How to determine the success of Smart Products?
A Machine Learning Approach

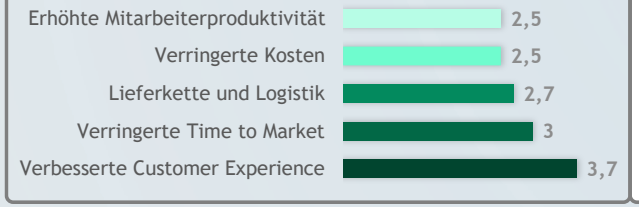
Louis Püschel

WAS IST EIN SMARTES PRODUKT?

"The Internet of Things (IoT) refers to the connectivity of physical objects, equipped with sensors and actuators, to the Internet via data communication technology, enabling interaction with and/or among these objects."

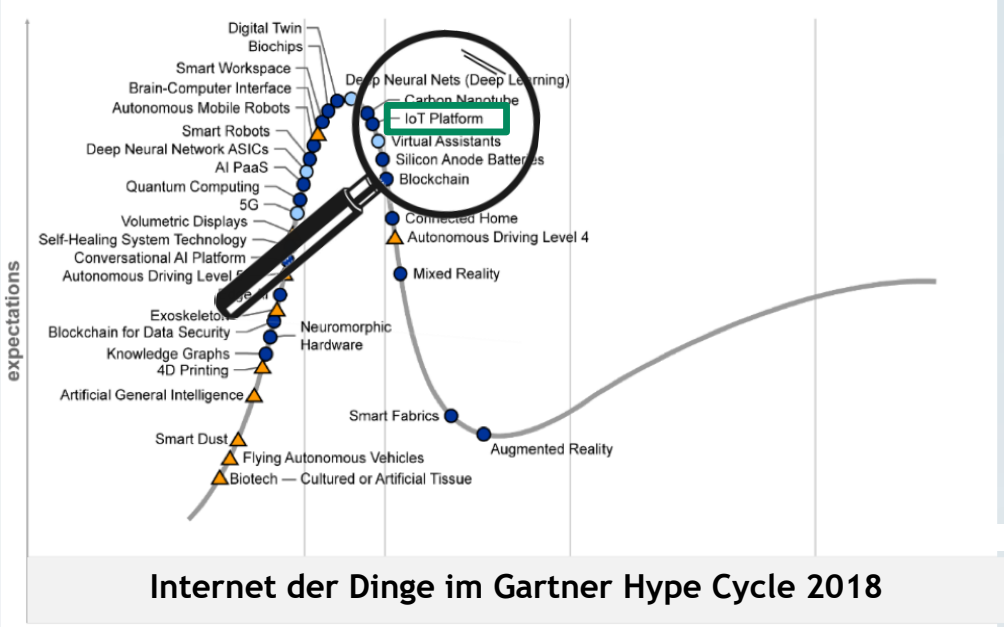
MOTIVATION

Internet der Dinge:
Wertschöpfung bis 2022 $14,4 Billionen



Anzahl verbundener Geräte

2015	2025
ca. 15,4 Milliarden	ca. 75,4 Milliarden



Internet der Dinge im Gartner Hype Cycle 2018

Smart City *Exemplarisch*

Husqvarna, Google, BOSCH, amazon.com

Health, Well-Being *Exemplarisch*

PHILIPS, CliniCloud, fitbit, GARMIN, SIEMENS, Microsoft

Industrial *Exemplarisch*

ROLLS ROYCE, CATERPILLAR, HILTI, BOSCH, AIRBUS

PROJEKT-FRAGE?

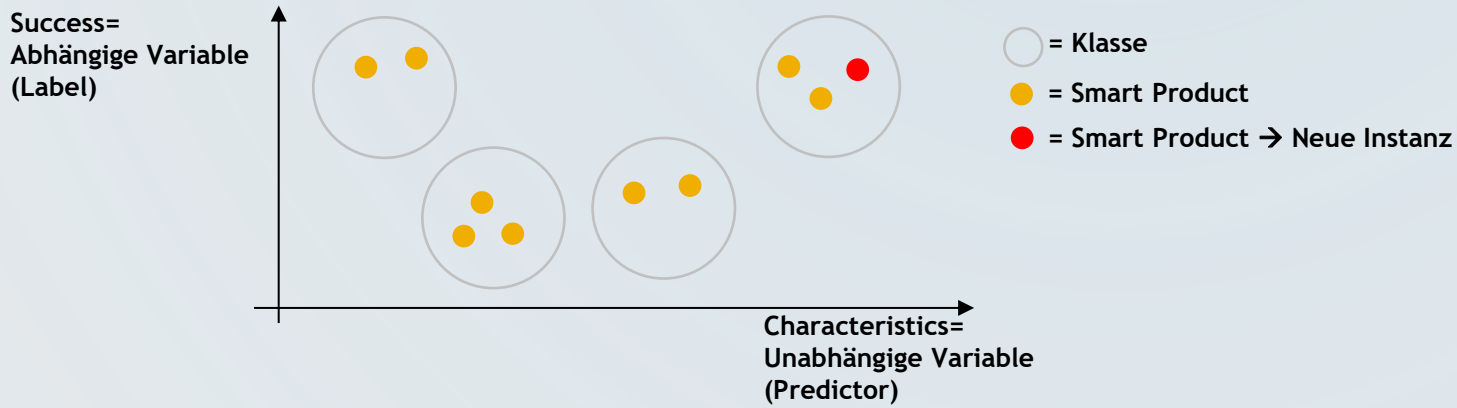
Welche Smarten Produkte sind besonders erfolgreich?

Um welches Produkt-Typen handelt es sich?

Wie kann Unternehmen eine Entscheidungshilfe an die Hand gegeben werden?

✓ Prognose des Erfolgs mit Hilfe von Machine Learning

PROGNOSE MITTELS SUPPORT VECTOR MACHINE



Erklärung / These

- SVM **trainiert aufgrund** von **Characteristics** und **Markterfolg** (Success) der Smarten Produkte
- **Je nach** dem welche **Characteristics** das Smarte Produkte hat, wird es einen **bestimmten Erfolg** haben
- **Erfolg** ergibt sich aus **Google-Suchanfragen**
- **Anwendung** SVM auf gänzlich **neues Objekt/Instanz**

WAS BRAUCHEN WIR DAZU? DIE VORARBEITEN!

