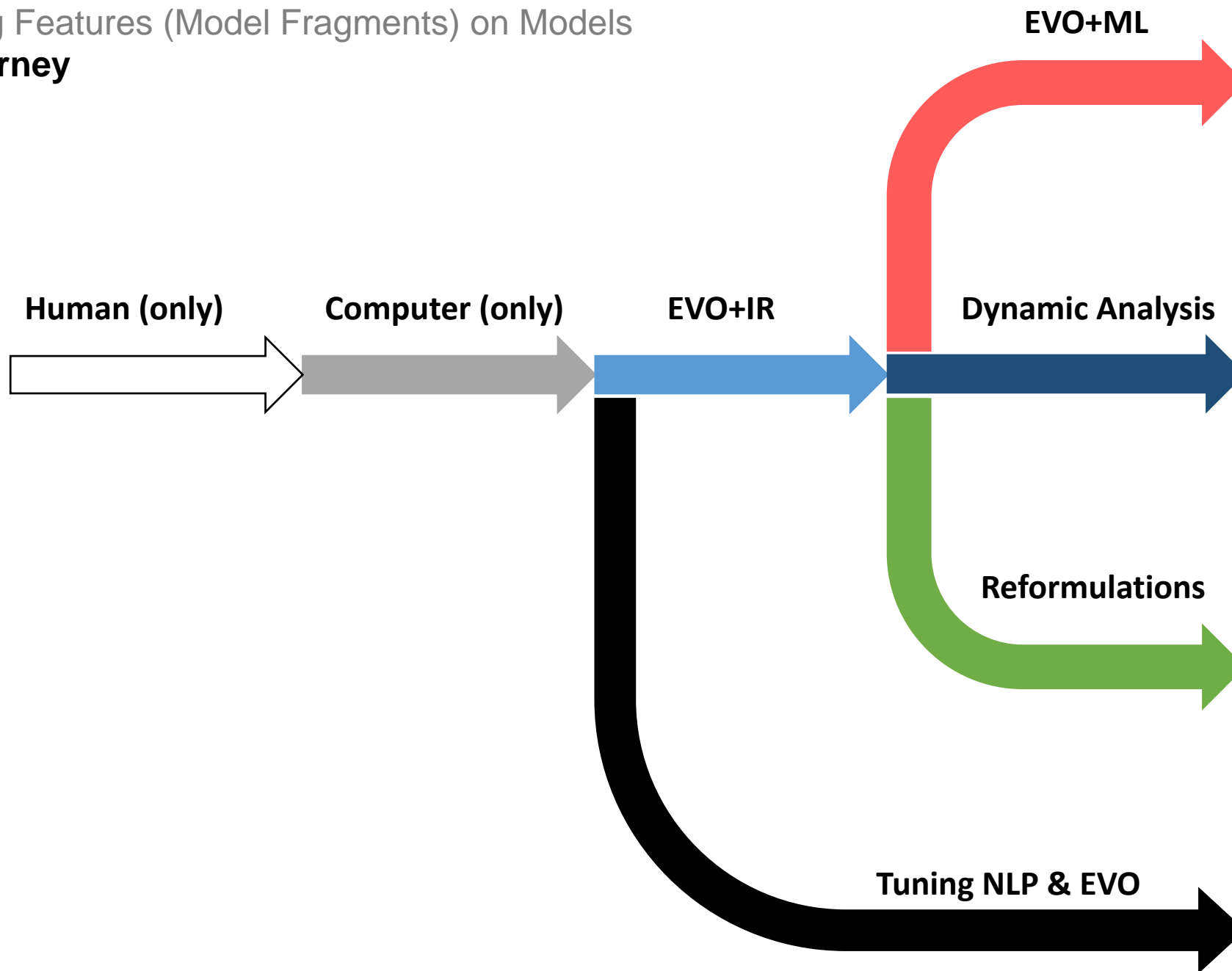
But models are not text only.

But models have model and metamodel.

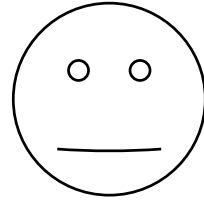
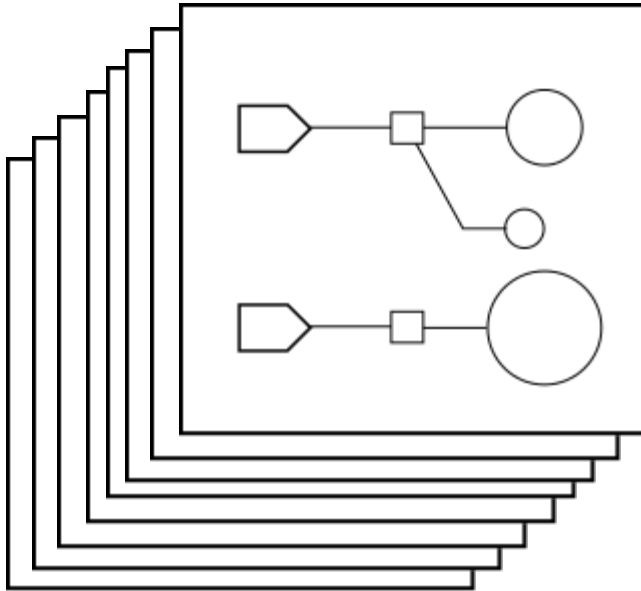
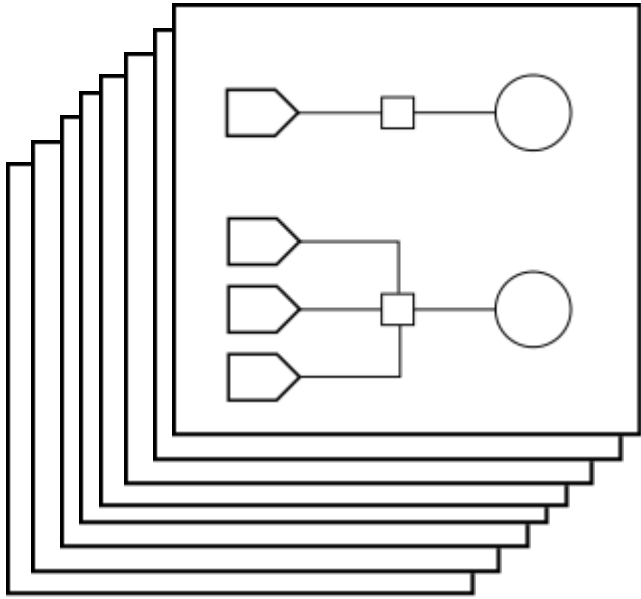
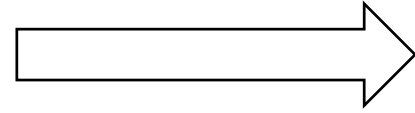
ML and models?

Feature encoding is the first challenge.

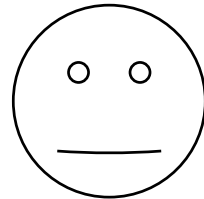
Locating Features (Model Fragments) on Models
Our journey



Human (only)



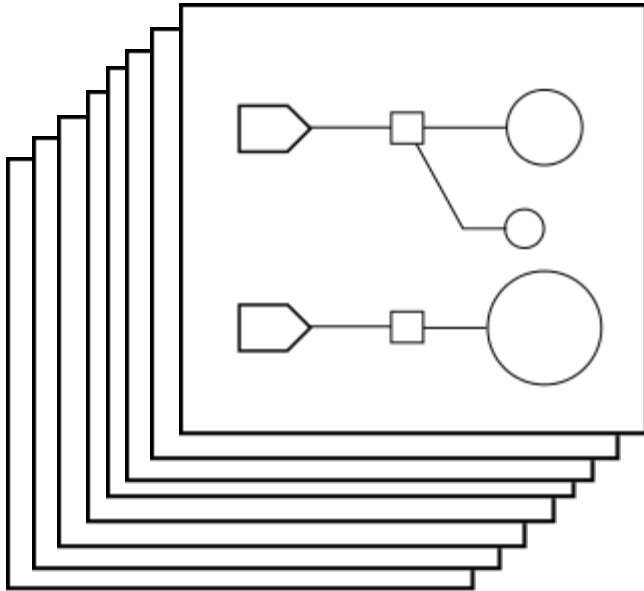
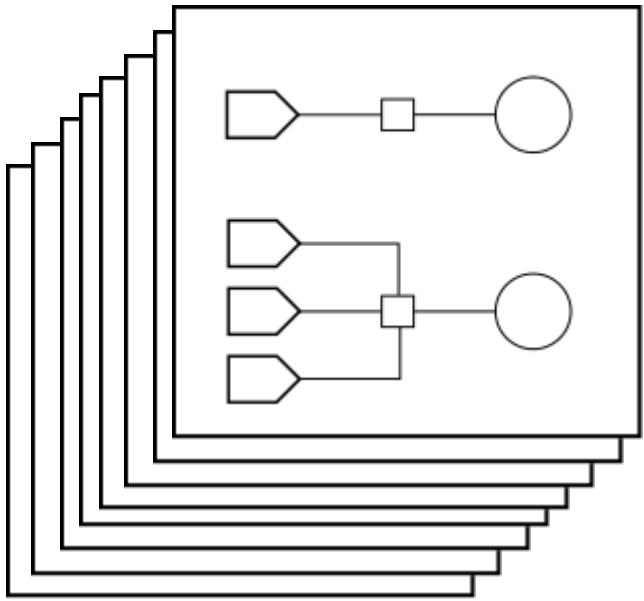
Industry



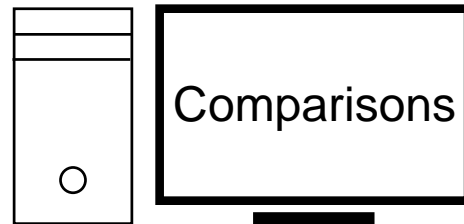
University

“Blood, sweat and tears” Approach

- From focus groups to discussions (you name it).
- Eventually you identify reusable model fragments 😊
- BUT, extracting all model fragments takes more time than is available.



“Machine replaces humans” Approach



- Mechanical model comparisons.
- Time is not a problem anymore.
- BUT, results.....

Building up on:

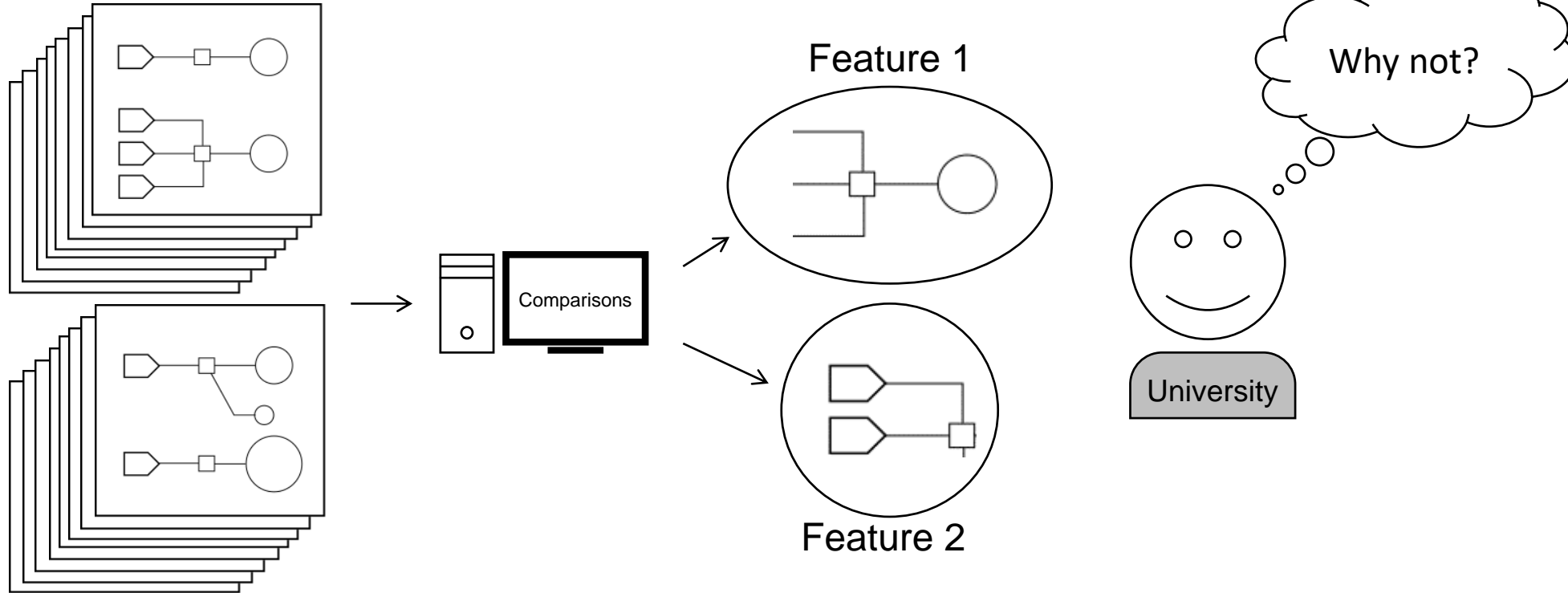
Xiaorui Zhang, Øystein Haugen, Birger Møller-Pedersen:

Model Comparison to Synthesize a Model-Driven Software Product Line.

