

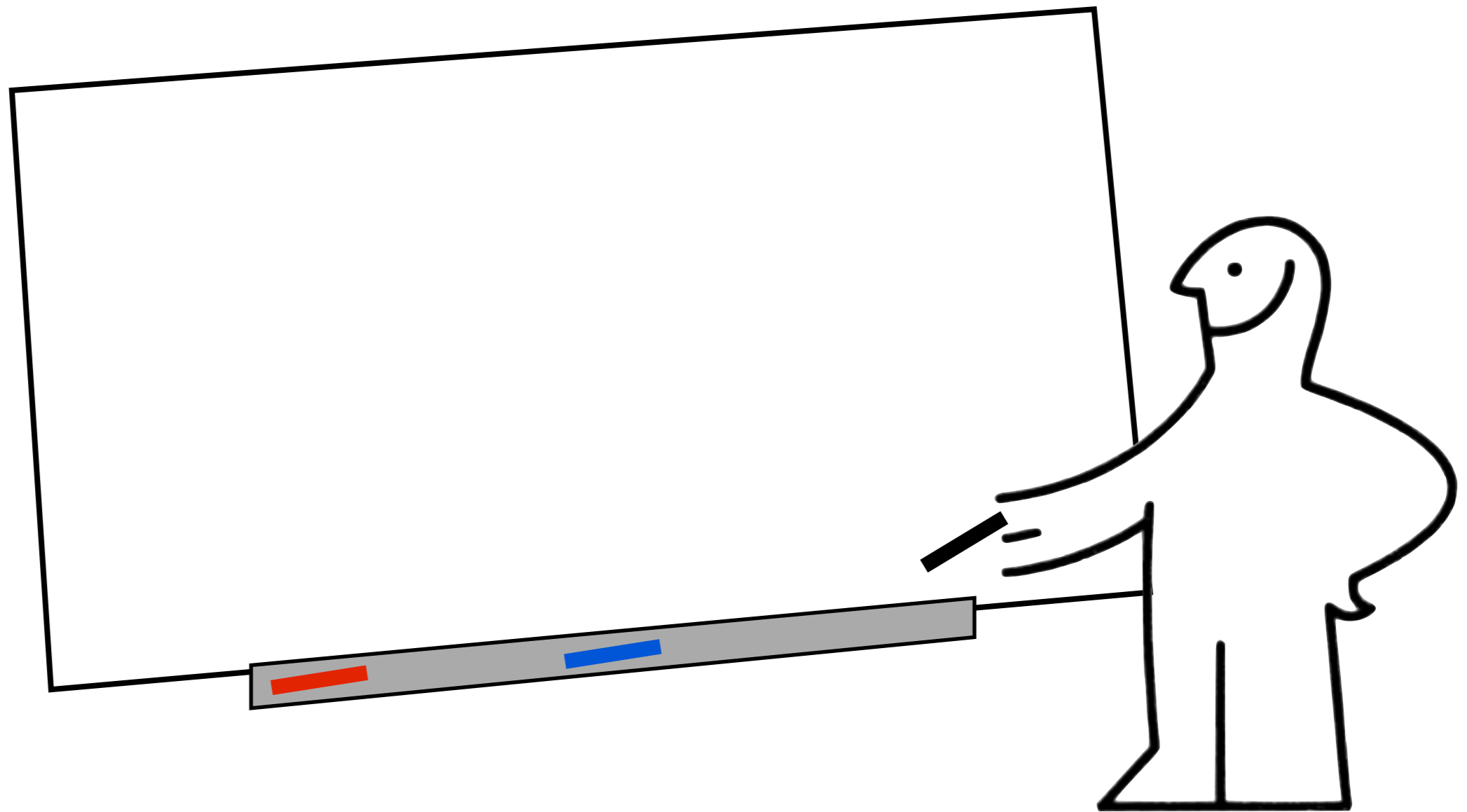
# Forces on architecture decisions



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Uwe van Heesch  
Paris Avgeriou  
Rich Hilliard

