

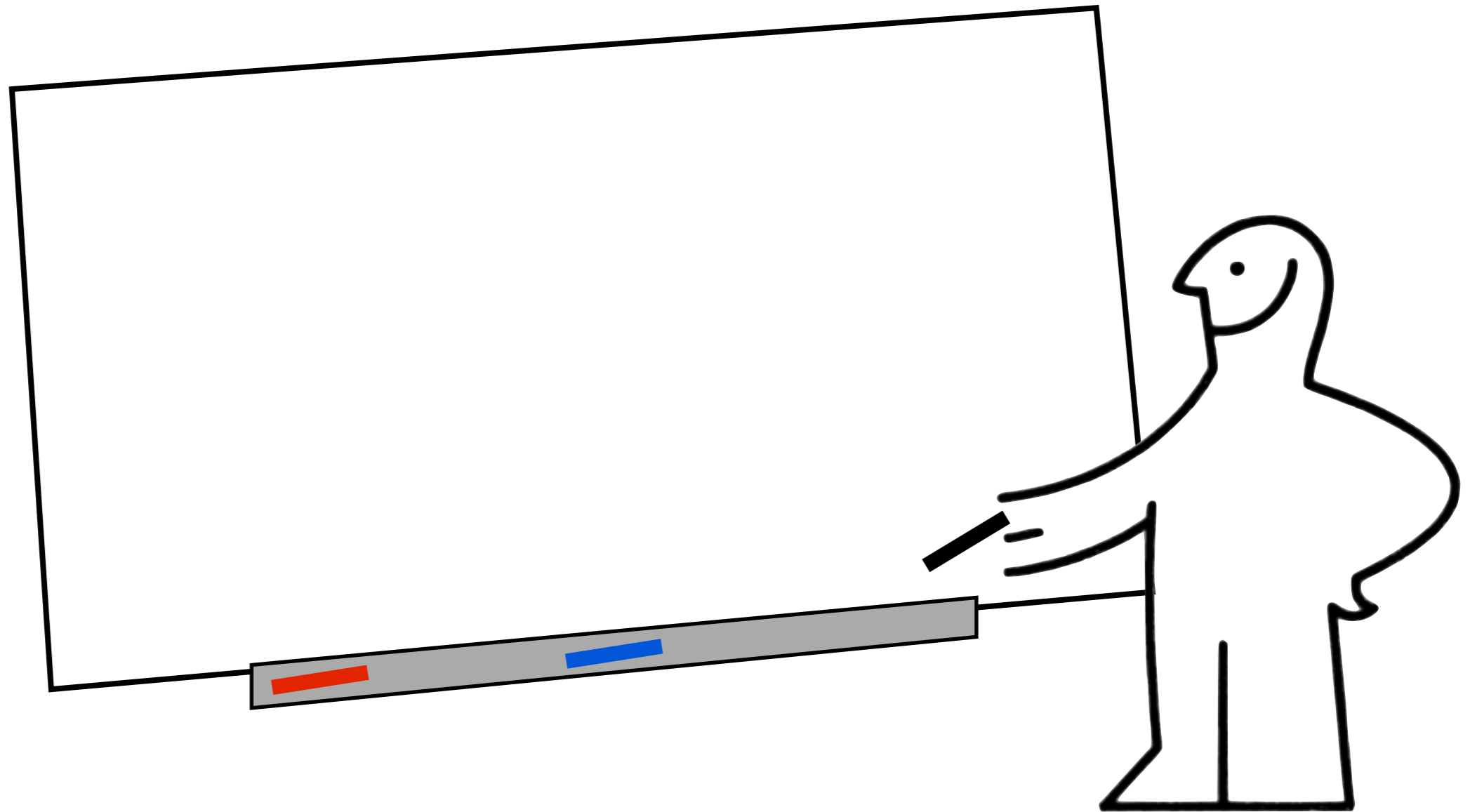
Forces on architecture decisions



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Uwe van Heesch
Paris Avgeriou
Rich Hilliard

Creating software architecture is making decisions

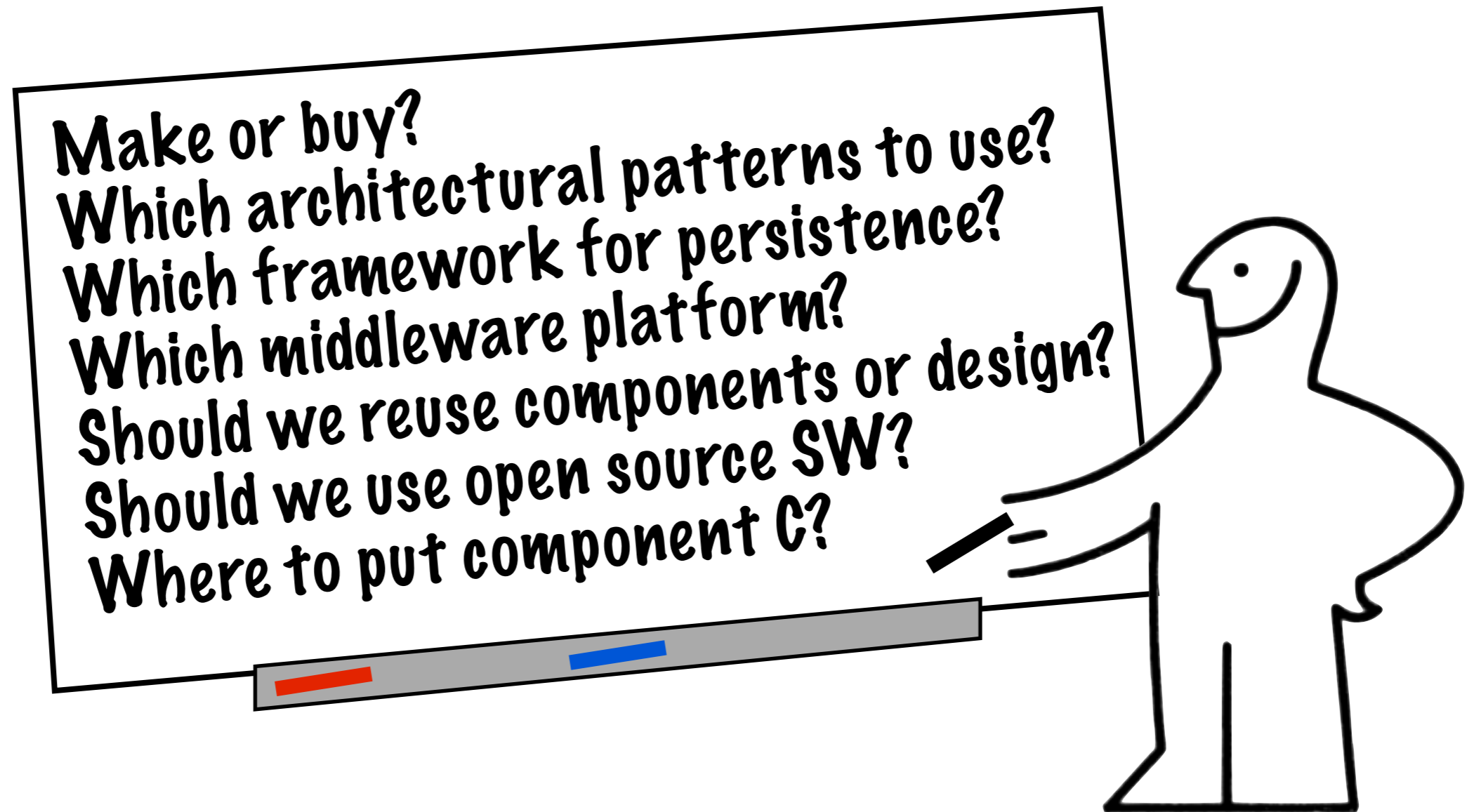


Architect



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Creating software architecture is making decisions