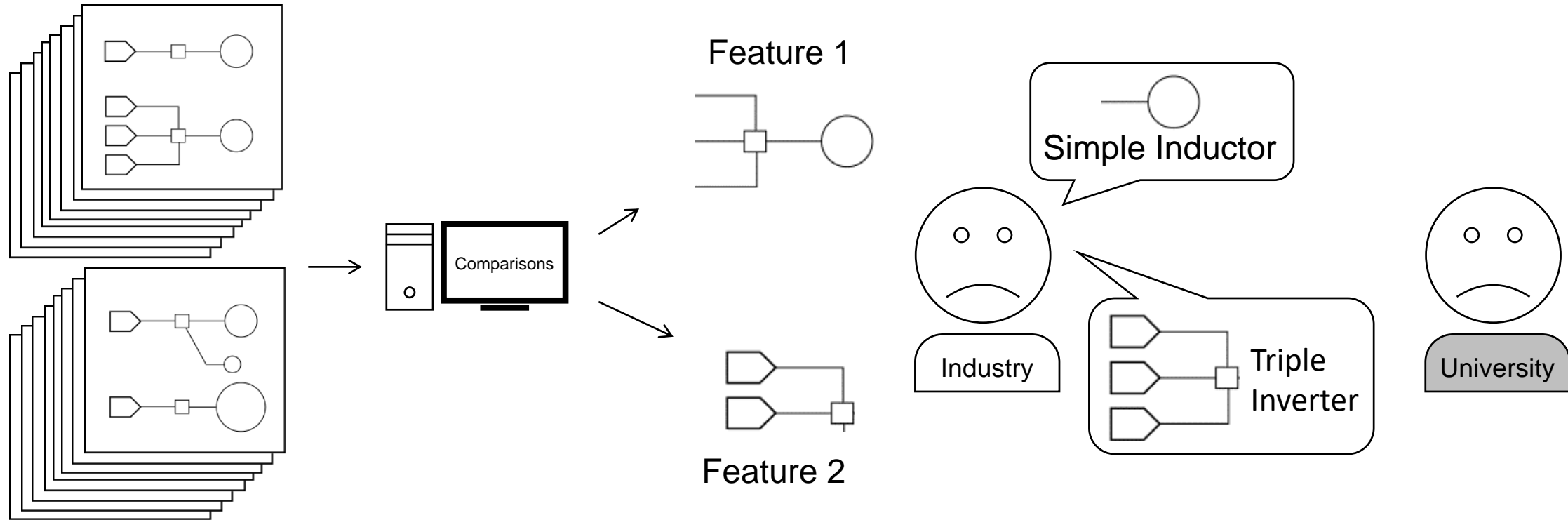
SPLC 2011: 90-99

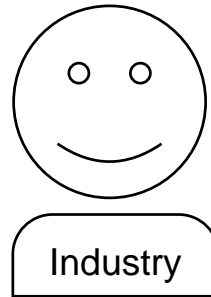
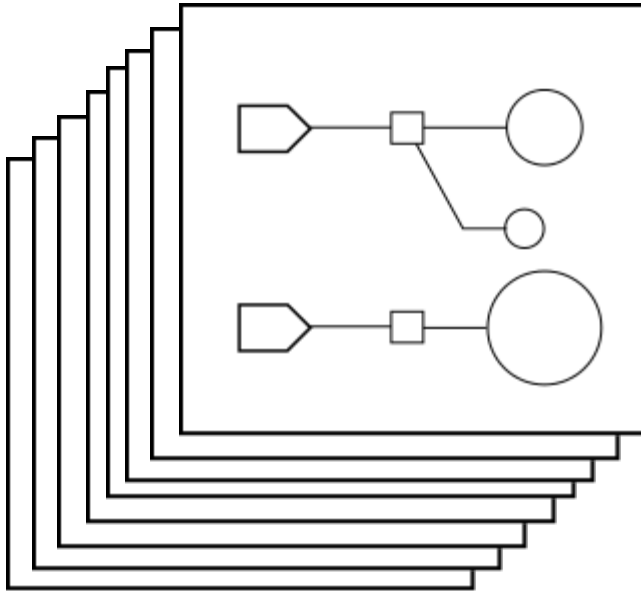
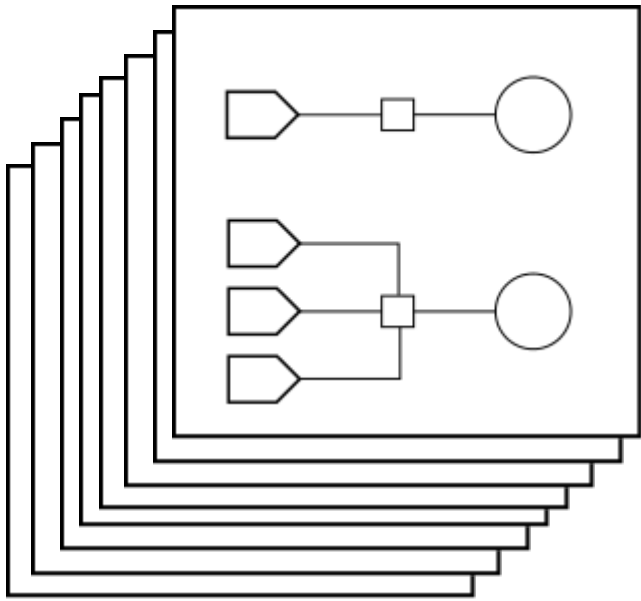
Results...

Computer (only)



Results... are not for university, they are for industry.



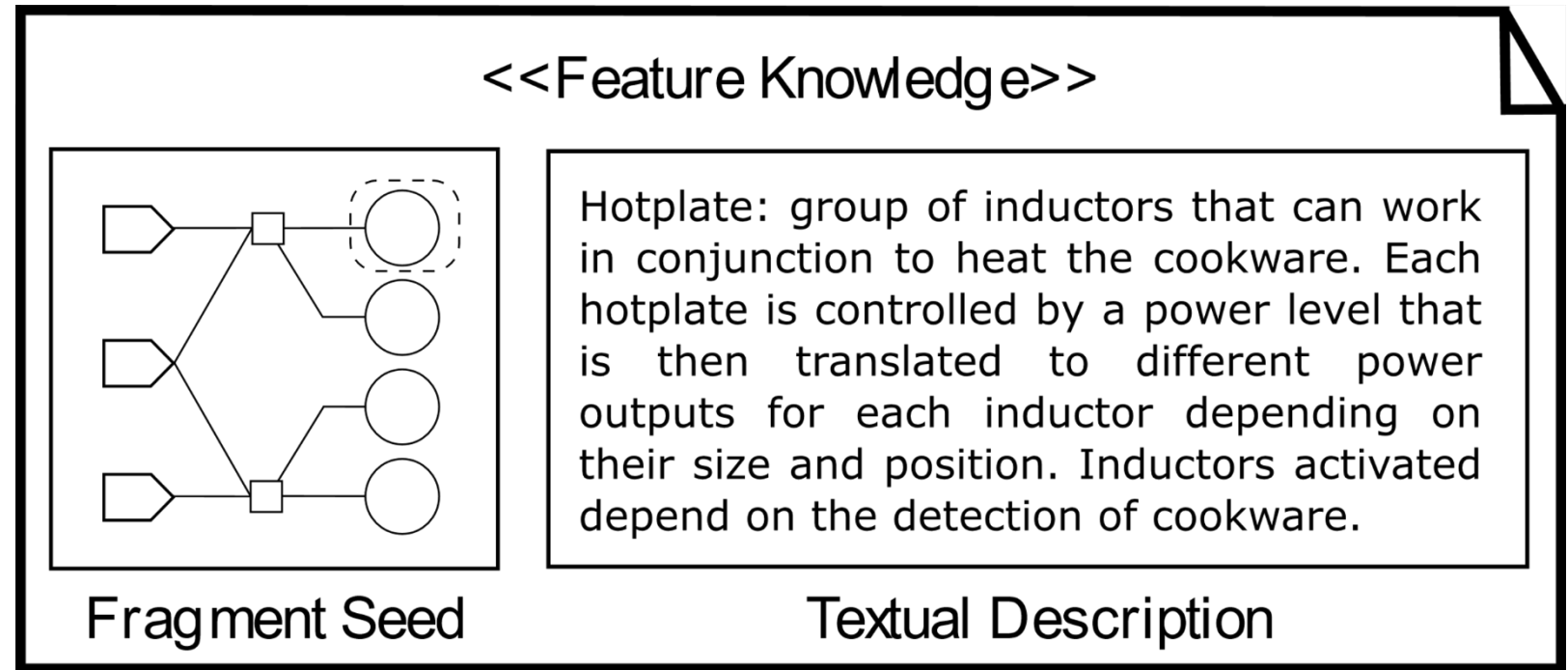


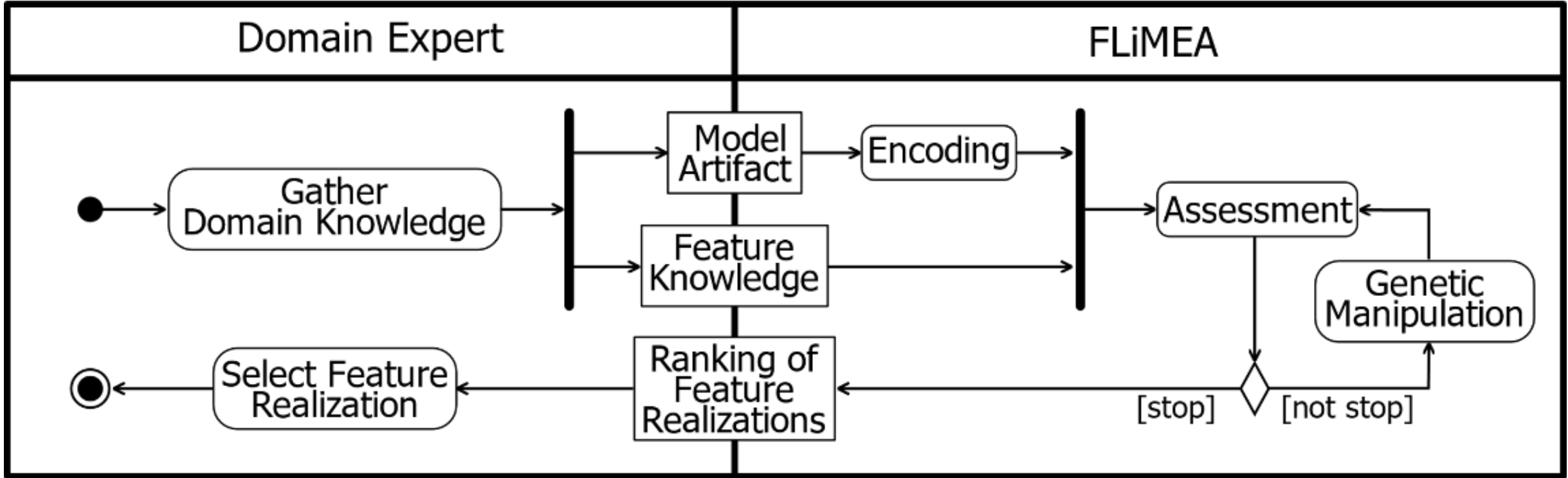
“Machine and human complement each other” Approach

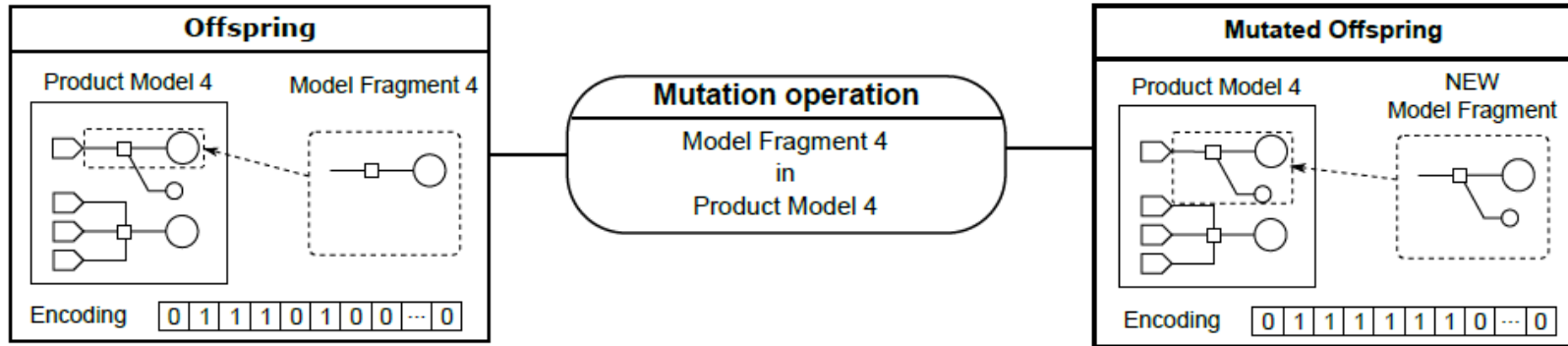
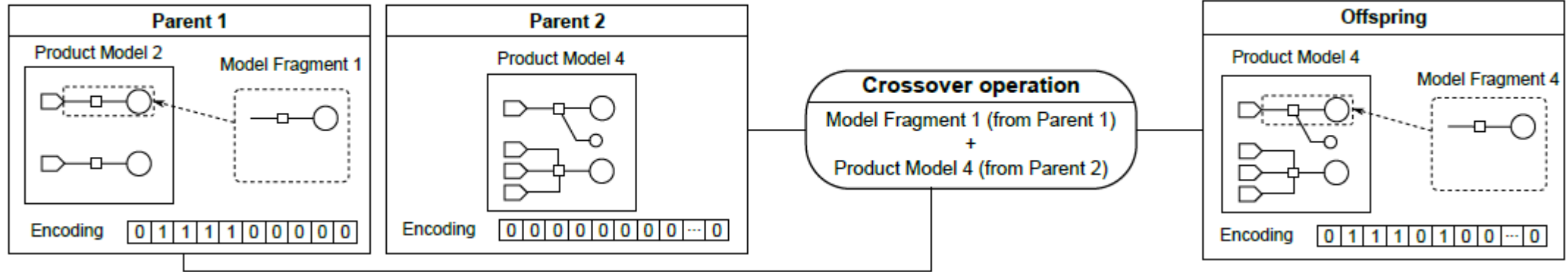
- Human has domain knowledge.
- Machine capability to search very large problem spaces.



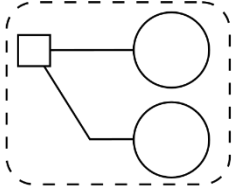
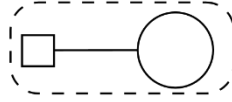
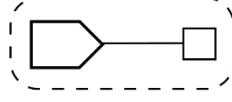
Domain experts guide the search providing its knowledge about the feature:





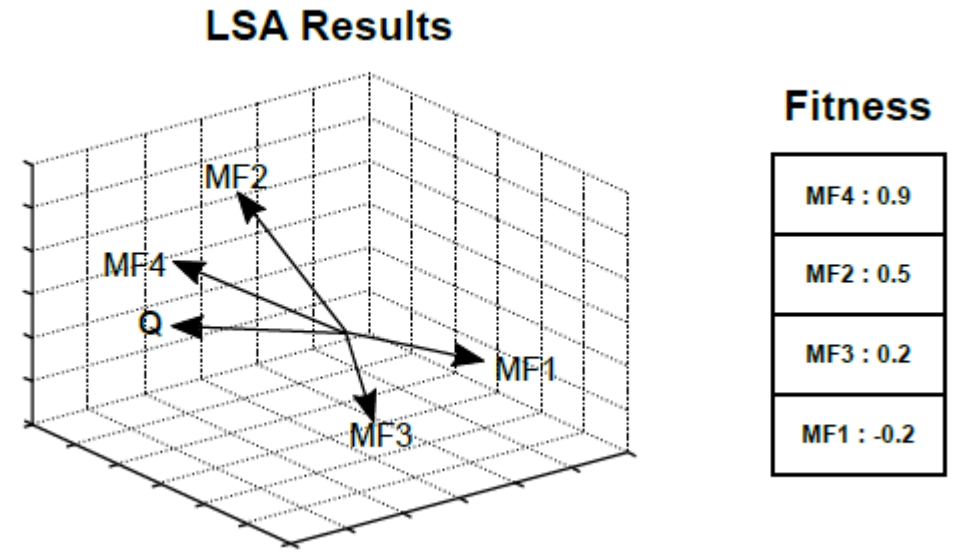




#	Model Fragment	
1	MF2	
2	MF1	
...	...	
n	MF5	



Terms	Model Fragments							Query
	MF1	MF2	MF3	MF4	MF5	MF6	MF7	
	Inverter	0	2	5	7	2	5	2
	Provider	0	2	5	5	2	5	2
	Power	0	4	7	4	4	4	2
	Inductor	0	10	5	2	5	2	2

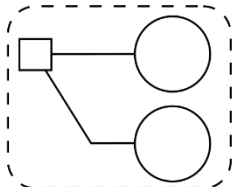
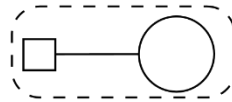
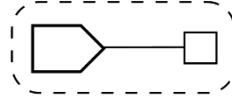