# Creating software architecture is making decisions

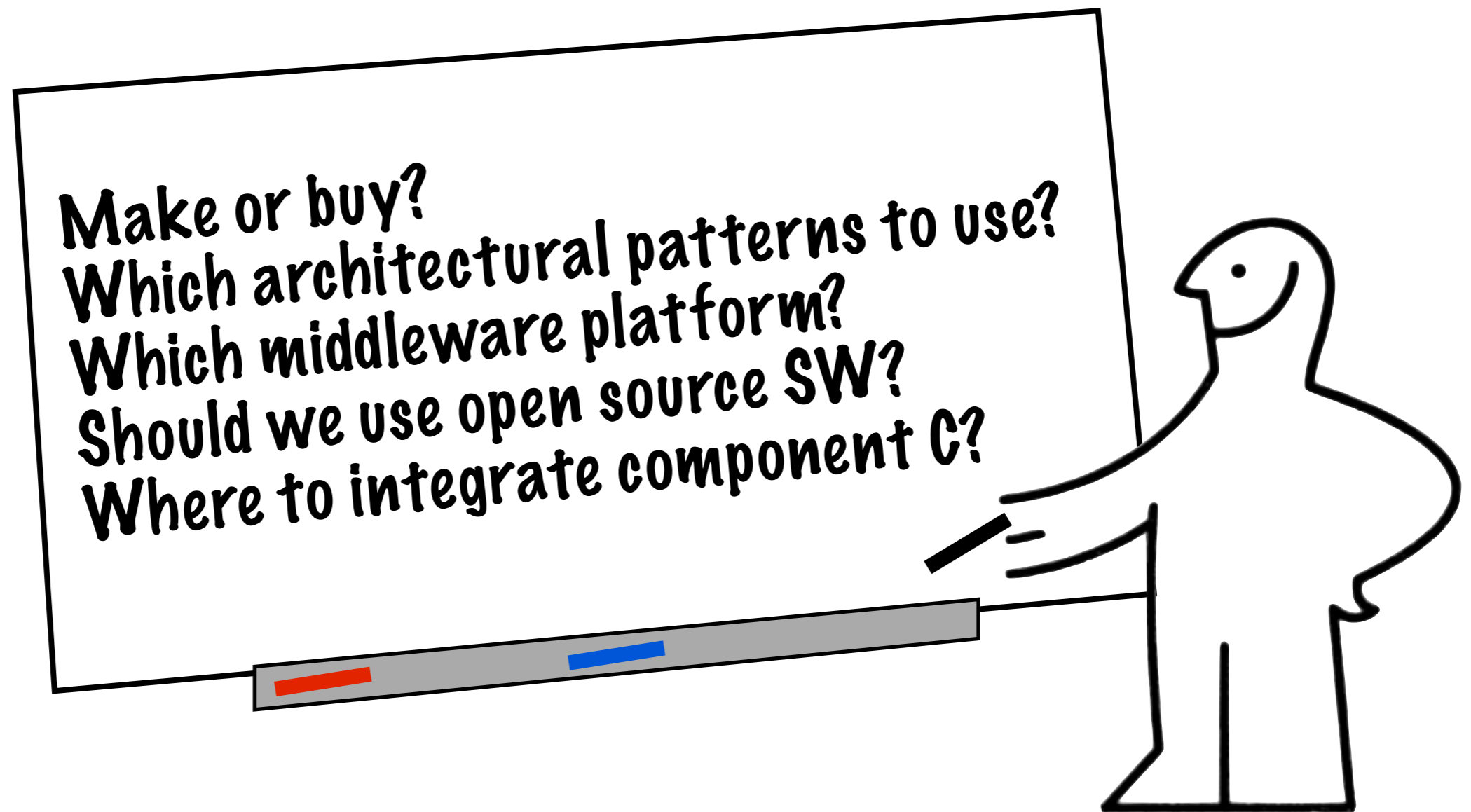


Architect



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# Creating software architecture is making decisions

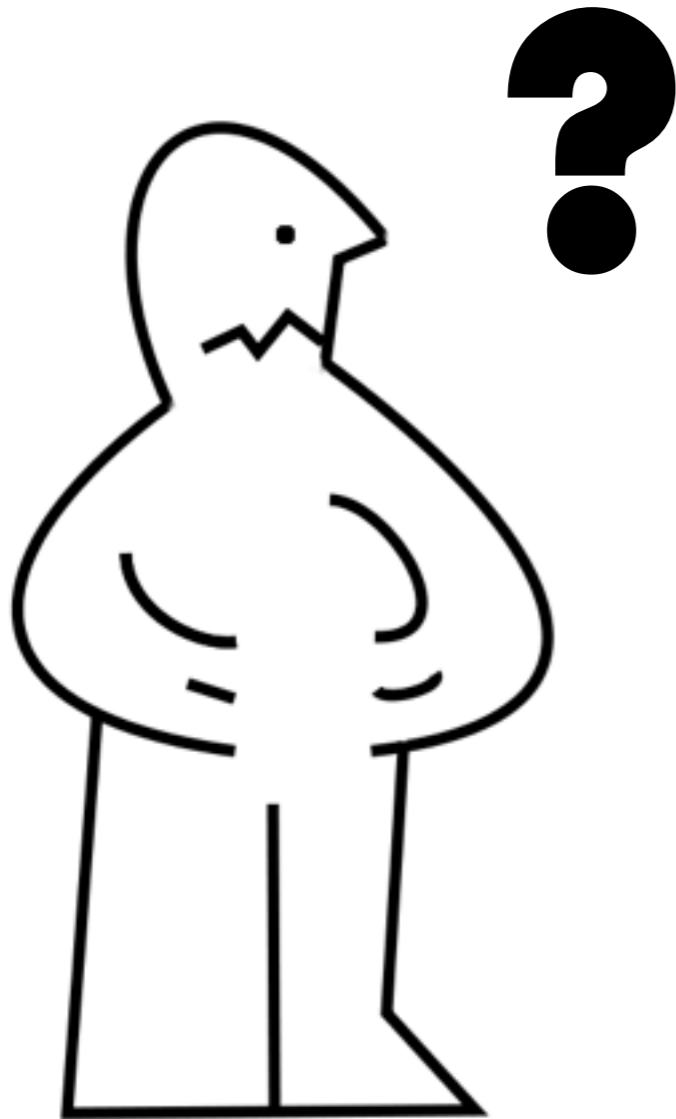


Architect



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Each decision implies a choice between 2 or more alternatives



PostgreSQL

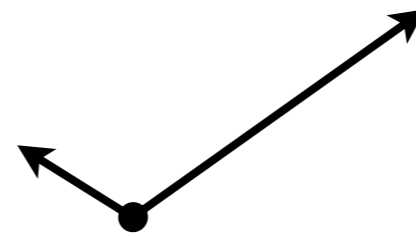


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# Decisions are driven by **forces**.



PostgreSQL



Reliability

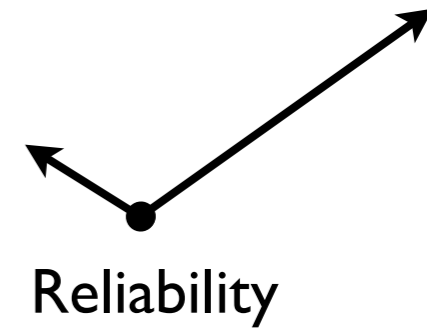


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# Decisions are driven by **forces**.



PostgreSQL

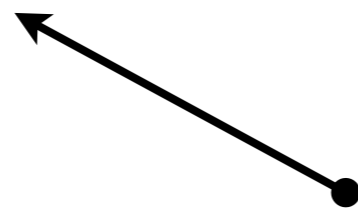


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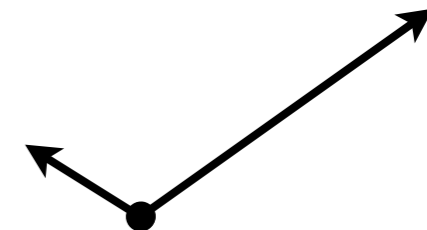
# Decisions are driven by **forces**.