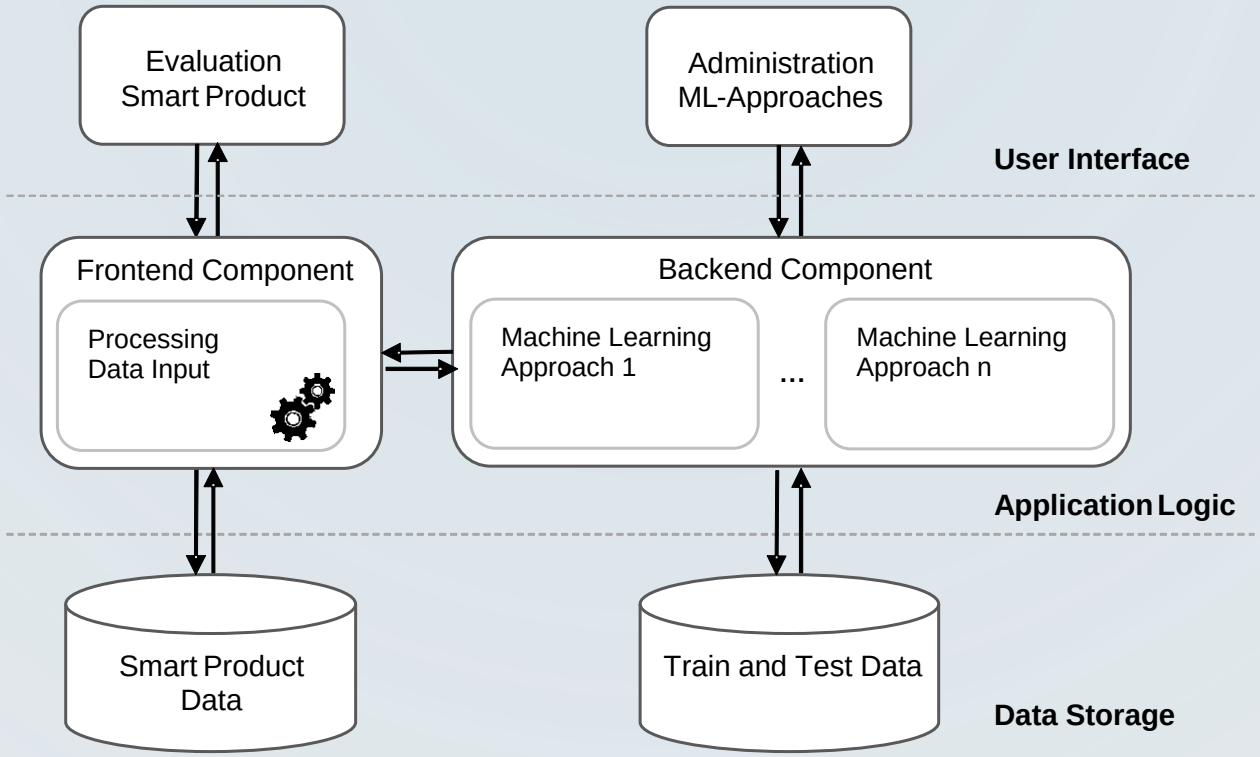
Taxonomie
Allgemeingültige Beschreibung Smarter Produkt

Datensatz
Ca. 200 klassifizierte Smarte Produkte, deren Erfolgskennzahlen und Typ-Zuordnung

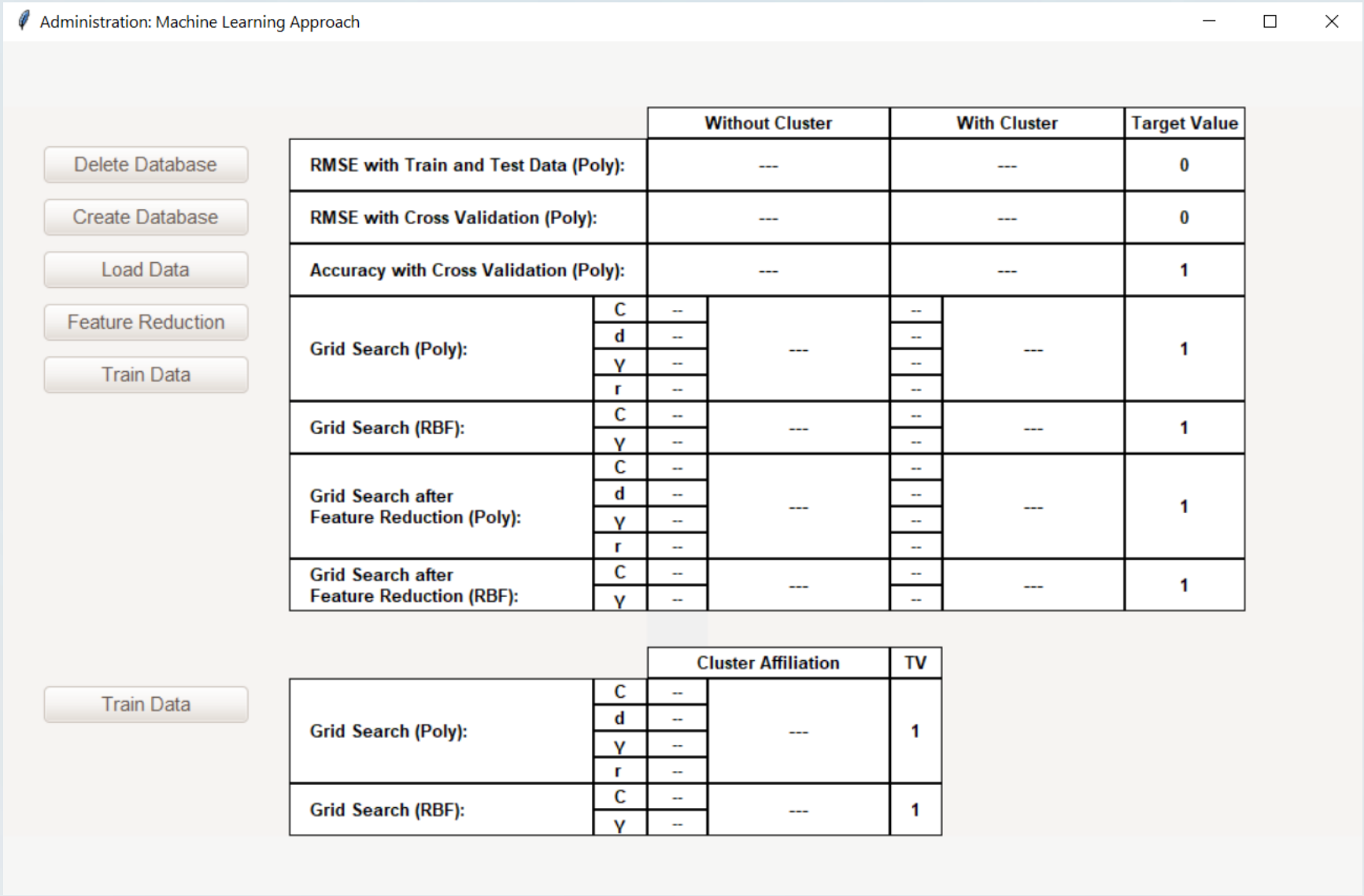
	Dimension	Characteristics			
Service	Ecosystem Integration	None	Proprietary	Open	
	Value Proposition	Thing-centric		Service-centric	
	Offline Functionality	None		Limited	
Data	Data Usage	Transactional	Analytical (basic)	Analytical (extended)	
	Data Source	Thing State	Thing Context	Thing Usage	Cloud
Interaction	Interaction Partner	User(s)	Business(es)	Thing(s)	
	Interaction Multiplicity	One-to-one		One-to-many	
	Interaction Direction	Unidirectional		Bi-directional	
Thing	Autonomy	None	Self-Controlled	Self-Learning	
	Acting Capabilities	Own		Intermediary	
	Sensing Capabilities	Lean		Rich	