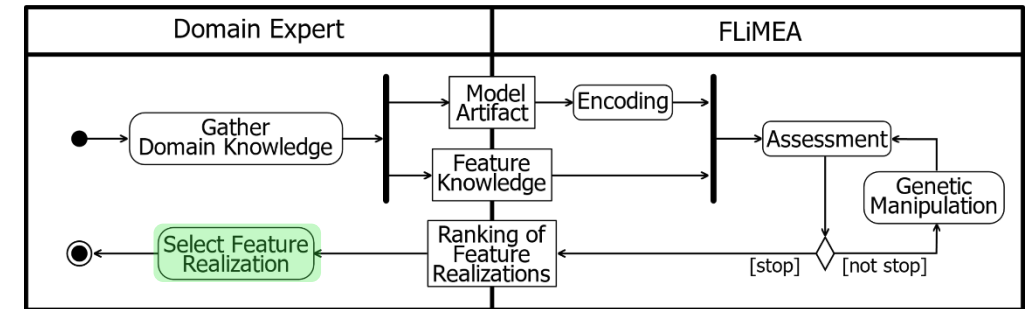
$$fitness(p_1) = \cos(\theta) = \frac{A \cdot B}{\|A\| \cdot \|B\|}$$



Population



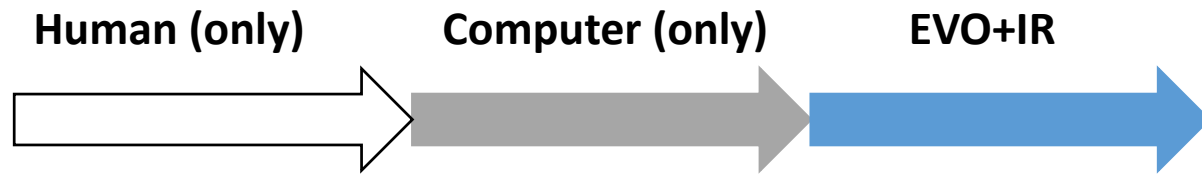
#	Model Fragment	Fitness
1	MF2 	0.81
2	MF1 	0.75
...
n	MF5 	-0.15



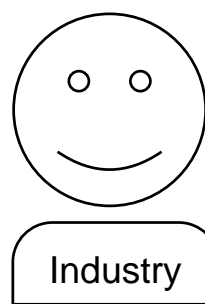
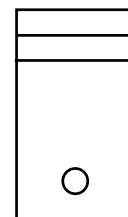
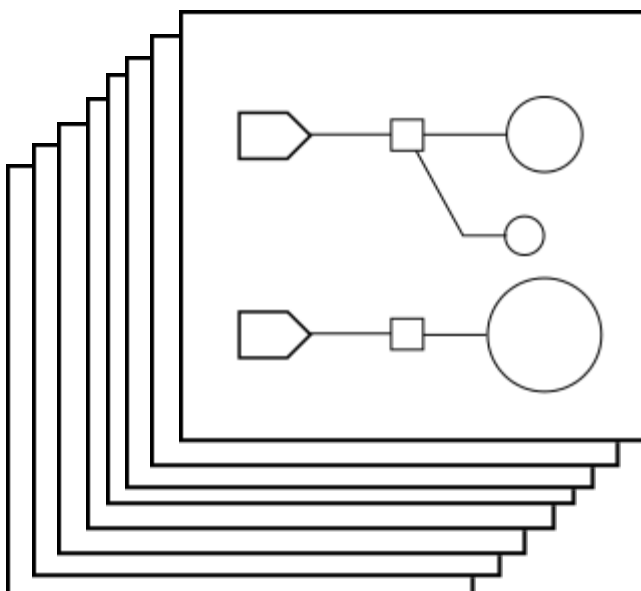
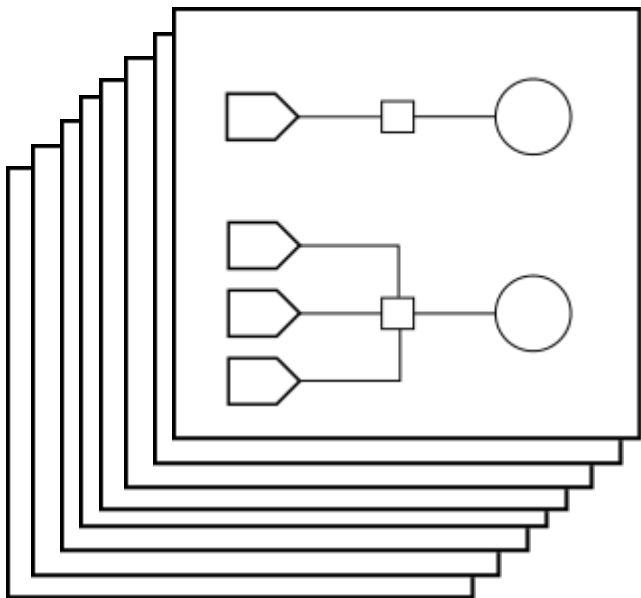
- FLiMEA produces a ranking of feature realizations matching the feature description provided.
- The feature realizations are ordered based on the fitness calculated.
- The domain expert can decide which one fits better to their understanding.

Locating Features (Model Fragments) on Models

Our journey



Result?

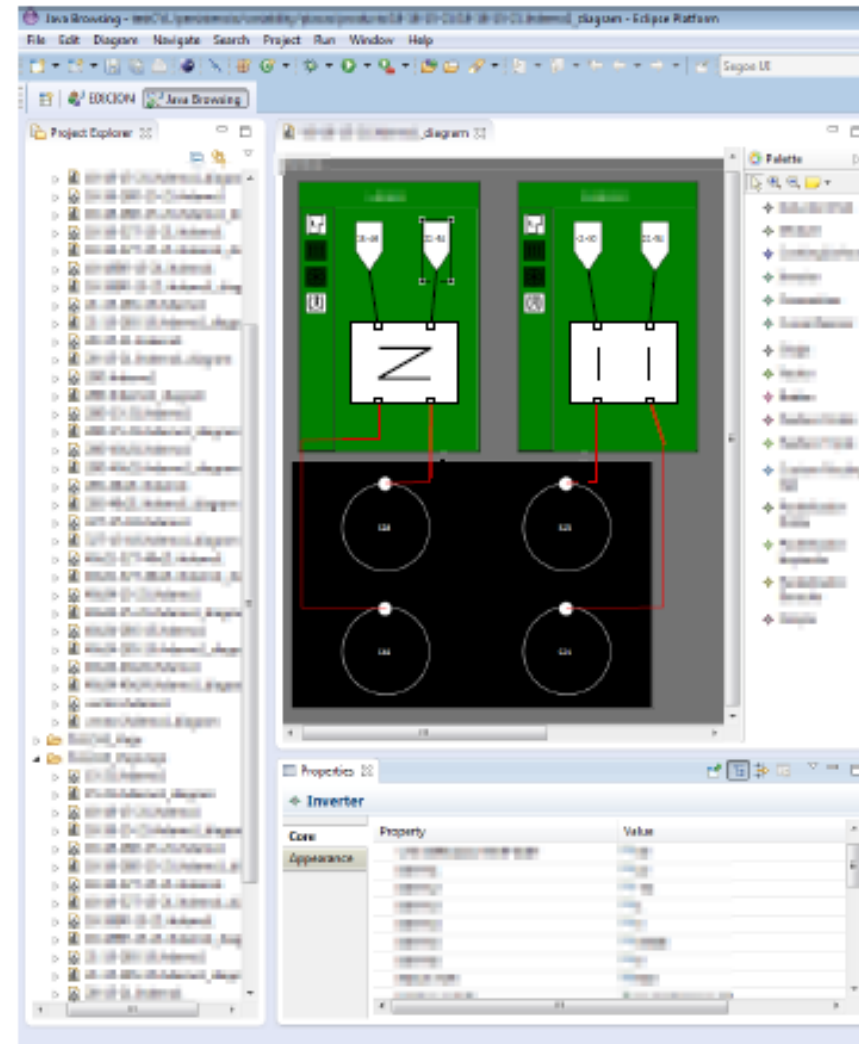
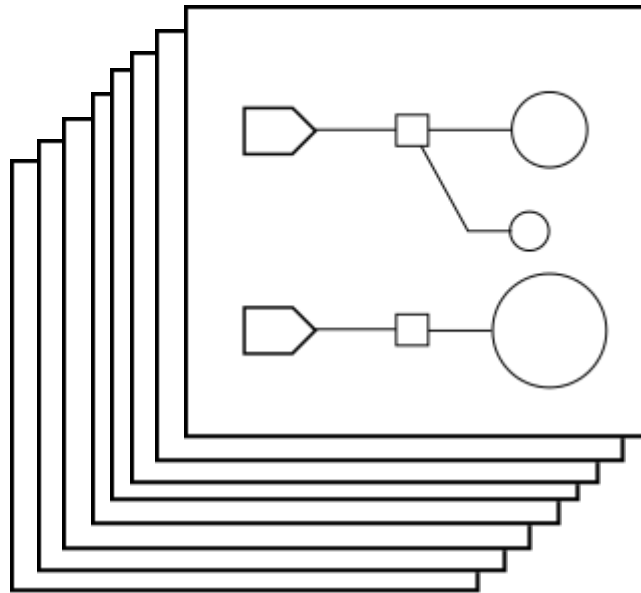
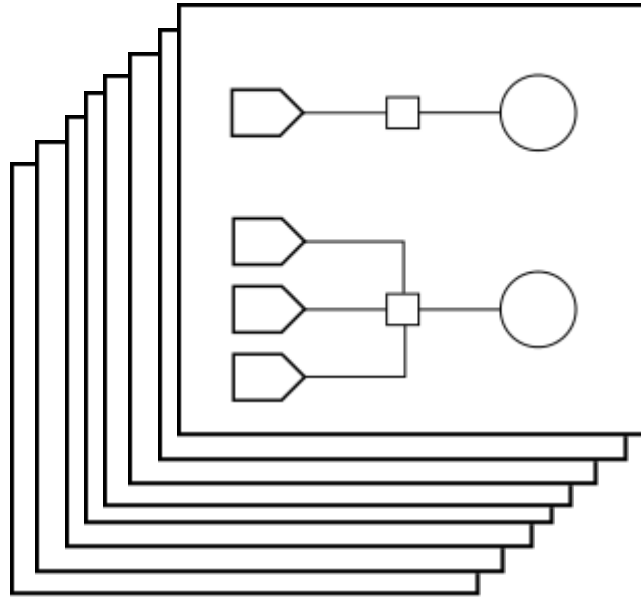


“Machine and human complement each other” Approach

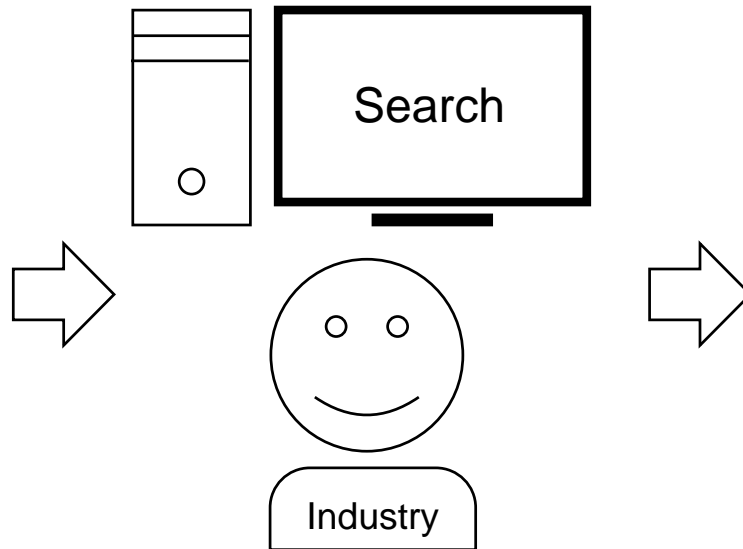
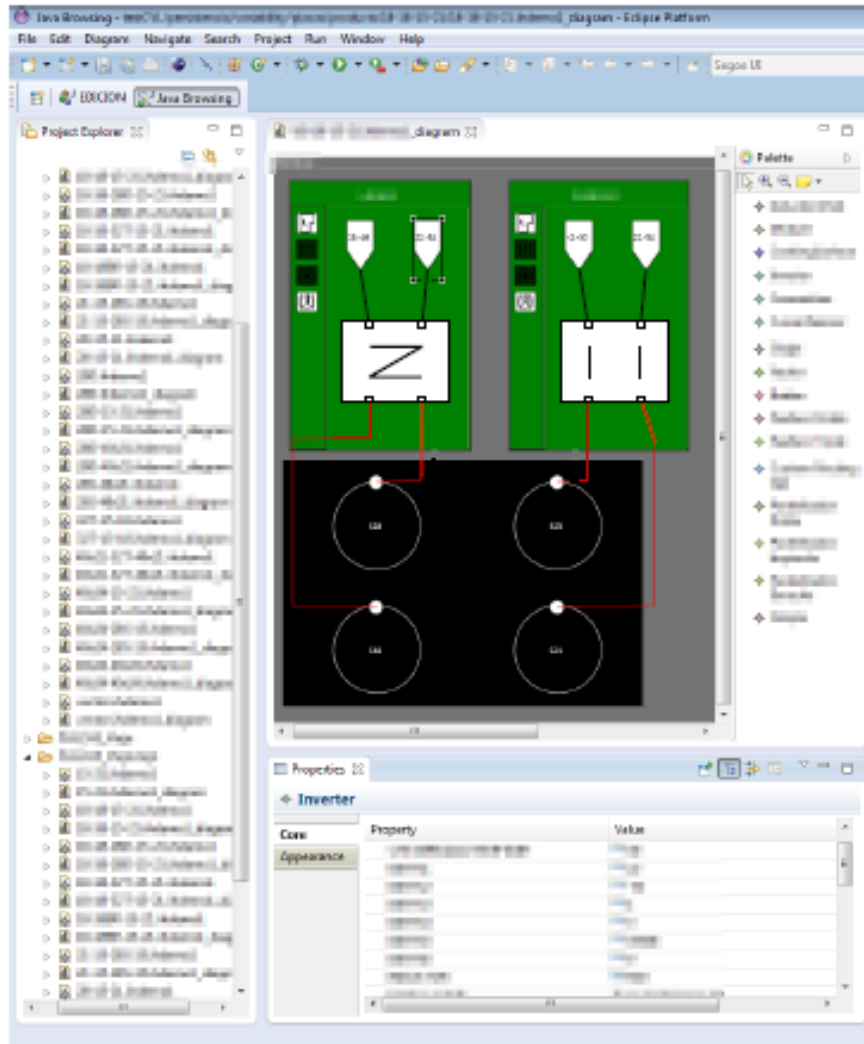
- Human has domain knowledge.
- Machine capability to search very large problem spaces.
- Result: **Library of model fragments.**

Hotplates 20 / 20						Inverter Nets 17 / 17					PCs 18 / 18		PUs 19 / 19	
PL2_DWL	PL2_DWR	PL3_S	XS_ML	S_ML	M_ML	P3P2	1XP2NC130	POOL_L	POOL_R	TRI	PC_DEFAULT_50	PC_50	POWER_DEFAULT	POWER_5
						# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	PC_S2_50	PC_XS_50	POWER_S2	POWER_XS_PW
XL_ML	L_ML	S_BR_ML	HP_XS_P	HP_ML		TRI_50	2XP1NCPMD	2805	P2P2NCP1NCP1	1XP2NC150280	PC_M_50	PC_MD_50	POWER_M	POWER_M2
						# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 4	# Inverters: 2 # Routes: 2 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 3	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	# Inverters: 2 # Routes: 4 # PGs: 2 # Parallel: 2	PC_3_POOL_50	PC_2_POOL_50	POWER_3_POOL	POWER_2_POOL
											PC_M_ML_50	PC_XL_50	POWER_4_POOL	POWER_M_XLT
											PC_XL_XLT_50	PC_XLT_50	POWER_XLT	POWER_XL_XLT
											PC_XL_XLT_50_50	PC_SBR_50	POWER_XL_XLT_...	POWER_XL_XLT_...
											PC_XL_50	PC_50	IND_SBR	POWER_XL

“Classic” models...



