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Normalized Information Systems:

Toward Continuous Rejuvenation of Software Applications

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University of Antwerp

Universiteit Antwerpen

Contents

- Normalized Systems Key Insights
- Software Dimensions of Evolvability
- Rejuvenating Software Applications
- Discussion and Conclusion
- Questions

KEY INSIGHTS OF NST

Key Insight 1: On Coupling

"expect families of routines to be constructed on *rational principles* so that families fit together as **building blocks"**

from: Doug McIlroy, *Mass Produced Software Components*,
1968 NATO Conference on Software Engineering, Garmisch, Germany.

Key Insight 1: On Coupling

The Law of Increasing Complexity
Manny Lehman

"As an evolving program is continually changed, its complexity, reflecting deteriorating structure, increases unless work is done to maintain or reduce it."

Proceedings of the IEEE, vol. 68, nr. 9, september 1980, pp. 1068.

Key Insight 1:
Deplete Combinatorial Effects

Systems Theoretic Stability

Core concept:

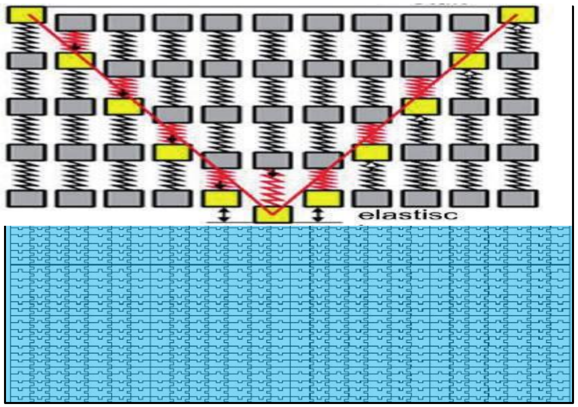
Coupling/Ripple Effects/

Combinatorial Effects

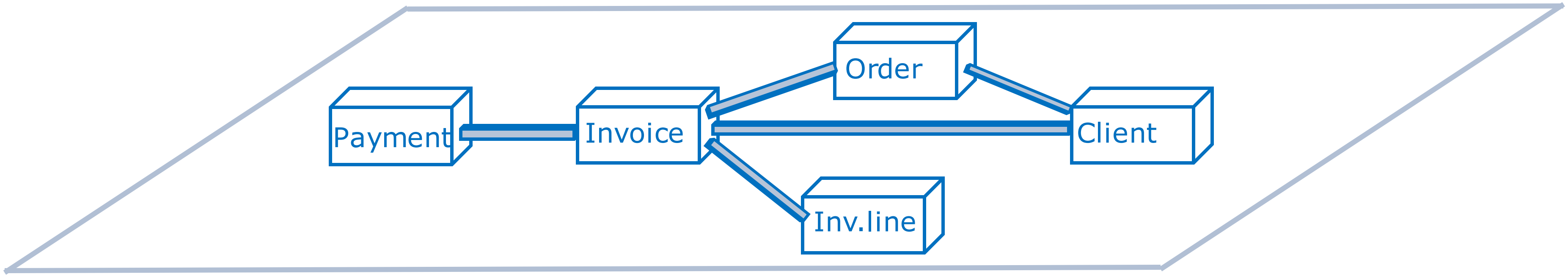
NS Principles

- Separation of concerns
- Data version transparency
- Action version transparency
- Separation of state

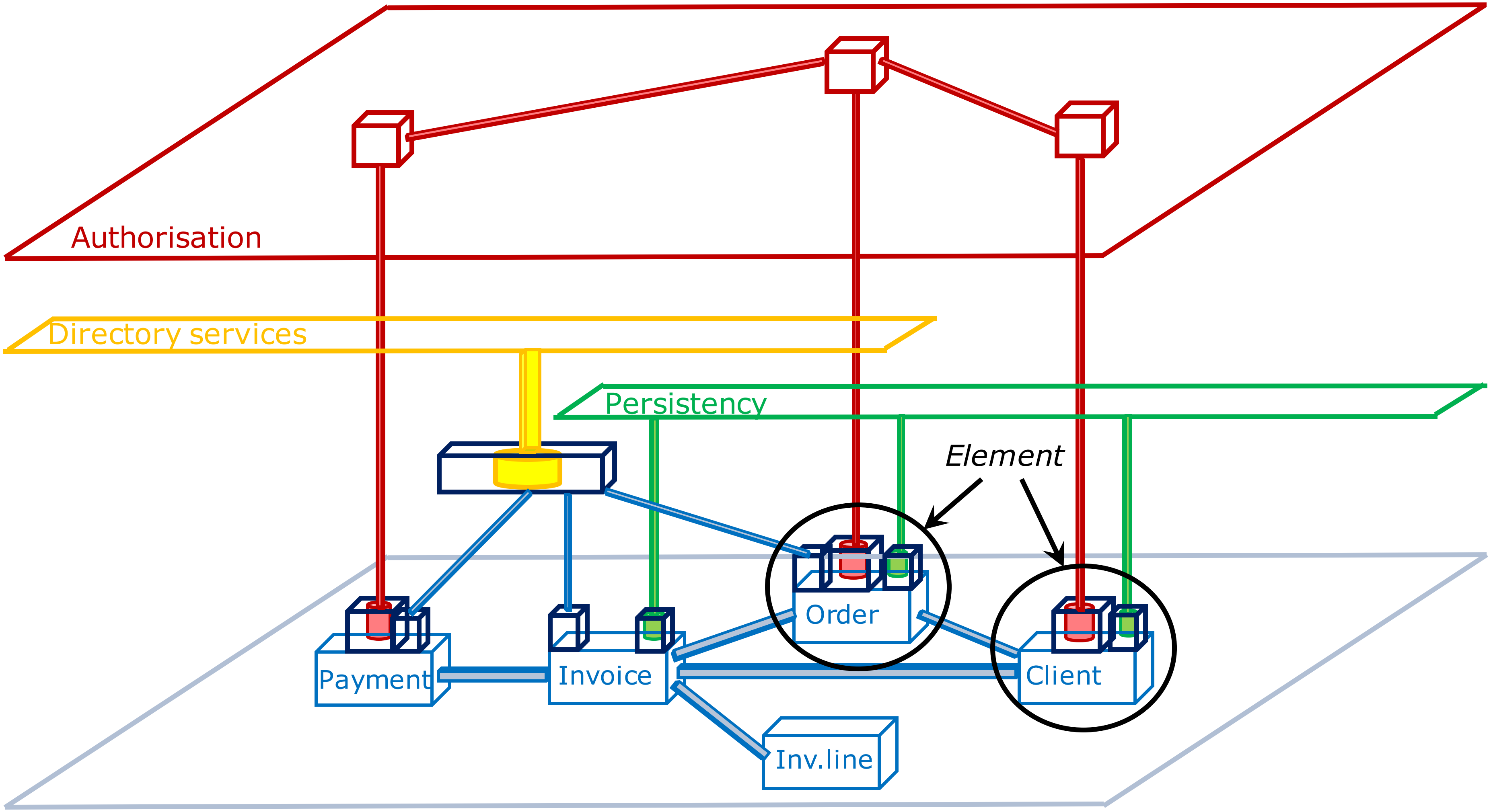
NS ➔ Fine-grained Modularity



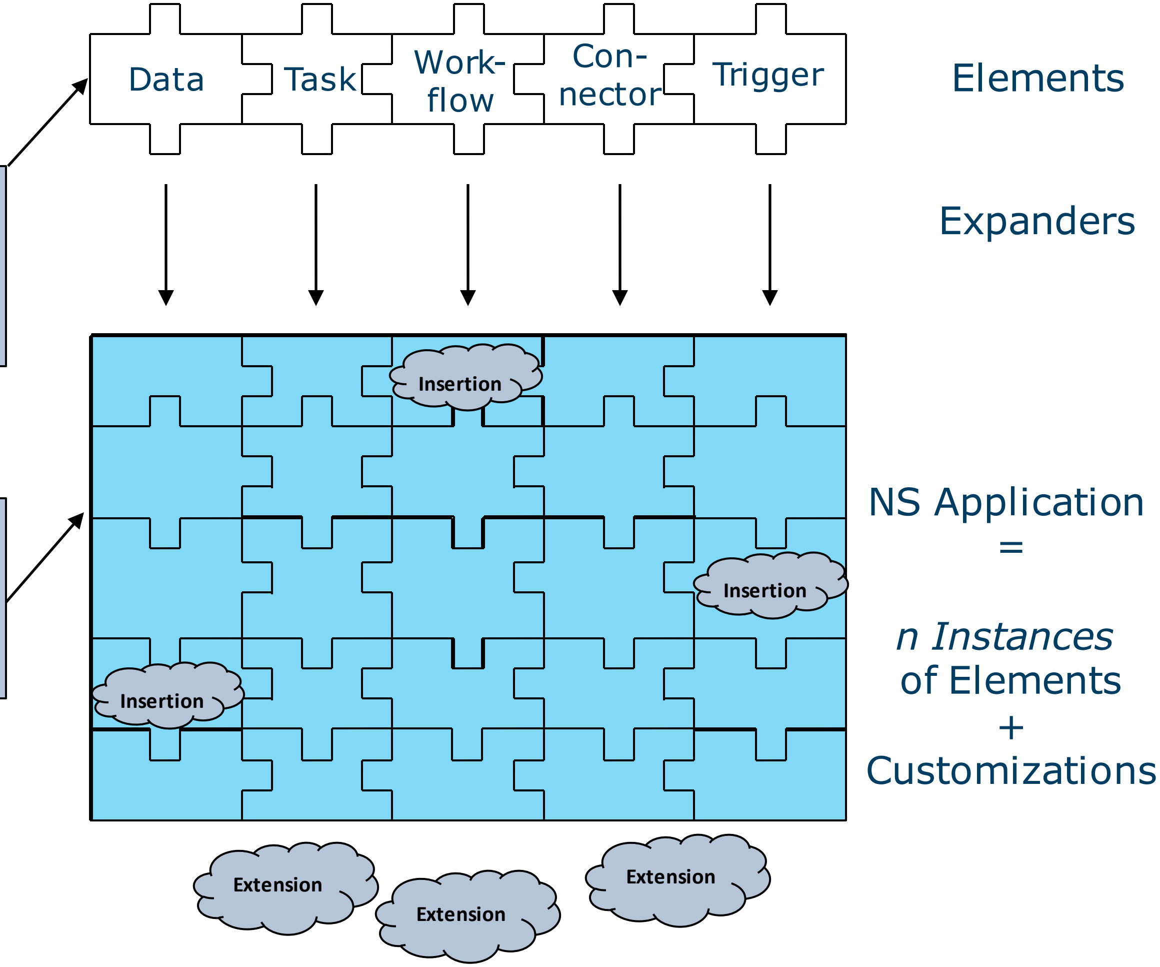
Key Insight 2: On Concerns



Key Insight 2: On Concerns



Key Insight 2:
Generate Recurring Structure



Elementary, functional building blocks, exhibiting proven evolvability

Generated skeletons provide > 90% of application code

NS Application
=
n Instances
of Elements
+
Customizations

Key Insight 3: On Updating

- Structure should be recurring, as variations:
  - increase complexity of codebase
  - decrease consistency in behaviour
- Recurring structure may need to vary over time:
  - new insights
  - discovery of flaws
  - changes in technologies

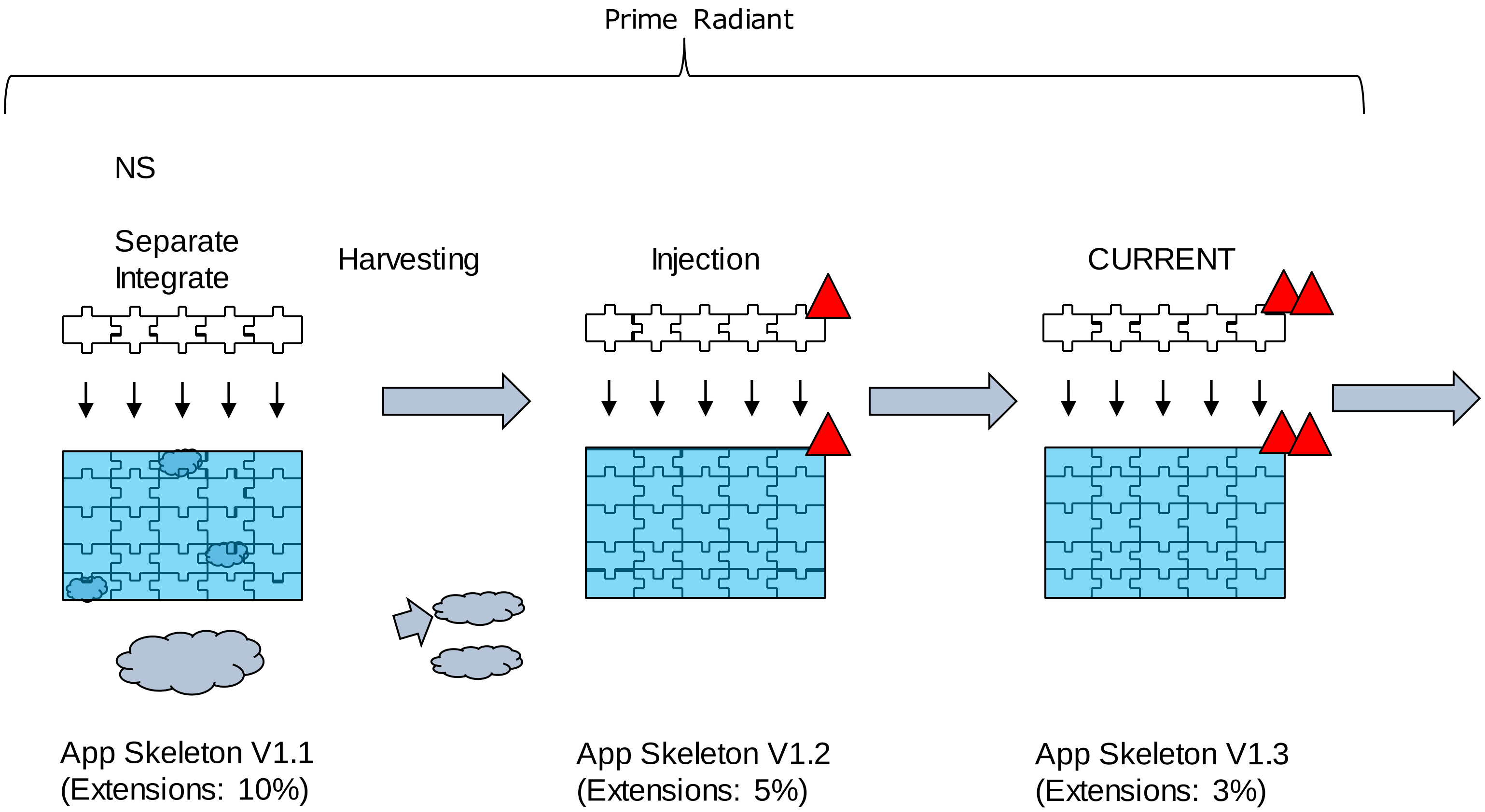
Structural changes may need to be applied with retroactive effect, but the efforts increase with the frequency of change.