	A	B	C	D	E	F	G	H
1	sensing	acting_own	acting_inter	autonomy	direction	multiplicity	partner_use	partner_t
2	0.00	0.50	0.50	0.50	0.00	1.00	0.33	0.00
3	0.00	0.00	0.50	0.00	0.00	0.00	0.33	0.00
4	0.00	0.00	0.50	0.00	0.00	1.00	0.33	0.33
5	0.00	0.50	0.00	0.00	0.00	1.00	0.33	0.00
6	1.00	0.50	0.50	0.50	1.00	0.00	0.33	0.00
7	0.00	0.50	0.50	1.00	1.00	1.00	0.33	0.00
8	0.00	0.50	0.50	0.00	0.00	0.00	0.33	0.00
9	1.00	0.50	0.50	0.00	1.00	0.00	0.33	0.00
10	1.00	0.50	0.50	0.00	1.00	1.00	0.33	0.00
11	0.00	0.00	0.50	0.50	1.00	1.00	0.33	0.00
12	0.00	0.50	0.50	0.50	0.00	1.00	0.33	0.00
13	1.00	0.00	0.50	0.50	0.00	1.00	0.33	0.00
14	1.00	0.50	0.50	0.50	0.00	0.00	0.33	0.00
15	0.00	0.00	0.50	0.00	0.00	0.00	0.33	0.00
16	0.00	0.00	0.50	0.00	0.00	0.00	0.33	0.00
17	0.00	0.50	0.50	0.00	1.00	1.00	0.33	0.00
18	0.00	0.50	0.50	0.50	0.00	1.00	0.33	0.00
19	0.00	0.50	0.50	0.00	1.00	1.00	0.33	0.00
20	0.00	0.00	0.50	1.00	1.00	0.00	0.33	0.00
21	1.00	0.00	0.50	0.00	0.00	1.00	0.33	0.00
22	1.00	0.00	0.50	0.00	0.00	0.00	0.33	0.00

UMSETZUNG: DREISCHICHTEN ARCHITEKTUR



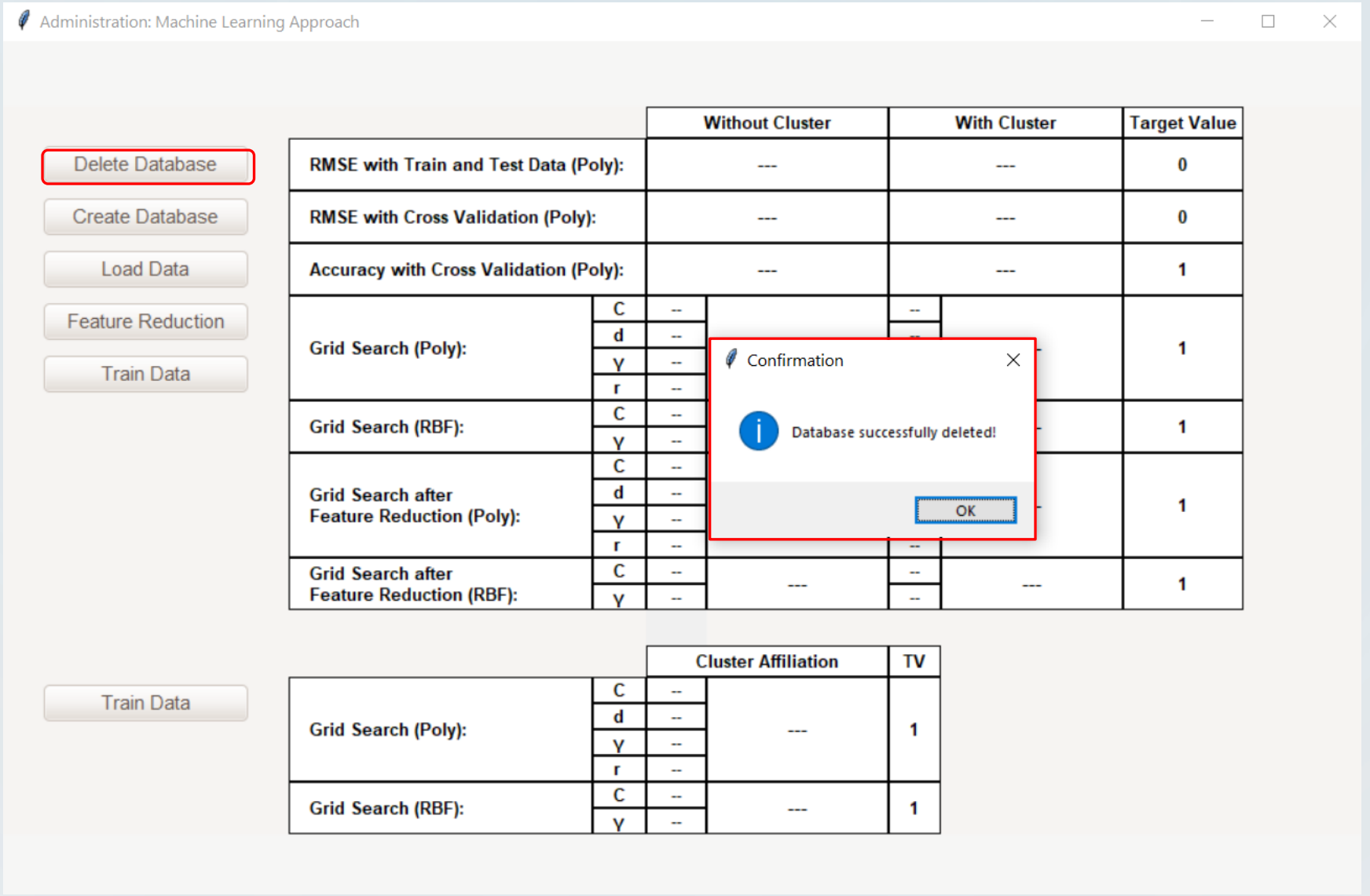
UMSETZUNG: BACKEND USER INTERFACE



		Without Cluster		With Cluster		Target Value
RMSE with Train and Test Data (Poly):		---		---		0
RMSE with Cross Validation (Poly):		---		---		0
Accuracy with Cross Validation (Poly):		---		---		1
Grid Search (Poly):	C	--	---	--	---	1
	d	--		--		
	Y	--		--		
	r	--		--		
Grid Search (RBF):	C	--	---	--	---	1
	Y	--		--		
Grid Search after Feature Reduction (Poly):	C	--	---	--	---	1
	d	--		--		
	Y	--		--		
	r	--		--		
Grid Search after Feature Reduction (RBF):	C	--	---	--	---	1
	Y	--		--		