PostgreSQL



Experience



Reliability



5

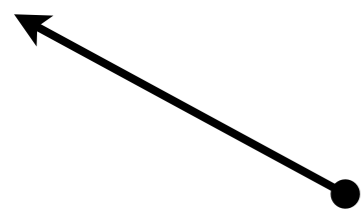


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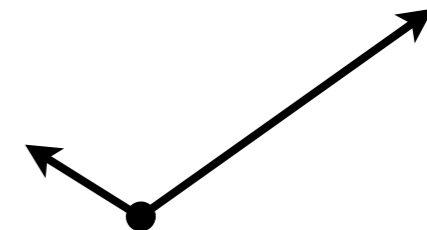
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PostgreSQL



Experience



Reliability



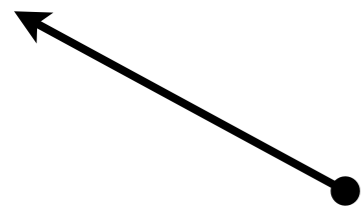
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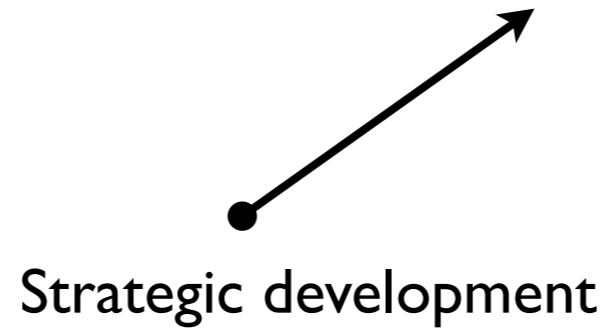
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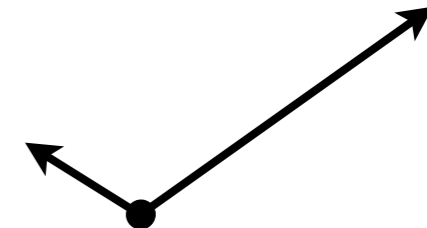
PostgreSQL



Experience



Strategic development



Reliability

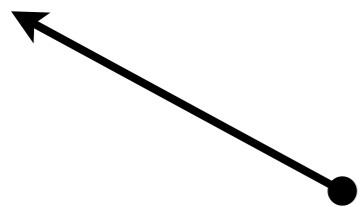


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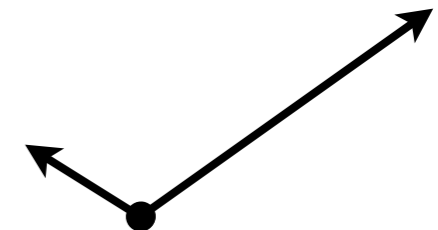
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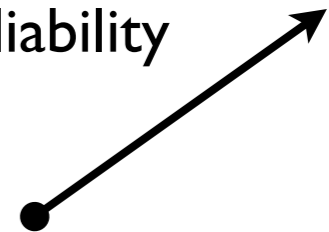
PostgreSQL



Experience



Reliability



Strategic development

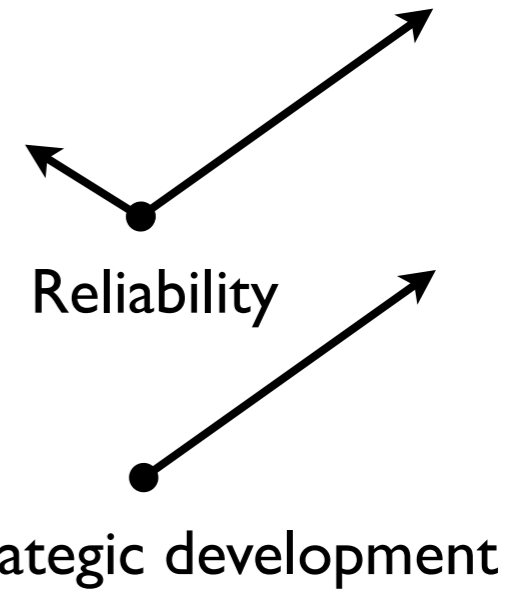
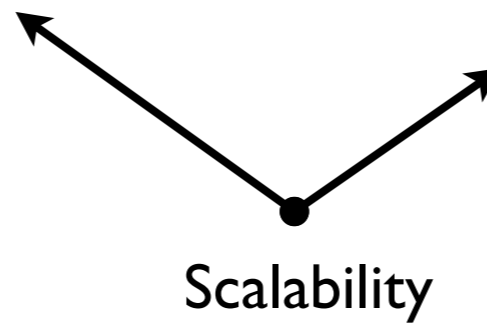
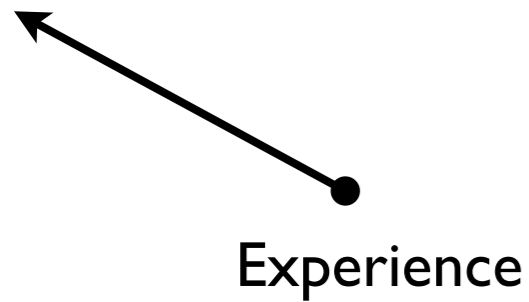


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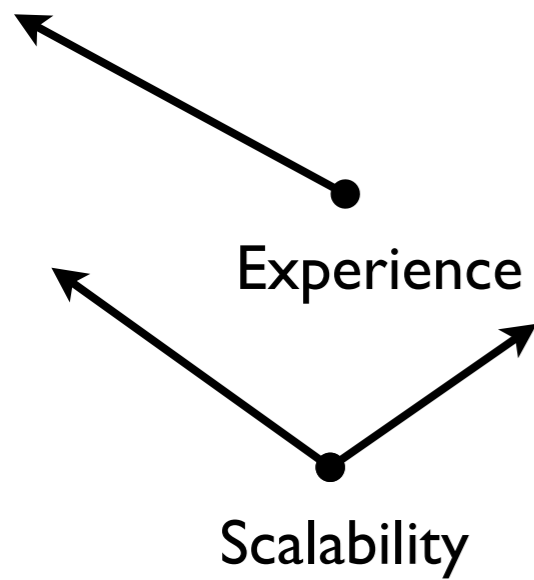


PostgreSQL

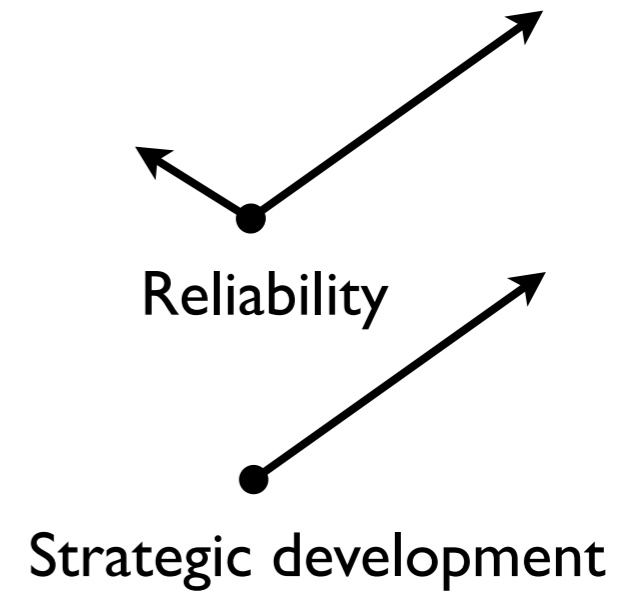


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# Decisions are driven by **forces**.