N instances, update every K ➔ ***#updates*** = $\boxed{\frac{N(N+K)}{2K}}$

N=100

K	Total
100	100
50	150
20	300
10	550
5	1050
2	2550
1	5050

Key Insight 3:
Rejuvenate Skeleton Texture



Prime Radiant

NS

Separate
Integrate

Harvesting

Injection

CURRENT

App Skeleton V1.1
(Extensions: 10%)

App Skeleton V1.2
(Extensions: 5%)

App Skeleton V1.3
(Extensions: 3%)

DIMENSIONS OF EVOLVABILITY

Dimensions of Evolvability

- ***mirrors : analysis models***

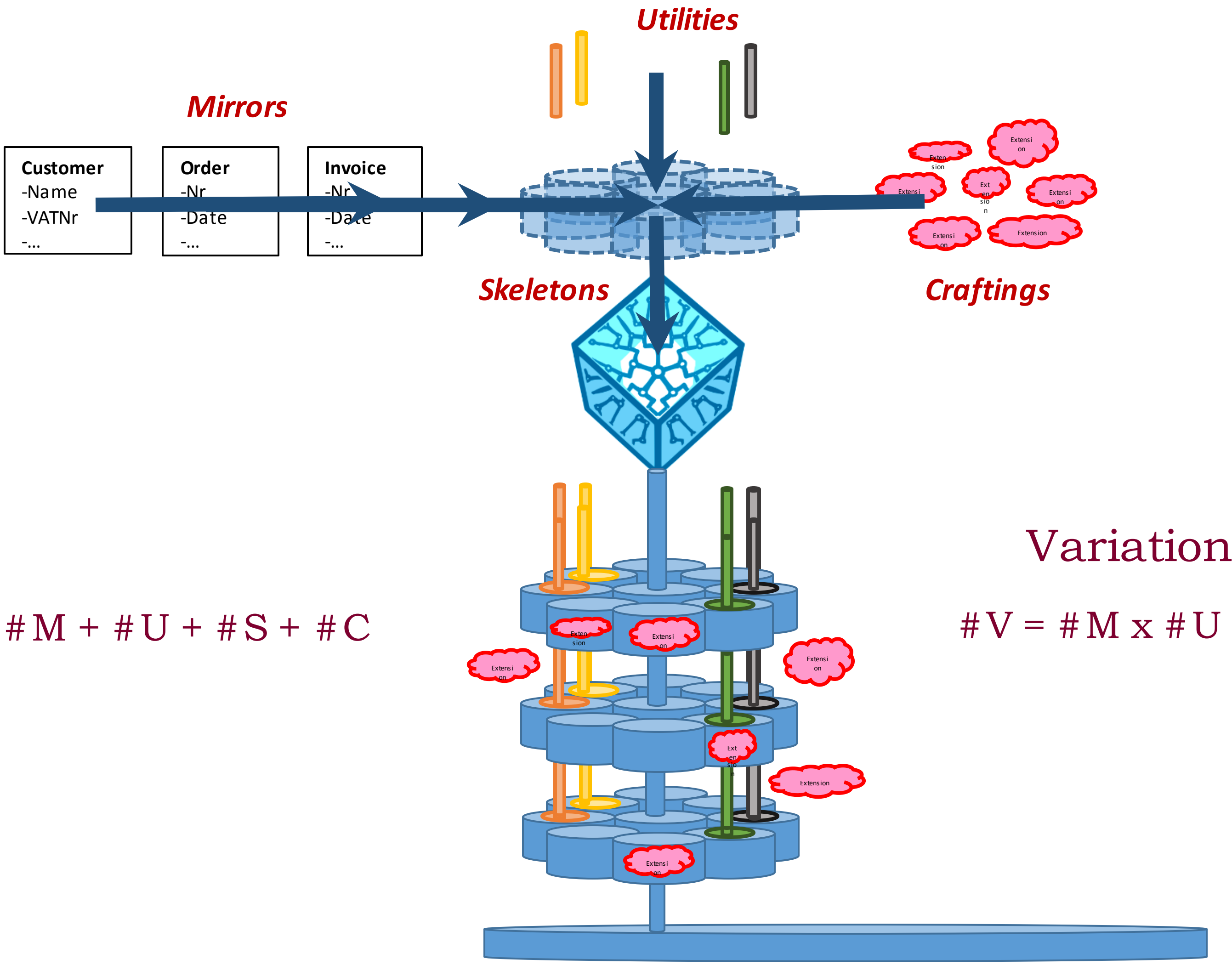
  new data attributes/relations, new elements
- ***skeletons : element structures***

  new or improved implementations of concerns
- ***utilities: technology frameworks***

  new frameworks to implement various concerns
- ***craftings : custom plugin code***

  new or improved implementations of tasks, screens

Dimensions of Evolvability

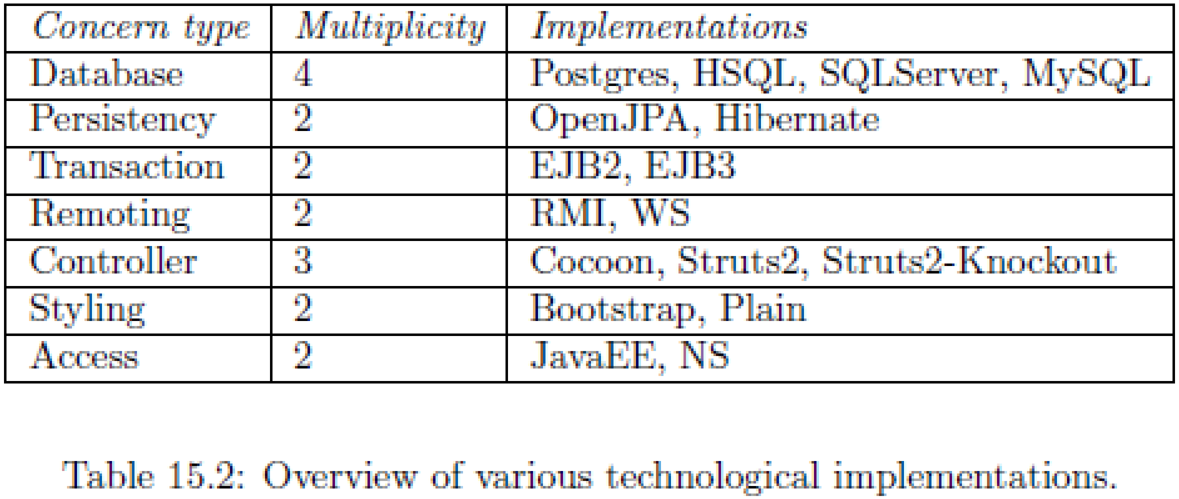


$\#V = \#M + \#U + \#S + \#C$

Variation Gain

$\#V = \#M \times \#U \times \#S \times \#C$

Insulating utilities/frameworks



Concern type	*Multiplicity*	*Implementations*
Database	4	Postgres, HSQL, SQLServer, MySQL
Persistency	2	OpenJPA, Hibernate
Transaction	2	EJB2, EJB3
Remoting	2	RMI, WS
Controller	3	Cocoon, Struts2, Struts2-Knockout
Styling	2	Bootstrap, Plain
Access	2	JavaEE, NS

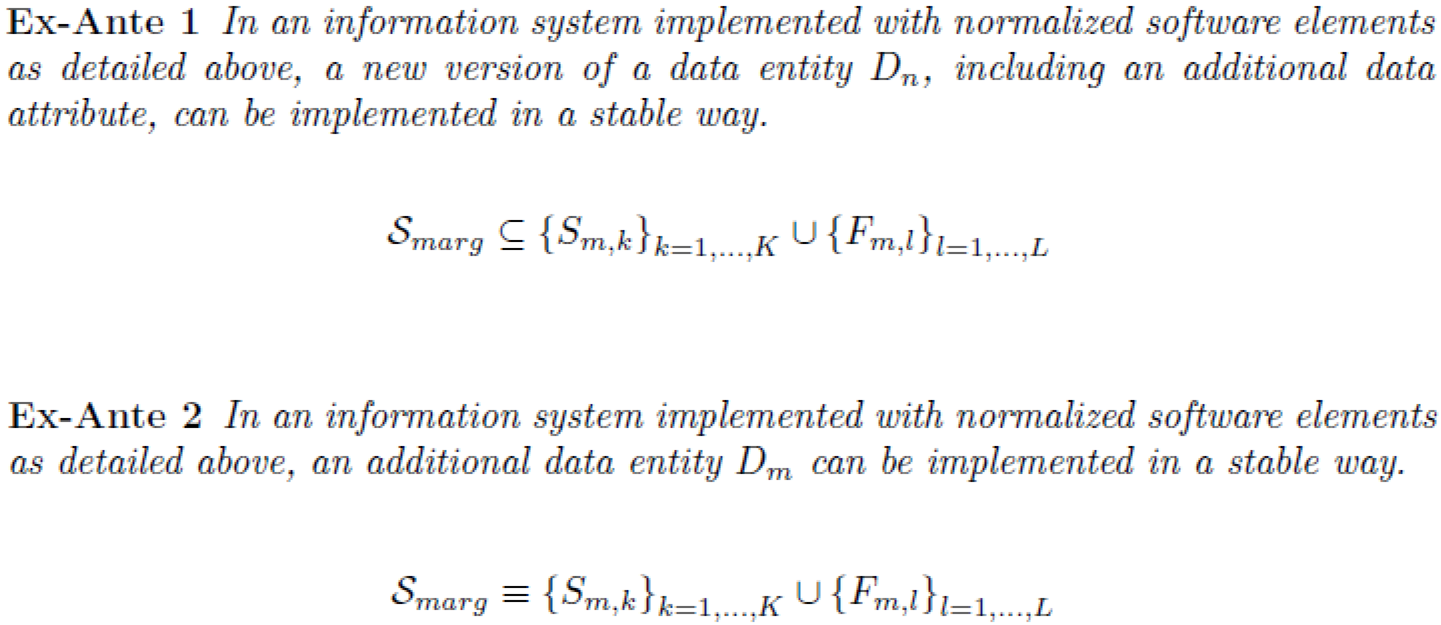
Table 15.2: Overview of various technological implementations.

Variation Gain

#U = 4+2+2+2+3+2+2 = 17

#U = 4x2x2x2x3x2x2 = 384

Evolution: Functional: Data



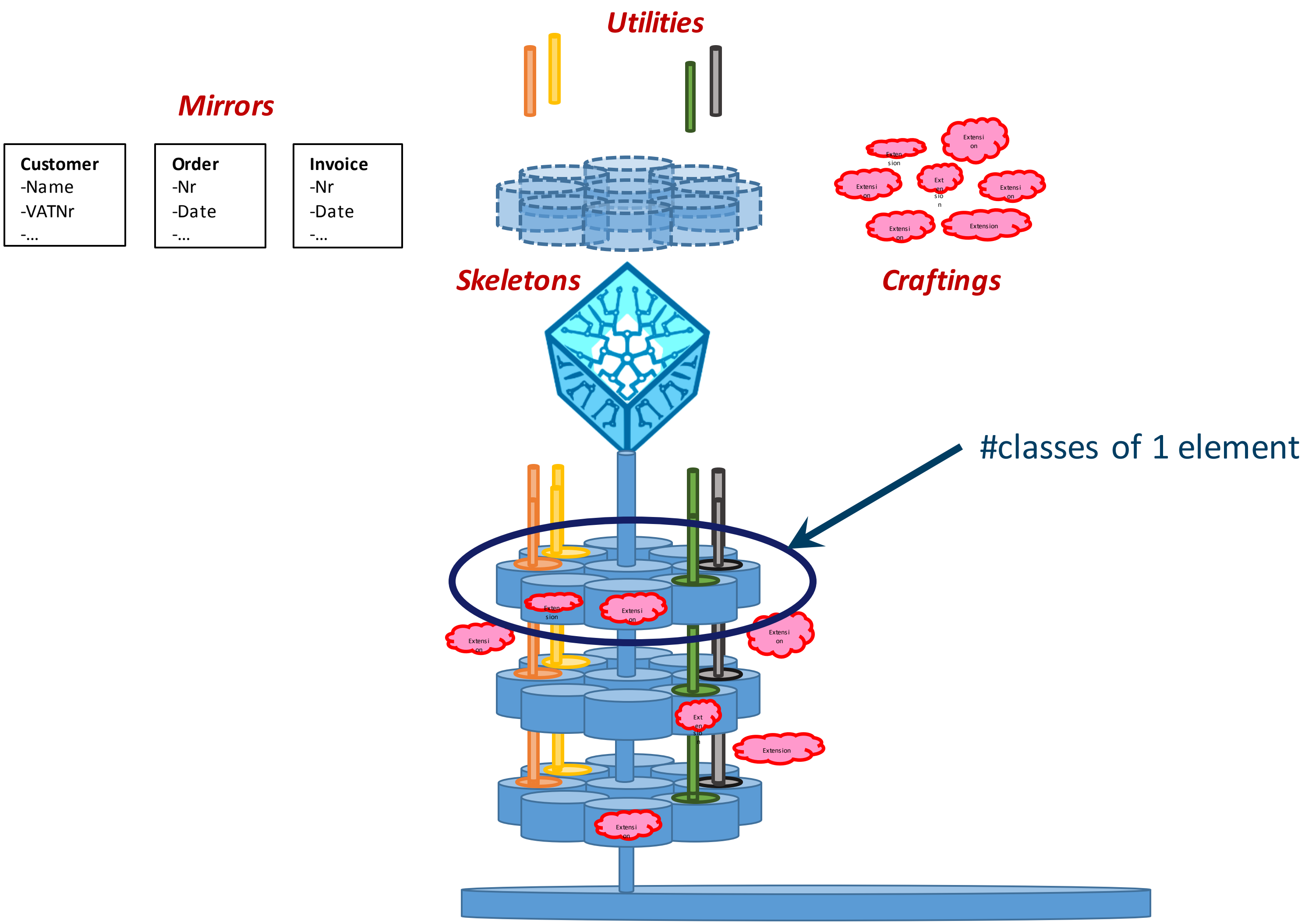
Ex-Ante 1 *In an information system implemented with normalized software elements as detailed above, a new version of a data entity D_n, including an additional data attribute, can be implemented in a stable way.*