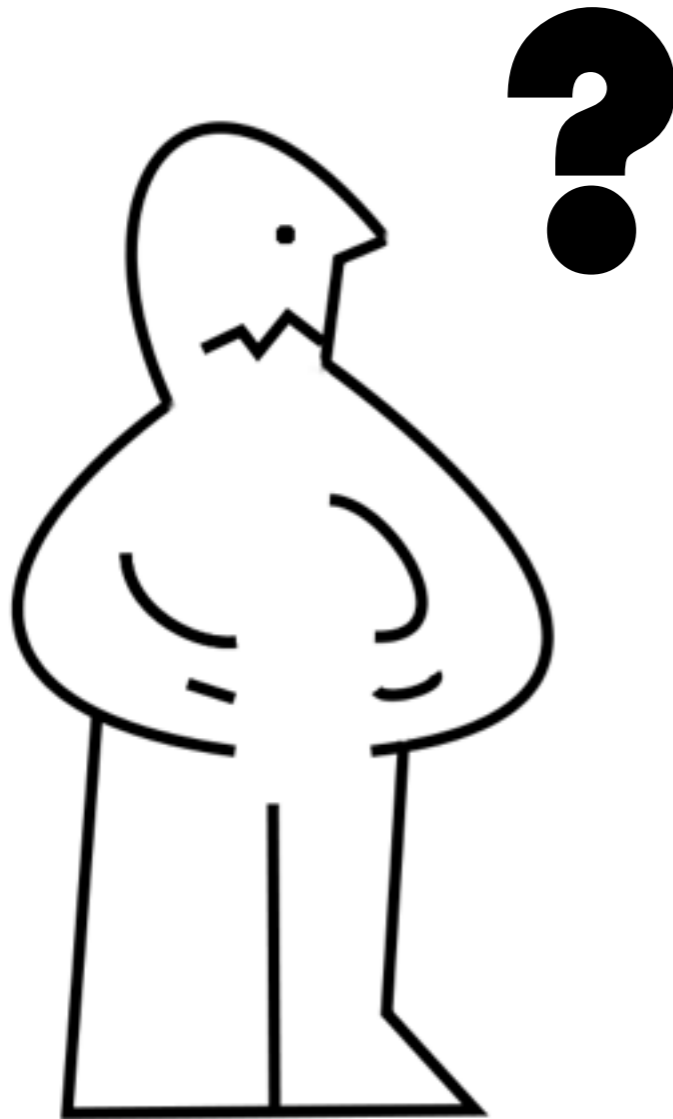


Architect



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Each decision implies a choice between 2 or more alternatives



PostgreSQL



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These choices are driven by **forces**.



PostgreSQL

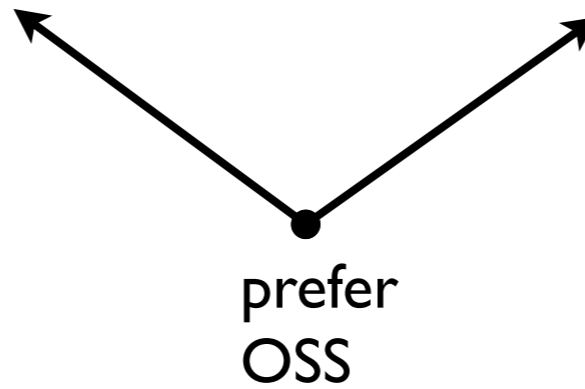


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PostgreSQL



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PostgreSQL

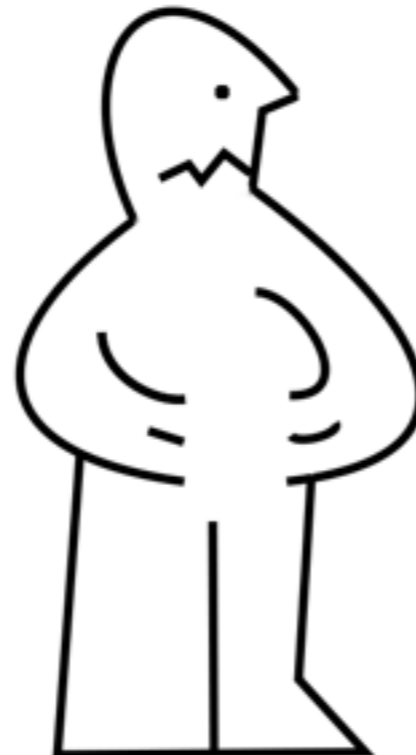
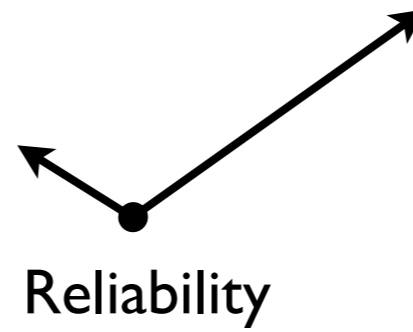


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Decisions are driven by **forces**.



PostgreSQL

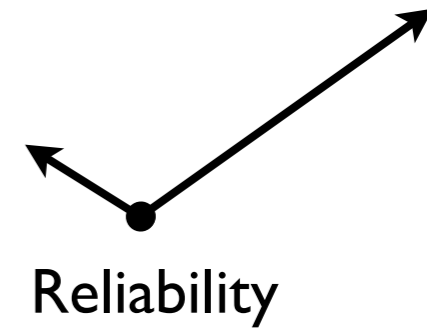


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PostgreSQL

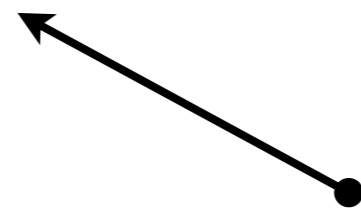


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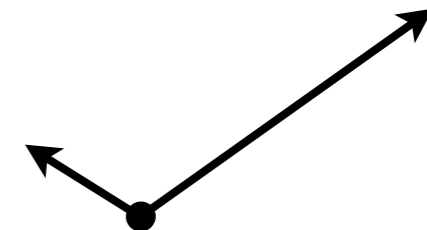
Decisions are driven by **forces**.



PostgreSQL



Experience

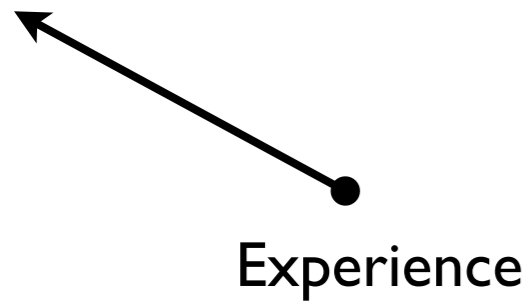


Reliability



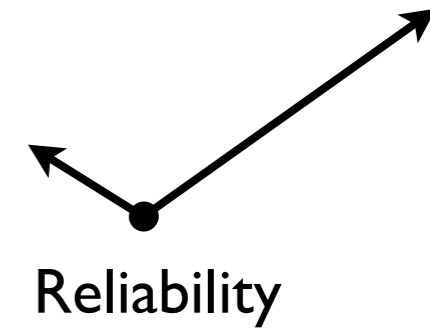
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Experience

PostgreSQL



Reliability

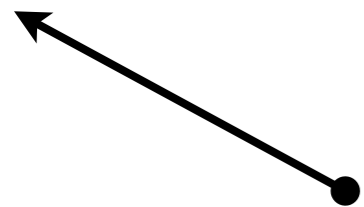


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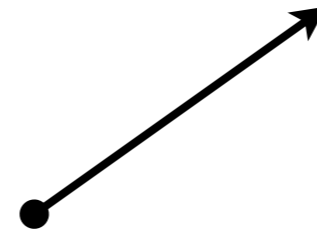
Decisions are driven by **forces**.