“Classic” models... but this is all about model fragments...



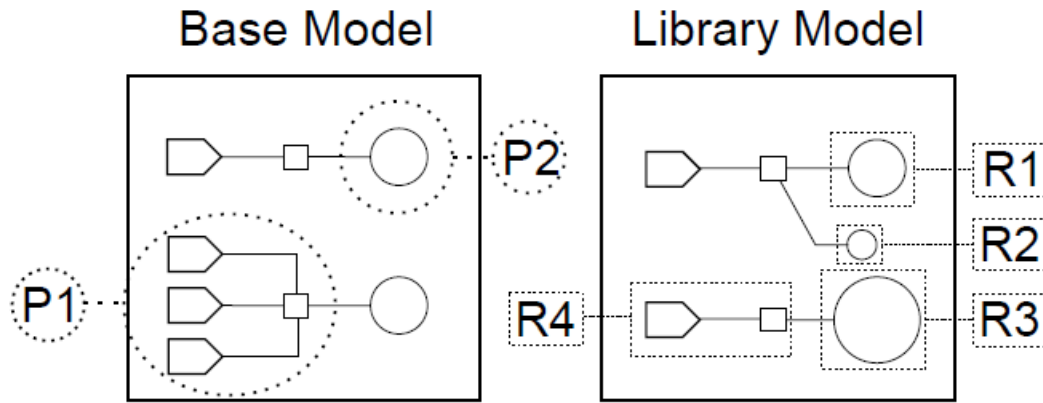
Inverter Nets 17 / 17				
PIP2	1KP2NC150	POD1L	POD1R	TRI
# Inverters: 2	# Inverters: 2	# Inverters: 2	# Inverters: 2	# Inverters: 2
# Routes: 4	# Routes: 4	# Routes: 4	# Routes: 4	# Routes: 4
# PGIs: 2	# PGIs: 2	# PGIs: 2	# PGIs: 2	# PGIs: 2
# Parallel: 2	# Parallel: 2	# Parallel: 2	# Parallel: 2	# Parallel: 2
TRI_SB	2KP1NCPND	2R05	FPP2NCP1NCP1	1KP2NC150280
# Inverters: 2	# Inverters: 2	# Inverters: 2	# Inverters: 2	# Inverters: 2
# Routes: 4	# Routes: 4	# Routes: 4	# Routes: 4	# Routes: 4
# PGIs: 2	# PGIs: 2	# PGIs: 2	# PGIs: 2	# PGIs: 2
# Parallel: 4	# Parallel: 2	# Parallel: 3	# Parallel: 2	# Parallel: 2

PCS 18 / 18	
PC_DEFAULT_50	PC_5_50
PC_S2_50	PC_XS_50
PC_M_50	PC_M2_50
PC_3_POOL_50	PC_2_POOL_50
PC_4_POOL_50	PC_4_POOL_50
PC_M_XL_50	PC_XL_50
PC_XL_XL_50	PC_XL_XL_SB_50
PC_XL_XL_SB_50	PC_S_PR_50
PC_XL_XL_50	PC_XL_50

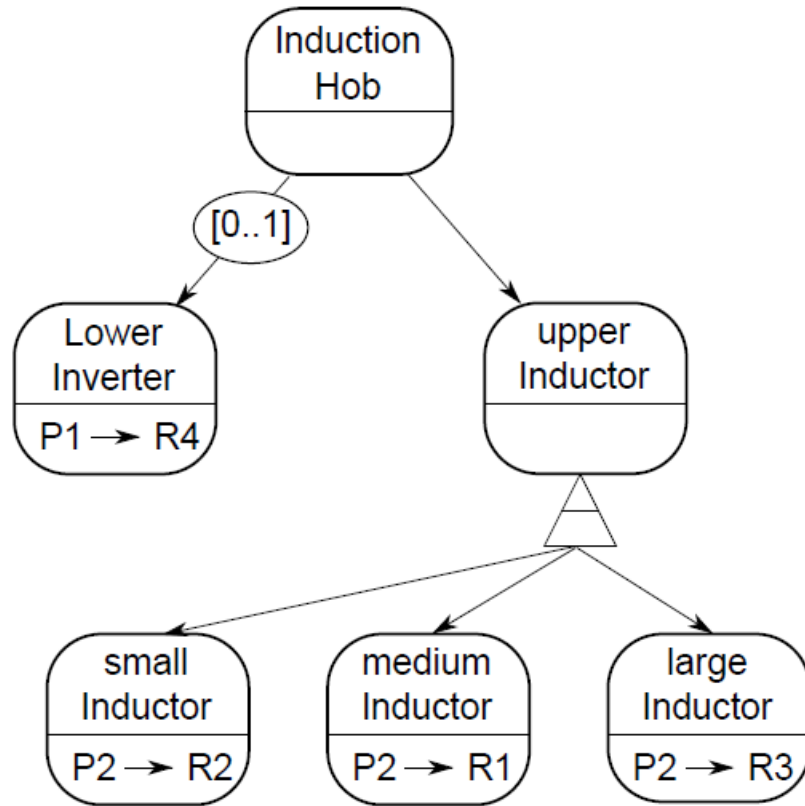
Hotplates 29 / 29					
PL2_DW_L	PL2_DW_R	PL3_S	XS_ML	S_ML	M_ML
2	2	0	0	0	0
2	2	0	XS	S	M
XL_ML	L_ML	S_BR_ML	HP_XS_P	HP_ML	
0	0	2	0	0	1
XL	L	S	XS	M	L

PTs 19 / 19	
POWER_DEFAULT	POWER_S
POWER_S2	POWER_XS_PW
POWER_M	POWER_M2
POWER_1_POOL	POWER_2_POOL
POWER_3_POOL	POWER_4_POOL
POWER_XL_T	POWER_XL_T
POWER_XL_XL_T	POWER_XL_XL_T
IND_3_BR	POWER_XL

Product Realization
layer



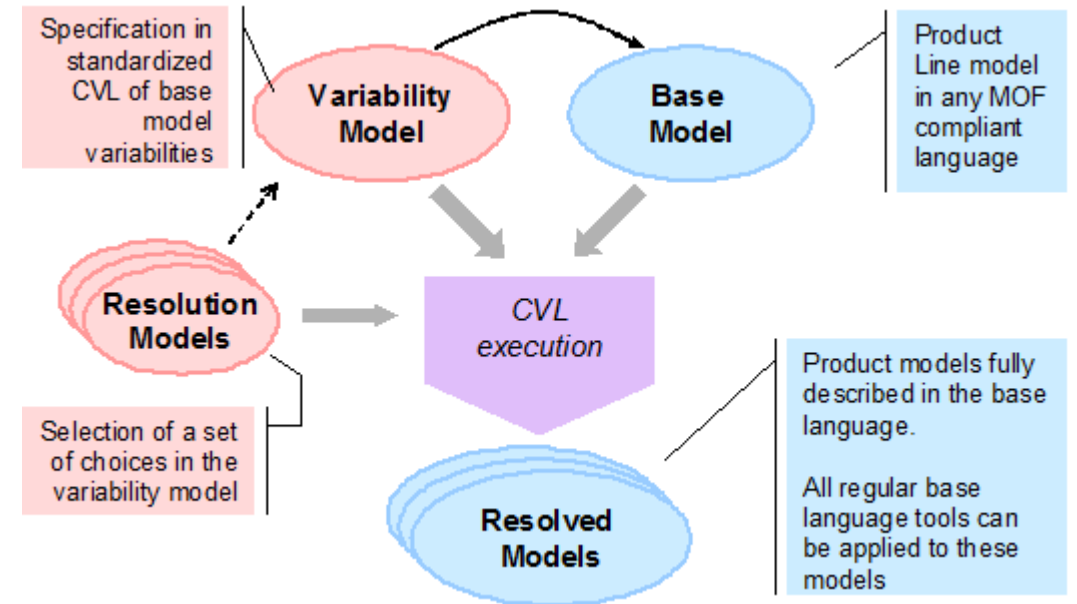
Feature Specification
layer



This is useful here:

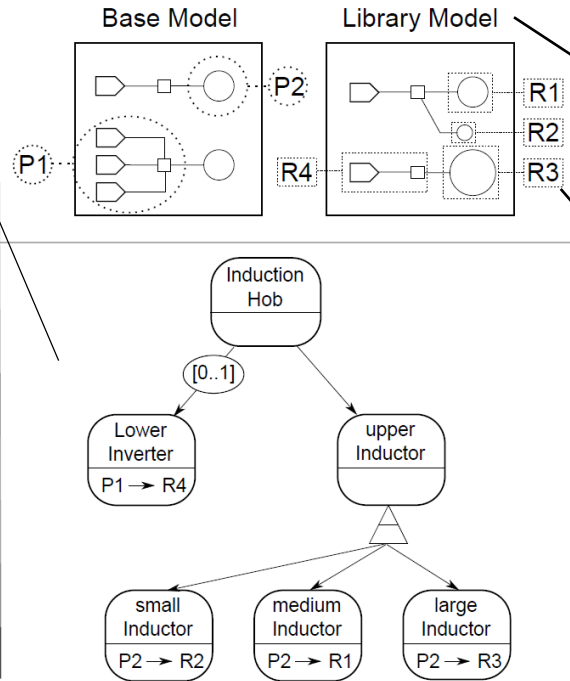
Øystein Haugen, Andrzej Wasowski, Krzysztof Czarnecki:

CVL: common variability language. SPLC 2013: 277



Product Realization layer

Feature Specification layer



IH Model Family

Stage Configuration Wizard

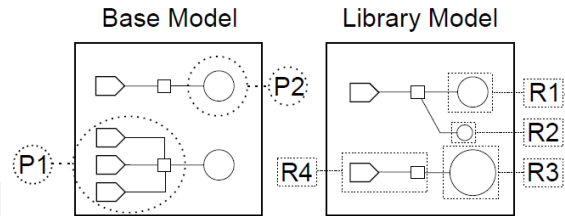
CVL Library

Hotplate Fragment Editor

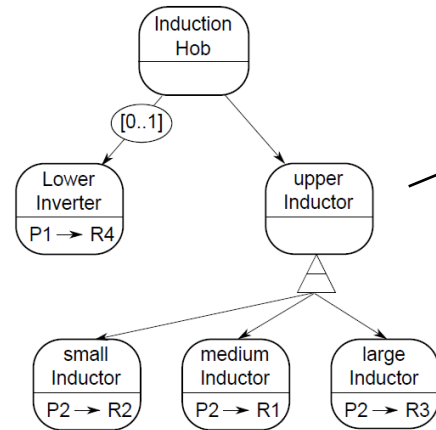
New IH Model from CVL Library Fragments

Modifying Hotplate Model Fragment

Product Realization layer



Feature Specification layer



Stage Configuration Wizard

Drop an Inverter Net

An Inverter Net is missing

CVL Partial Resolution

Cooking Zone :

Drop a Hotplate

Some Hotplates are missing

CVL Partial Resolution

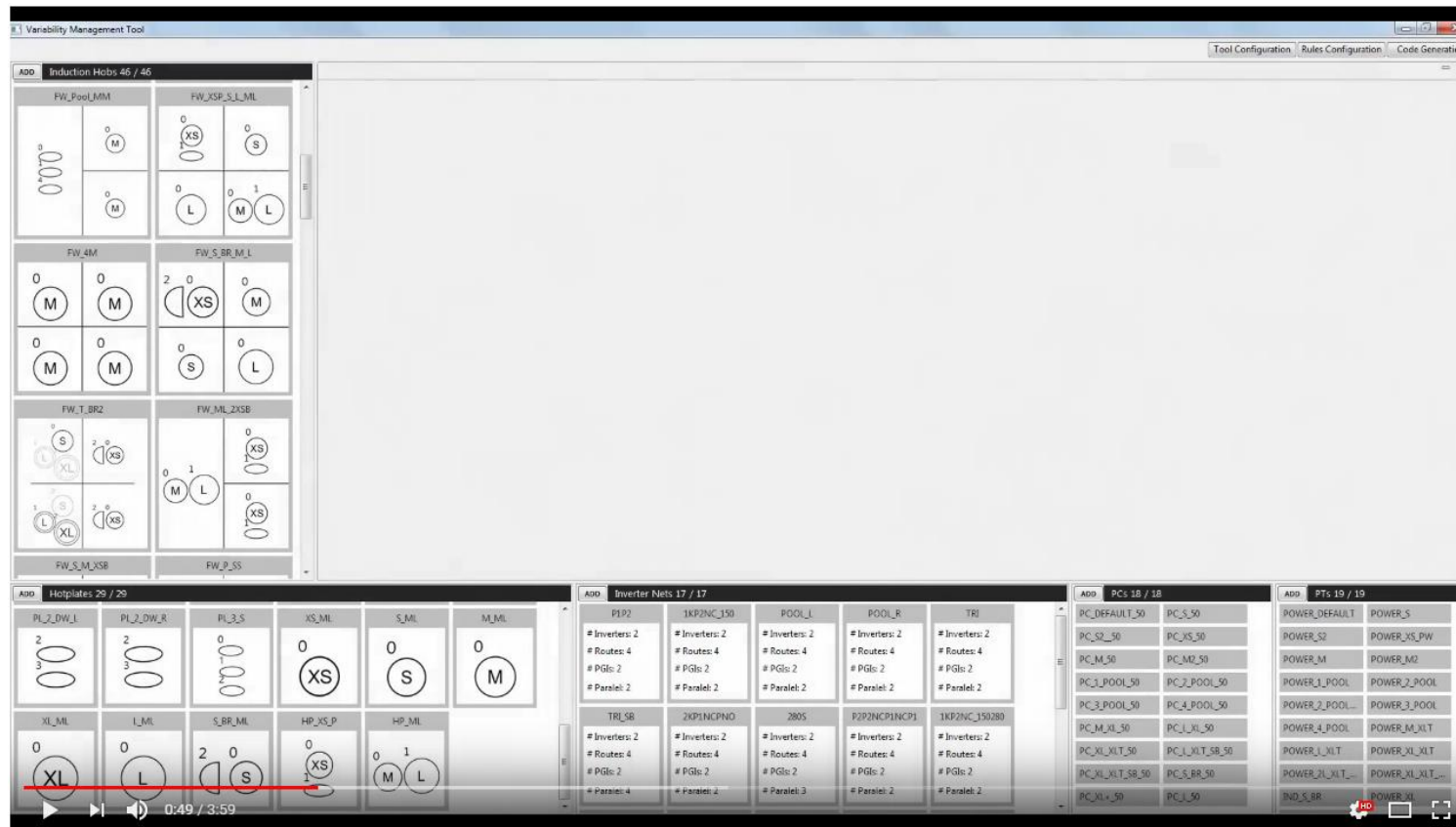
Cooking Zone :