		Cluster Affiliation		TV
Grid Search (Poly):	C	--	---	1
	d	--		
	Y	--		
	r	--		
Grid Search (RBF):	C	--	---	1
	Y	--		

UMSETZUNG: BACKEND USER INTERFACE



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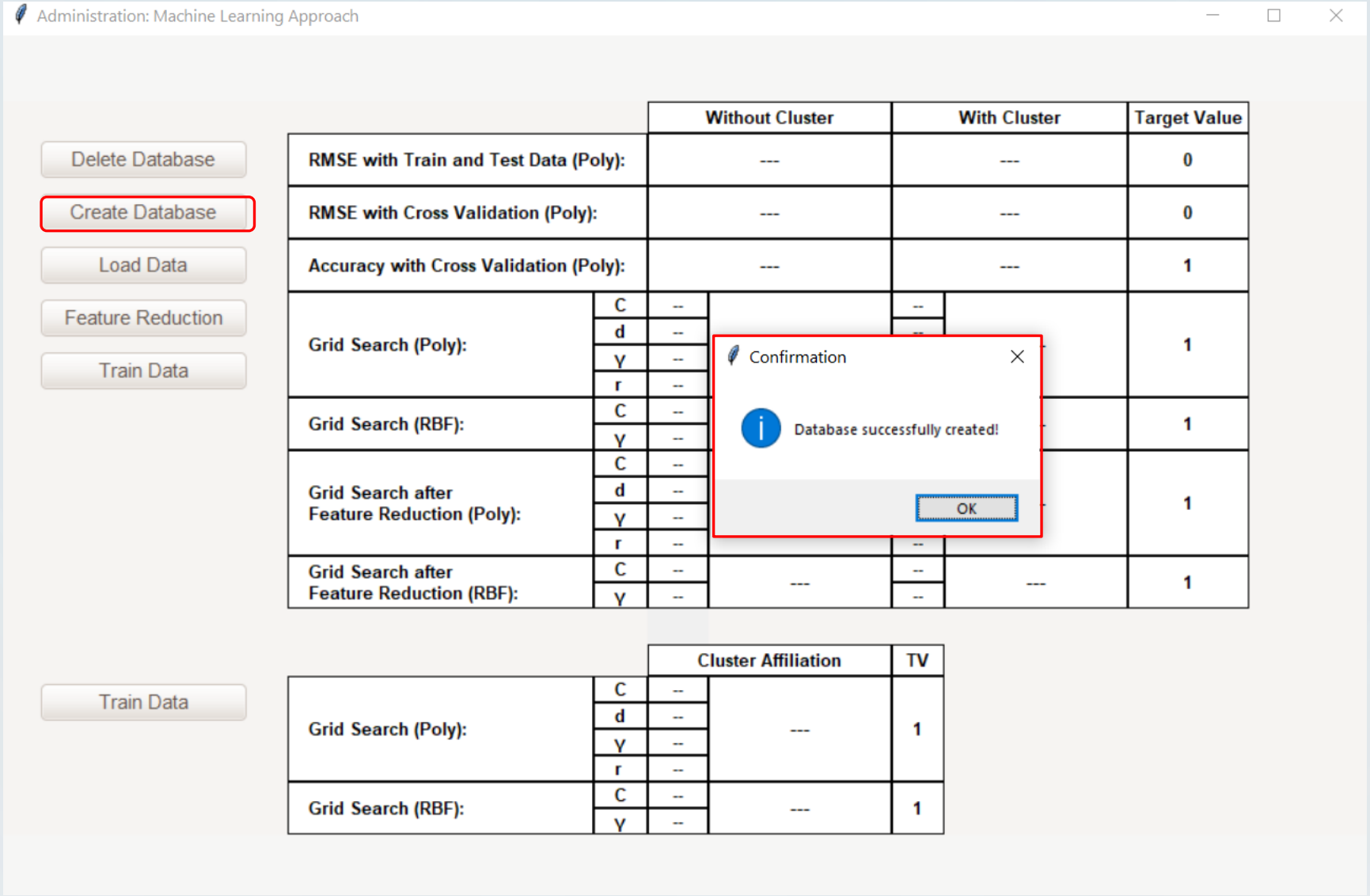