$$\mathcal{S}_{marg} \subseteq \{S_{m,k}\}_{k=1,\ldots,K} \cup \{F_{m,l}\}_{l=1,\ldots,L}$$

Ex-Ante 2 *In an information system implemented with normalized software elements as detailed above, an additional data entity D_m can be implemented in a stable way.*

$$\mathcal{S}_{marg} \equiv \{S_{m,k}\}_{k=1,\ldots,K} \cup \{F_{m,l}\}_{l=1,\ldots,L}$$

Dimensions of Evolvability



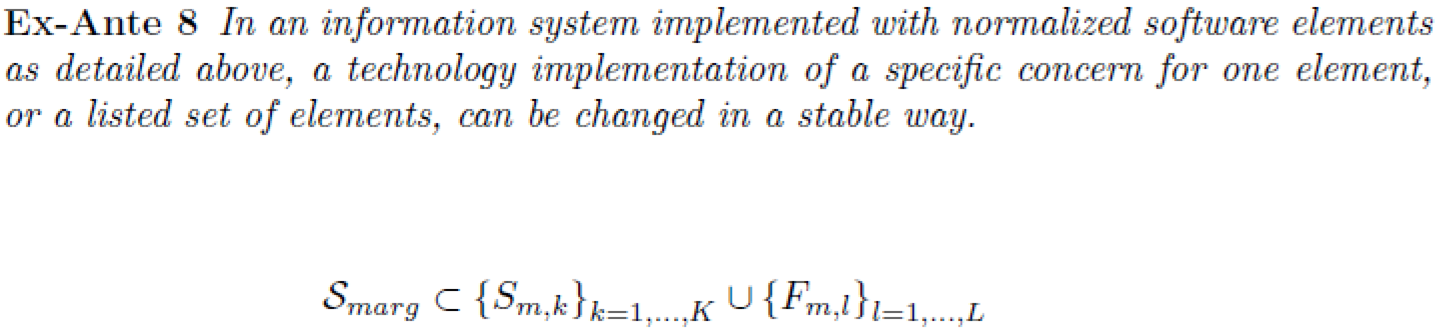
Customer
-Name
-VATNr
-…

Order
-Nr
-Date
-…

Invoice
-Nr
-Date
-…

#classes of 1 element

Evolution: Software: Concerns



Ex-Ante 8 *In an information system implemented with normalized software elements as detailed above, a technology implementation of a specific concern for one element, or a listed set of elements, can be changed in a stable way.*

$$\mathcal{S}_{marg} \subset \{S_{m,k}\}_{k=1,\ldots,K} \cup \{F_{m,l}\}_{l=1,\ldots,L}$$

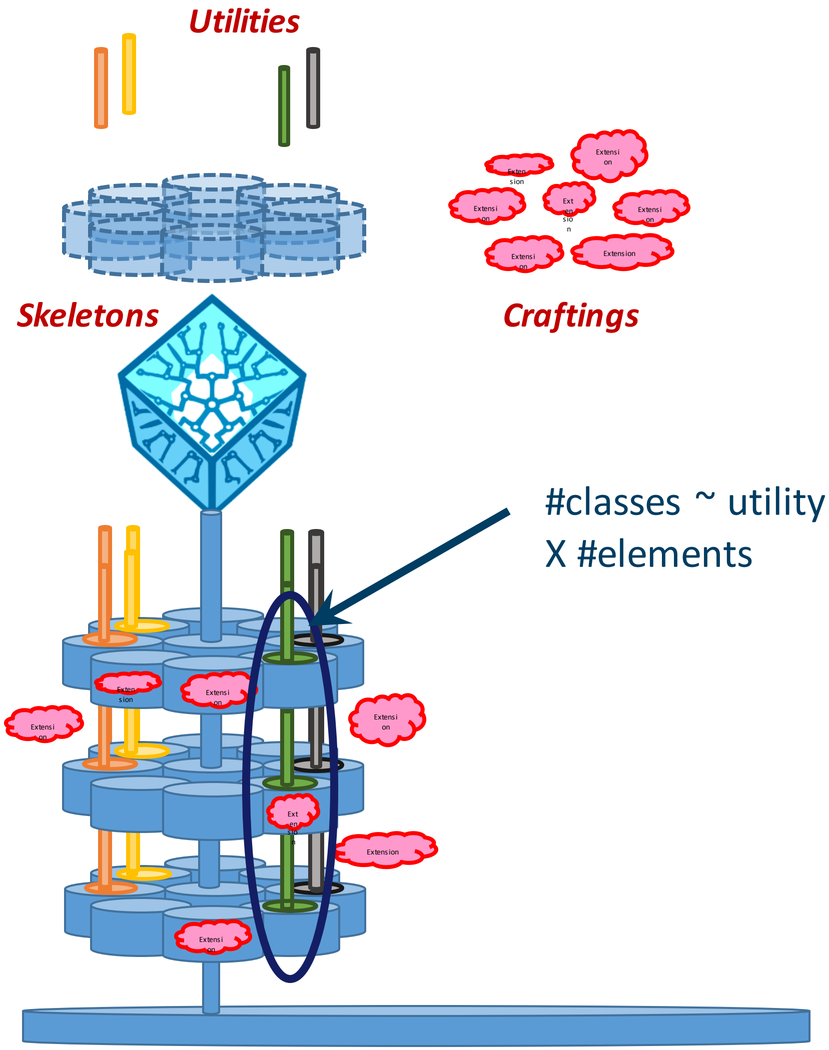
Dimensions of Evolvability

Mirrors

Customer
-Name
-VATNr
-…

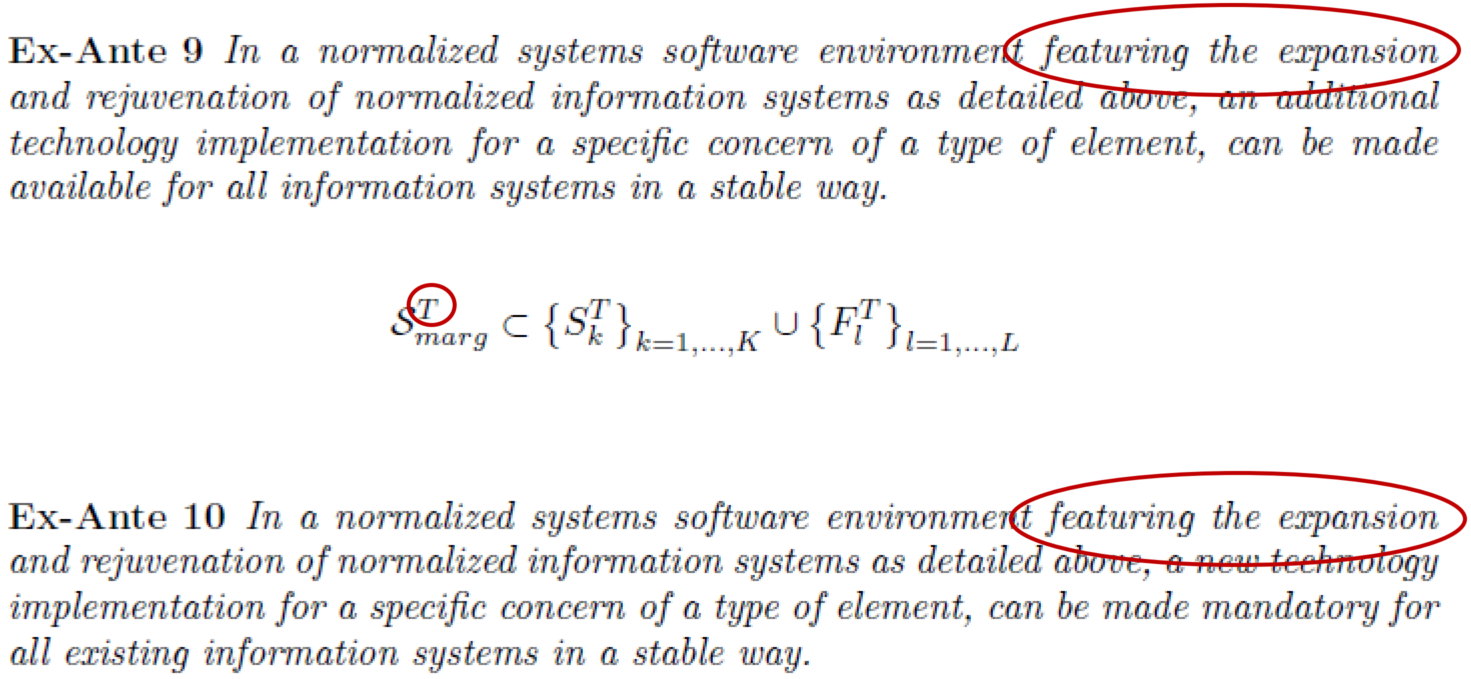
Order
-Nr
-Date
-…

Invoice
-Nr
-Date
-…



#classes ~ utility
X #elements

Evolution: Software: Concerns

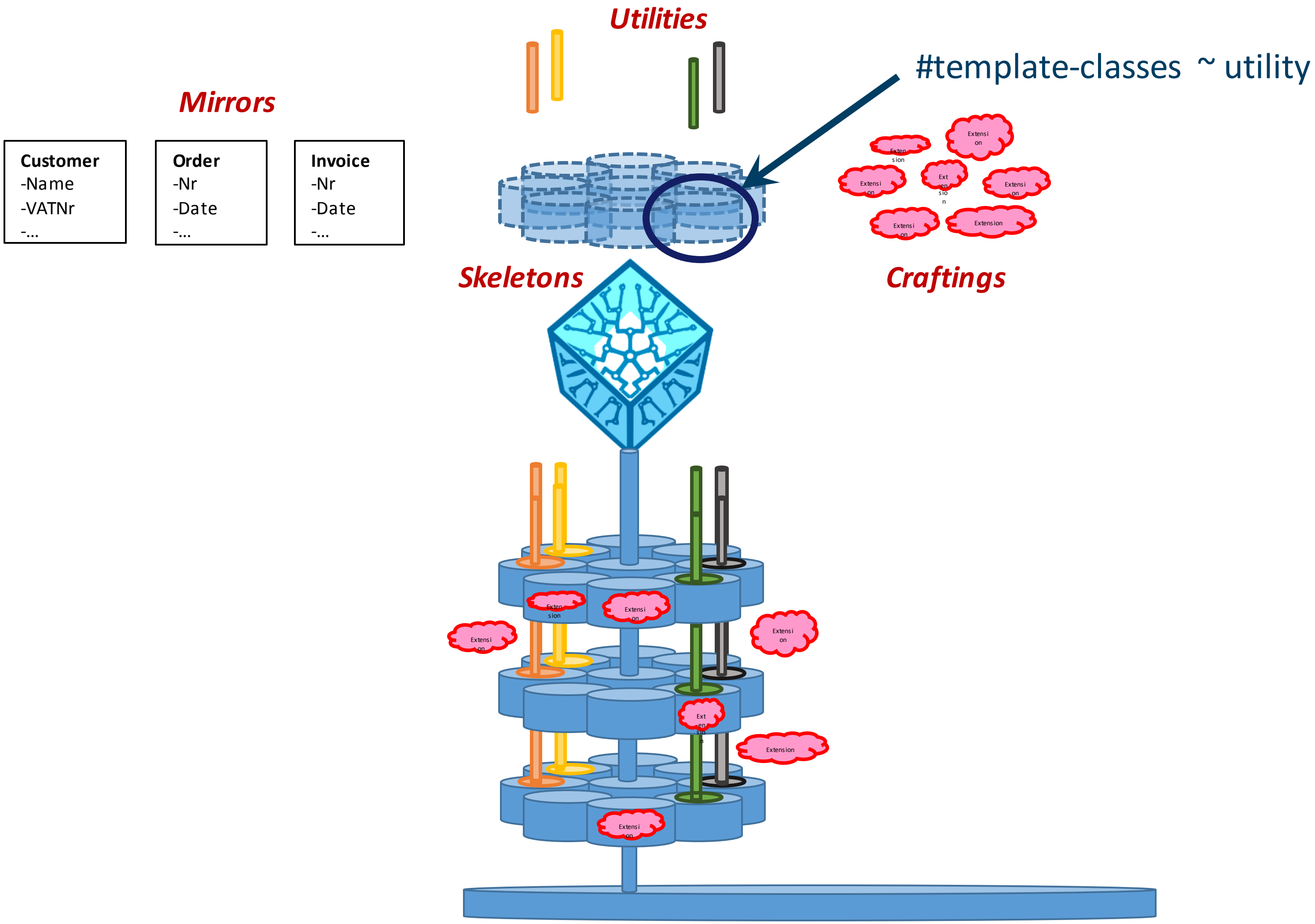


Ex-Ante 9 *In a normalized systems software environment featuring the expansion and rejuvenation of normalized information systems as detailed above, an additional technology implementation for a specific concern of a type of element, can be made available for all information systems in a stable way.*

$$S^T_{marg} \subset \{S^T_k\}_{k=1,\ldots,K} \cup \{F^T_l\}_{l=1,\ldots,L}$$

Ex-Ante 10 *In a normalized systems software environment featuring the expansion and rejuvenation of normalized information systems as detailed above, a new technology implementation for a specific concern of a type of element, can be made mandatory for all existing information systems in a stable way.*