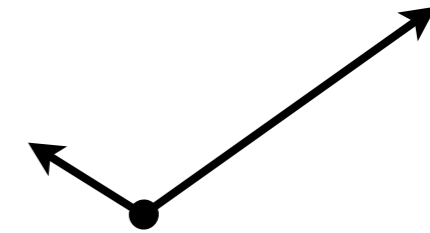
PostgreSQL



Experience



Strateg. development



Reliability

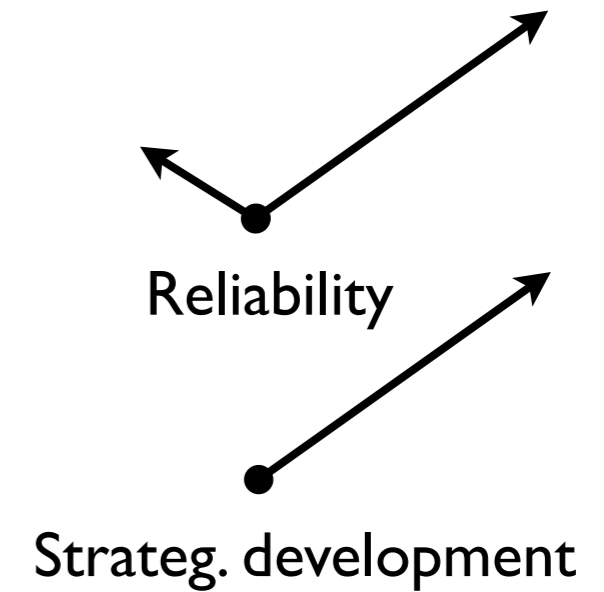
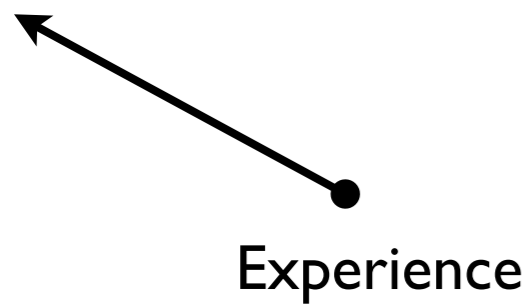


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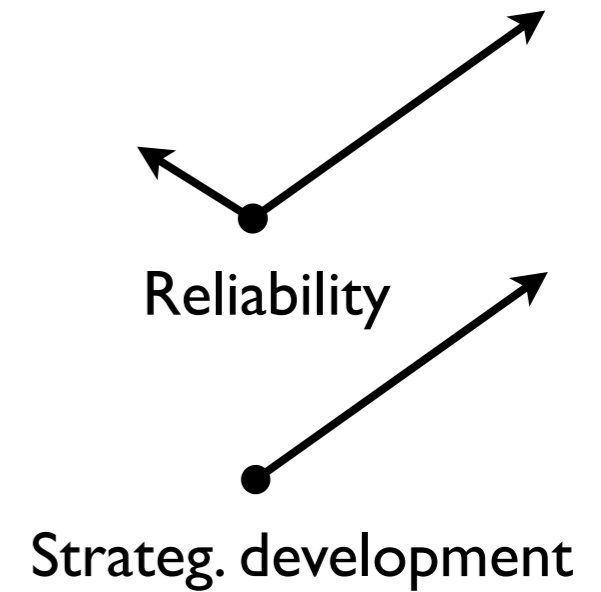
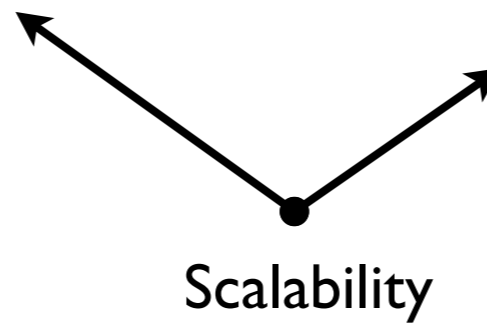
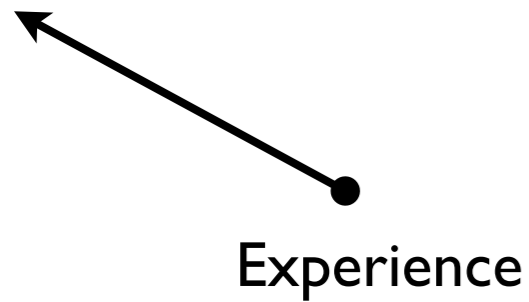
PostgreSQL



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PostgreSQL

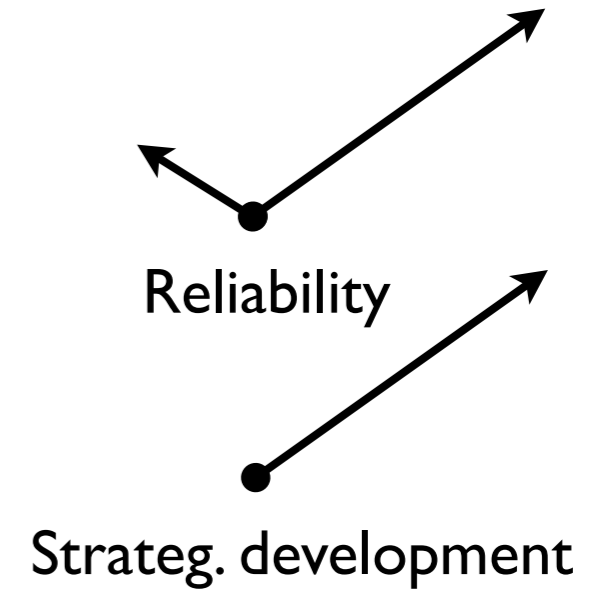
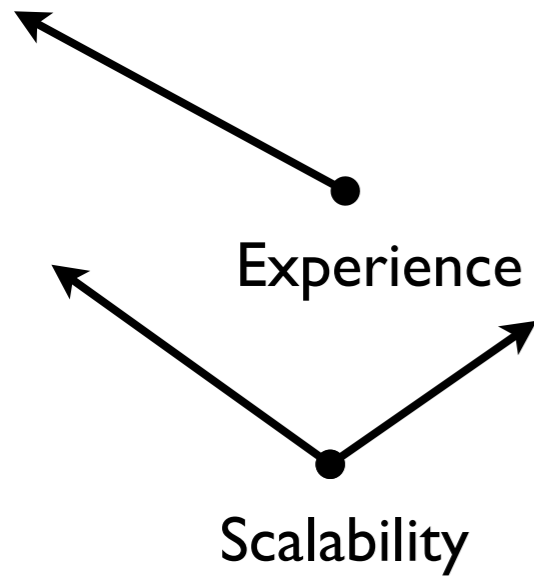