Drop a Hotplate

Power Tables

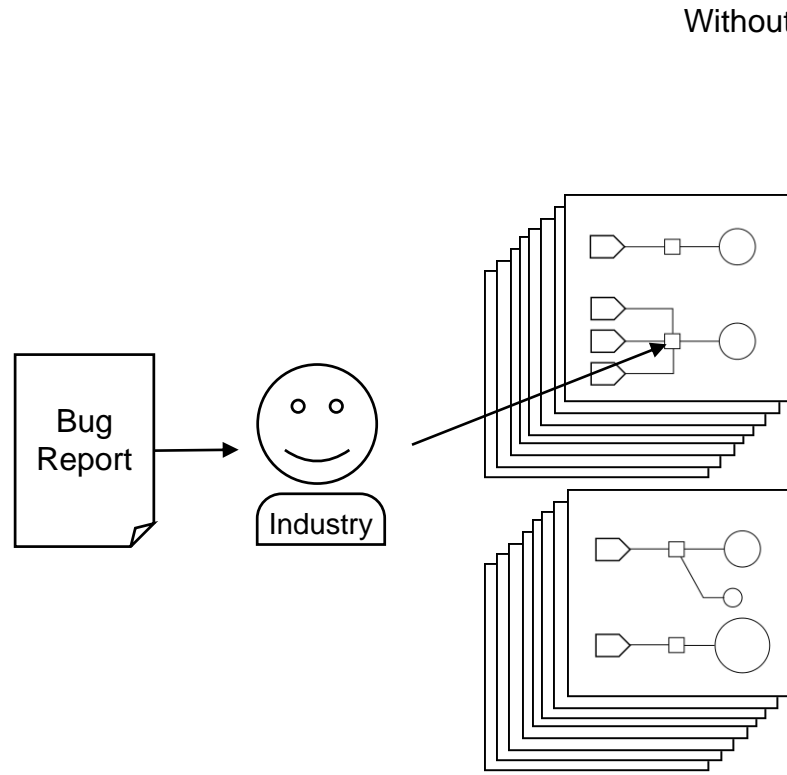
Inductor0	Inductor1	Inductor2	Inductor3	Inductor4	Inductor5
Power0_0	Power0_1	Power0_2	Power0_3	Power0_4	Power0_5
Power0_6	Power0_7	Power0_8	Power0_9	Power0_10	Power0_11
Power0_12	Power0_13	Power0_14	Power0_15	Power0_16	Power0_17
Power0_18	Power0_19	Power0_20	Power0_21	Power0_22	Power0_23
Power0_24	Power0_25	Power0_26	Power0_27	Power0_28	Power0_29
Power0_30	Power0_31	Power0_32	Power0_33	Power0_34	Power0_35
Power0_36	Power0_37	Power0_38	Power0_39	Power0_40	Power0_41
Power0_42	Power0_43	Power0_44	Power0_45	Power0_46	Power0_47
Power0_48	Power0_49	Power0_50	Power0_51	Power0_52	Power0_53
Power0_54	Power0_55	Power0_56	Power0_57	Power0_58	Power0_59
Power0_60	Power0_61	Power0_62	Power0_63	Power0_64	Power0_65
Power0_66	Power0_67	Power0_68	Power0_69	Power0_70	Power0_71
Power0_72	Power0_73	Power0_74	Power0_75	Power0_76	Power0_77
Power0_78	Power0_79	Power0_80	Power0_81	Power0_82	Power0_83
Power0_84	Power0_85	Power0_86	Power0_87	Power0_88	Power0_89
Power0_90	Power0_91	Power0_92	Power0_93	Power0_94	Power0_95
Power0_96	Power0_97	Power0_98	Power0_99	Power0_100	Power0_101
Power0_102	Power0_103	Power0_104	Power0_105	Power0_106	Power0_107
Power0_108	Power0_109	Power0_110	Power0_111	Power0_112	Power0_113
Power0_114	Power0_115	Power0_116	Power0_117	Power0_118	Power0_119
Power0_120	Power0_121	Power0_122	Power0_123	Power0_124	Power0_125
Power0_126	Power0_127	Power0_128	Power0_129	Power0_130	Power0_131
Power0_132	Power0_133	Power0_134	Power0_135	Power0_136	Power0_137
Power0_138	Power0_139	Power0_140	Power0_141	Power0_142	Power0_143
Power0_144	Power0_145	Power0_146	Power0_147	Power0_148	Power0_149
Power0_150	Power0_151	Power0_152	Power0_153	Power0_154	Power0_155
Power0_156	Power0_157	Power0_158	Power0_159	Power0_160	Power0_161
Power0_162	Power0_163	Power0_164	Power0_165	Power0_166	Power0_167
Power0_168	Power0_169	Power0_170	Power0_171	Power0_172	Power0_173
Power0_174	Power0_175	Power0_176	Power0_177	Power0_178	Power0_179
Power0_180	Power0_181	Power0_182	Power0_183	Power0_184	Power0_185
Power0_186	Power0_187	Power0_188	Power0_189	Power0_190	Power0_191
Power0_192	Power0_193	Power0_194	Power0_195	Power0_196	Power0_197
Power0_198	Power0_199	Power0_200	Power0_201	Power0_202	Power0_203
Power0_204	Power0_205	Power0_206	Power0_207	Power0_208	Power0_209
Power0_210	Power0_211	Power0_212	Power0_213	Power0_214	Power0_215
Power0_216	Power0_217	Power0_218	Power0_219	Power0_220	Power0_221
Power0_222	Power0_223	Power0_224	Power0_225	Power0_226	Power0_227
Power0_228	Power0_229	Power0_230	Power0_231	Power0_232	Power0_233
Power0_234	Power0_235	Power0_236	Power0_237	Power0_238	Power0_239
Power0_240	Power0_241	Power0_242	Power0_243	Power0_244	Power0_245
Power0_246	Power0_247	Power0_248	Power0_249	Power0_250	Power0_251
Power0_252	Power0_253	Power0_254	Power0_255	Power0_256	Power0_257
Power0_258	Power0_259	Power0_260	Power0_261	Power0_262	Power0_263
Power0_264	Power0_265	Power0_266	Power0_267	Power0_268	Power0_269
Power0_270	Power0_271	Power0_272	Power0_273	Power0_274	Power0_275
Power0_276	Power0_277	Power0_278	Power0_279	Power0_280	Power0_281
Power0_282	Power0_283	Power0_284	Power0_285	Power0_286	Power0_287
Power0_288	Power0_289	Power0_290	Power0_291	Power0_292	Power0_293
Power0_294	Power0_295	Power0_296	Power0_297	Power0_298	Power0_299
Power0_300	Power0_301	Power0_302	Power0_303	Power0_304	Power0_305
Power0_306	Power0_307	Power0_308	Power0_309	Power0_310	Power0_311
Power0_312	Power0_313	Power0_314	Power0_315	Power0_316	Power0_317
Power0_318	Power0_319	Power0_320	Power0_321	Power0_322	Power0_323
Power0_324	Power0_325	Power0_326	Power0_327	Power0_328	Power0_329
Power0_330	Power0_331	Power0_332	Power0_333	Power0_334	Power0_335
Power0_336	Power0_337	Power0_338	Power0_339	Power0_340	Power0_341
Power0_342	Power0_343	Power0_344	Power0_345	Power0_346	Power0_347
Power0_348	Power0_349	Power0_350	Power0_351	Power0_352	Power0_353
Power0_354	Power0_355	Power0_356	Power0_357	Power0_358	Power0_359
Power0_360	Power0_361	Power0_362	Power0_363	Power0_364	Power0_365
Power0_366	Power0_367	Power0_368	Power0_369	Power0_370	Power0_371
Power0_372	Power0_373	Power0_374	Power0_375	Power0_376	Power0_377
Power0_378	Power0_379	Power0_380	Power0_381	Power0_382	Power0_383
Power0_384	Power0_385	Power0_386	Power0_387	Power0_388	Power0_389
Power0_390	Power0_391	Power0_392	Power0_393	Power0_394	Power0_395
Power0_396	Power0_397	Power0_398	Power0_399	Power0_400	Power0_401
Power0_402	Power0_403	Power0_404	Power0_405	Power0_406	Power0_407
Power0_408	Power0_409	Power0_410	Power0_411	Power0_412	Power0_413
Power0_414	Power0_415	Power0_416	Power0_417	Power0_418	Power0_419
Power0_420	Power0_421	Power0_422	Power0_423	Power0_424	Power0_425
Power0_426	Power0_427	Power0_428	Power0_429	Power0_430	Power0_431
Power0_432	Power0_433	Power0_434	Power0_435	Power0_436	Power0_437
Power0_438	Power0_439	Power0_440	Power0_441	Power0_442	Power0_443
Power0_444	Power0_445	Power0_446	Power0_447	Power0_448	Power0_449
Power0_450	Power0_451	Power0_452	Power0_453	Power0_454	Power0_455
Power0_456	Power0_457	Power0_458	Power0_459	Power0_460	Power0_461
Power0_462	Power0_463	Power0_464	Power0_465	Power0_466	Power0_467
Power0_468	Power0_469	Power0_470	Power0_471	Power0_472	Power0_473
Power0_474	Power0_475	Power0_476	Power0_477	Power0_478	Power0_479
Power0_480	Power0_481	Power0_482	Power0_483	Power0_484	Power0_485
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Power0_498	Power0_499	Power0_500	Power0_501	Power0_502	Power0_503
Power0_504	Power0_505	Power0_506	Power0_507	Power0_508	Power0_509
Power0_510	Power0_511	Power0_512	Power0_513	Power0_514	Power0_515
Power0_516	Power0_517	Power0_518	Power0_519	Power0_520	Power0_521
Power0_522	Power0_523	Power0_524	Power0_525	Power0_526	Power0_527
Power0_528	Power0_529	Power0_530	Power0_531	Power0_532	Power0_533
Power0_534	Power0_535	Power0_536	Power0_537	Power0_538	Power0_539
Power0_540	Power0_541	Power0_542	Power0_543	Power0_544	Power0_545
Power0_546	Power0_547	Power0_548	Power0_549	Power0_550	Power0_551
Power0_552	Power0_553	Power0_554	Power0_555	Power0_556	Power0_557
Power0_558	Power0_559	Power0_560	Power0_561	Power0_562	Power0_563
Power0_564	Power0_565	Power0_566	Power0_567	Power0_568	Power0_569
Power0_570	Power0_571	Power0_572	Power0_573	Power0_574	Power0_575
Power0_576	Power0_577	Power0_578	Power0_579	Power0_580	Power0_581
Power0_582	Power0_583	Power0_584	Power0_585	Power0_586	Power0_587
Power0_588	Power0_589	Power0_590	Power0_591	Power0_592	Power0_593
Power0_594	Power0_595	Power0_596	Power0_597	Power0_598	Power0_599
Power0_600	Power0_601	Power0_602	Power0_603	Power0_604	Power0_605
Power0_606	Power0_607	Power0_608	Power0_609	Power0_610	Power0_611
Power0_612	Power0_613	Power0_614	Power0_615	Power0_616	Power0_617
Power0_618	Power0_619	Power0_620	Power0_621	Power0_622	Power0_623
Power0_624	Power0_625	Power0_626	Power0_627	Power0_628	Power0_629
Power0_630	Power0_631	Power0_632	Power0_633	Power0_634	Power0_635
Power0_636	Power0_637	Power0_638	Power0_639	Power0_640	Power0_641
Power0_642	Power0_643	Power0_644	Power0_645	Power0_646	Power0_647
Power0_648	Power0_649	Power0_650	Power0_651	Power0_652	Power0_653
Power0_654	Power0_655	Power0_656	Power0_657	Power0_658	Power0_659
Power0_660	Power0_661	Power0_662	Power0_663	Power0_664	Power0_665
Power0_666	Power0_667	Power0_668	Power0_669	Power0_670	Power0_671
Power0_672	Power0_673	Power0_674	Power0_675	Power0_676	Power0_677
Power0_678	Power0_679	Power0_680	Power0_681	Power0_682	Power0_683
Power0_684	Power0_685	Power0_686	Power0_687	Power0_688	Power0_689
Power0_690	Power0_691	Power0_692	Power0_693	Power0_694	Power0_695
Power0_696	Power0_697	Power0_698	Power0_699	Power0_700	Power0_701
Power0_702	Power0_703	Power0_704	Power0_705	Power0_706	Power0_707
Power0_708	Power0_709	Power0_710	Power0_711	Power0_712	Power0_713
Power0_714	Power0_715	Power0_716	Power0_717	Power0_718	Power0_719
Power0_720	Power0_721	Power0_722	Power0_723	Power0_724	Power0_725
Power0_726	Power0_727	Power0_728	Power0_729	Power0_730	Power0_731
Power0_732	Power0_733	Power0_734	Power0_735	Power0_736	Power0_737
Power0_738	Power0_739	Power0_740	Power0_741	Power0_742	Power0_743
Power0_744	Power0_745	Power0_746	Power0_747	Power0_748	Power0_749
Power0_750	Power0_751	Power0_752	Power0_753	Power0_754	Power0_755
Power0_756	Power0_757	Power0_758	Power0_759	Power0_760	Power0_761
Power0_762	Power0_763	Power0_764	Power0_765	Power0_766	Power0_767
Power0_768	Power0_769	Power0_770	Power0_771	Power0_772	Power0_773
Power0_774	Power0_775	Power0_776	Power0_777	Power0_778	Power0_779
Power0_780	Power0_781	Power0_782	Power0_783	Power0_784	Power0_785
Power0_786	Power0_787	Power0_788	Power0_789	Power0_790	Power0_791
Power0_792	Power0_793	Power0_794	Power0_795	Power0_796	Power0_797
Power0_798	Power0_799	Power0_800	Power0_801	Power0_802	Power0_803
Power0_804	Power0_805	Power0_806	Power0_807	Power0_808	Power0_809
Power0_810	Power0_811	Power0_812	Power0_813	Power0_814	Power0_815
Power0_816	Power0_817	Power0_818	Power0_819	Power0_820	Power0_821
Power0_822	Power0_823	Power0_824	Power0_825	Power0_826	Power0_827
Power0_828	Power0_829	Power0_830	Power0_831	Power0_832	Power0_833
Power0_834	Power0_835	Power0_836	Power0_837	Power0_838	Power0_839
Power0_840	Power0_841	Power0_842	Power0_843	Power0_844	Power0_845
Power0_846	Power0_847	Power0_848	Power0_849	Power0_850	Power0_851
Power0_852	Power0_853	Power0_854	Power0_855	Power0_856	Power0_857
Power0_858	Power0_859	Power0_860	Power0_861	Power0_862	Power0_863
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You can see this in action:

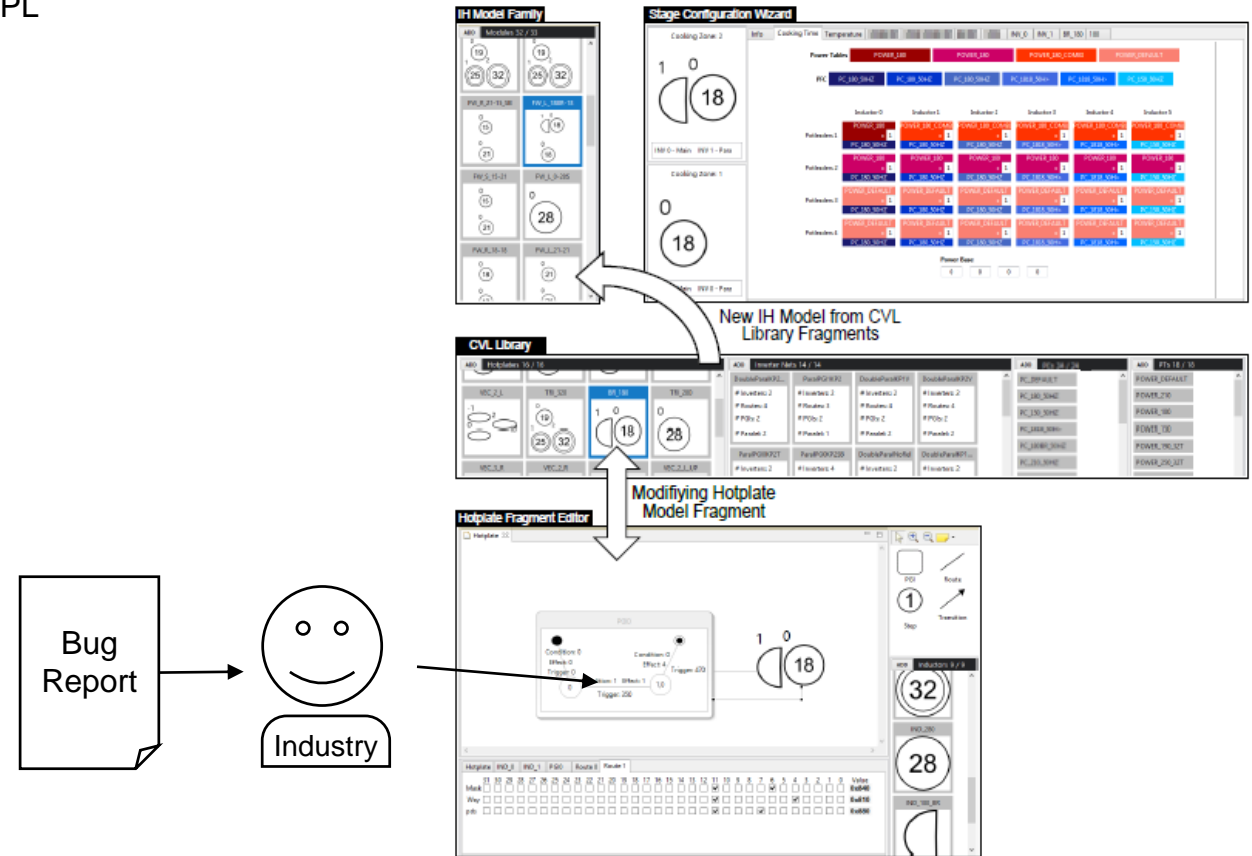


<http://carloscetina.com/variabilitytool.htm>

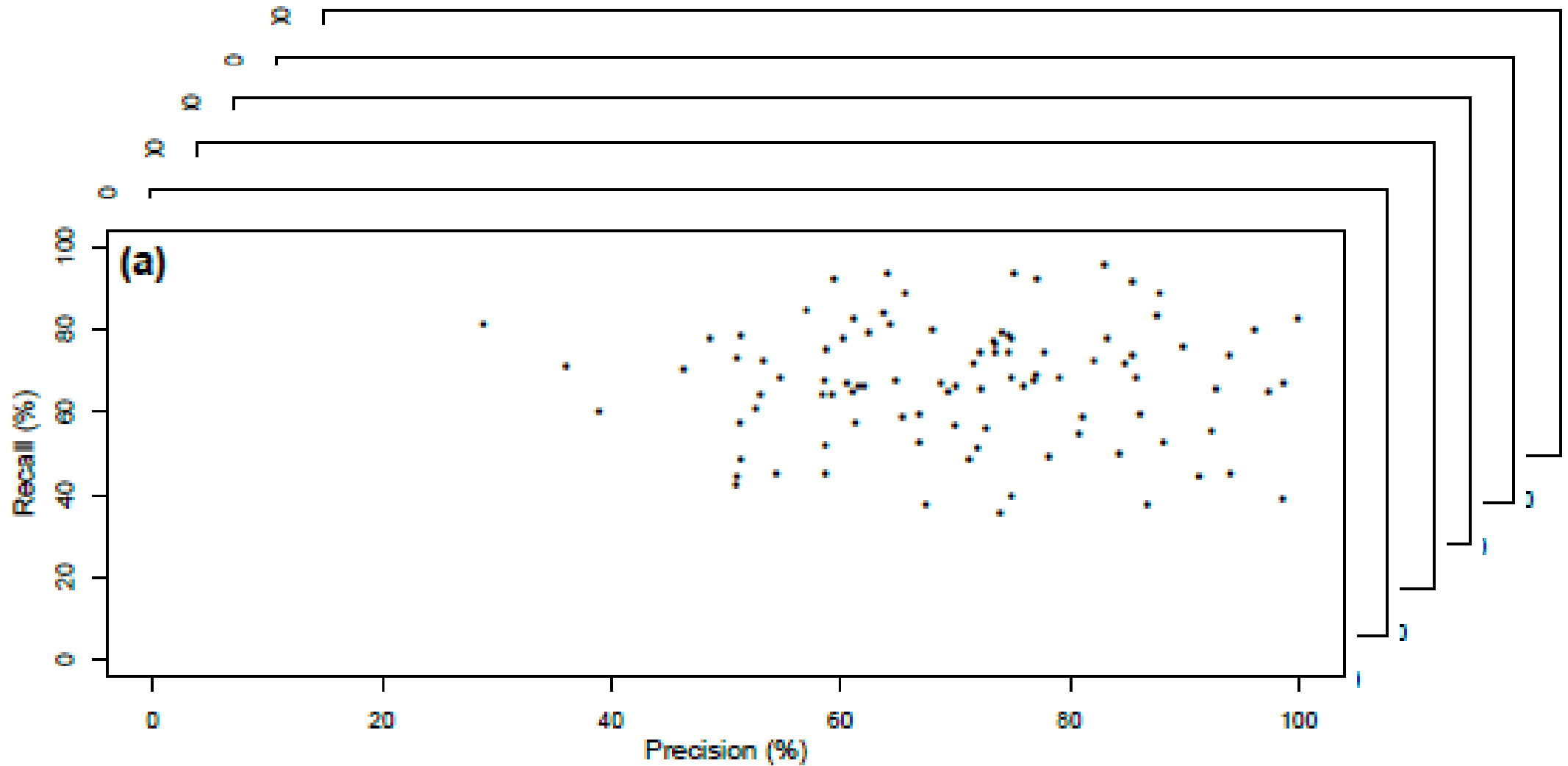
Now, models are in SPL department.



With SPL



Outperforms baselines...



but never ever 100% recall and 100% precision!

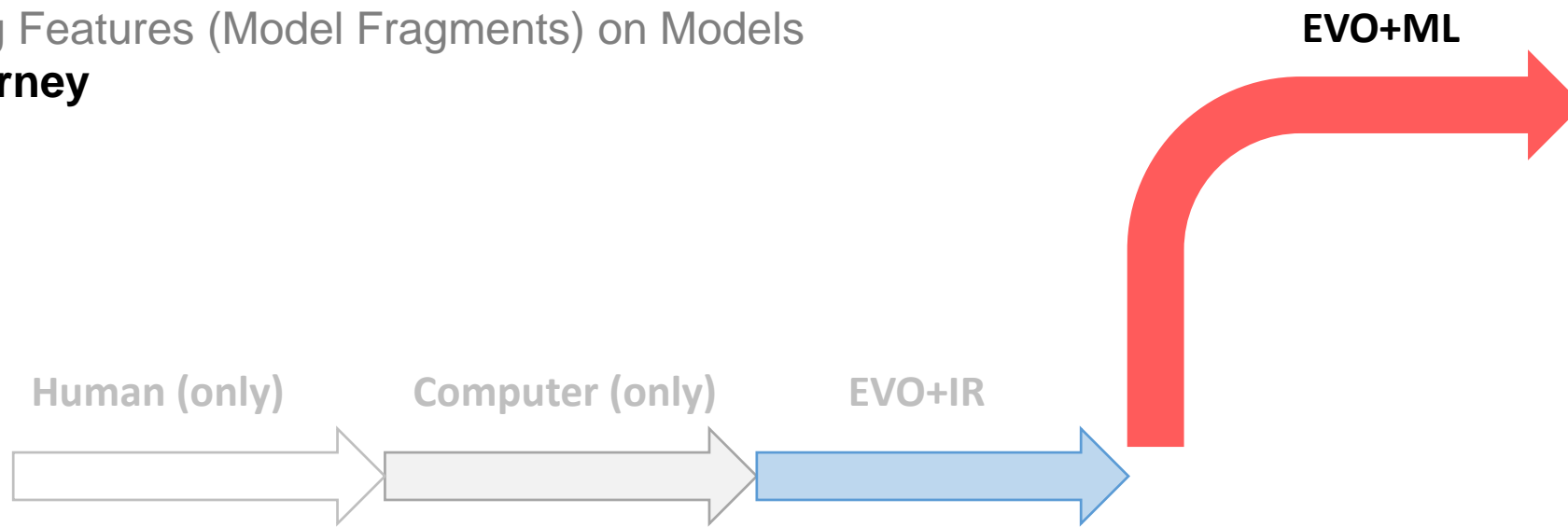


Jane Cleland-Huang - Towards Effective Software and Systems Traceability

<https://www.youtube.com/watch?v=1C3Di2ilNh0&t=3179s>

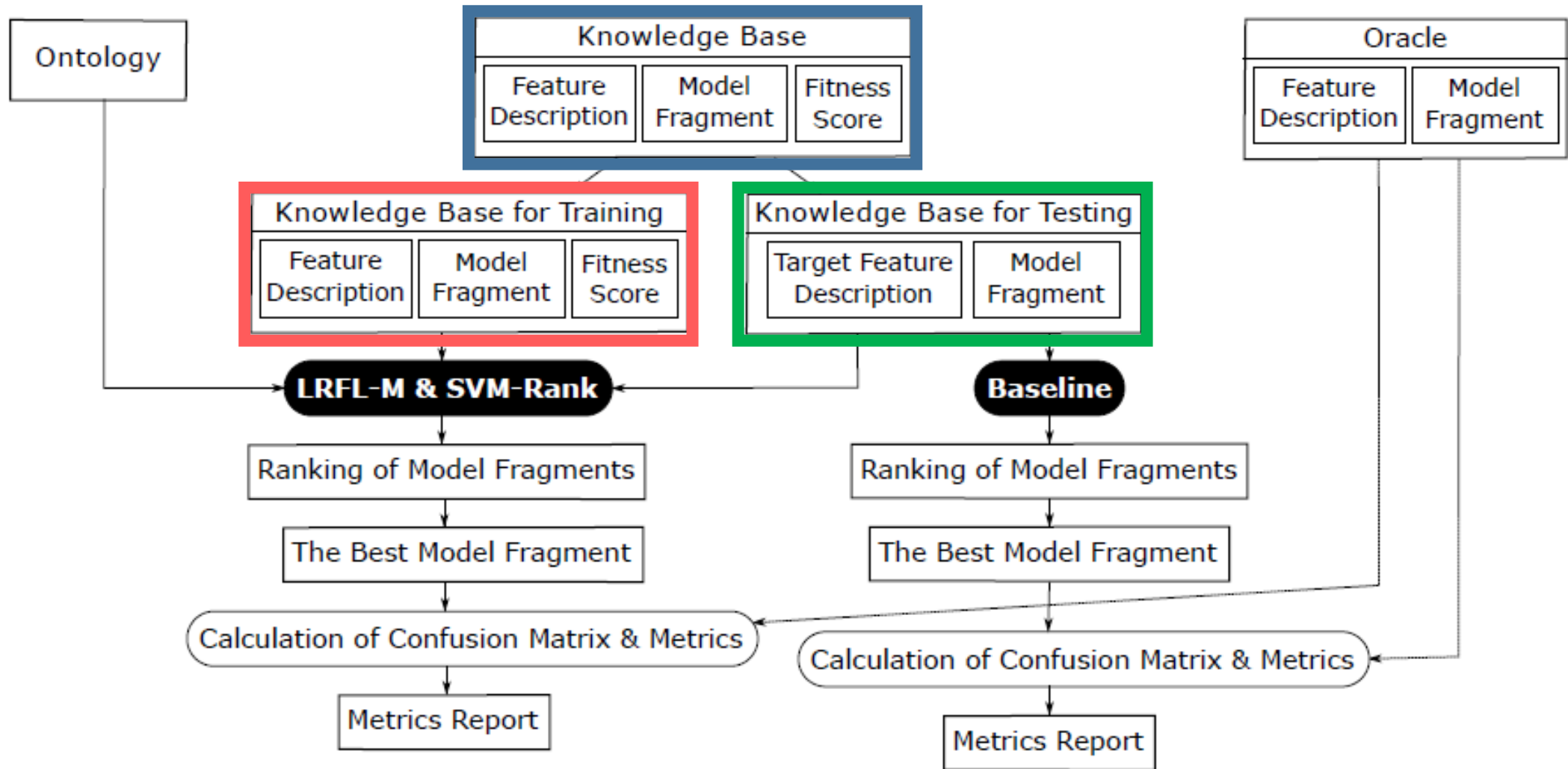
Locating Features (Model Fragments) on Models