Dimensions of Evolvability



Utilities

#template-classes ~ utility

Mirrors

Customer
-Name
-VATNr
-…

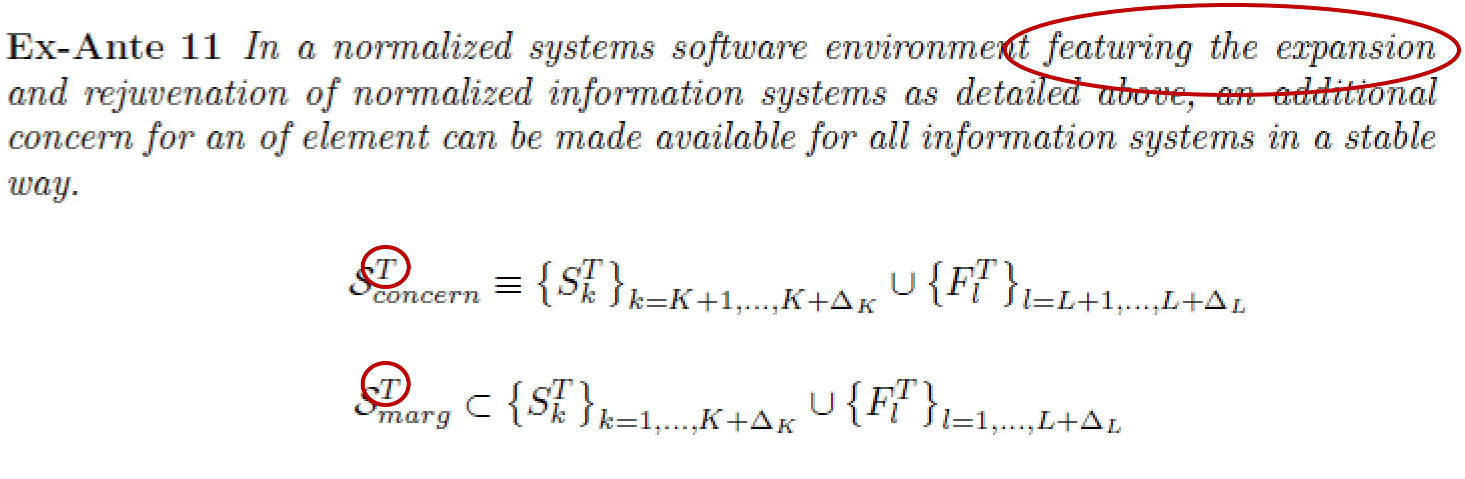
Order
-Nr
-Date
-…

Invoice
-Nr
-Date
-…

Skeletons

Craftings

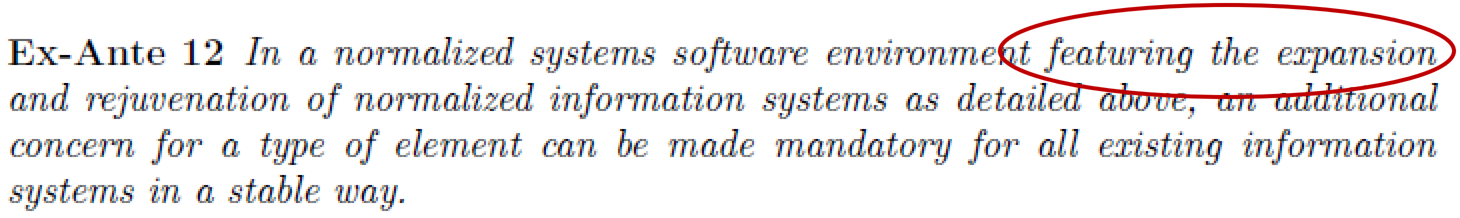
Evolution: Software: Concerns



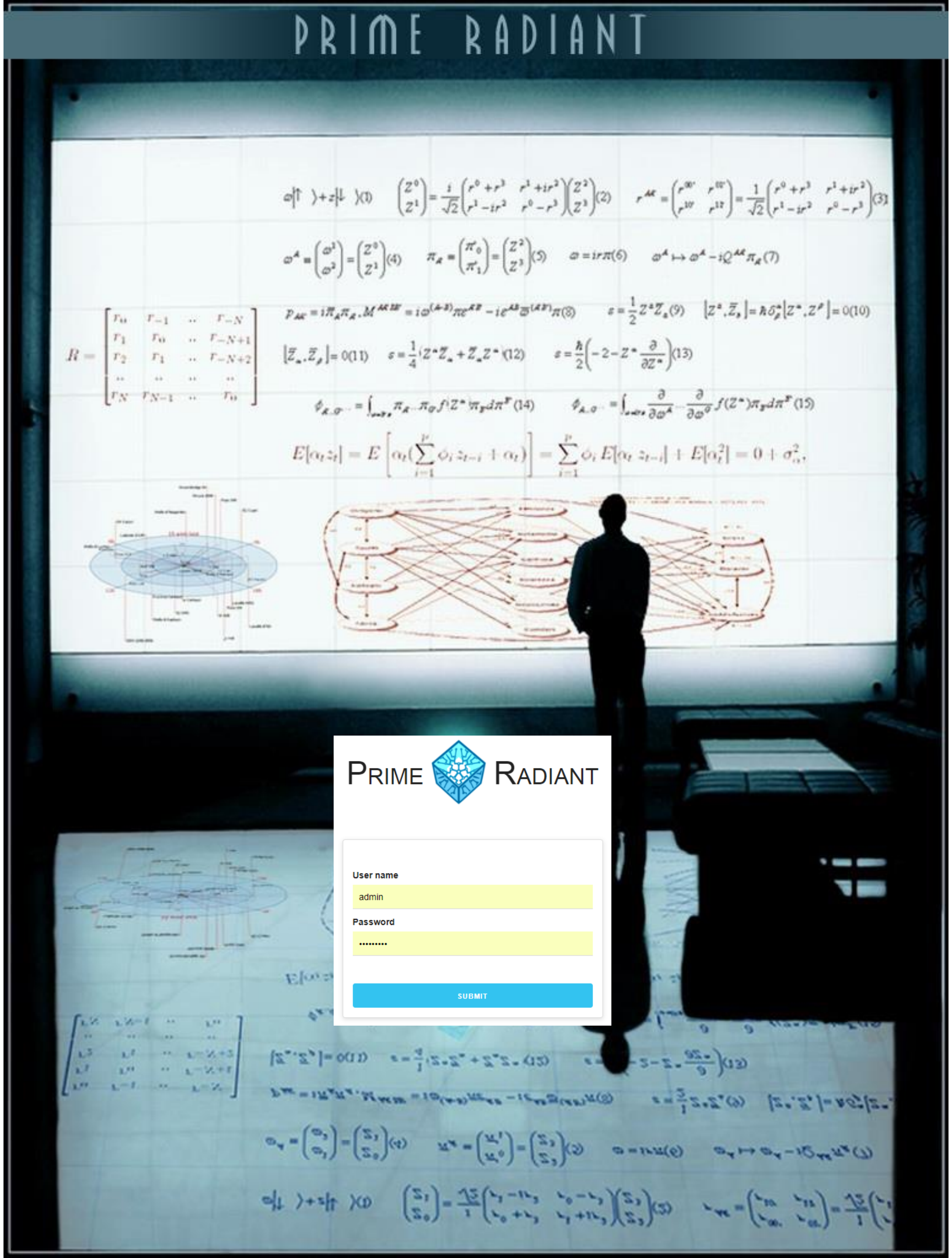
Ex-Ante 11 *In a normalized systems software environment featuring the expansion and rejuvenation of normalized information systems as detailed above, an additional concern for an of element can be made available for all information systems in a stable way.*

$$\mathcal{S}^T_{concern} \equiv \{S^T_k\}_{k=K+1,\ldots,K+\Delta_K} \cup \{F^T_l\}_{l=L+1,\ldots,L+\Delta_L}$$

$$\mathcal{S}^T_{marg} \subset \{S^T_k\}_{k=1,\ldots,K+\Delta_K} \cup \{F^T_l\}_{l=1,\ldots,L+\Delta_L}$$



Ex-Ante 12 *In a normalized systems software environment featuring the expansion and rejuvenation of normalized information systems as detailed above, an additional concern for a type of element can be made mandatory for all existing information systems in a stable way.*