PostgreSQL

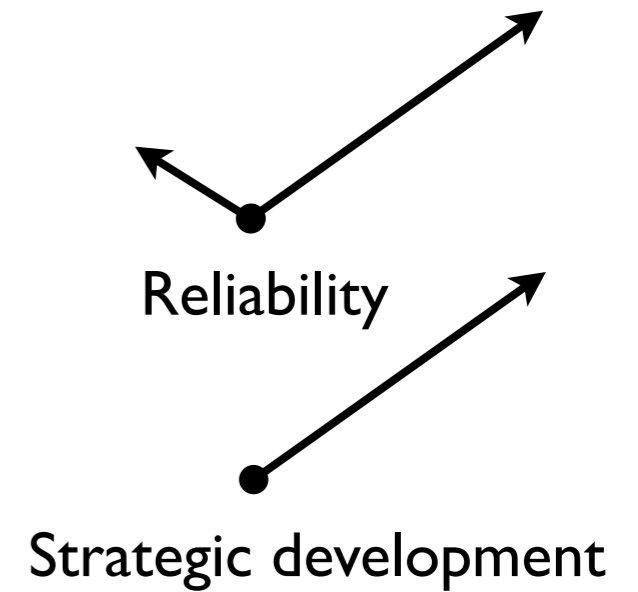
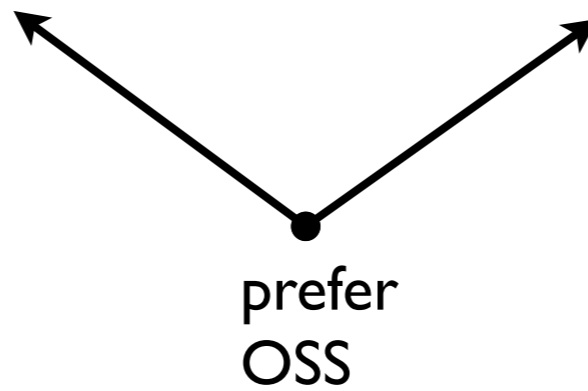
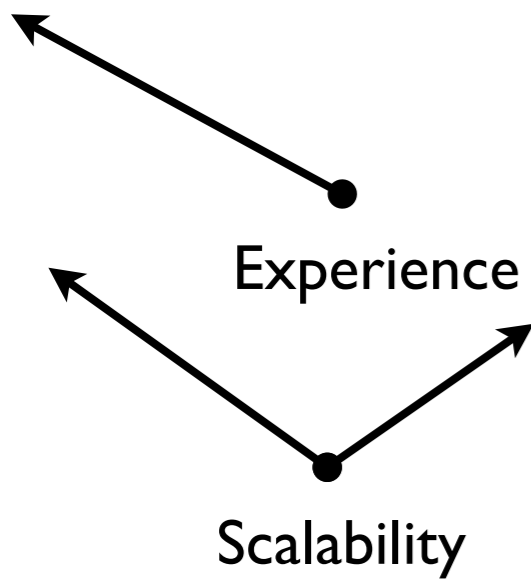


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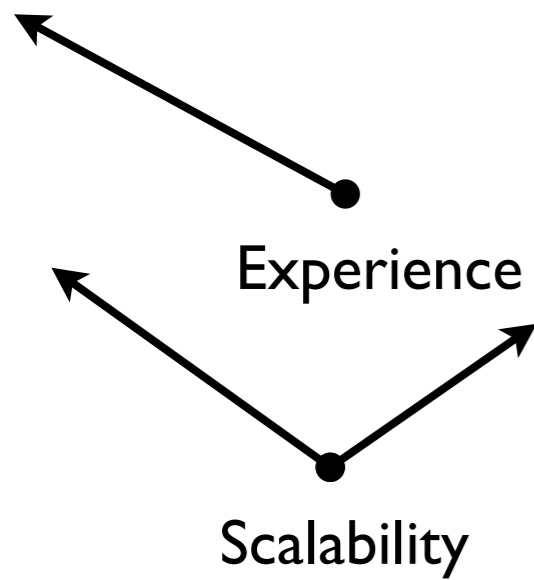


PostgreSQL

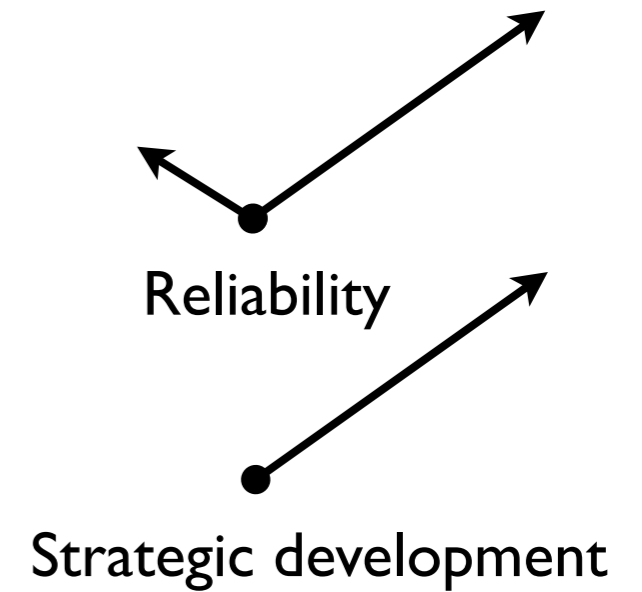


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# Decisions are driven by **forces**.



PostgreSQL



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# Decisions are driven by forces.