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PostgreSQL

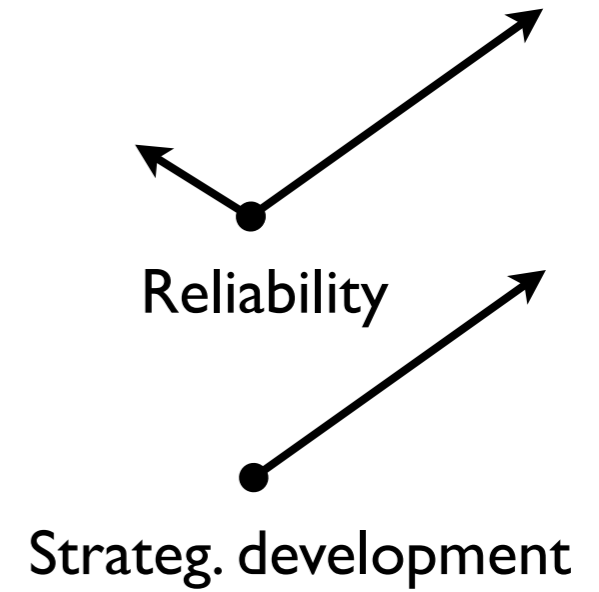
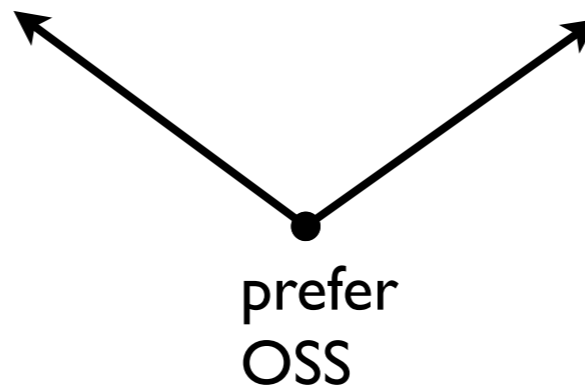
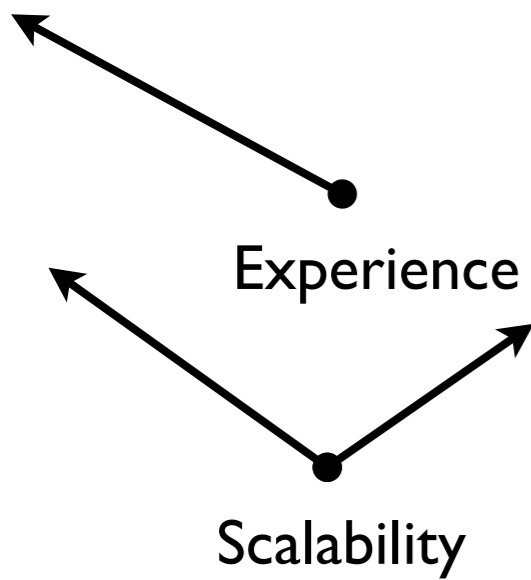


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PostgreSQL

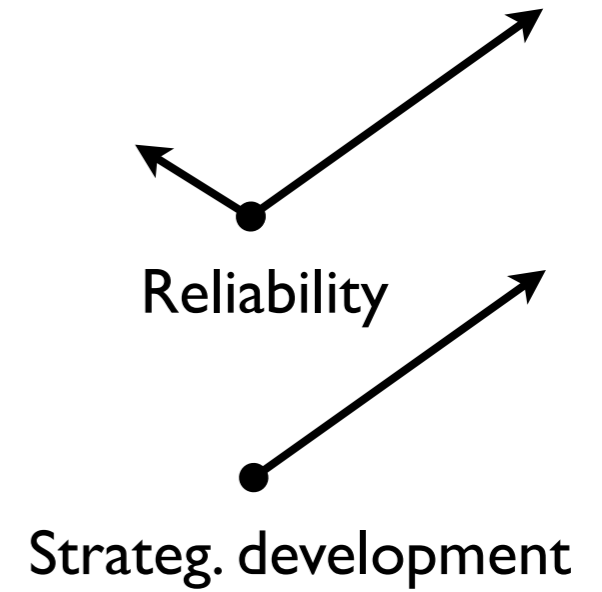
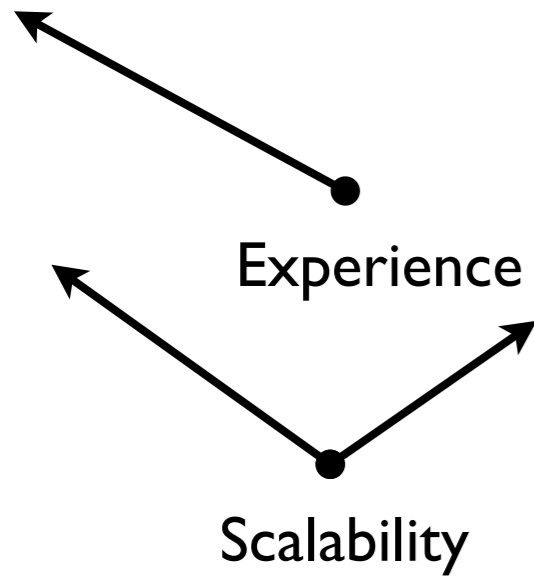


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Decisions are driven by **forces**.



PostgreSQL



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Decisions are driven by forces.



PostgreSQL



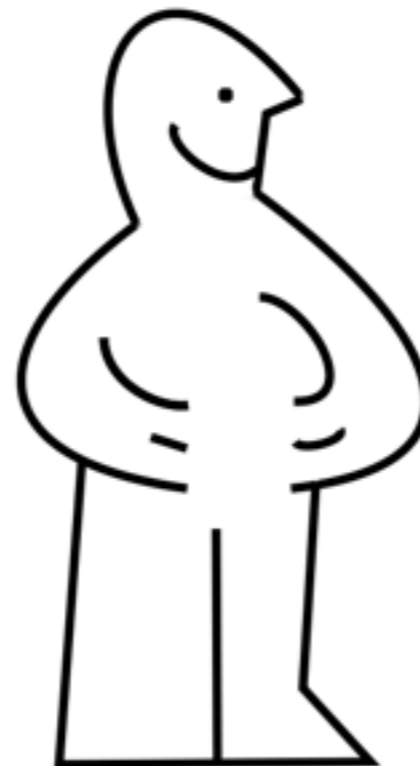
Resulting force

Reliability

Strateg. development

Experience

Scalability



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A force is **any aspect of an architectural problem arising in the system or its environment** (operational, development, business, organizational, political, economic, legal, regulatory, ecological, social, etc.), to be **considered when choosing among the available decision alternatives.**