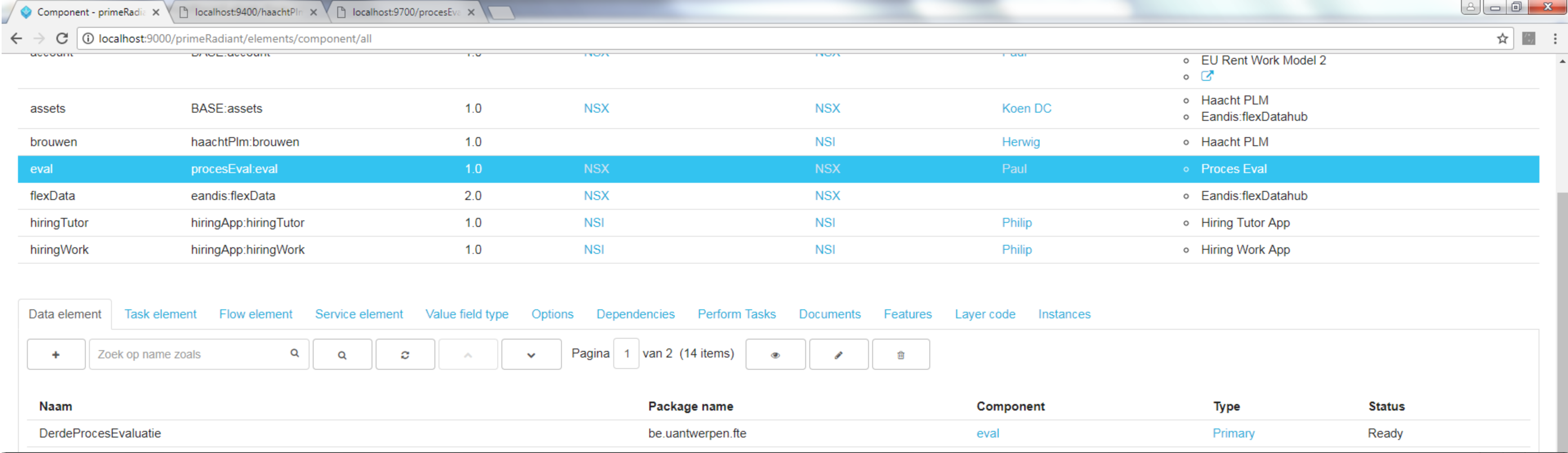


User name

admin

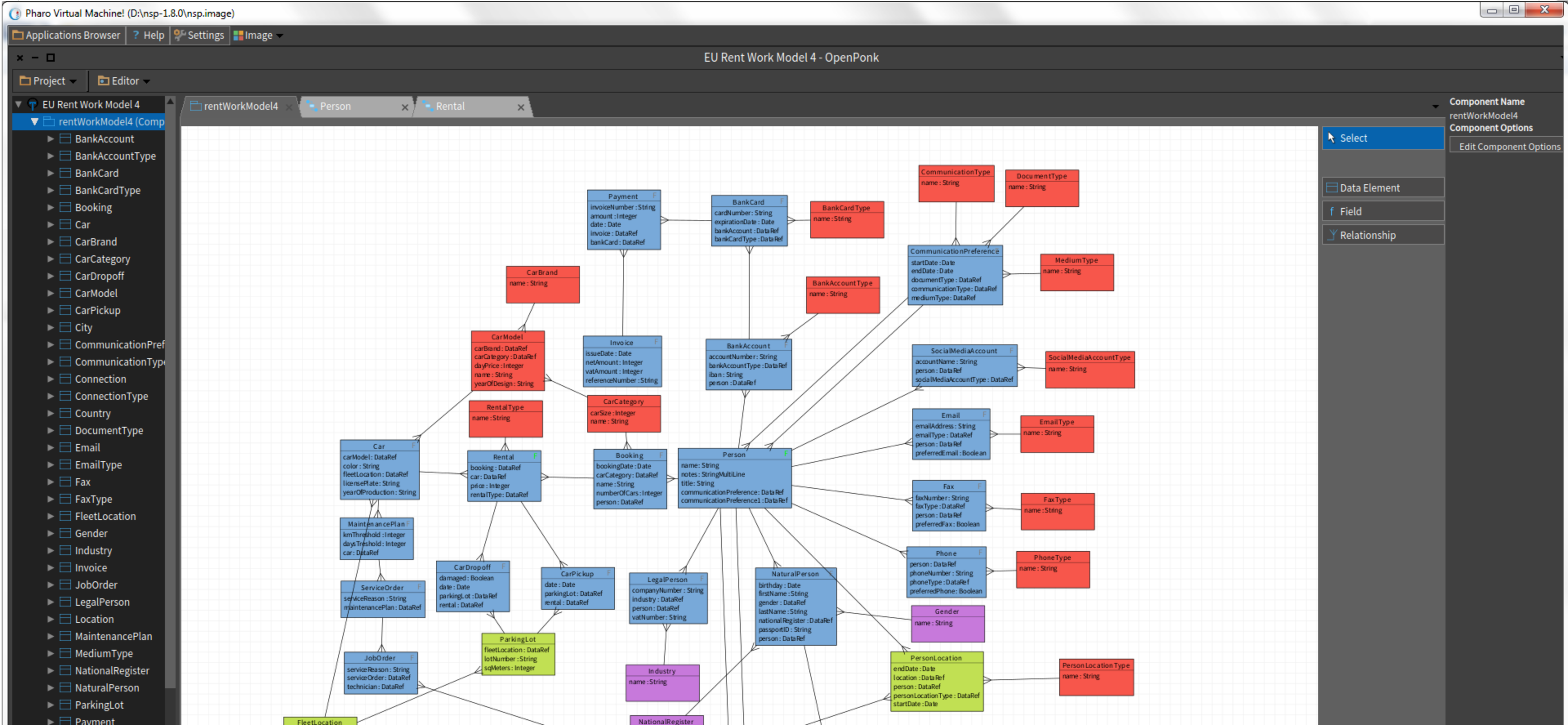
Password

•••••••••

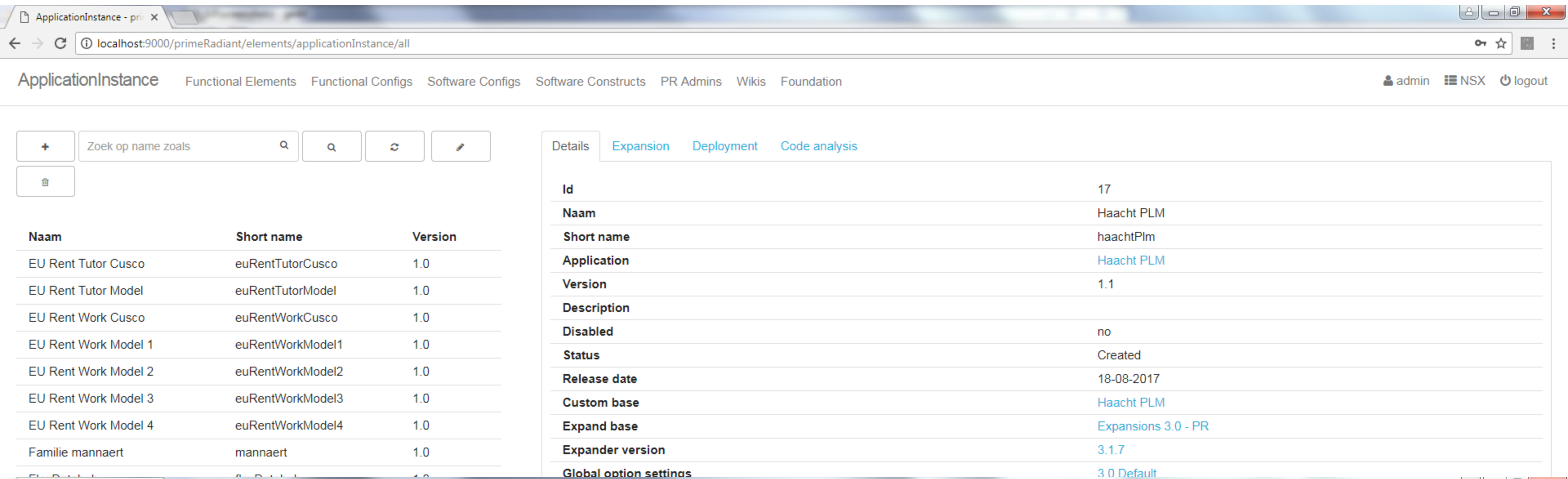


account	BASE:account	1.0	NSX	NSX	Paul	○ EU Rent Work Model 2 ○
assets	BASE:assets	1.0	NSX	NSX	Koen DC	○ Haacht PLM ○ Eandis:flexDatahub
brouwen	haachtPlm:brouwen	1.0		NSI	Herwig	○ Haacht PLM
eval	procesEval:eval	1.0	NSX	NSX	Paul	○ Proces Eval
flexData	eandis:flexData	2.0	NSX	NSX		○ Eandis:flexDatahub
hiringTutor	hiringApp:hiringTutor	1.0	NSI	NSI	Philip	○ Hiring Tutor App
hiringWork	hiringApp:hiringWork	1.0	NSI	NSI	Philip	○ Hiring Work App

Naam	Package name	Component	Type	Status
DerdeProcesEvaluatie	be.uantwerpen.fte	eval	Primary	Ready

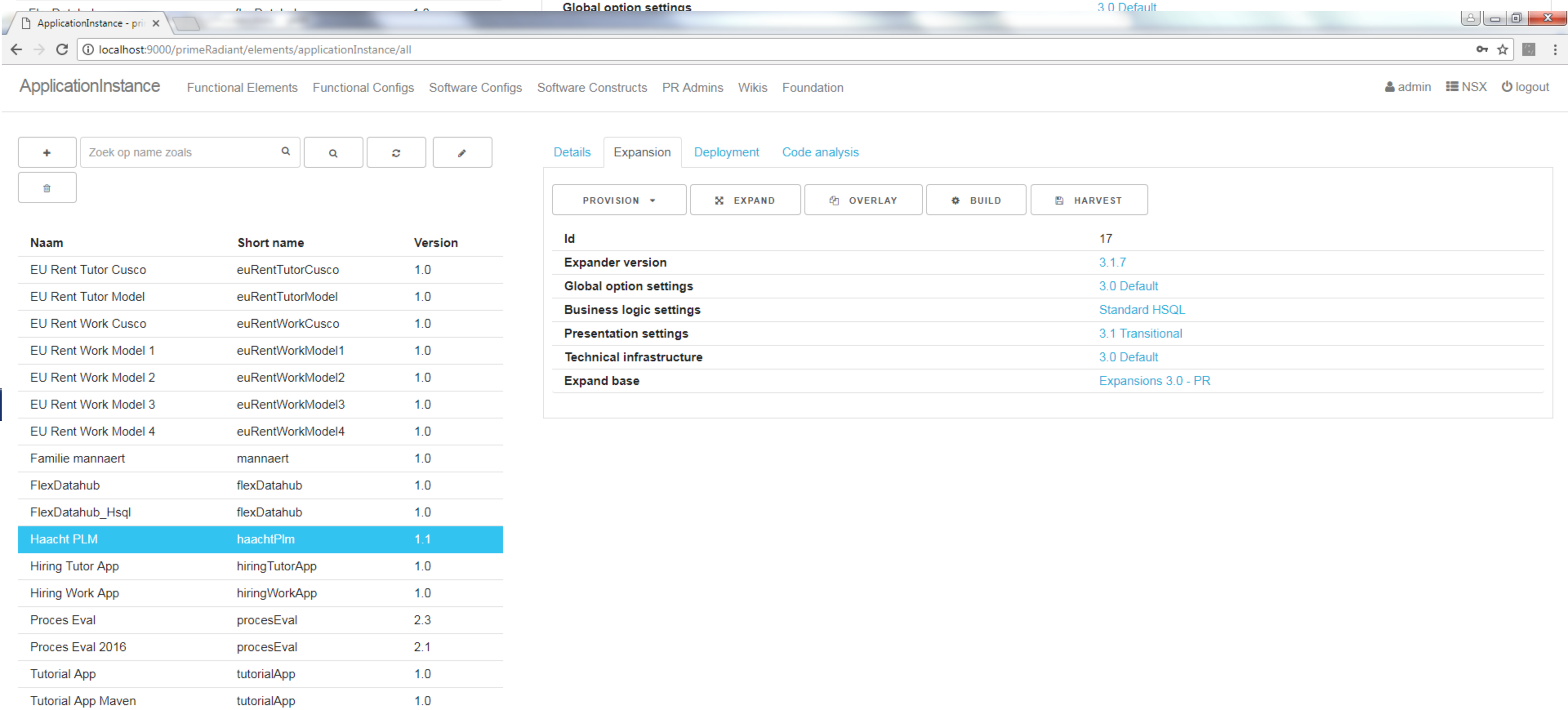


- EU Rent Work Model 4
  - rentWorkModel4 (Comp
    - BankAccount
    - BankAccountType
    - BankCard
    - BankCardType
    - Booking
    - Car
    - CarBrand
    - CarCategory
    - CarDropoff
    - CarModel
    - CarPickup
    - City
    - CommunicationPref
    - CommunicationTyp
    - Connection
    - ConnectionType
    - Country
    - DocumentType
    - Email
    - EmailType
    - Fax
    - FaxType
    - FleetLocation
    - Gender
    - Industry
    - Invoice
    - JobOrder
    - LegalPerson
    - Location
    - MaintenancePlan
    - MediumType
    - NationalRegister
    - NaturalPerson
    - ParkingLot
    - Payment



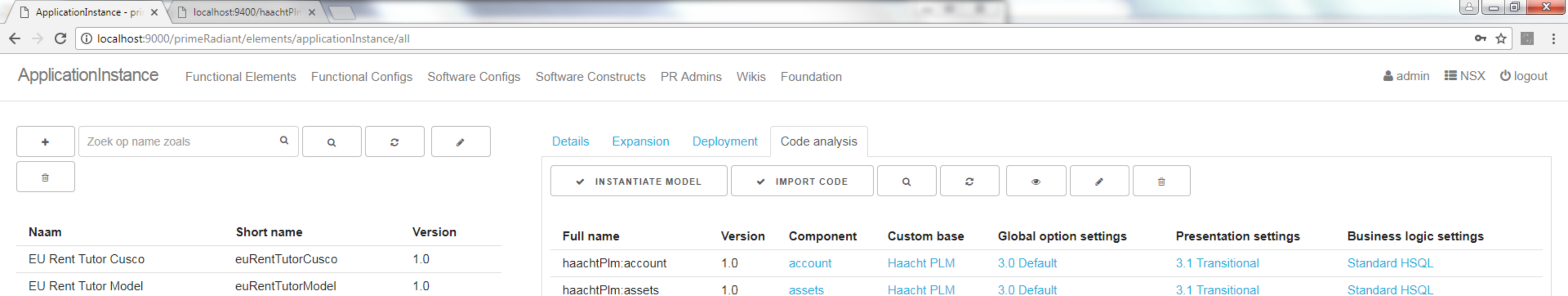
Naam	Short name	Version
EU Rent Tutor Cusco	euRentTutorCusco	1.0
EU Rent Tutor Model	euRentTutorModel	1.0
EU Rent Work Cusco	euRentWorkCusco	1.0
EU Rent Work Model 1	euRentWorkModel1	1.0
EU Rent Work Model 2	euRentWorkModel2	1.0
EU Rent Work Model 3	euRentWorkModel3	1.0
EU Rent Work Model 4	euRentWorkModel4	1.0
Familie mannaert	mannaert	1.0

Id	17
Naam	Haacht PLM
Short name	haachtPlm
Application	Haacht PLM
Version	1.1
Description	
Disabled	no
Status	Created
Release date	18-08-2017
Custom base	Haacht PLM
Expand base	Expansions 3.0 - PR
Expander version	3.1.7
Global option settings	3.0 Default