PostgreSQL



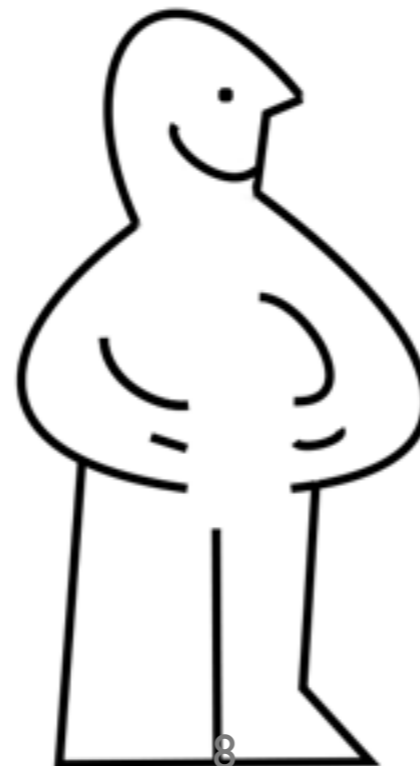
Resulting force

Reliability

Strategic 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.**





# Related concepts



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# Related concepts

business goals

requirements

quality attributes

laws

hw/sw interfaces

principles

value/cost of a decision

standards

...

previously made decisions

regulations

constraints



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requirements

constraints      quality attributes

laws                  standards                  principles

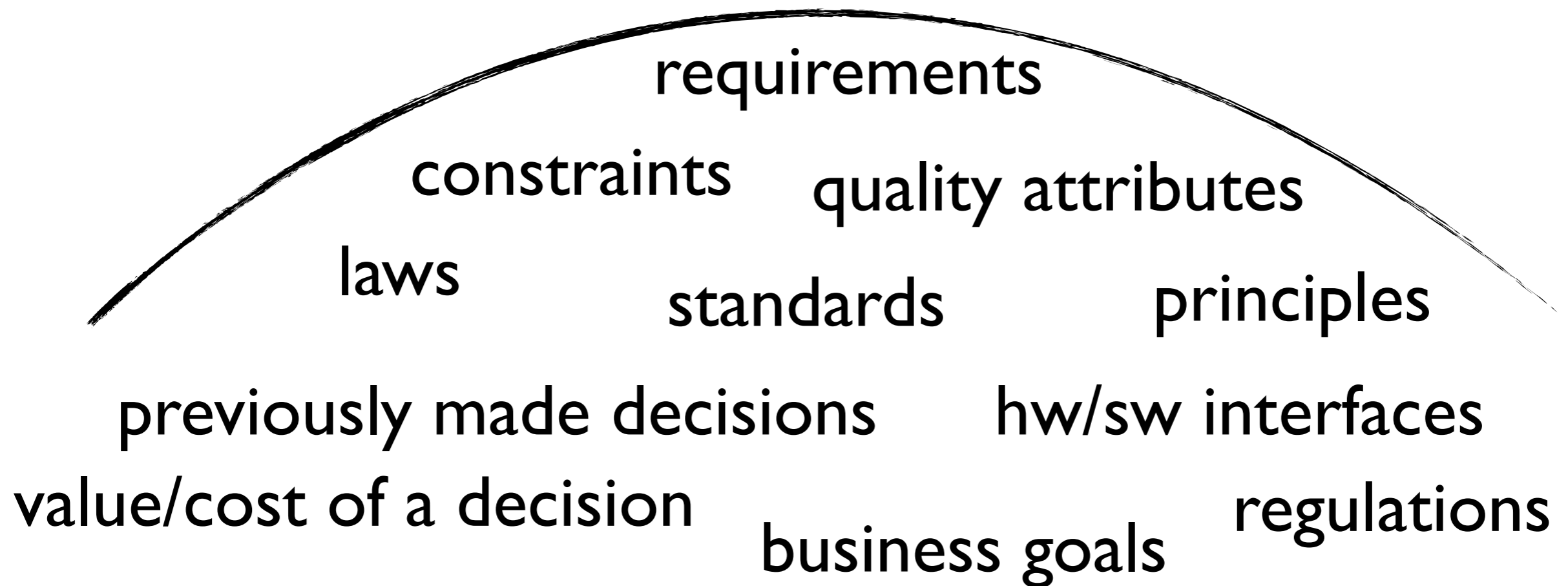
previously made decisions      hw/sw interfaces

value/cost of a decision      business goals      regulations



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# Decision Forces



# Making forces explicit has two main benefits:

- **support** for rational decisions
- **preserving the rationale** that went into decisions