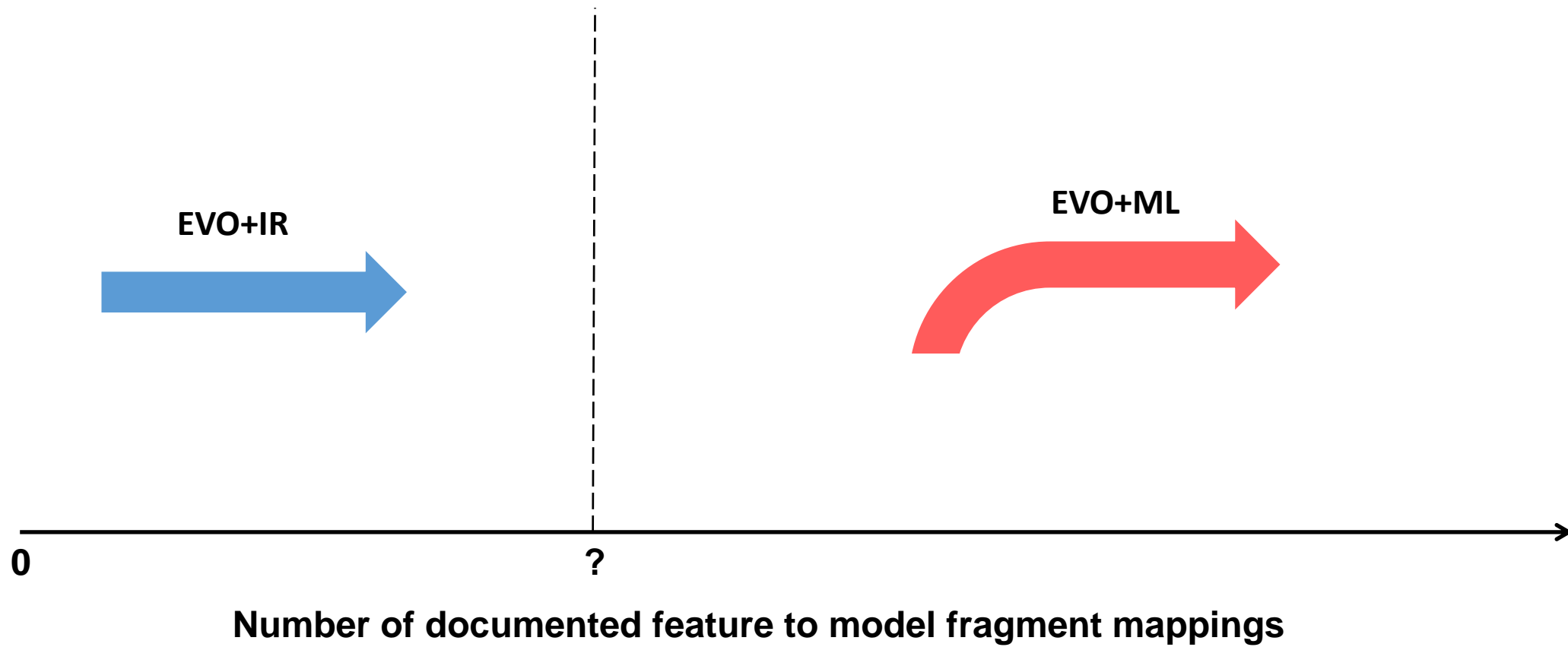
Our journey





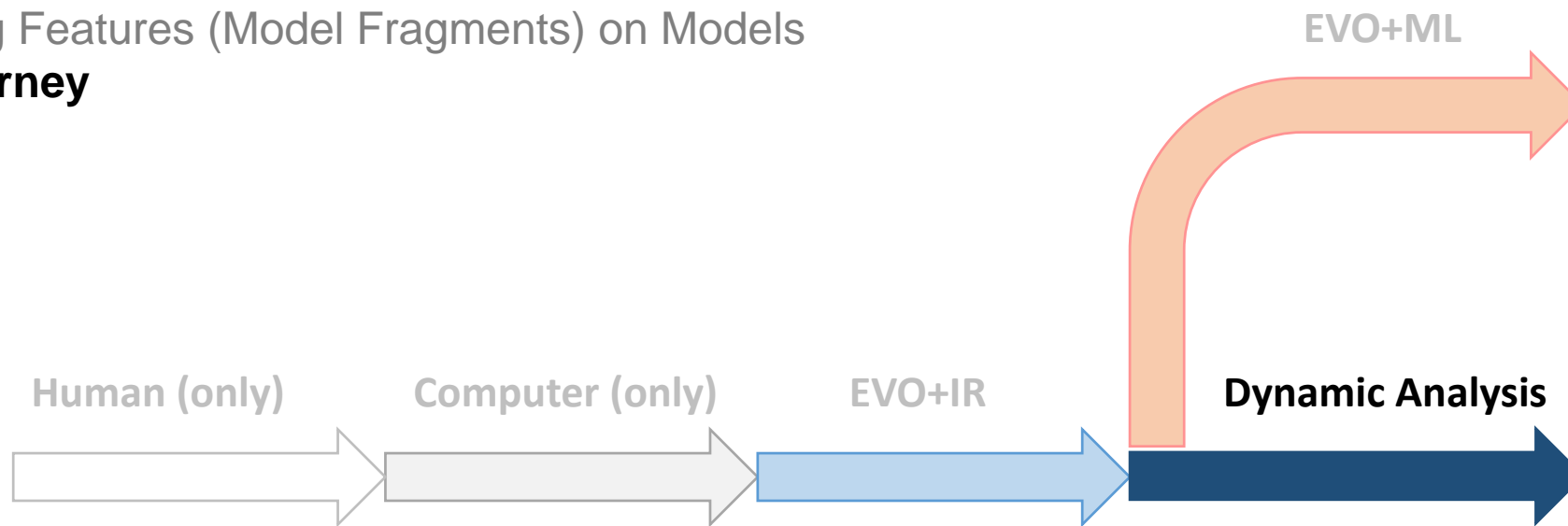
<p>Ontology</p> <pre>graph TD C1((C1 Coupling)) --- R6 --- C6((C6 Cabin)) C1 --- R1 --- C2((C2 Car)) C6 --- R5 --- C5((C5 Desk)) C5 --- R4 --- C4((C4 Button)) C2 --- R2 --- C3((C3 Door)) C3 --- R3 --- C4</pre>	<p>Feature Description</p> <p>The system will turn on the LED of the button that closes the doors on one side of the train if all the doors of the correspondent coupling are closed or blocked.</p>	<p>Model Fragment</p> <pre>graph TD Coupling[Coupling] --- Car1[Car1] Coupling --- Car2[Car2] Coupling --- Car3[Car3] Car1 --- Door1[Door1] Car2 --- Door2[Door2] Car3 --- Door3[Door3] Door1 --- Button[Button] Door2 --- Button Door3 --- Button</pre>																																				
	<p>Encoded Feature Description</p> <table><tr><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>C6</td></tr><tr><td>1</td><td>0</td><td>2</td><td>1</td><td>0</td><td>0</td></tr></table>	C1	C2	C3	C4	C5	C6	1	0	2	1	0	0	<p>Encoded Model Fragment</p> <table><tr><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>C6</td><td>R1</td><td>R2</td><td>R3</td><td>R4</td><td>R5</td><td>R6</td></tr><tr><td>1</td><td>3</td><td>3</td><td>1</td><td>0</td><td>0</td><td>3</td><td>3</td><td>3</td><td>0</td><td>0</td><td>0</td></tr></table>	C1	C2	C3	C4	C5	C6	R1	R2	R3	R4	R5	R6	1	3	3	1	0	0	3	3	3	0	0	0
C1	C2	C3	C4	C5	C6																																	
1	0	2	1	0	0																																	
C1	C2	C3	C4	C5	C6	R1	R2	R3	R4	R5	R6																											
1	3	3	1	0	0	3	3	3	0	0	0																											

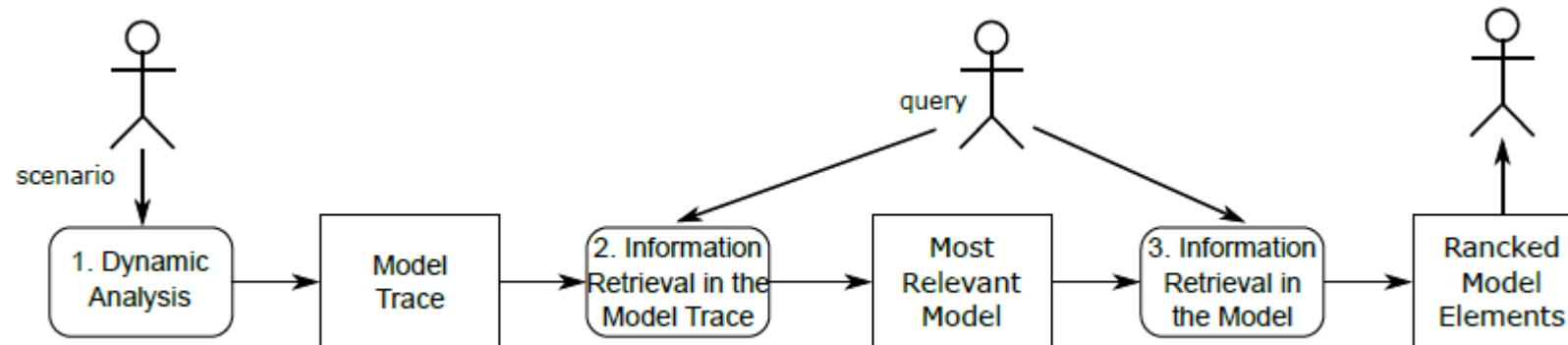
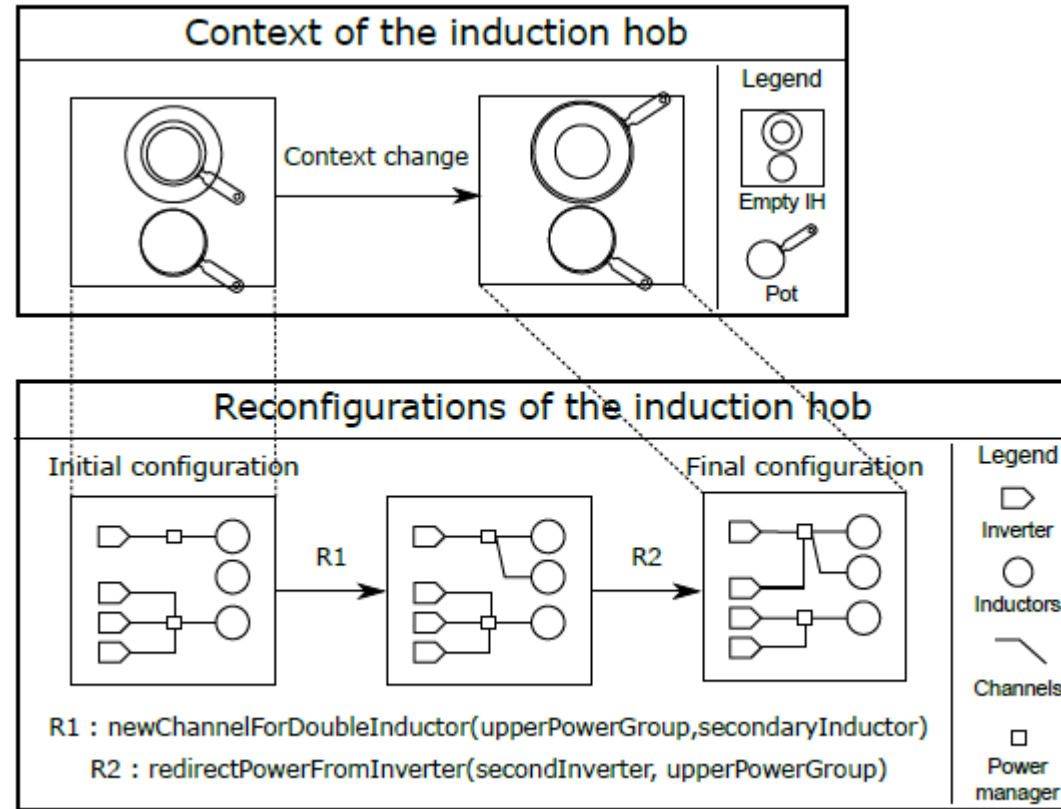