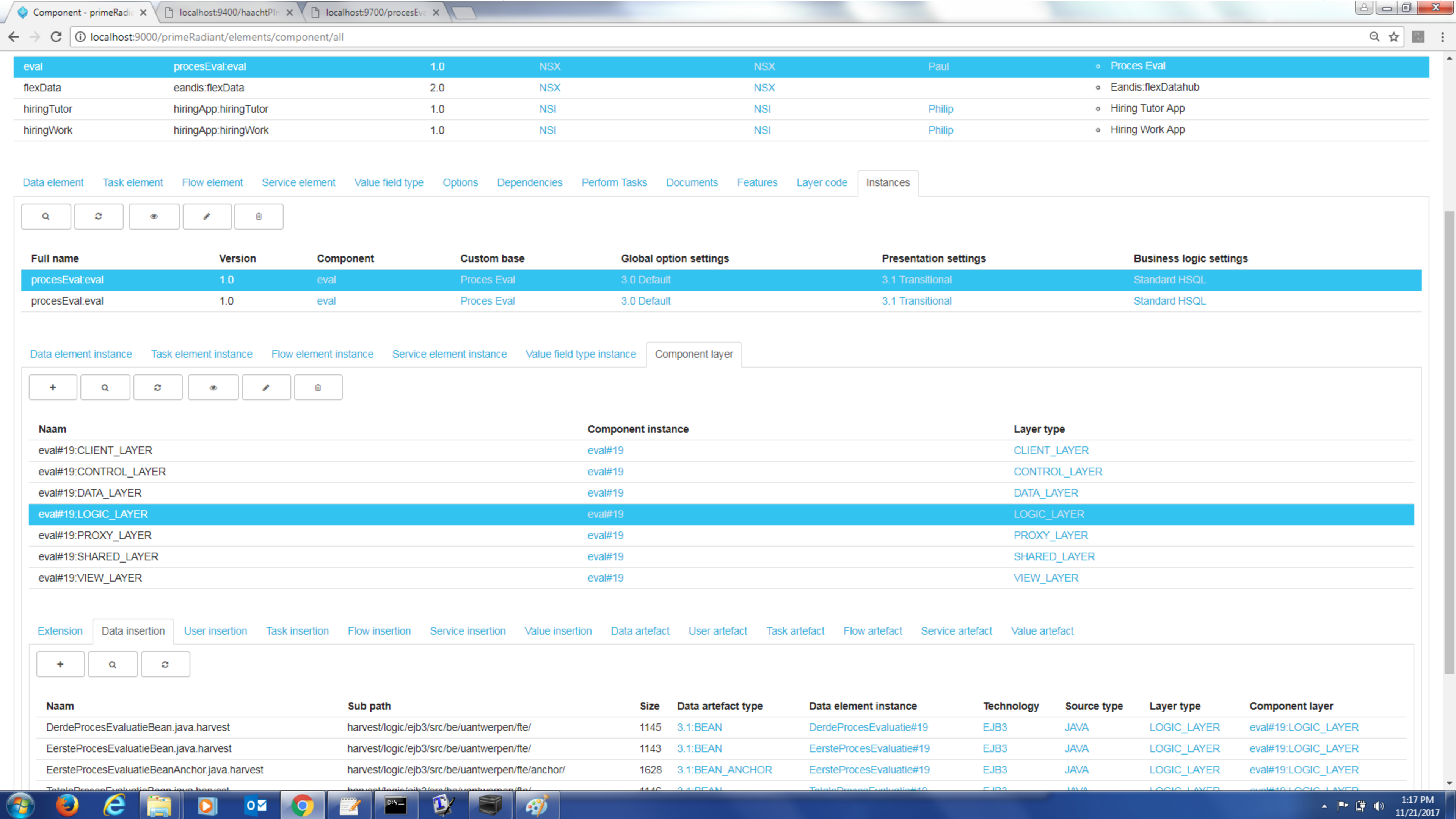
Naam	Short name	Version
EU Rent Tutor Cusco	euRentTutorCusco	1.0
EU Rent Tutor Model	euRentTutorModel	1.0
EU Rent Work Cusco	euRentWorkCusco	1.0
EU Rent Work Model 1	euRentWorkModel1	1.0
EU Rent Work Model 2	euRentWorkModel2	1.0
EU Rent Work Model 3	euRentWorkModel3	1.0
EU Rent Work Model 4	euRentWorkModel4	1.0
Familie mannaert	mannaert	1.0
FlexDatahub	flexDatahub	1.0
FlexDatahub_Hsql	flexDatahub	1.0
Haacht PLM	haachtPlm	1.1
Hiring Tutor App	hiringTutorApp	1.0
Hiring Work App	hiringWorkApp	1.0
Proces Eval	procesEval	2.3
Proces Eval 2016	procesEval	2.1
Tutorial App	tutorialApp	1.0
Tutorial App Maven	tutorialApp	1.0

Id	17
Expander version	3.1.7
Global option settings	3.0 Default
Business logic settings	Standard HSQL
Presentation settings	3.1 Transitional
Technical infrastructure	3.0 Default
Expand base	Expansions 3.0 - PR



Naam	Short name	Version
EU Rent Tutor Cusco	euRentTutorCusco	1.0
EU Rent Tutor Model	euRentTutorModel	1.0

Full name	Version	Component	Custom base	Global option settings	Presentation settings	Business logic settings
haachtPlm:account	1.0	account	Haacht PLM	3.0 Default	3.1 Transitional	Standard HSQL
haachtPlm:assets	1.0	assets	Haacht PLM	3.0 Default	3.1 Transitional	Standard HSQL

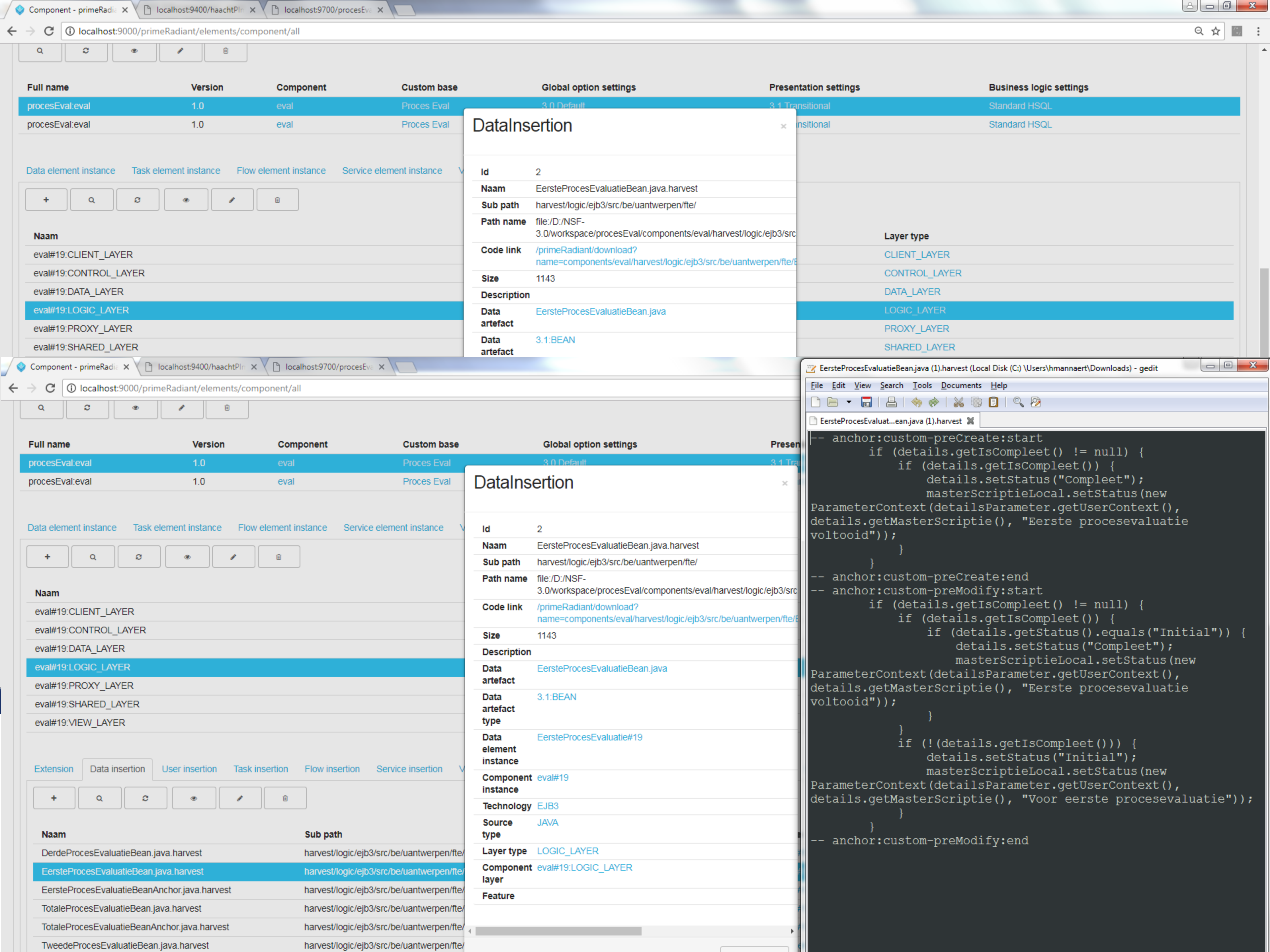


eval	procesEval:eval	1.0	NSX	NSX	Paul	Proces Eval
flexData	eandis:flexData	2.0	NSX	NSX		Eandis:flexDatahub
hiringTutor	hiringApp:hiringTutor	1.0	NSI	NSI	Philip	Hiring Tutor App
hiringWork	hiringApp:hiringWork	1.0	NSI	NSI	Philip	Hiring Work App

Full name	Version	Component	Custom base	Global option settings	Presentation settings	Business logic settings
procesEval:eval	1.0	eval	Proces Eval	3.0 Default	3.1 Transitional	Standard HSQL
procesEval:eval	1.0	eval	Proces Eval	3.0 Default	3.1 Transitional	Standard HSQL

Naam	Component instance	Layer type
eval#19:CLIENT_LAYER	eval#19	CLIENT_LAYER
eval#19:CONTROL_LAYER	eval#19	CONTROL_LAYER
eval#19:DATA_LAYER	eval#19	DATA_LAYER
eval#19:LOGIC_LAYER	eval#19	LOGIC_LAYER
eval#19:PROXY_LAYER	eval#19	PROXY_LAYER
eval#19:SHARED_LAYER	eval#19	SHARED_LAYER
eval#19:VIEW_LAYER	eval#19	VIEW_LAYER

Naam	Sub path	Size	Data artefact type	Data element instance	Technology	Source type	Layer type	Component layer
DerdeProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/	1145	3.1:BEAN	DerdeProcesEvaluatie#19	EJB3	JAVA	LOGIC_LAYER	eval#19:LOGIC_LAYER
EersteProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/	1143	3.1:BEAN	EersteProcesEvaluatie#19	EJB3	JAVA	LOGIC_LAYER	eval#19:LOGIC_LAYER
EersteProcesEvaluatieBeanAnchor.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/anchor/	1628	3.1:BEAN_ANCHOR	EersteProcesEvaluatie#19	EJB3	JAVA	LOGIC_LAYER	eval#19:LOGIC_LAYER



Full name	Version	Component	Custom base	Global option settings	Presentation settings	Business logic settings
procesEval:eval	1.0	eval	Proces Eval	3.0 Default	3.1 Transitional	Standard HSQL
procesEval:eval	1.0	eval	Proces Eval		nsitional	Standard HSQL

Naam	Layer type
eval#19:CLIENT_LAYER	CLIENT_LAYER
eval#19:CONTROL_LAYER	CONTROL_LAYER
eval#19:DATA_LAYER	DATA_LAYER
eval#19:LOGIC_LAYER	LOGIC_LAYER
eval#19:PROXY_LAYER	PROXY_LAYER
eval#19:SHARED_LAYER	SHARED_LAYER

DataInsertion

Id	2
Naam	EersteProcesEvaluatieBean.java.harvest
Sub path	harvest/logic/ejb3/src/be/uantwerpen/fte/
Path name	file:/D:/NSF-3.0/workspace/procesEval/components/eval/harvest/logic/ejb3/src
Code link	/primeRadiant/download?name=components/eval/harvest/logic/ejb3/src/be/uantwerpen/fte/E
Size	1143
Description	
Data artefact	EersteProcesEvaluatieBean.java
Data artefact type	3.1:BEAN
Data element instance	EersteProcesEvaluatie#19
Component instance	eval#19
Technology	EJB3
Source type	JAVA
Layer type	LOGIC_LAYER
Component layer	eval#19:LOGIC_LAYER
Feature	

Naam	Layer type
eval#19:CLIENT_LAYER	
eval#19:CONTROL_LAYER	
eval#19:DATA_LAYER	
eval#19:LOGIC_LAYER	
eval#19:PROXY_LAYER	
eval#19:SHARED_LAYER	
eval#19:VIEW_LAYER	

Naam	Sub path
DerdeProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/
EersteProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/
EersteProcesEvaluatieBeanAnchor.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/
TotaleProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/
TotaleProcesEvaluatieBeanAnchor.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/
TweedeProcesEvaluatieBean.java.harvest	harvest/logic/ejb3/src/be/uantwerpen/fte/

EersteProcesEvaluatieBean.java (1).harvest (Local Disk (C:) \Users\hmannaert\Downloads) - gedit
File Edit View Search Tools Documents Help
EersteProcesEvaluat...ean.java (1).harvest

```
-- anchor:custom-preCreate:start
        if (details.getIsCompleet() != null) {
            if (details.getIsCompleet()) {
                details.setStatus("Compleet");
                masterScriptieLocal.setStatus(new
ParameterContext(detailsParameter.getUserContext(),
details.getMasterScriptie(), "Eerste procesevaluatie
voltooid"));
            }
        }
-- anchor:custom-preCreate:end
-- anchor:custom-preModify:start
        if (details.getIsCompleet() != null) {
            if (details.getIsCompleet()) {
                if (details.getStatus().equals("Initial")) {
                    details.setStatus("Compleet");
                    masterScriptieLocal.setStatus(new
ParameterContext(detailsParameter.getUserContext(),
details.getMasterScriptie(), "Eerste procesevaluatie
voltooid"));
                }
            }
            if (!(details.getIsCompleet())) {
                details.setStatus("Initial");
                masterScriptieLocal.setStatus(new
ParameterContext(detailsParameter.getUserContext(),
details.getMasterScriptie(), "Voor eerste procesevaluatie"));
            }
        }
-- anchor:custom-preModify:end
```