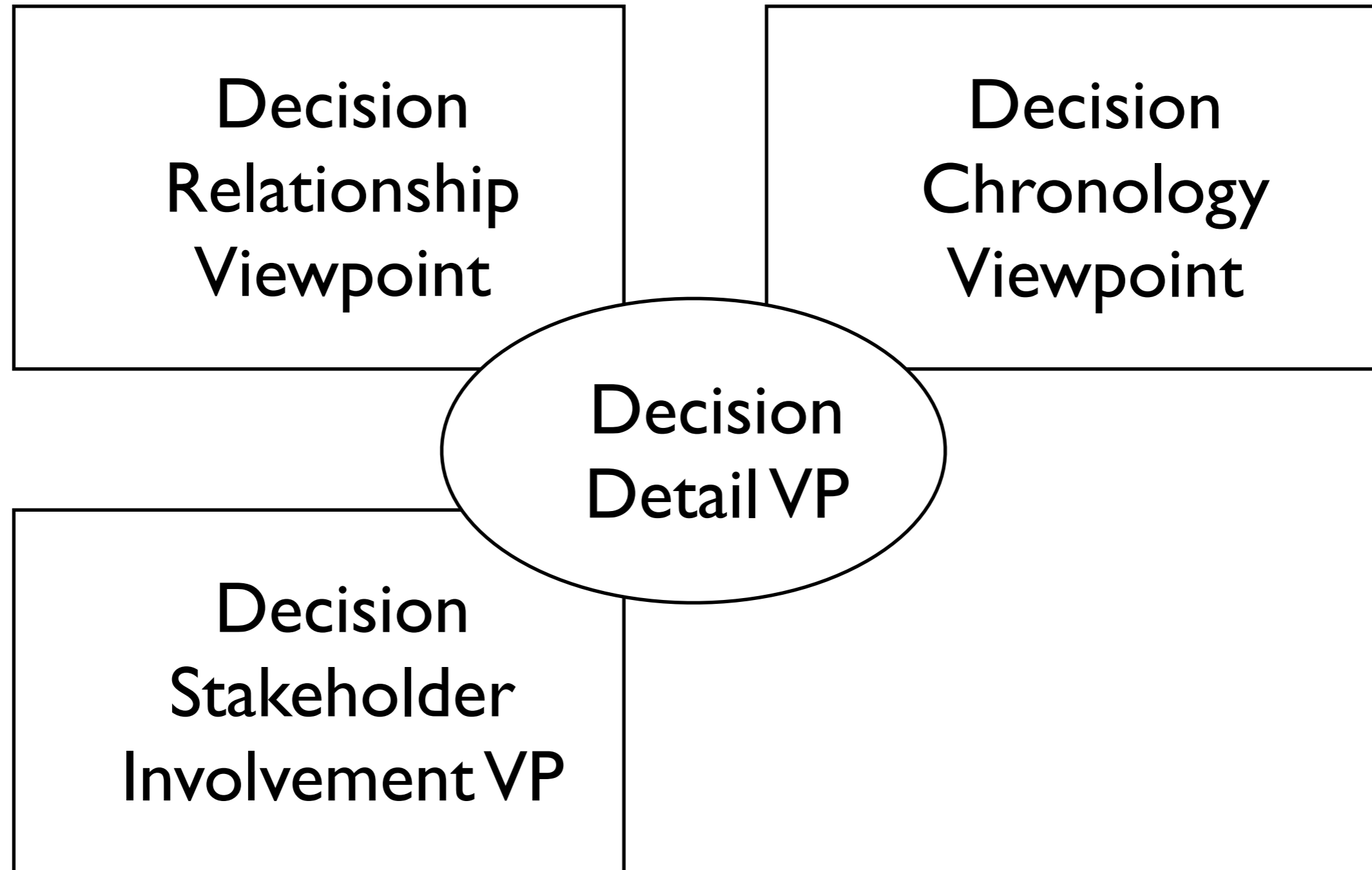


# How to make forces explicit?



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# A description framework for architecture decisions



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



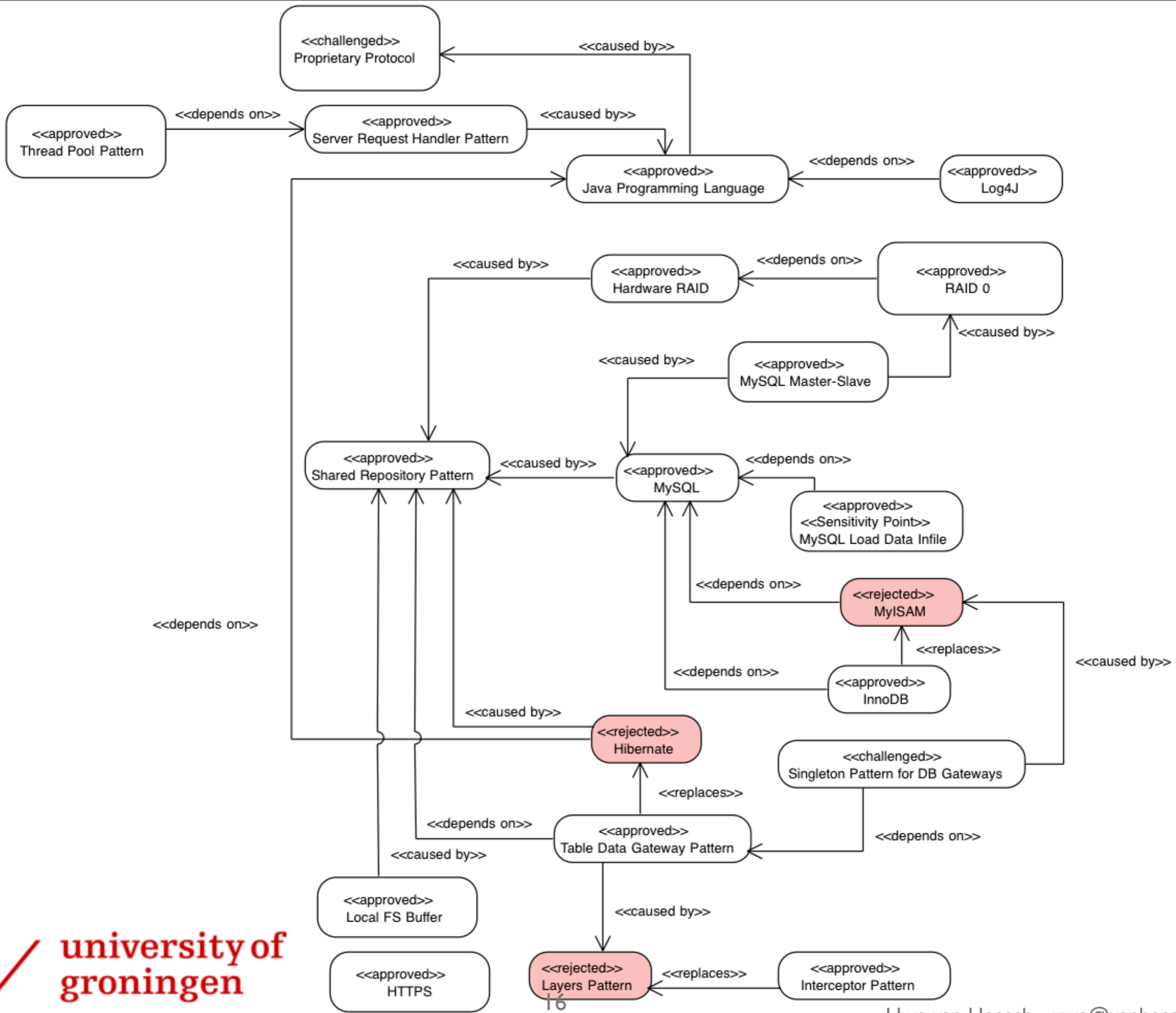
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# Decision Relationship Viewpoint