Locating Features (Model Fragments) on Models

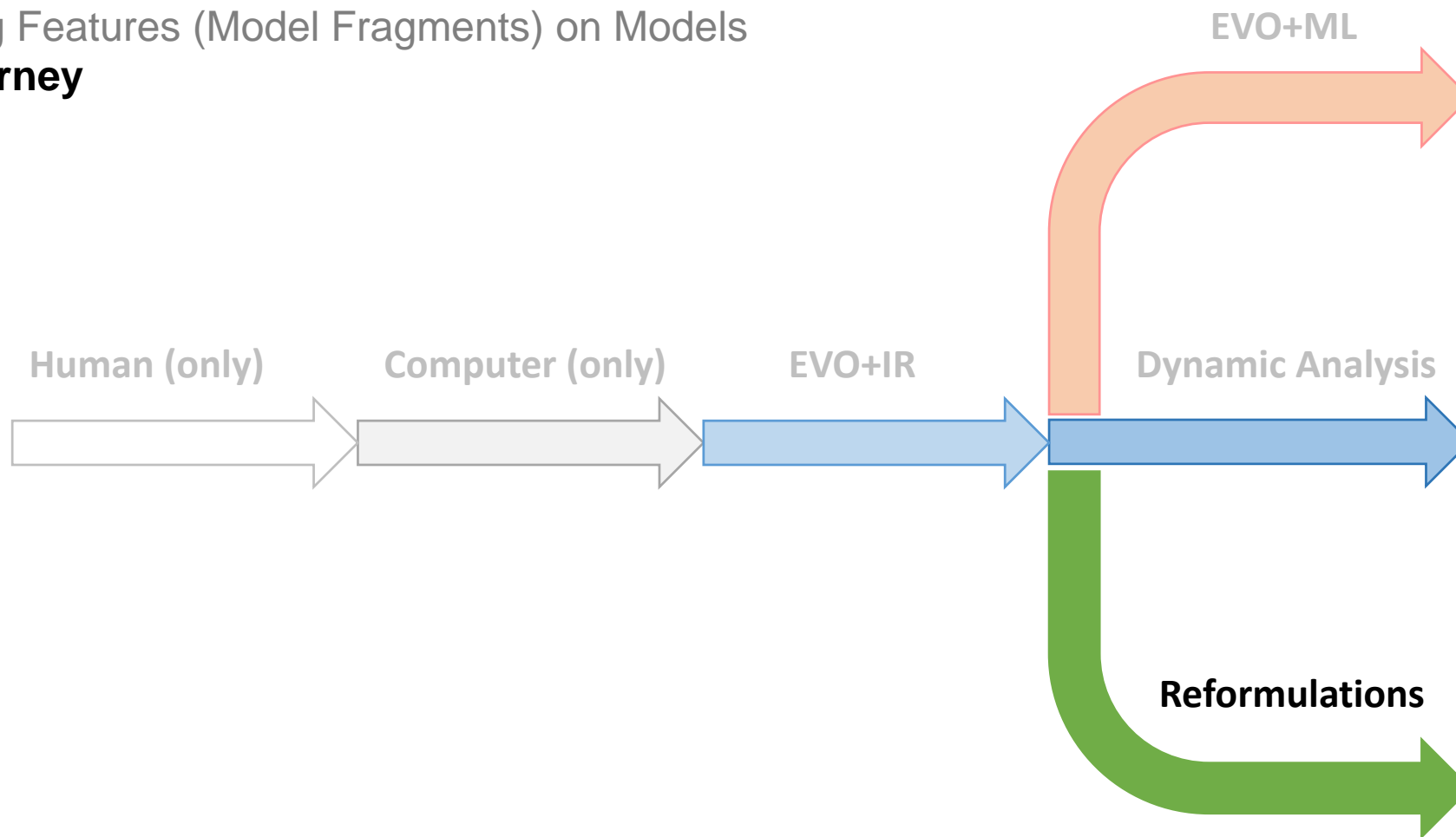
Our journey



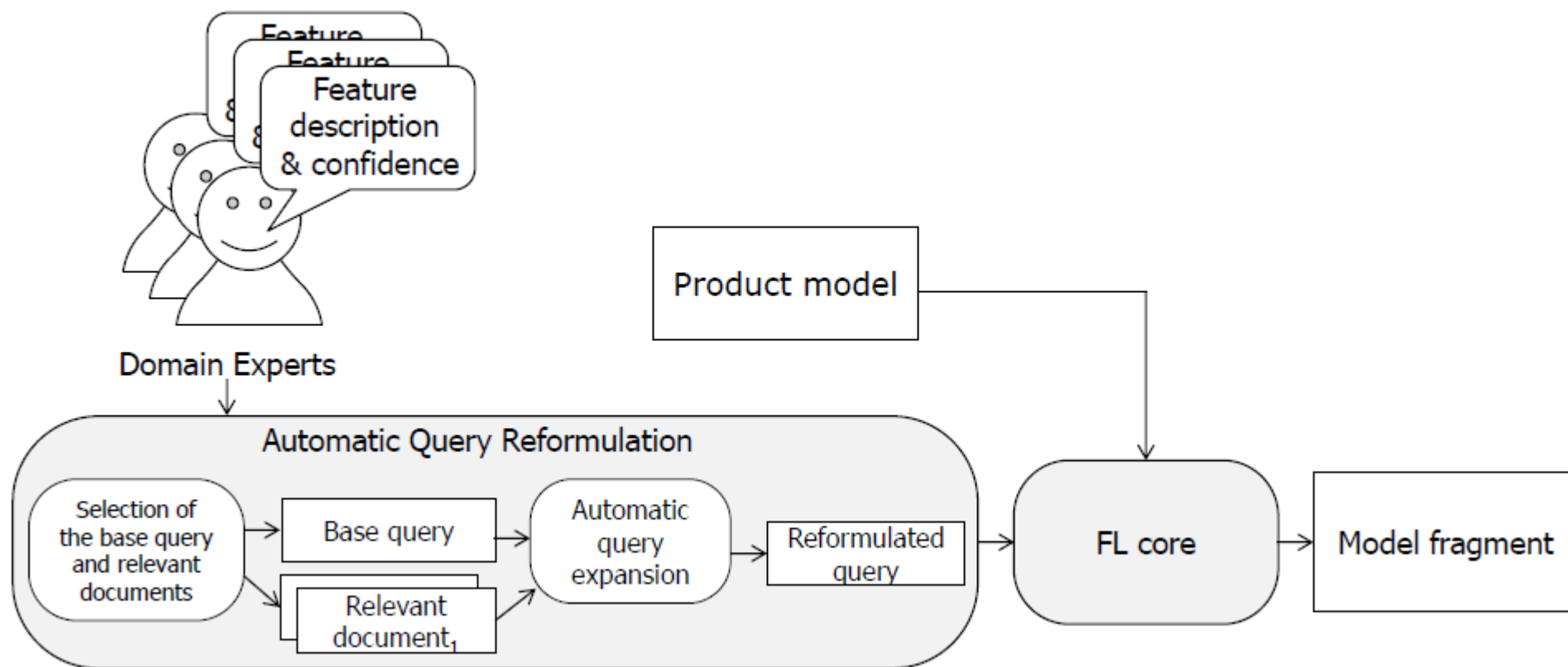


Locating Features (Model Fragments) on Models

Our journey



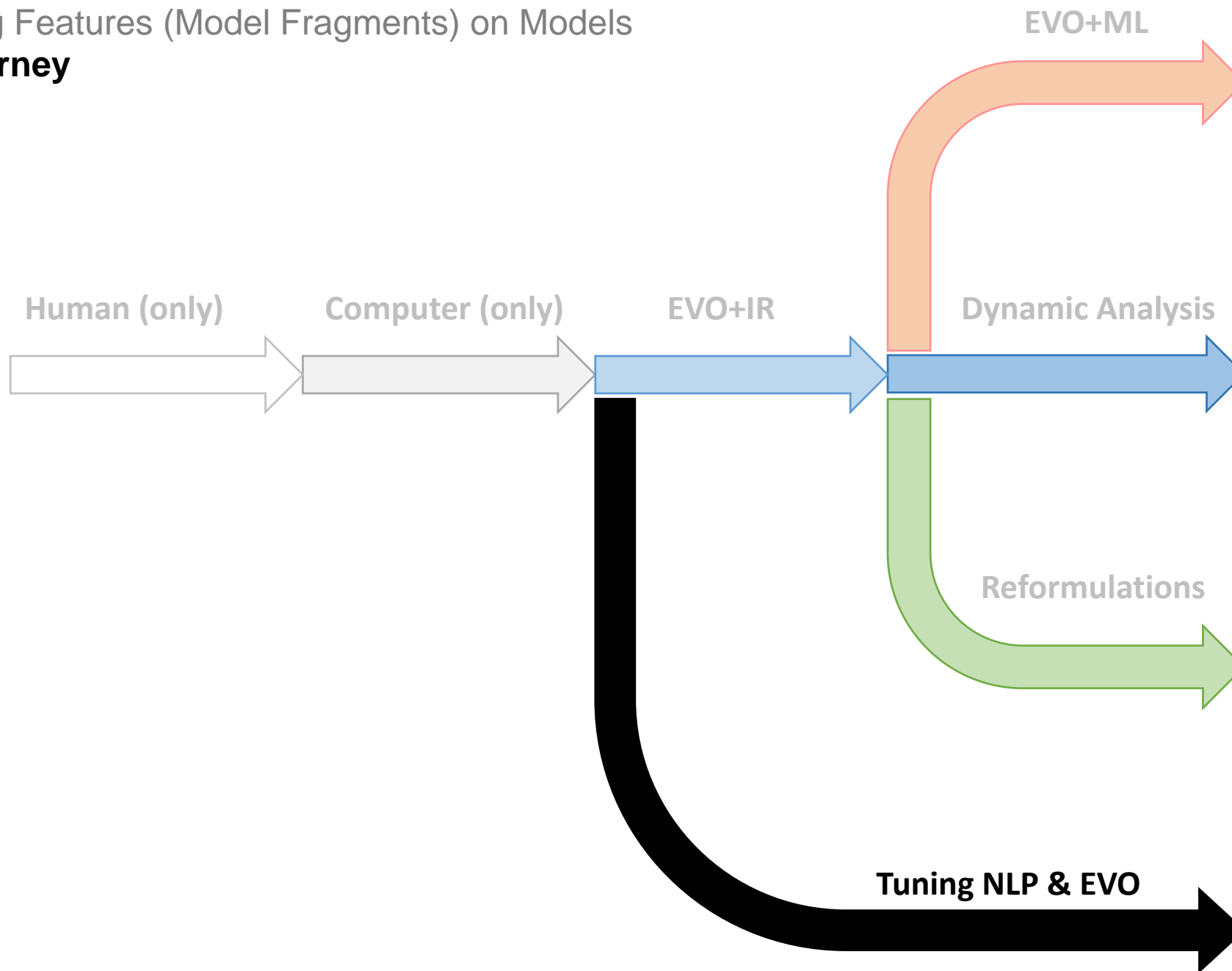
Reformulations

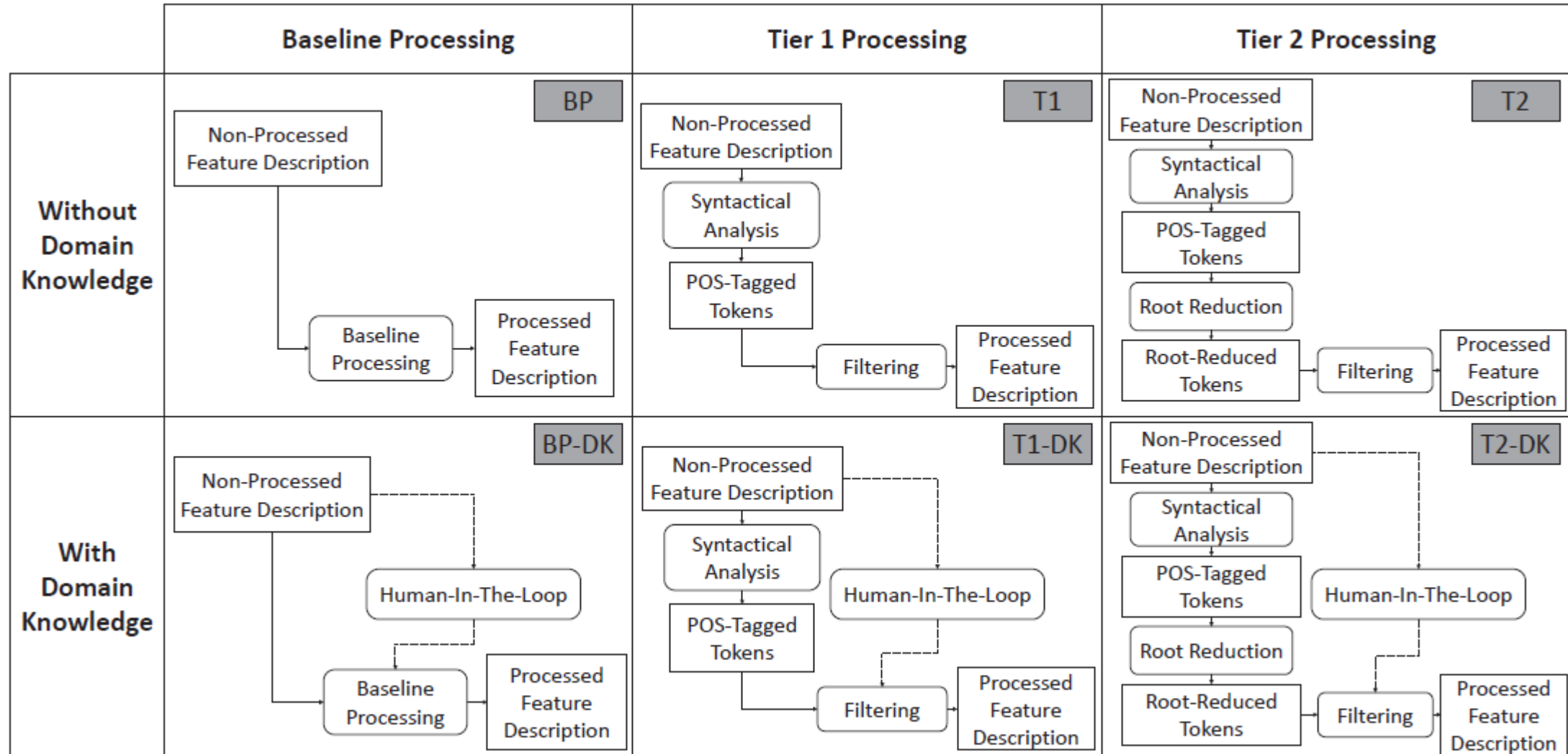


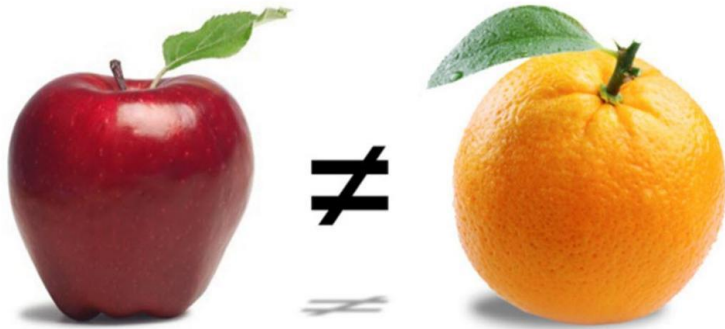
Author	Base query	Relevant documents	k Value	Industrial domain	Artifact
[Yang and Tan, 2012]	Developer	Source code	LoC	No	Code
[Rivas et al., 2014]	User	Biomedical articles	10	No	Text
[Hill et al., 2009]	Developer	Source code	LoC	No	Code
[Lu et al., 2015]	Developer	Internet site	20	No	Code
[Marcus et al., 2004]	User	Source code	5	No	Code
[Gay et al., 2009]	Developer	Source code	1, 3, and 5	No	Code
[Haiduc et al., 2013]	User	Source code	5	No	Code
[Dumitru et al., 2011]	User	Internet sites	25	No	Product specifications
[Tian et al., 2014]	User	Internet site	10,000	No	Text and code
[Dietrich et al., 2013]	Analyst	Requirement traces	-	No	Code and documents
[Lv et al., 2015]	User	Online documentation	10	No	Code
Our work	Domain expert	Domain experts	3	Yes	Models

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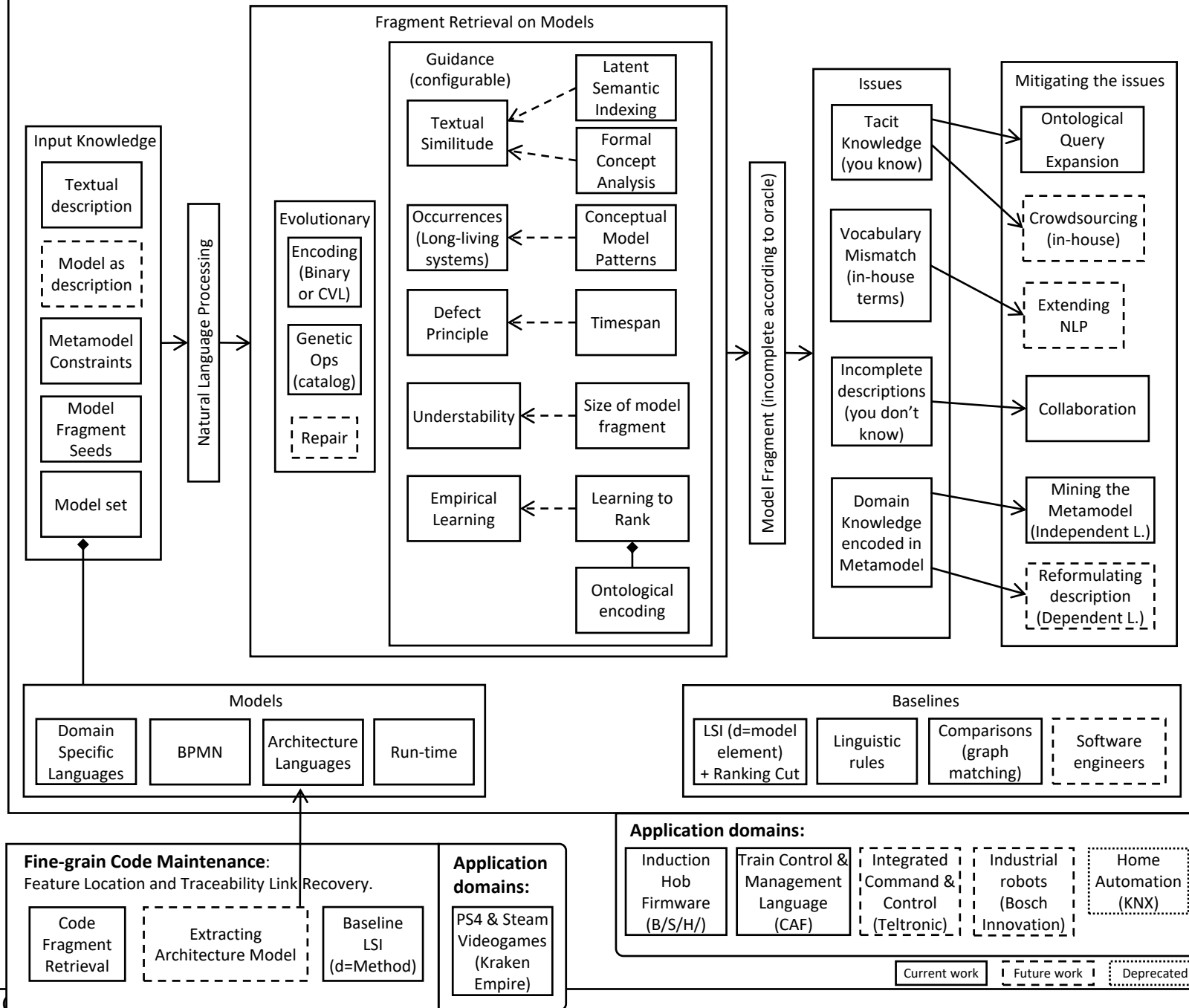
Ballarin, Manuel; Marcen, Ana; Pelechano, Vicente; Cetina, Carlos;
Measures to report the Location Problem of Model Fragment Location.
 MoDELS. 2019

Measurements for Model Search		Conceptual Representation	
		-	+
Search Space	Size: number of model elements in the model.		
	Volume: number of models.		

Legend	
Model	Model Fragment

Solution	Density: ratio of model fragment elements to model elements.		
	Multiplicity: number of times the solution appears in the search space.		
	Dispersion: ratio of connected elements in the solution.		

Model Maintenance Activities: Feature Location, Traceability Link Recovery (Requirement – Model Fragment) and Bug Location.



There is a lot of hard and exciting work to do. If you want to join us in this quest, just let me know.

Thanks!



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Daniel Blasco



Francisca Pérez



Jorge Echeverria



Ana Marcen



Mar zamorano



Manuel Ballarín



Raúl Lapeña



Øystein Haugen



Óscar Pastor

More info:

Font, Jaime; Arcega, Lorena; Haugen, Øystein; Cetina, Carlos; Achieving **Feature Location in Families of Models** through the use of Search-Based Software Engineering. IEEE Transactions on Evolutionary computation. 2018

Marcén, Ana Cristina; Pérez, Francisca; Cetina, Carlos; Ontological Evolutionary Encoding to Bridge **Machine Learning and Conceptual Models**: Approach and Industrial Evaluation. 36th International Conference on Conceptual Modeling. 2017

Pérez, Francisca; Marcén, Ana Cristina; Lapeña, Raúl; Cetina, Carlos; Introducing **Collaboration for Locating Features in Models**: Approach and Industrial Evaluation. 25th International Conference on Cooperative Information Systems. 2017