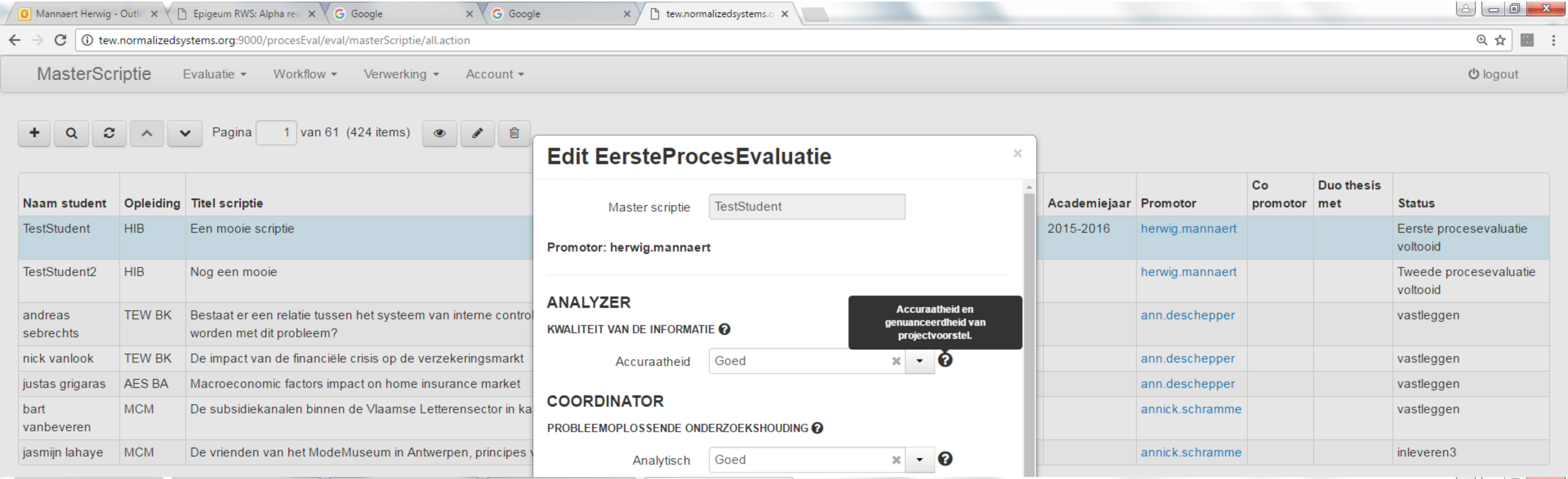
REJUVENATING APPLICATIONS

Rejuvenating Applications

- Regenerating a software application with
  - a given model (data, task, flow, connector, and trigger element parameters)
  - a given codebase of custom code (extensions and insertions)
- Applying
  - a new version of the skeletons or generator/expander templates
  - possibly new (versions of) utility frameworks

Types of ½ Applications

- Budget follow-up tool
- Master thesis evaluation
- Diplomatic card services
- Data centre management
- Solar panels monitoring
- Beverage product lifecycle
- Energy datahub management
- IoT data inflow engine
- Privacy and digital vault
- …. (incl. many from *Dutch Tax Authority*)



Naam student	Opleiding	Titel scriptie	Academiejaar	Promotor	Co promotor	Duo thesis met	Status
TestStudent	HIB	Een mooie scriptie	2015-2016	herwig.mannaert			Eerste procesevaluatie voltooid
TestStudent2	HIB	Nog een mooie		herwig.mannaert			Tweede procesevaluatie voltooid
andreas sebrechts	TEW BK	Bestaat er een relatie tussen het systeem van interne contro worden met dit probleem?		ann.deschepper			vastleggen
nick vanlook	TEW BK	De impact van de financiële crisis op de verzekeringsmarkt		ann.deschepper			vastleggen
justas grigaras	AES BA	Macroeconomic factors impact on home insurance market		ann.deschepper			vastleggen
bart vanbeveren	MCM	De subsidiekanalen binnen de Vlaamse Letterensector in ka		annick.schramme			vastleggen
jasmijn lahaye	MCM	De vrienden van het ModeMuseum in Antwerpen, principes		annick.schramme			inleveren3

Edit EersteProcesEvaluatie

Master scriptie: TestStudent

Promotor: herwig.mannaert

ANALYZER

KWALITEIT VAN DE INFORMATIE

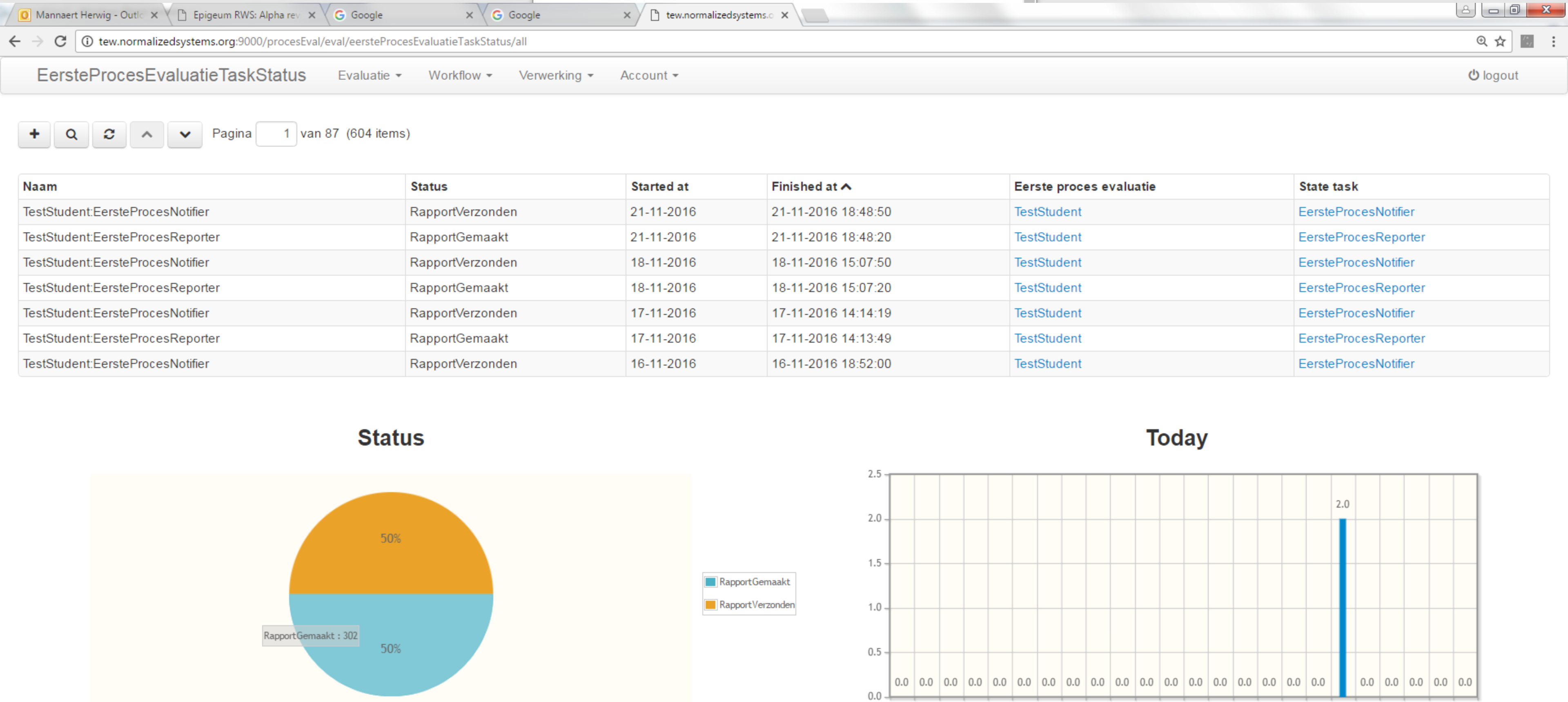
Accuraatheid en genuanceerdheid van projectvoorstel.

Accuraatheid: Goed

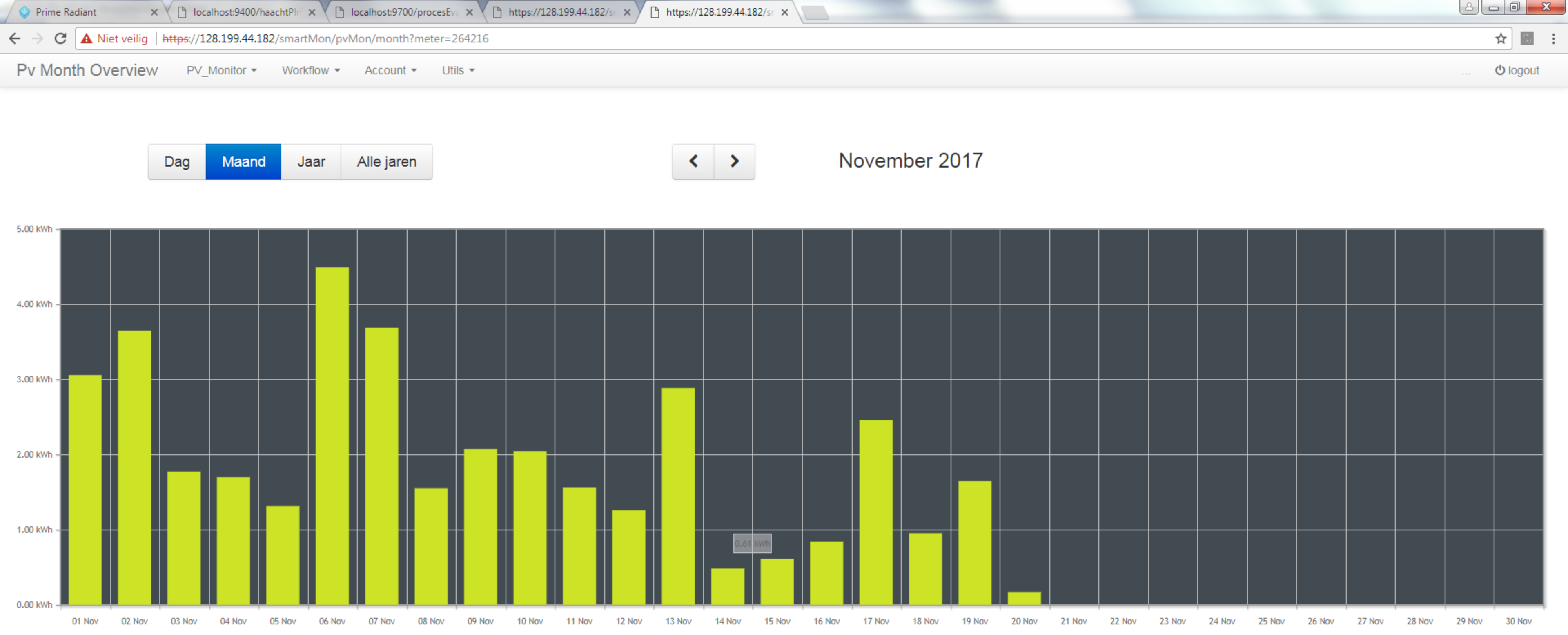
COORDINATOR

PROBLEEMOPLOSSENDE ONDERZOEKSHOUDING

Analytisch: Goed

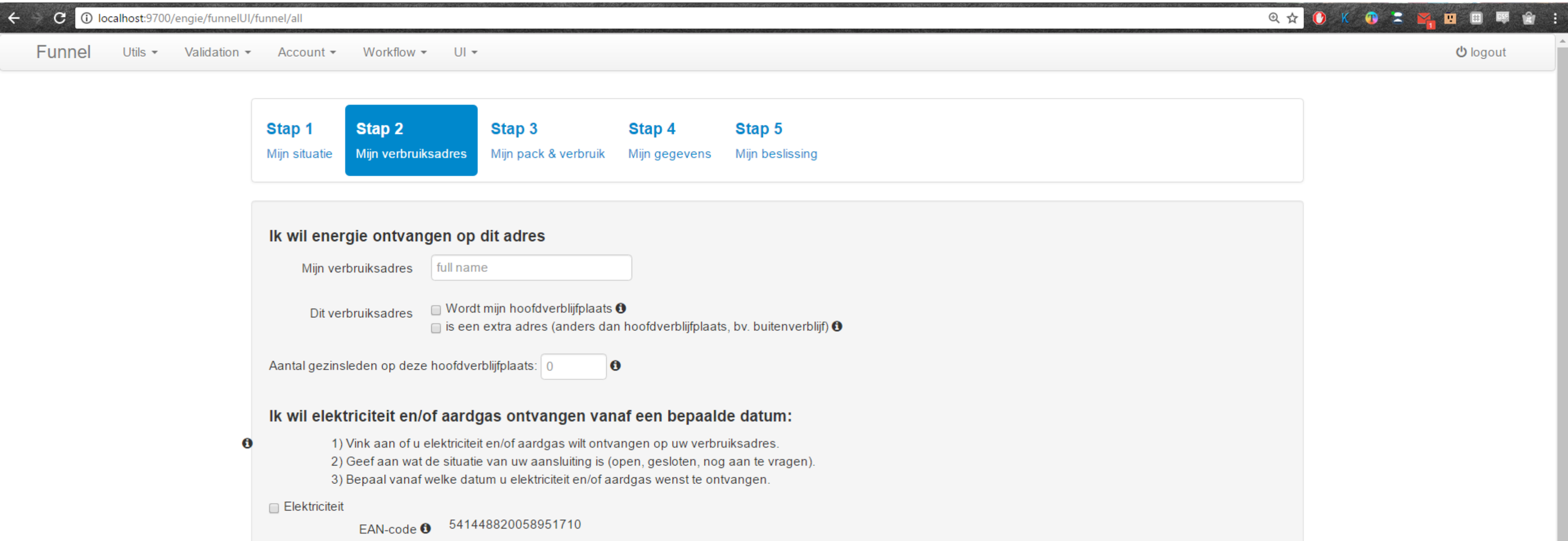


Naam	Status	Started at	Finished at	Eerste proces evaluatie	State task
TestStudent:EersteProcesNotifier	RapportVerzonden	21-11-2016	21-11-2016 18:48:50	TestStudent	EersteProcesNotifier
TestStudent:EersteProcesReporter	RapportGemaakt	21-11-2016	21-11-2016 18:48:20	TestStudent	EersteProcesReporter
TestStudent:EersteProcesNotifier	RapportVerzonden	18-11-2016	18-11-2016 15:07:50	TestStudent	EersteProcesNotifier
TestStudent:EersteProcesReporter	RapportGemaakt	18-11-2016	18-11-2016 15:07:20	TestStudent	EersteProcesReporter
TestStudent:EersteProcesNotifier	RapportVerzonden	17-11-2016	17-11-2016 14:14:19	TestStudent	EersteProcesNotifier
TestStudent:EersteProcesReporter	RapportGemaakt	17-11-2016	17-11-2016 14:13:49	TestStudent	EersteProcesReporter
TestStudent:EersteProcesNotifier	RapportVerzonden	16-11-2016	16-11-2016 18:52:00	TestStudent	EersteProcesNotifier