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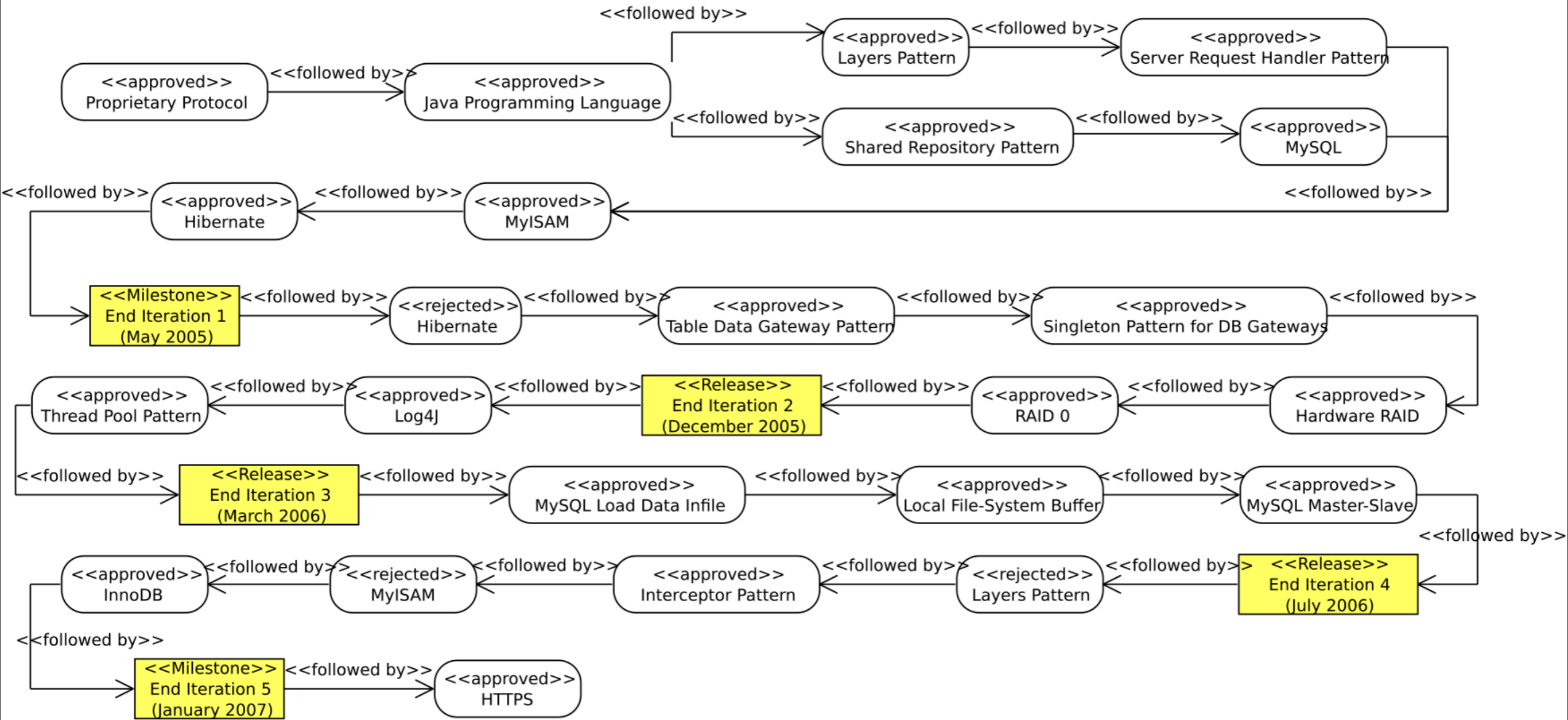




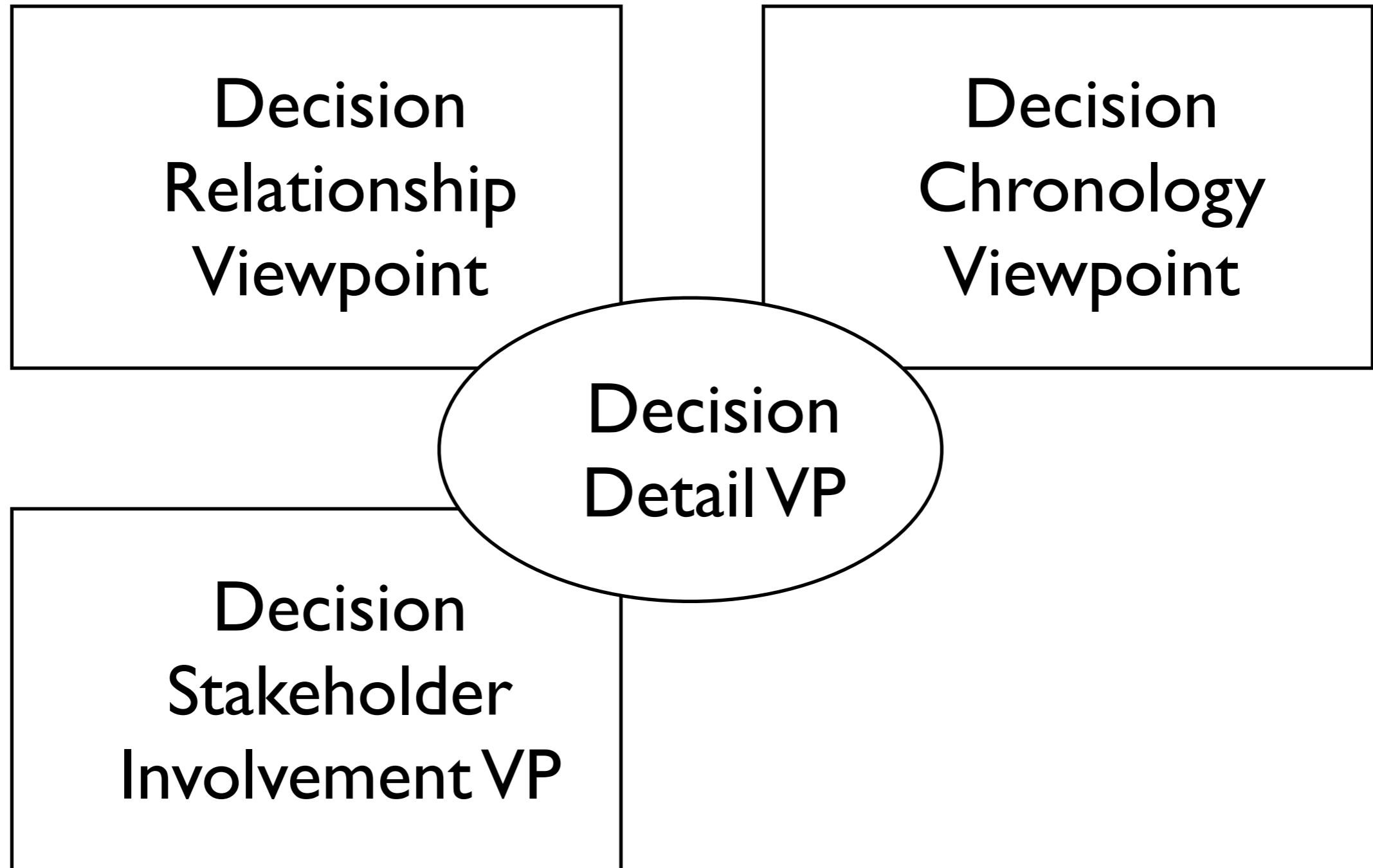
# Decision Chronology Viewpoint



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# A framework for architecture decisions