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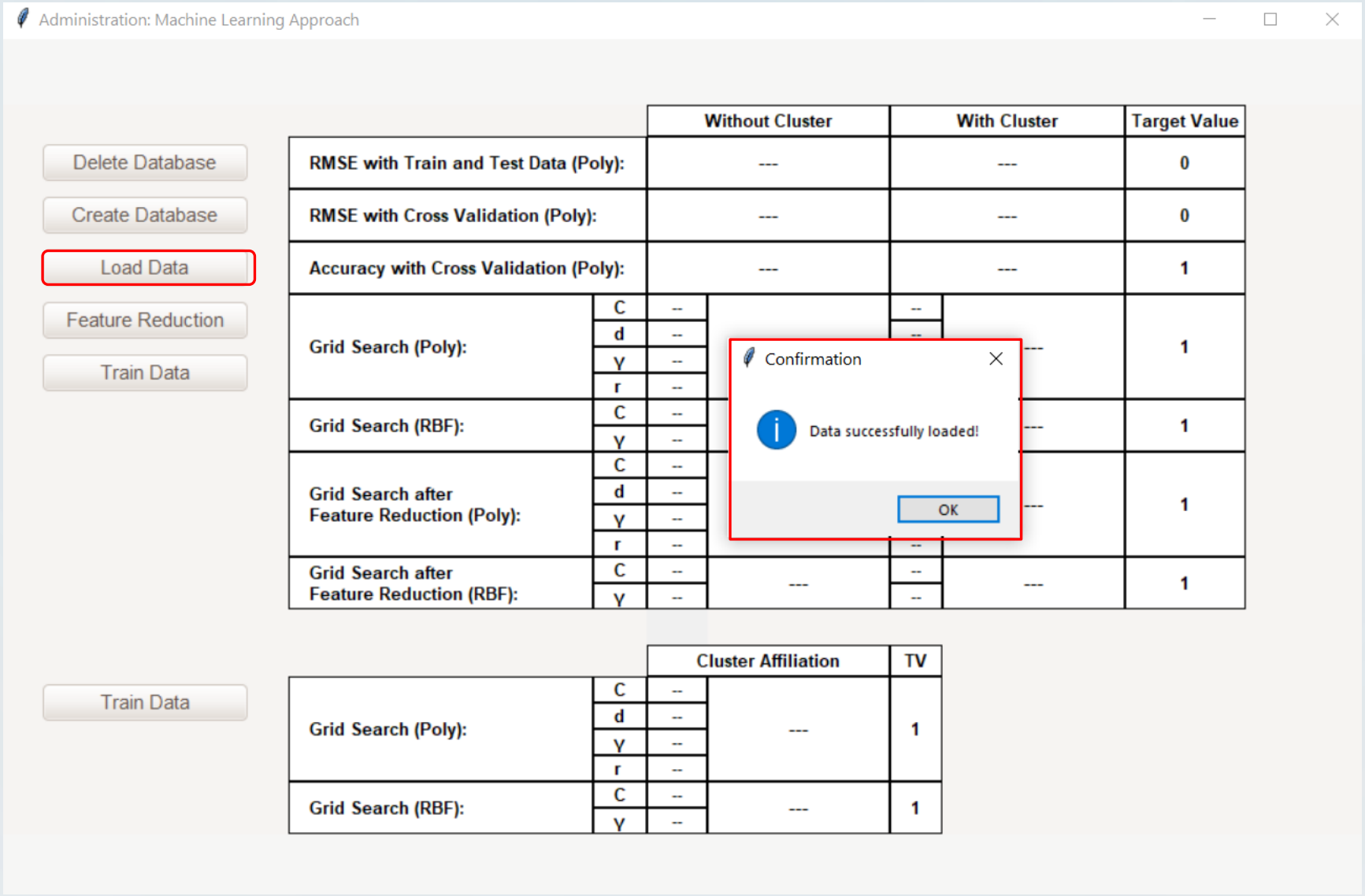

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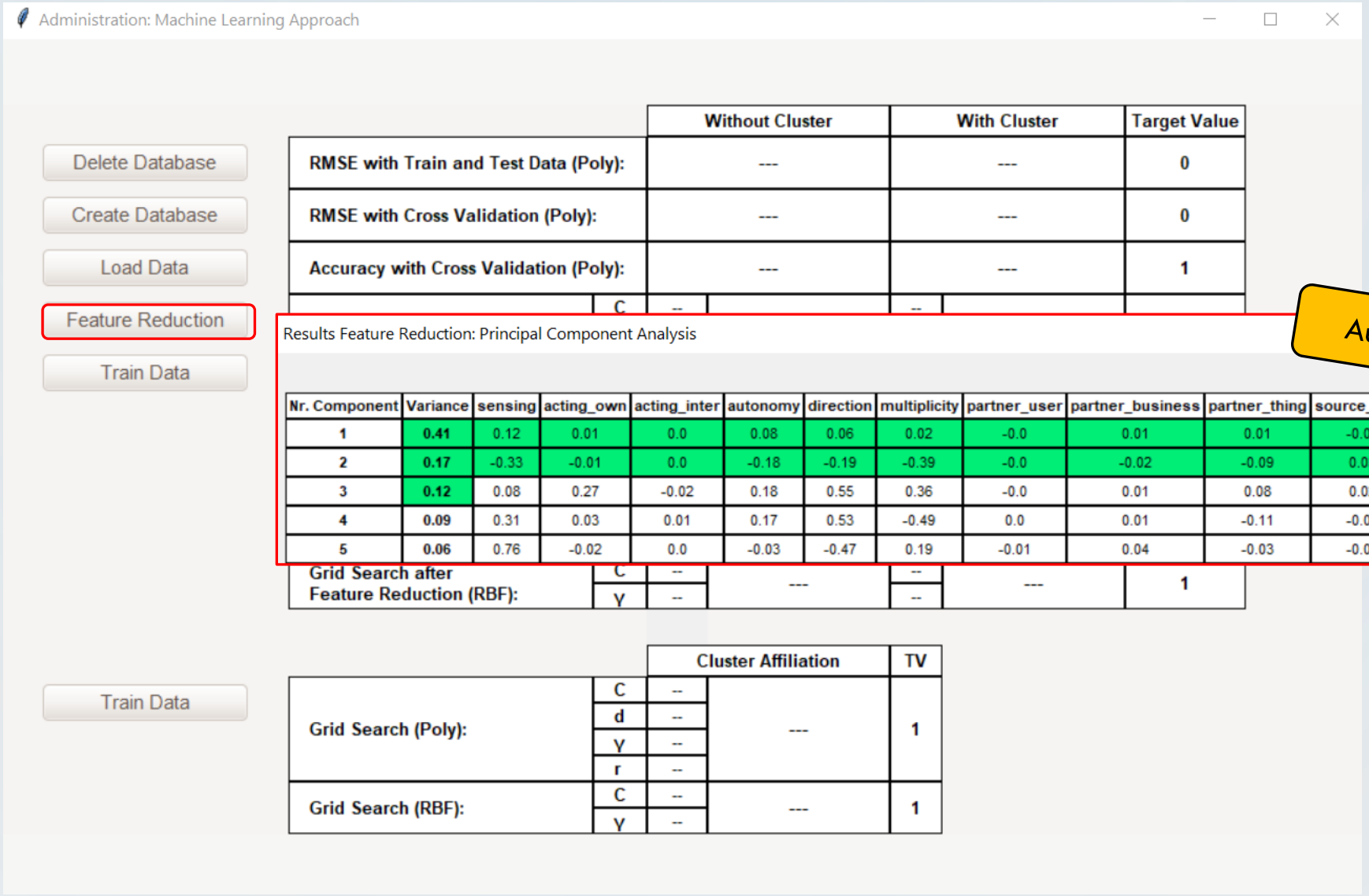
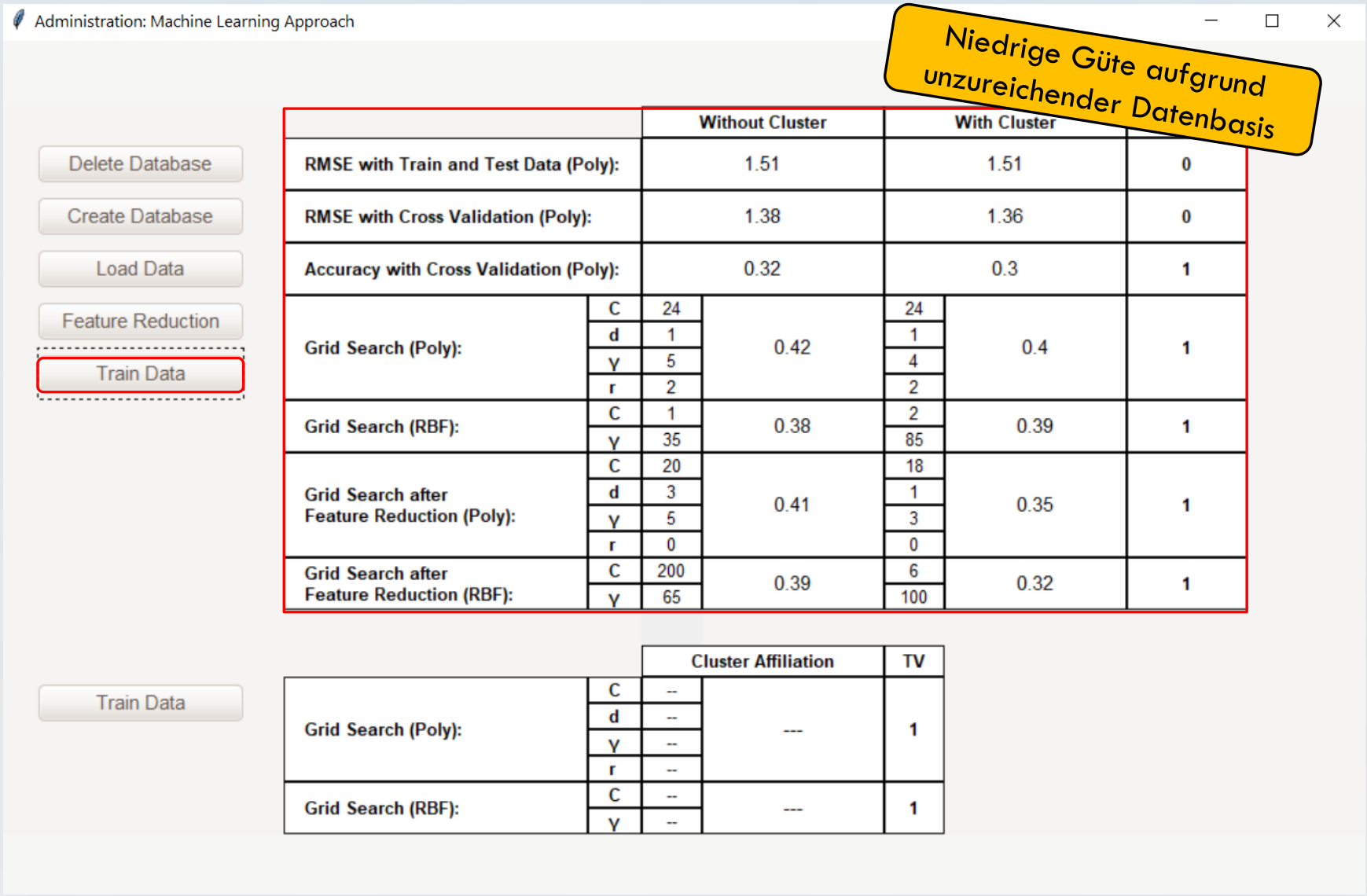