Pv Month Overview

November 2017



Funnel

Stap 1 Mijn situatie

Stap 2 Mijn verbruiksadres

Stap 3 Mijn pack & verbruik

Stap 4 Mijn gegevens

Stap 5 Mijn beslissing

Ik wil energie ontvangen op dit adres

Mijn verbruiksadres: full name

Dit verbruiksadres:
□ Wordt mijn hoofdverblijfplaats ℹ
□ is een extra adres (anders dan hoofdverblijfplaats, bv. buitenverblijf) ℹ

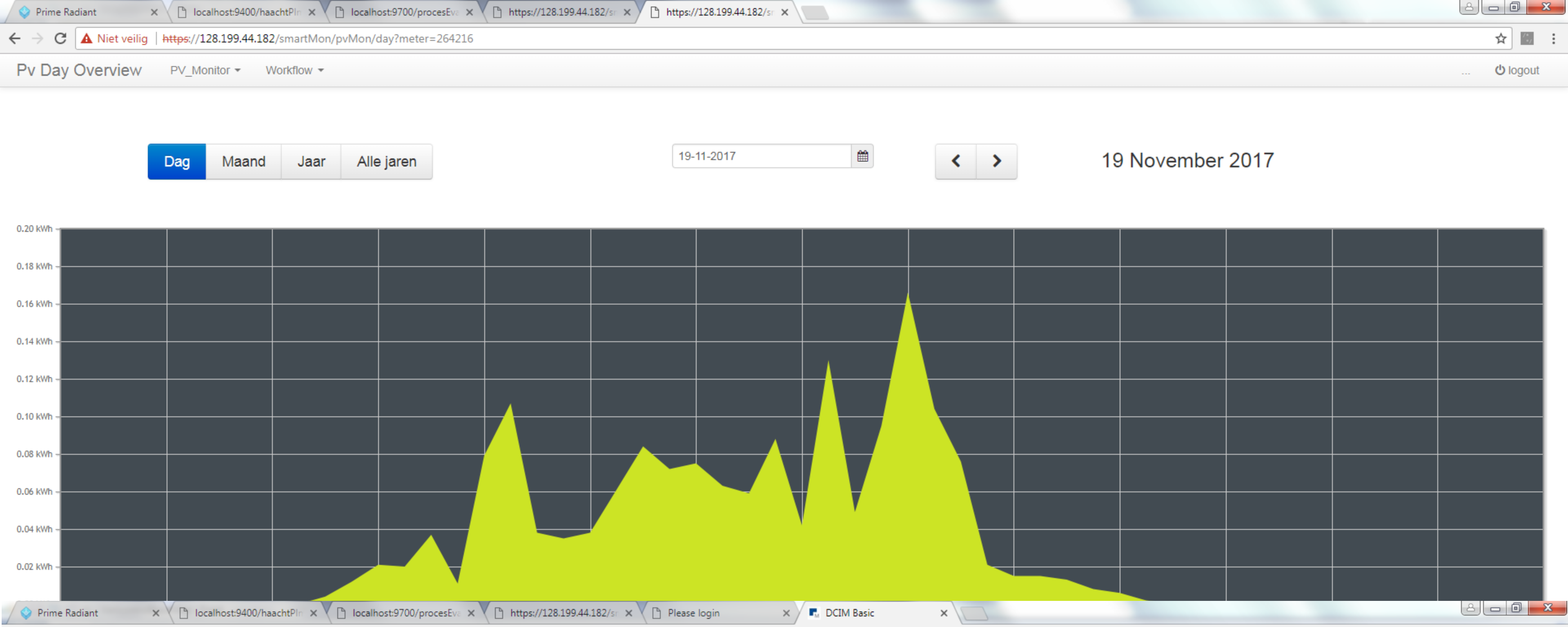
Aantal gezinsleden op deze hoofdverblijfplaats: 0 ℹ

Ik wil elektriciteit en/of aardgas ontvangen vanaf een bepaalde datum:

ℹ
1) Vink aan of u elektriciteit en/of aardgas wilt ontvangen op uw verbruiksadres.
2) Geef aan wat de situatie van uw aansluiting is (open, gesloten, nog aan te vragen).
3) Bepaal vanaf welke datum u elektriciteit en/of aardgas wenst te ontvangen.

□ Elektriciteit

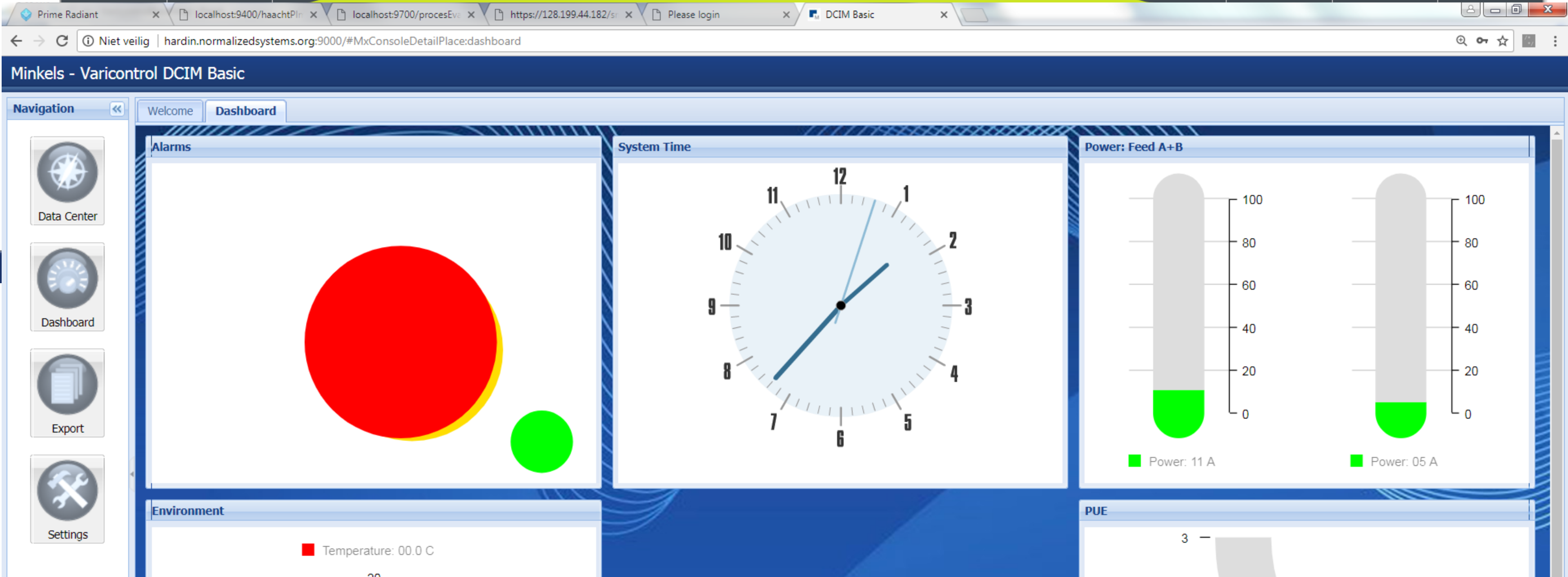
EAN-code ℹ 541448820058951710



Niet veilig | https://128.199.44.182/smartMon/pvMon/day?meter=264216

19-11-2017

19 November 2017



Niet veilig | hardin.normalizedsystems.org:9000/#MxConsoleDetailPlace:dashboard

🟩 Power: 11 A

🟩 Power: 05 A

🟥 Temperature: 00.0 C

Some Figures on ½ Codebase

Applications	± 20
Components	43
Data elements Attributes	1546 7094
Task elements	535
Flow elements	133

Skeletons	Total
Classes	± 40.000

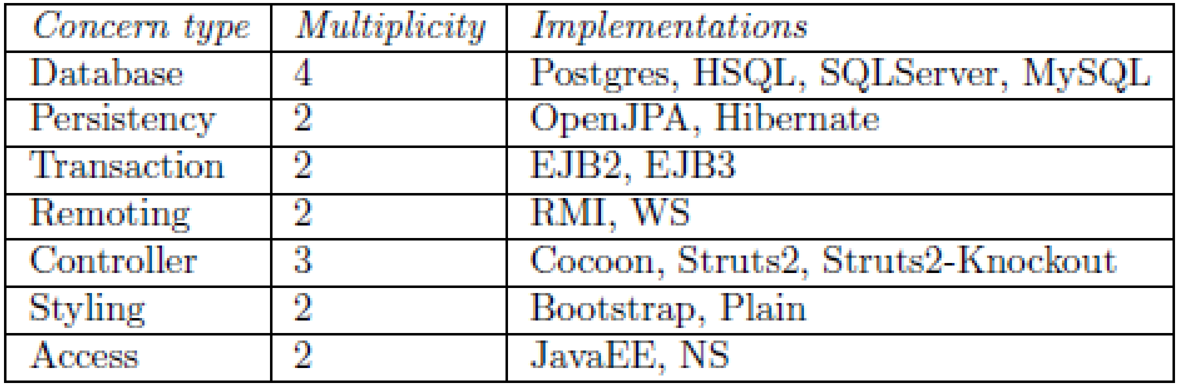
Extensions	Total
Data layer	6
Logic layer	1731
Shared layer	250
Proxy layer	5
Control layer	218
View layer	1186

Insertions	Total
Data element	1436
User connector	146
Task element	401
Flow element	0

Some Reports on Applications

- Detailed status report:
  - Model with various elements/attributes
  - Custom extensions/insertions in various layers
- Evolution report:
  - Model with various elements/attributes
  - Custom extensions/insertions in various layers
- Example: IoT Data Inflow Engine
  - Component monitoring

Some Figures on Utilities



Concern type	*Multiplicity*	*Implementations*
Database	4	Postgres, HSQL, SQLServer, MySQL
Persistency	2	OpenJPA, Hibernate
Transaction	2	EJB2, EJB3
Remoting	2	RMI, WS
Controller	3	Cocoon, Struts2, Struts2-Knockout
Styling	2	Bootstrap, Plain
Access	2	JavaEE, NS

Table 15.2: Overview of various technological implementations.

Variation Gain

4+2+2+2+3+2+2 = 17

4x2x2x2x3x2x2 = 384

From Continuous Integration to Continuous Rejuvenation

- Current CICD encompasses:
  - custom code evolution
  - model evolution
- CICD+Rejuvenation introduces:
  - new generator/skeleton versions
  - newly supported utility frameworks
- Our CICD environment expands and builds
  - most applications in several utility settings
  - all applications in new generator/skeleton version

From Continuous Integration to Continuous Rejuvenation

- Applications between 10 and 0 years old:
  - Some have been rejuvenated > 10 times

- Last rejuvenation max 3 or 6 months old:
  - Skeleton code (>90%) max 3-6 months old
  - Used frameworks supported by newest skeletons
  - Custom code
    - Has no conflicts with new(er)(est) skeletons
    - Does not depend on obsolete frameworks

From Continuous Integration to Continuous Rejuvenation

- All applications may benefit at once from:
  - Newly supported frameworks
  - Additional features skeletons
  - Improved security features
- Applications have benefitted in the past from:
  - New knockoutjs UI implementation
  - Auto-generation of waterfall screens
  - Configurable authentication/authorization
  - Improved high-throughput flow processing
  - …

DISCUSSION AND CONCLUSION

Discussion and Conclusions

- Contributions
  - *Insight* into current problems ~ Lehman’s Law
  - Proposing the structure of a possible *solution*
    - Software elements to guarantee stability
    - Applications as instantiations of elements
  - Charting *dimensions of evolvability*
    - Decoupling of skeletons and frameworks
    - Separating skeletons and custom code
  - Setting up a *rejuvenation CICD* environment
    - For a pretty significant *application set*

Discussion: Limitations

- Limitations:
  - Limited time span
  - Limited application set
  - Limited set of frameworks
  - *No collaborative model realized*

    ➔ *working on an “Expander API”*

***Goal*:**

All participating expander developers can make improvements to skeletons, that may be applied to all applications

Some References

- Mannaert Herwig, Verelst Jan, De Bruyn Peter.- Normalized Systems Theory: From Foundations for Evolvable Software Toward a General Theory for Evolvable Design. ISBN 978-90-77160-09-1 - Koppa, 2016, 507 p.
  [c:irua:136759]
- Mannaert Herwig, Verelst Jan, Ven Kris.- Towards evolvable software architectures based on systems theoretic stability. Software practice and experience - ISSN 0038-0644 - 42:1(2012), p. 89-116
  http://dx.doi.org/doi:10.1002/spe.1051
- Mannaert Herwig, Verelst Jan, Ven Kris.- The transformation of requirements into software primitives : studying evolvability based on systems theoretic stability. Science of computer programming - ISSN 0167-6423 - 76:12(2011), p. 1210-1222
  http://dx.doi.org/doi:10.1016/j.scico.2010.11.009
  [c:irua:91112]
- De Bruyn Peter, Mannaert Herwig, Verelst Jan, Huysmans Philip.- Enabling Normalized Systems in Practice – Exploring a Modeling Approach. Business and Information Systems Engineering - 60: 55 (2018), p. 55-67.
  https://doi.org/10.1007/s12599-017-0510-4

Questions

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