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Typical forces

Typical forces

requirements



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Typical forces

requirements

business goals

Typical forces

requirements

business goals

constraints

Typical forces

requirements

business goals

regulations

constraints

Typical forces

requirements

business goals

laws

regulations

constraints



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Typical forces

requirements

business goals

laws

standards

regulations

constraints



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Typical forces

requirements

business goals

laws

principles

standards

regulations

constraints



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Typical forces

requirements

business goals

hw/sw interfaces

laws

principles

standards

regulations

constraints



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Typical forces

requirements

business goals

hw/sw interfaces

laws

principles

standards

previously made ADs

regulations

constraints



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requirements

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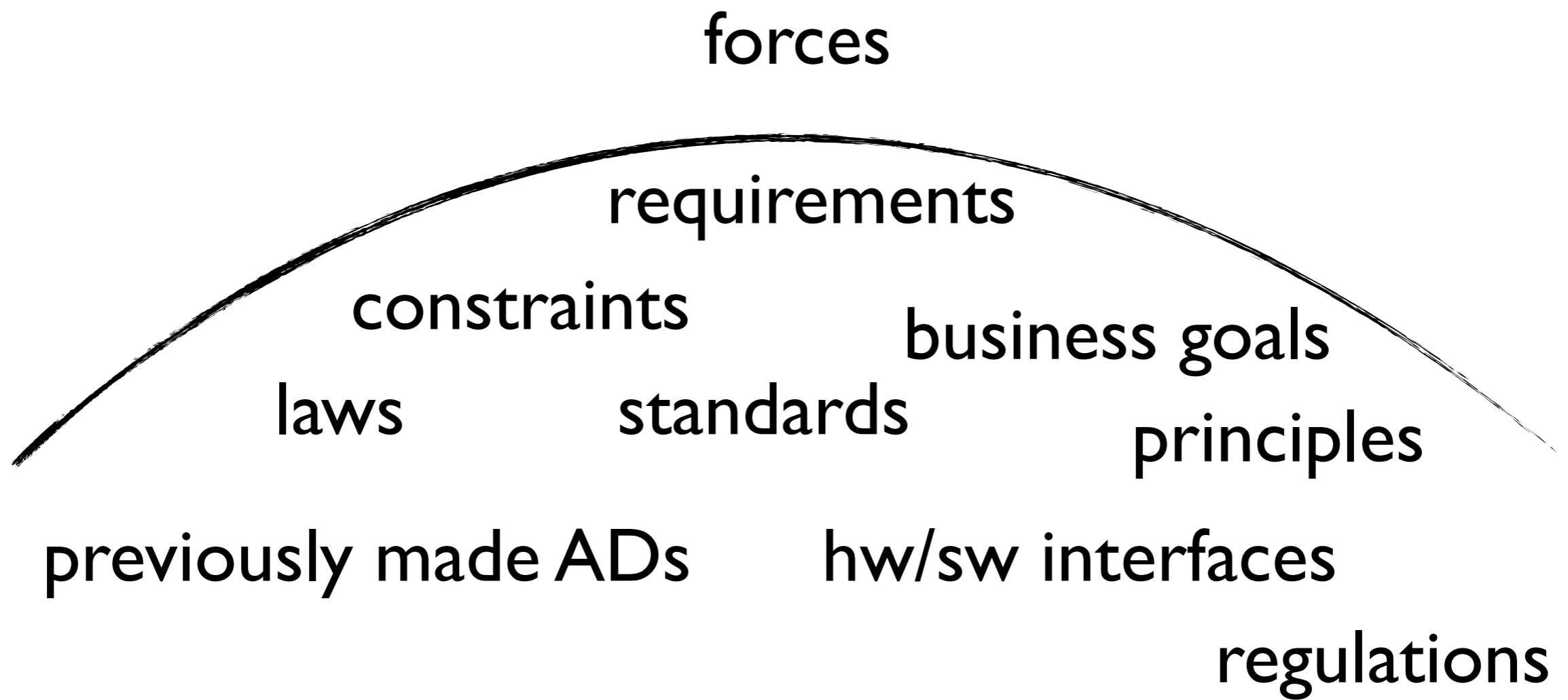
previously made ADs

hw/sw interfaces

regulations

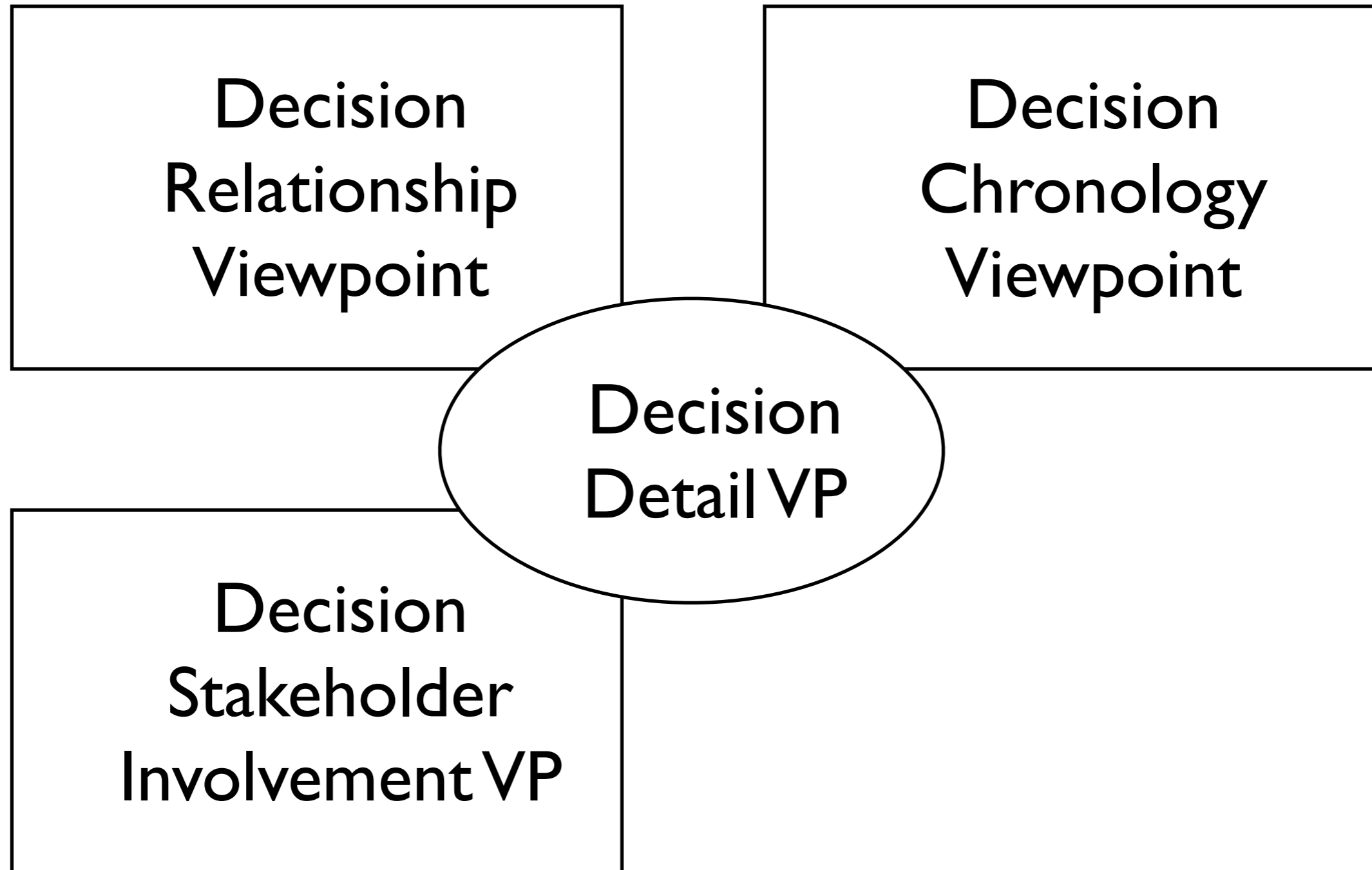


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How to model and document forces?