		Without Cluster		With Cluster		Target Value
RMSE with Train and Test Data (Poly):		---		---		0
RMSE with Cross Validation (Poly):		---		---		0
Accuracy with Cross Validation (Poly):		---		---		1
	C	--		--		
Grid Search after Feature Reduction (RBF):	C	--	---	--	---	1
	Y	--		--		

Nr. Component	Variance	sensing	acting_own	acting_inter	autonomy	direction	multiplicity	partner_user	partner_business	partner_thing	source_state	so
1	0.41	0.12	0.01	0.0	0.08	0.06	0.02	-0.0	0.01	0.01	-0.01	
2	0.17	-0.33	-0.01	0.0	-0.18	-0.19	-0.39	-0.0	-0.02	-0.09	0.03	
3	0.12	0.08	0.27	-0.02	0.18	0.55	0.36	-0.0	0.01	0.08	0.02	
4	0.09	0.31	0.03	0.01	0.17	0.53	-0.49	0.0	0.01	-0.11	-0.04	
5	0.06	0.76	-0.02	0.0	-0.03	-0.47	0.19	-0.01	0.04	-0.03	-0.01	

		Cluster Affiliation		TV
Grid Search (Poly):	C	--	---	1
	d	--		
	Y	--		
	r	--		
Grid Search (RBF):	C	--	---	1
	Y	--		

