



ONE-WAY MODEL TRANSFORMATIONS

In the Context of Technology Roadmapping

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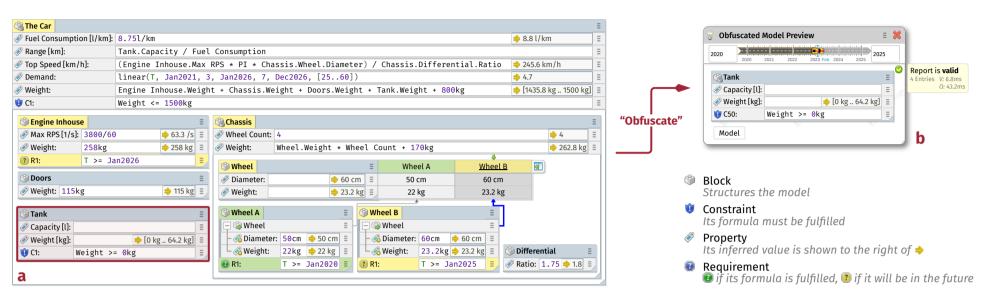


Figure 1: Obfuscation of the "Tank" block. Given a model (a), the user selects a set of model elements to obfuscate (marked with) and receives an interactive preview of the obfuscated model (b). This preview is continuously validated against the base model and allows to export the model for further use (i.e., communication with an industry partner).

⇒ false 🗉

🔶 8

뉮 2

🔶 fals

Why?

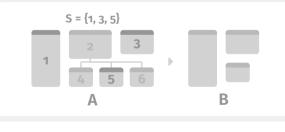
A lot of innovations require multiple parties to **exchange information**. However, with technology roadmapping, there are several reasons against sharing a complete model (e.g., the protection of **intellectual property**).

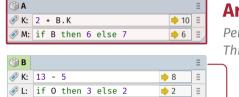
Currently, standalone models to be shared with others are produced manually. Hence, we propose an automated process to produce these models by removing or obfuscating unselected parts.

What?

Given a model **A** and a selection of its elements **S**, we want to produce a model **B**, that satisfies these constraints:

- 1. **B** has to be self-contained
- 2. B has all $e \in S$, but none from A\S
- 3. **B** allows no inference on any $e \in A \setminus S$
- 4. All $e \in \boldsymbol{S}$ have the same results in \boldsymbol{A} and \boldsymbol{B}





🛷 O: 🛛 false

а

🏐 B

a

а

🔗 K: 13 - 5

🛷 O: false

✓ L: if O then 3 else 2

W: T - months(2) >= Jan2020

Arithmetic Simplification

Perform constant folding for unselected calculations. This evaluates 13 - 5 (property "K" in **a**) to 8 (property B_K in **b**).

	🏐 Collee	ctor		Ξ	🏐 A	≣			
	🧼 A2:	B_W(T)	⇒ true	Ξ	√ K: 2 + Collector.B_K ⇒ 10	Ξ			
•	🧼 B2:	-1	⇒ -1	Ξ	♂ M: if Collector.A2 then 6 els ⇒ 6	E			
	🛷 В_К:	8	⇒ 8	Ξ					
	😲 C8:	$(B_L(T) + (if B_0(T) th)$			Because we limit ourselves to "arithmetic simplification" in this example, the speci				
	🧼 B_L:		 2	Ξ	"Collector" block holds a lot of unchanged				
	🛷 в_о:	false	⇒ false	Ξ	elements.				
	🧼 B_W:	T >= Mar2020	⇒ true	Ξ	b				

🟐 A

Ξ

🏐 A		Ξ
🧼 K:	2 + B.K	⇒ 10 目
🧼 M:	if B then 6 else 7	⇒6 ≣

Inline Definitions

Perform impact-preserving constant propagation. This inlines "O" (which is false in **a**) in "L" (see **b**).

	-		🛞 Collee						
_	Ξ					~	B W & true		true
	Ξ			· ·	-	-	true		
e	Ξ			🧼 B2:		\$	-1		
	=	U	-	🛷 В_К:	13 - 5	\$	8		
	_/			🧼 B_L:	if false then 3 e	•	2		
				🧼 B_O:	false	\$	false		
					(T - months(2)) >	>	true		

🧼 K:	2 +	- Co	llecto	r.B	_K			뉮 10	Ξ
🧼 M:	if	Col	lector	•.A2	then	6	els	🔶 6	
			we can					/	
Con	stro	ints.	Furthe	ermo	re, we	т	ust h	andle	2
all i	upd	ates	of sele	cted	expres	ssi	ons.		

<u></u>		-
🧼 K:	2 + B.L	⇒ 5 ≣
🧼 M:	if B then 6 else 7	븢 6 🗄
_		

Tailor Expressions

Remove unselected time information. Replaces the interpolation of "0" (in **a**) with 5 (property B_0 in **b**).

b

٦	🚳 Collector	≡	🏐 A			
		⇒ true 🗉	√ K: 2 + Collector.B_L	⇒ 5 ≡		

How?

We devised a set of **16 transformations** and analyzed them according to 9 properties (scope, ...), as well as all four constraints (see "What?" above).

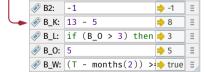
Furthermore, we've implemented a subset within the technology roadmapping tool **IRIS**, which is capable of modeling time, uncertainty, and more with its Excel-like syntax (cf. Figure 1).



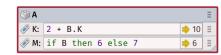
 If 0 > 3 then 3 else 2
 3 =

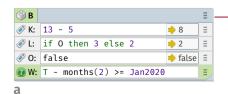
 Inear(T, Jan1990,2, Oct199 + 5 =

 W: T - months(2) >= Jan2020



IRIS uses T to represent the currently selected point in time. For this example, we assume, that the range of T is restricted tostart with the year 2020 (or later).



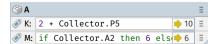


Identifier Obfuscation

Scramble unselected identifiers.

This changes the name of all unselected elements.

	🏐 Coll	ector		≣
	🧼 A2:	R3 & true 🗧	> true	Ξ
	🧼 B2:	-1	-1	Ξ
•	🫷 P5:	13 - 5	8	Ξ
	🫷 P6:	if P7 then 3 else 🛓	2	Ξ
	🦪 P7:	false 🕴	🕨 false	Ξ
	🦪 R3:	(T - months(2)) >=) true	Ξ



To keep the examples consistent, we selected a simple renaming which "counts" the number of obfuscated statements. In production, we use random identifiers.

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Screenshots contain some icons by Yusuke Kamiyamane (https://p.yusukekamiyamane.com/, 🎯) and FatCow (https://www.fatcow.com, 🎯)).