A framework for architecture decisions



using the conventions from **ISO/IEC/IEEE 42010**

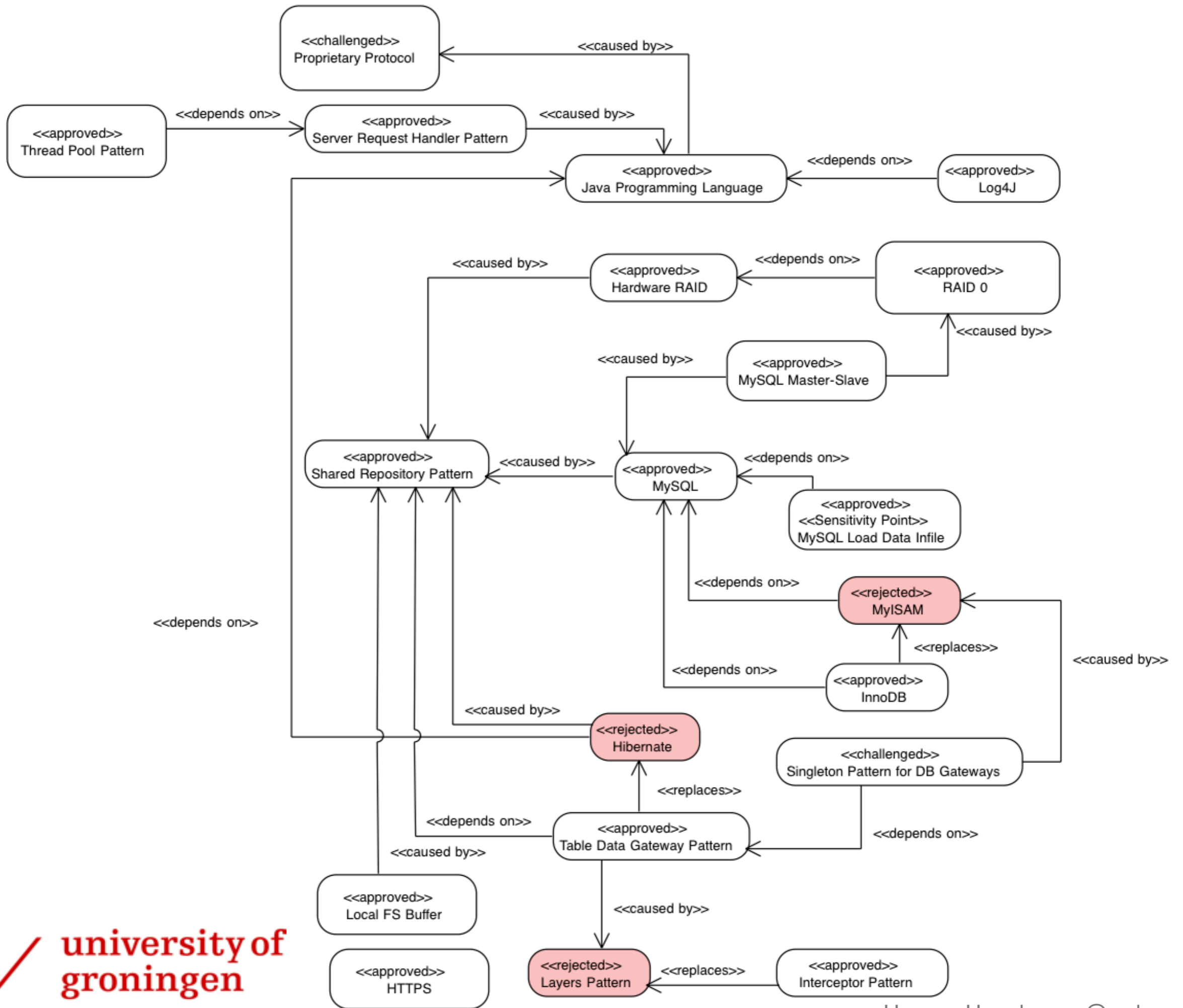


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Decision Relationship Viewpoint



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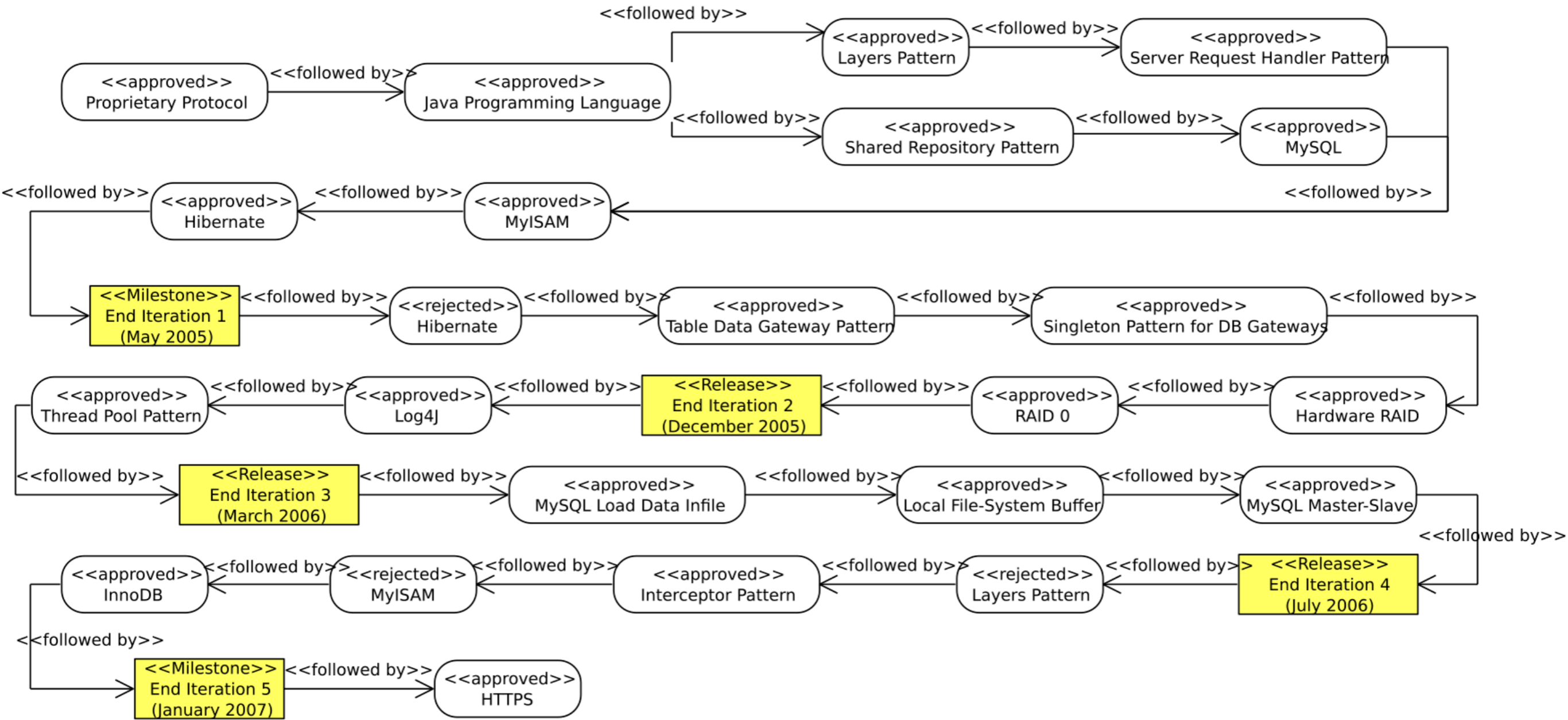


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Decision Chronology Viewpoint