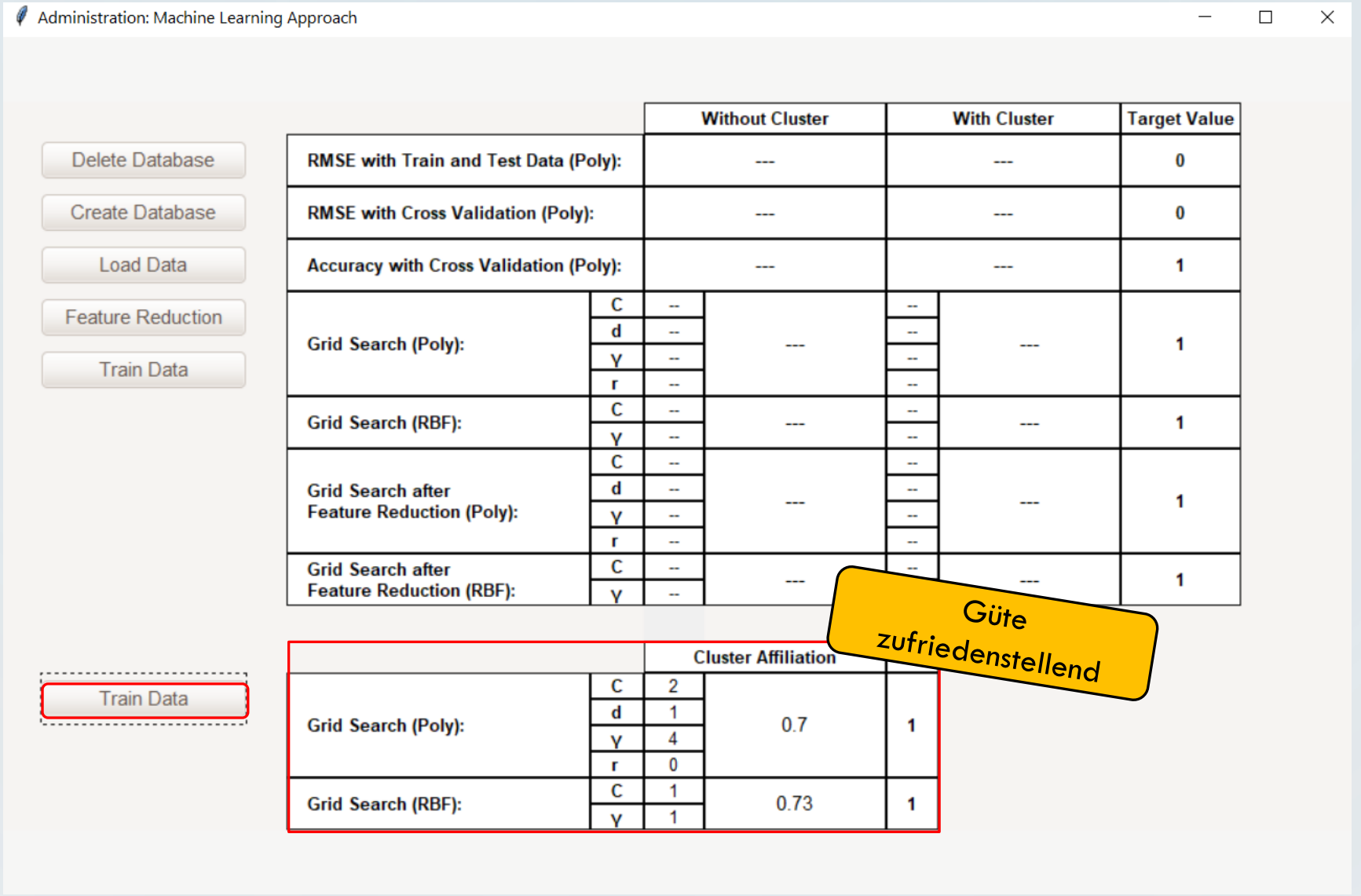
UMSETZUNG: BACKEND USER INTERFACE



		Without Cluster		With Cluster		
RMSE with Train and Test Data (Poly):		1.51		1.51		0
RMSE with Cross Validation (Poly):		1.38		1.36		0
Accuracy with Cross Validation (Poly):		0.32		0.3		1
Grid Search (Poly):	C	24	0.42	24	0.4	1
	d	1		1		
	γ	5		4		
	r	2		2		
Grid Search (RBF):	C	1	0.38	2	0.39	1
	γ	35		85		
Grid Search after Feature Reduction (Poly):	C	20	0.41	18	0.35	1
	d	3		1		
	γ	5		3		
	r	0		0		
Grid Search after Feature Reduction (RBF):	C	200	0.39	6	0.32	1
	γ	65		100		

		Cluster Affiliation		TV
Grid Search (Poly):	C	--	---	1
	d	--		
	γ	--		
	r	--		
Grid Search (RBF):	C	--	---	1
	γ	--		

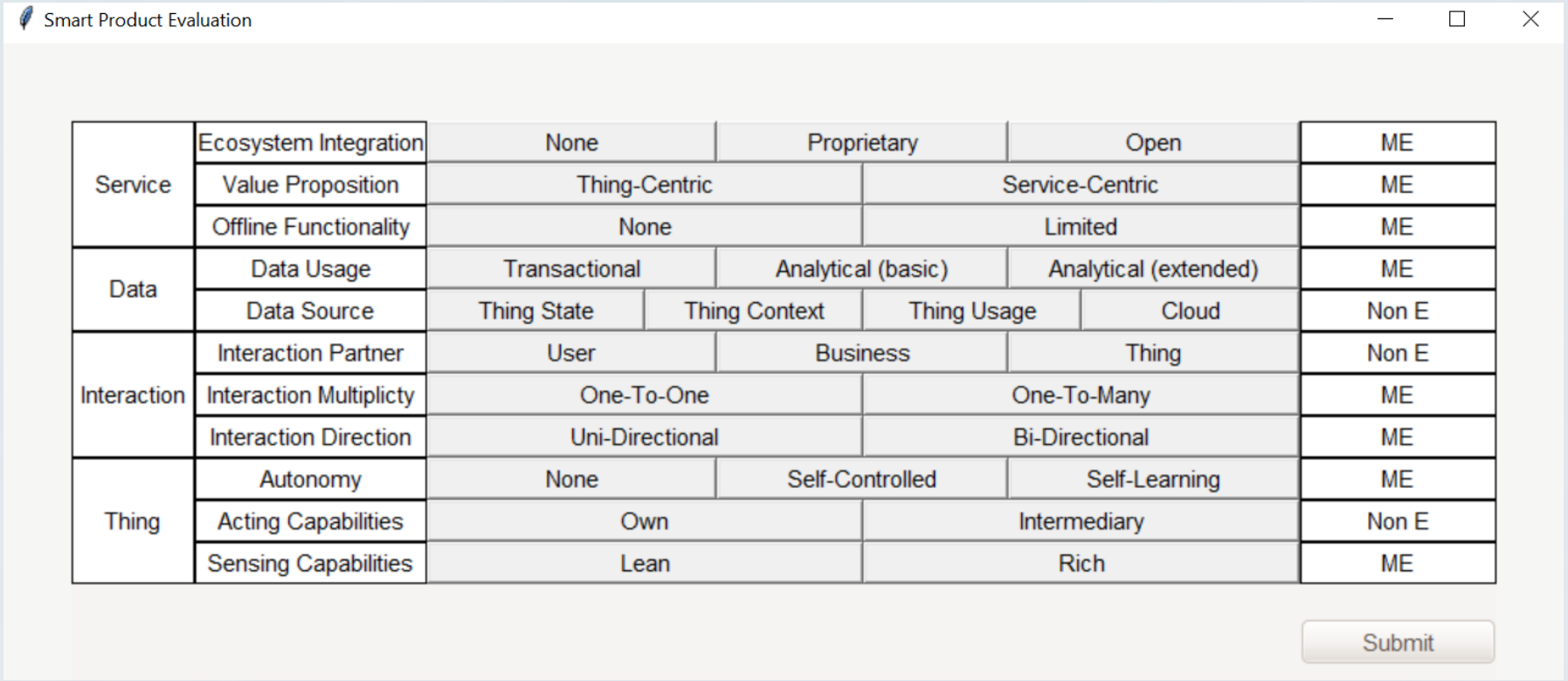
UMSETZUNG: BACKEND USER INTERFACE



		Without Cluster		With Cluster		Target Value
RMSE with Train and Test Data (Poly):		---		---		0
RMSE with Cross Validation (Poly):		---		---		0
Accuracy with Cross Validation (Poly):		---		---		1
Grid Search (Poly):	C	--	---	--	---	1
	d	--		--		
	γ	--		--		
	r	--		--		
Grid Search (RBF):	C	--	---	--	---	1
	γ	--		--		
Grid Search after Feature Reduction (Poly):	C	--	---	--	---	1
	d	--		--		
	γ	--		--		
	r	--		--		
Grid Search after Feature Reduction (RBF):	C	--	---	--	---	1
	γ	--				