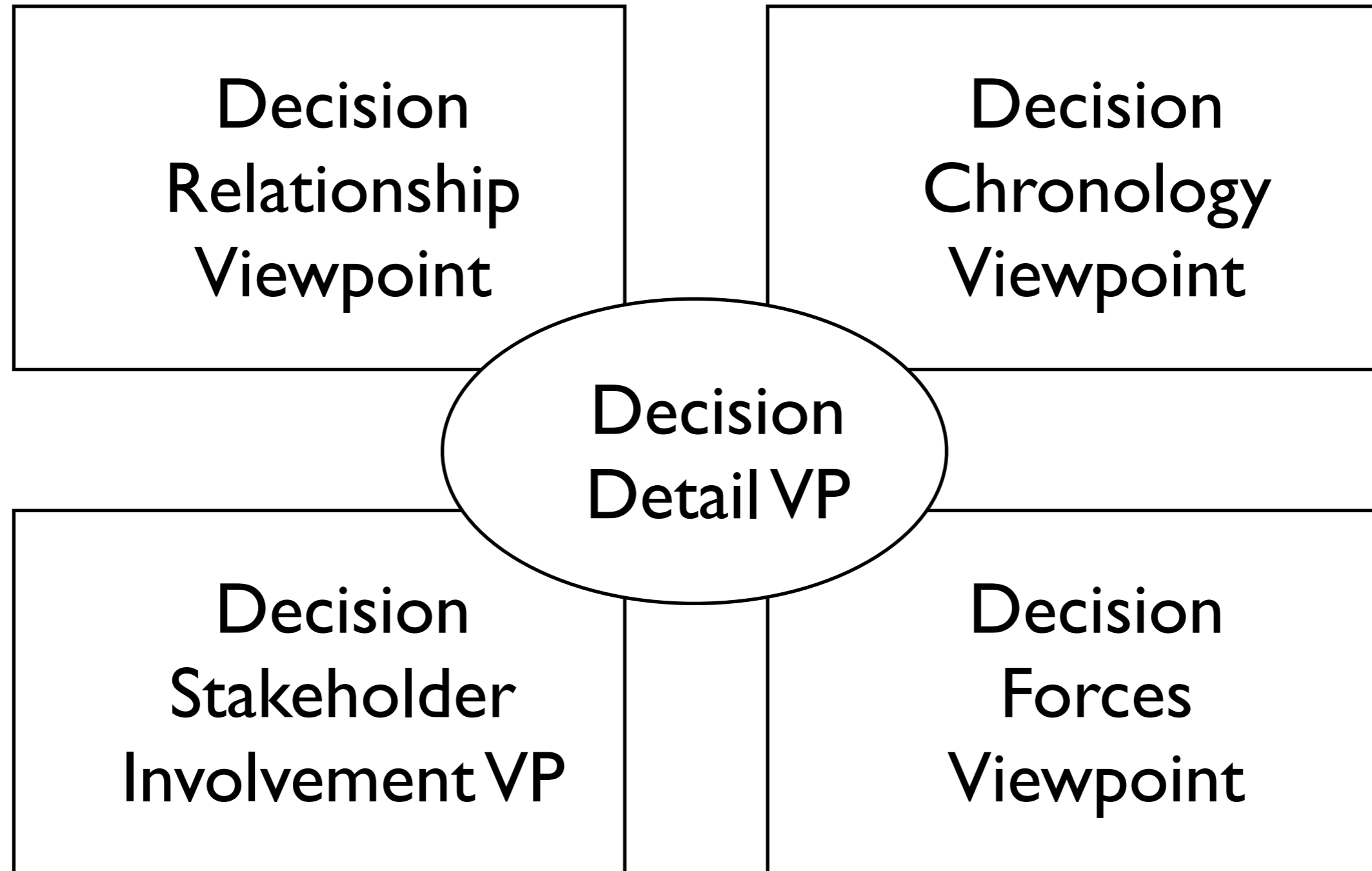


using the conventions from **ISO/IEC/IEEE 42010**



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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	
<b>Decision Forces</b>	<b>Architecture significant requirements</b>									
	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 <sup>rd</sup> party licences	Development costs	+	+	+			++	++
	<b>Other forces</b>									
	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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	R16	Client platform independence	Portability	+	++	++				
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	F4	Linux server available	Development costs		+	+	+	+		+
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	F7	Resource usage on server	Resource utilization	++	-	--	--	--	+	?



# decision topic



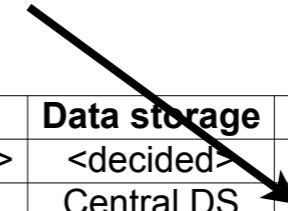
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decision topic

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	
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decision state

decision

decision topic

forces

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decision state

decision

decision topic

forces

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			<decided>	<discarded>	<discarded>	<decided>	<discarded>	<discarded>	<decided>
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<b>Other forces</b>									
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	
<b>Architecture significant requirements</b>										
<b>Decision Forces</b>	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 <sup>rd</sup> party licences	Development costs	+	+	+			++	
	<b>Other forces</b>									
	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	++	-	--	--	--	+		



# Validation of the forces viewpoint

- multiple-**case study**
- **3 groups** of graduating **students**
- working in **non-academic software projects**  
(2 industrial, 1 open source)
- used **decision framework** to describe 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

- collection of all work artifacts
- weekly focus groups
- participant observation
- **grounded theory** for data analysis



# Results

- + supports reasoning process of (novice) designers
  - + provides structure for systematic decisions
  - + preserves rationale that went into decisions
  - + satisfies SH concerns assigned to the viewpoint
- 
- different weights for forces needed
  - identifying forces requires experience



# Ongoing work

- **decision-centric evaluation** based on forces (DCAR)
- **identification of typical domain specific forces**
- **different approaches to weighing forces**
- **different approaches to force-impact ratings**
- **scaling** of decision views
- **improved tool support** for decision framework
- **universal format** for description of forces



# Thank you for your attention



[xkcd.com/927](http://xkcd.com/927)



university of  
 groningen

# Grounded theory approach used

- Convert data to PDF (enable uniform coding procedure)
- **Coding**: labelled **indicators** for **concepts** related to decision views
- **Identify concepts**: concepts represent candidate patterns of behavior, suggested by a set of indicators
- **Classify concepts into categories**: concepts from the groups were compared to identify **common categories**. A category is a concept on a higher level of abstraction.



# 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



# Shared meta model