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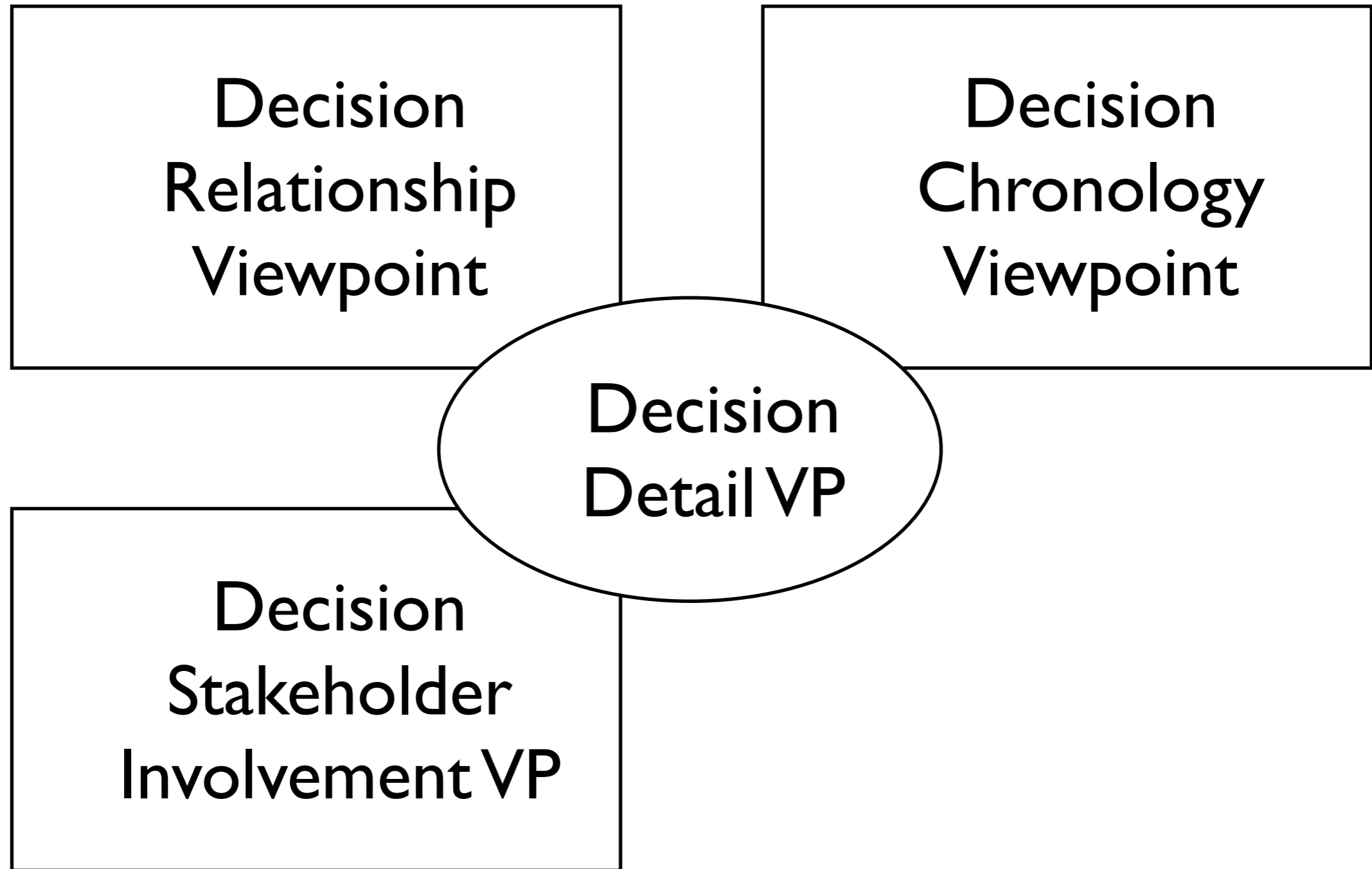


Decision Chronology Viewpoint



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A framework for architecture decisions

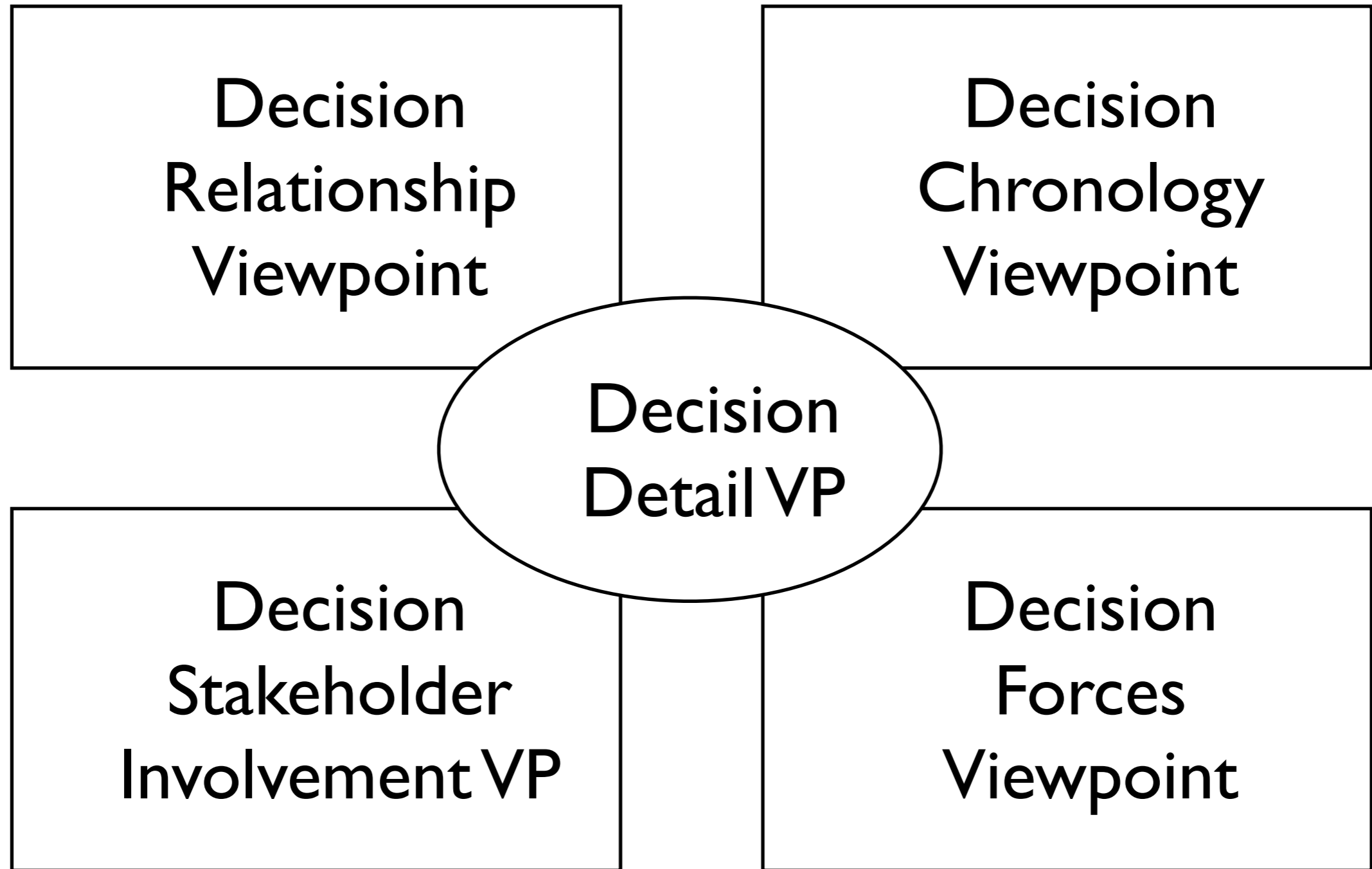


using the conventions from **ISO/IEC/IEEE 42010**



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A framework for architecture decisions



using the conventions from **ISO/IEC/IEEE 42010**



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Example of a forces view

			View technology			Data storage	Middleware	DBMS	
			<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>
			Java Swing	PHP	JSF	Central DS	EJB	MySQL	PostgreSQL
Architecture significant requirements									
	Code	Description	Concern(s)						
	R1	Avg. response time <= 0.1s	Time behavior	++	+	-	-	-	+
	R5	Integrate mult. payment providers	Extendability	+		+		+	
	R6	Reliability of data storage	Reliability				++	+	++
	R8	Availability of full service (99.9%)	Reliability	++	+	+	+	-	+
	R9	Support growing no of users	Scalability	++	+	-	-	+	-
	R13	Security (personal data protection)	Security	+		?	+		?
	R16	Client platform independence	Portability	+	++	++			
	R23	Operability of user interface	Usability	++	+	+			
	R24	Communication via Internet	Network comm.		++	++	+	+	+
	R26	HBCI support	Banking protocols	+	?	+		+	
	R27	No paid 3 rd party licences	Development costs	+	+	+			++
Other forces									
	F1	Inhouse experience	Development time						
	F1.1	Swing (very good)	Development time	++					
	F1.2	PHP (decent)	Development time		+				
	F1.3	JPA (good)	Development time						
	F1.4	MySQL (very good)	Development time				+		++
	F1.5	JSF (very good)	Development time			+			
	F2	Strategic knowledge development	Competitiveness						++
	F2.1	Learn Postgres	Competitiveness				+		++
	F2.2	Improve Javascript skills	Competitiveness	--	+	+			
	F2.3	Learn JQuery	Competitiveness	--	+	+			
	F4	Linux server available	Development costs		+	+	+	+	+
	F5	Non business criticality	Business criticality						+
	F7	Resource usage on server	Resource utilization	++	-	--	--	--	+