		Cluster Affiliation		
Grid Search (Poly):	C	2	0.7	1
	d	1		
	γ	4		
	r	0		
Grid Search (RBF):	C	1	0.73	1
	γ	1		

UMSETZUNG: FRONTEND USER INTERFACE



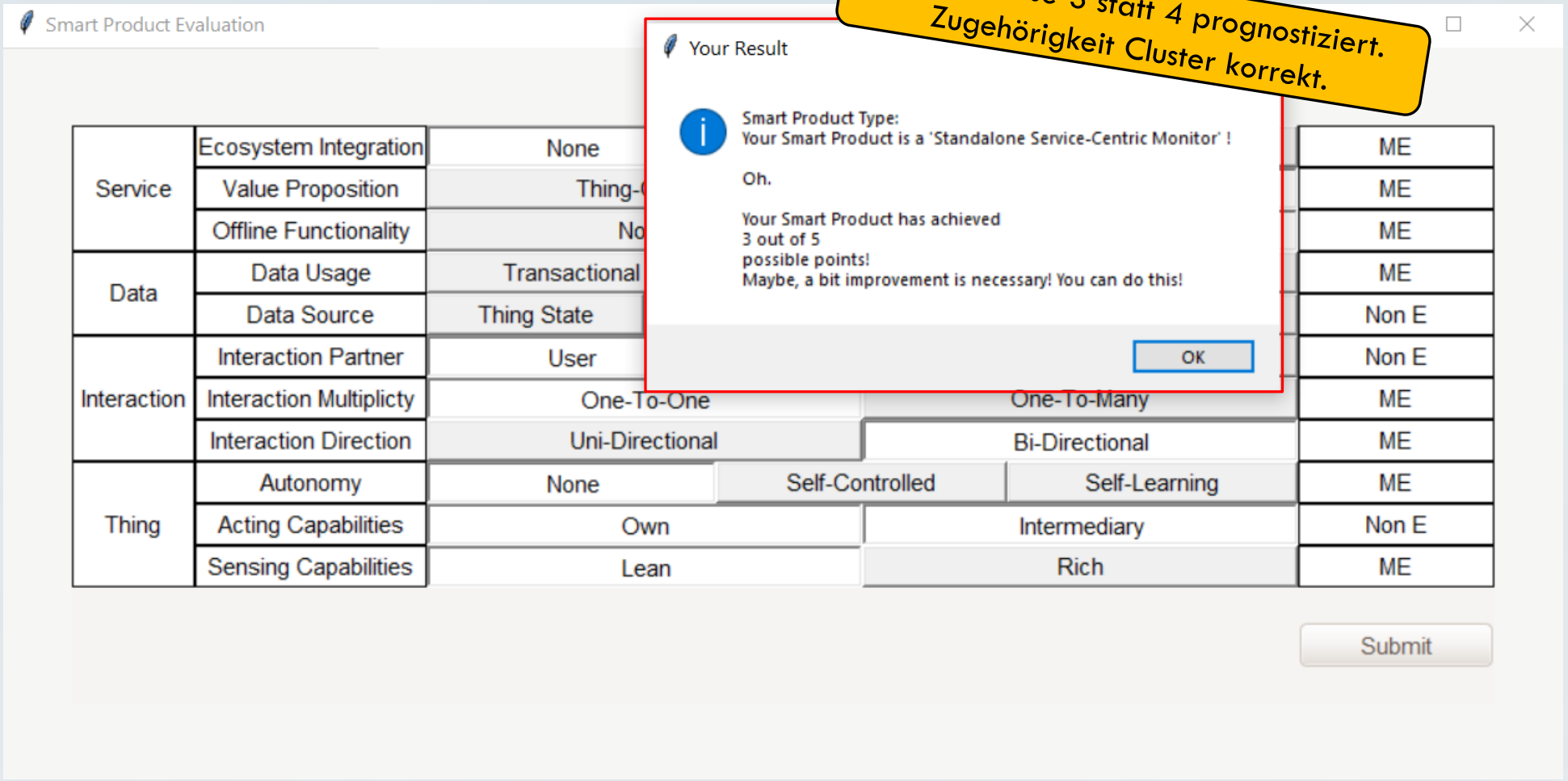
SHOW CASE AM BEISPIEL „FITBIT“

	Dimension	Characteristics			
Service	**Ecosystem Integration**	None	Proprietary	Open	
	Value Proposition	Thing-centric		Service-centric	
	Offline Functionality	None		Limited	
Data	**Data Usage**	Transactional	Analytical (basic)	Analytical (extended)	
	Data Source	Thing State	Thing Context	Thing Usage	Cloud
Interaction	**Interaction Partner**	User(s)	Business(es)	Thing(s)	
	Interaction Multiplicity	One-to-one		One-to-many	
	Interaction Direction	Unidirectional		Bi-directional	
Thing	**Autonomy**	None	Self-Controlled	Self-Learning	
	Acting Capabilities	Own		Intermediary	
	Sensing Capabilities	Lean		Rich	

Erfolg: Klassen 1 bis 5. Geräte **in Klasse 5 am erfolgreichsten**.
Fitbit in **Klasse 4**, war **nicht Bestandteil** des **Trainingsdatensatzes**.

UMSETZUNG: FRONTEND USER INTERFACE

Erfolgsklasse 3 statt 4 prognostiziert.
Zugehörigkeit Cluster korrekt.



FAZIT

Learnings

- **Verbesserung Gütemaße** für den Erfolg von Smart Things **notwendig**
- **Mögliche Gründe** für unzureichende Ergebnisse:
  - **Zu viele Features** (d.h. Charakteristika)
  - **Erweiterung des Datensatzes** um weitere Smart Things, um repräsentative Stichprobe zu erreichen
  - **Geräte mit ähnlichen Eigenschaften sind unterschiedlich erfolgreich**

- **Gütemaße für** die **Cluster-Zuordnung** erzielen **gute Ergebnisse**. Somit ist eine Zuordnung aufgrund von Nutzereingaben möglich

- Evaluierung im **Vergleich mit anderen Verfahren** (z.B. Neuronale Netze)

ÜBERSICHT DATEIEN DIE IM PROJEKT ENTSTANDEN SIND