			View technology			Data storage	Middleware	DBMS		
			<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>	
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	R13	Security (personal data protection)	Security	+		?	+		?	?
	R16	Client platform independence	Portability	+	++	++				
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	R24	Communication via Internet	Network comm.		++	++	+	+	+	+
	R26	HBCI support	Banking protocols	+	?	+		+		
	R27	No paid 3 rd party licences	Development costs	+	+	+			++	++
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	F4	Linux server available	Development costs		+	+	+	+		+
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	F7	Resource usage on server	Resource utilization	++	-	--	--	--	+	?



decision topic



			View technology			Data storage	Middleware	DBMS		
			<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>	
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	F7	Resource usage on server	Resource utilization	++	-	--	--	--	+	?



decision topic

decision



View technology			Data storage	Middleware	DBMS	
<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>
Java Swing	PHP	JSF	Central DS	EJB	MySQL	PostgreSQL

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decision topic

decision

decision state

View technology			Data storage	Middleware	DBMS	
<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>
Java Swing	PHP	JSF	Central DS	EJB	MySQL	PostgreSQL

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decision state

decision

decision topic

forces

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decision state

decision

decision topic

forces

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R13	Security (personal data protection)	Security	+		?	+		?	?
R16	Client platform independence	Portability	+	++	++				
R23	Operability of user interface	Usability	++	+	+				
R24	Communication via Internet	Network comm.		++	++	+	+	+	+
R26	HBCI support	Banking protocols	+	?	+		+		
R27	No paid 3 rd party licences	Development costs	+	+	+			++	++
Other forces									
F1	Inhouse experience	Development time							
F1.1	Swing (very good)	Development time	++						
F1.2	PHP (decent)	Development time		+					
F1.3	JPA (good)	Development time							
F1.4	MySQL (very good)	Development time				+		++	
F1.5	JSF (very good)	Development time			+				
F2	Strategic knowledge development	Competitiveness							++
F2.1	Learn Postgres	Competitiveness				+			++
F2.2	Improve Javascript skills	Competitiveness	--	+	+				
F2.3	Learn JQuery	Competitiveness	--	+	+				
F4	Linux server available	Development costs		+	+	+	+		+
F5	Non business criticality	Business criticality							+
F7	Resource usage on server	Resource utilization	++	-	--	--	--	+	?

Decision Forces

impact rating



Concerns framed by the forces viewpoint

Code	Concern
C3	What is the rationale for decision D ?
C4	What concerns C_i does decision D pertain to?
C5	What forces F_j impact/influence decision D ?
C6	What decisions D_k are influenced by force F ?
C7	What forces F_l have conflicting influences on decision D ?
C23	What decisions D_p or decision sub-graphs SG_q can be reused in other projects?



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			View technology			Data storage	Middleware	DBMS		
			<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>	
			Java Swing	PHP	JSF	Central DS	EJB	MySQL	PostgreSQL	
Architecture significant requirements										
Decision Forces	Code	Description	Concern(s)							
	R1	Avg. response time $\leq 0.1s$	Time behavior	++	+	-	-	-	+	
	R5	Integrate mult. payment providers	Extendability	+		+		+		
	R6	Reliability of data storage	Reliability				++	+	+	
	R8	Availability of full service (99.9%)	Reliability	++	+	+	+	-	+	
	R9	Support growing no of users	Scalability	++	+	-	-	+	-	
	R13	Security (personal data protection)	Security	+		?	+		?	
	R16	Client platform independence	Portability	+	++	++				
	R23	Operability of user interface	Usability	++	+	+				
	R24	Communication via Internet	Network comm.		++	++	+	+	+	
	R26	HBCI support	Banking protocols	+	?	+		+		
	R27	No paid 3 rd party licences	Development costs	+	+	+			++	
	Other forces									
	F1	Inhouse experience	Development time							
	F1.1	Swing (very good)	Development time	++						
F1.2	PHP (decent)	Development time		+						
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F2	Strategic knowledge development	Competitiveness							++	
F2.1	Learn Postgres	Competitiveness				+			++	
F2.2	Improve Javascript skills	Competitiveness	--	+	+					
F2.3	Learn JQuery	Competitiveness	--	+	+					
F4	Linux server available	Development costs		+	+	+	+		+	
F5	Non business criticality	Business criticality							+	
F7	Resource usage on server	Resource utilization	++	-	--	--	--	+	?	



Validation of the forces viewpoint

- multiple **case study**
- **3 groups** of graduating **students**
- working **in non-academic SW projects**
(2 industrial, 1 open source)
- used our **decision framework to model ADs**
- observed over a **period of seven weeks**



Research questions

RQ1: How does the forces viewpoint support the decision making process?

RQ2: Which decision-related concerns does the forces viewpoint support?



Data collection and analysis

- work artifacts
- weekly focus groups
- participant observation
- grounded theory for data analysis



Results

Code	Category	PrjA	PrjB	PrjC	Concerns	Res. Qu.
Cat1	Required students to think more carefully about decisions.	X	X	X		RQ1
Cat2	Triggered students to consider quality attribute requirements.	X	X	X		RQ1
Cat3	Prevents ad-hoc decisions.	X	X	X		RQ1
Cat4	Forces viewpoint will be used in other projects.	X	X	X		RQ1
Cat5	Triggered students to identify more alternatives.	X	X			RQ1
Cat6	Good way to document decisions.		X	X		RQ1
Cat7	Creating the forces view took a lot of time.	X				RQ1
Cat8	Prevents inefficient discussions about decisions.	X				RQ1
Cat9	Created with reasonable effort.	X				RQ1
Cat10	Saved time in the end.		X			RQ1
Cat11	Support for rational decisions.			X		RQ1
Cat12	Forces view complements relationship view.			X		RQ1
Cat13	Useful for architects, designers, programmers, and new project members.			X		RQ1
Cat14	Support for weighing forces is missing.			X		RQ1
Cat15	Identifying all forces is a matter of experience.			X		RQ1
Cat16	Forces view and relationship view are simultaneously refined.			X		RQ1
Cat17	Proper tool support needed.			X		RQ1
Cat18	Maintain overview over architectural decisions, concerns, and forces.	X	X	X	C4,C5,C6	RQ1,RQ2
Cat19	Helpful to systematically compare decision alternatives in the context of forces.	X	X	X	C5,C6	RQ1,RQ2
Cat20	Help for estimating requirements coverage.	X		X	C6	RQ1,RQ2
Cat21	Support for systematic trade-offs between forces.			X	C7	RQ1,RQ2
Cat22	Supports sharing architecture rationale.	X	X	X	C3, C23	RQ2

Results

- + supports decision making process of (inexperienced) designers
 - + provides a structure for making systematic decisions
 - + documents rationale that went into decisions
 - + satisfies the stakeholder concerns assigned to the viewpoint
-
- different weights for forces needed
 - identifying forces requires experience

Ongoing work

- decision-centric architecture evaluation based on forces
- lists of domain specific forces
- different approaches to weighing forces
- different approaches to force impact ratings
- improved tool support for decision framework



Thank you for your attention

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