Query Stability in Data-aware Business Processes*

Ognjen Savković

unibz

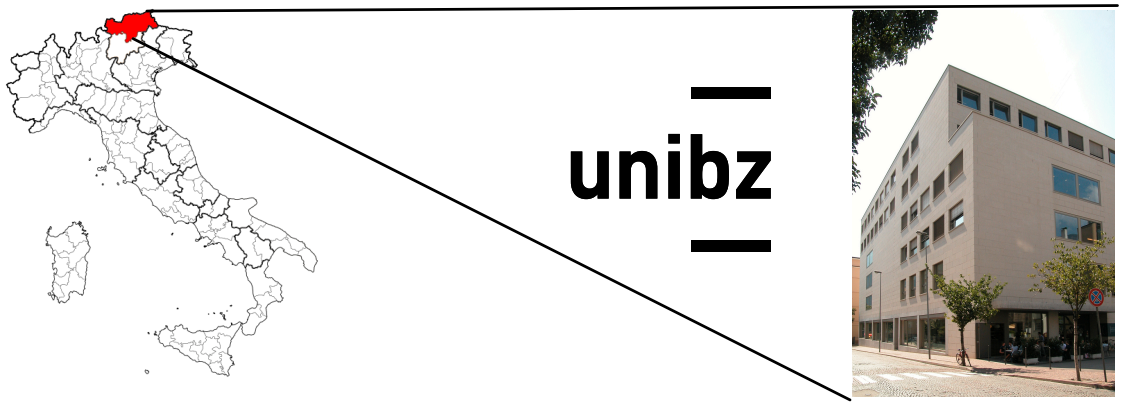
Free University of Bozen-Bolzano

joint work with
Elisa Marengo and **Werner Nutt**

EPCL PhD Workshop, April 2014, Dresden

*Supported by the project MAGIC, funded by the Province of Bozen-Bolzano

Students at Free University of Bozen-Bolzano (FUB)



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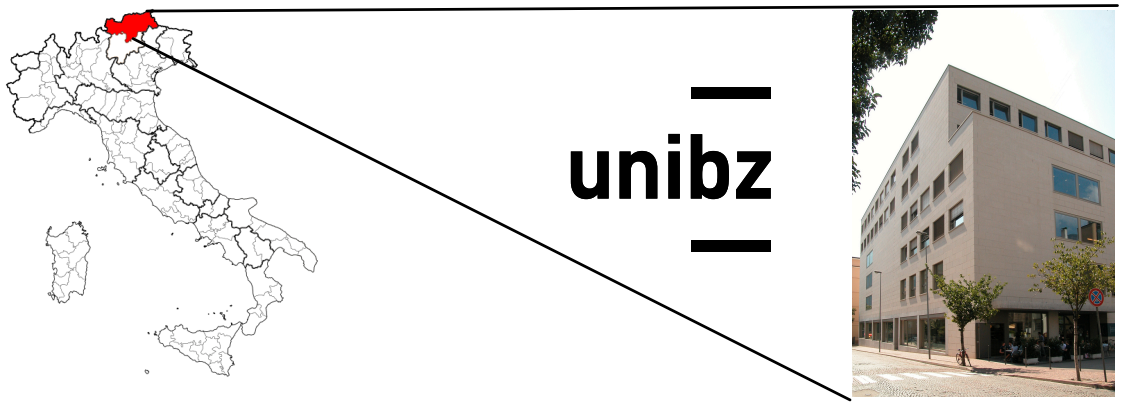

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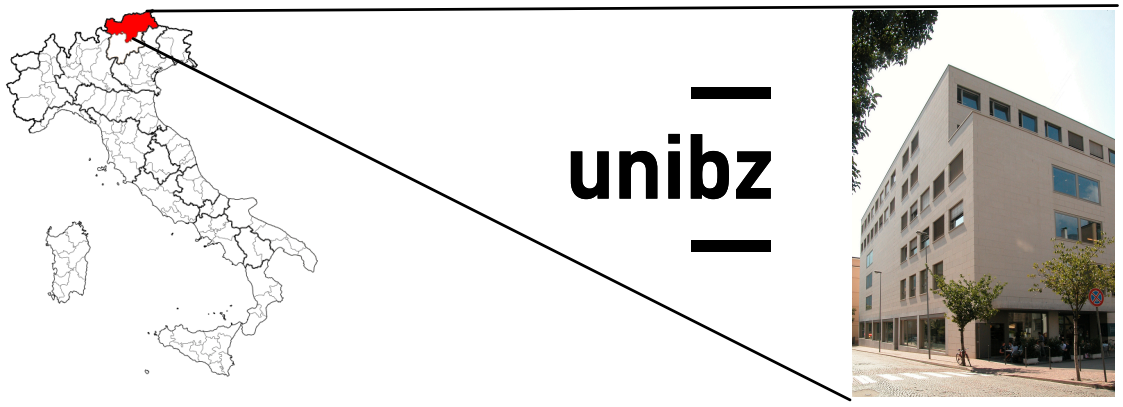

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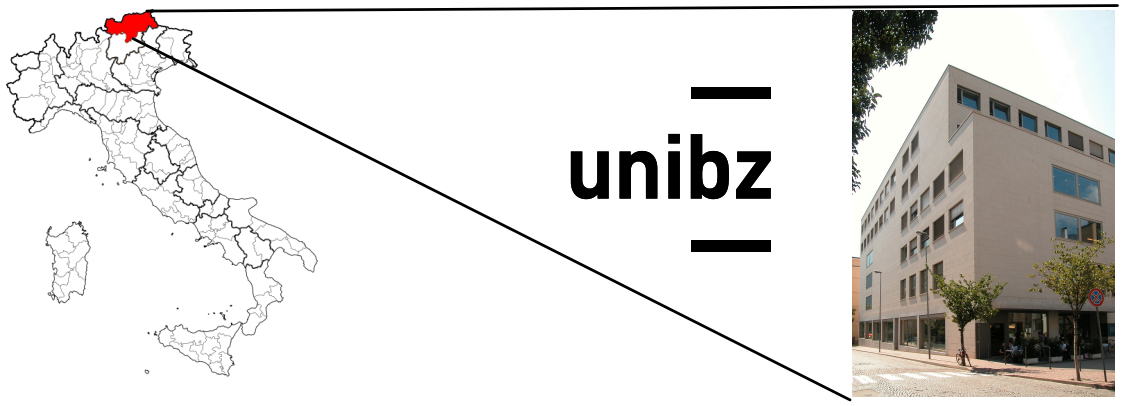

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Statistical Report about the Enrolled Students at FUB

Faculty of Economics	Student places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%
Bachelor in Economics and Management	[illegible]	[illegible]	[illegible]	20.78%
Bachelor in Tourism, Sport and Event Management	[illegible]	[illegible]	[illegible]	74.51%
Bachelor in Economics and Social Sciences	[illegible]	[illegible]	[illegible]	17.24%
Master in Entrepreneurship and Innovation	[illegible]	[illegible]	[illegible]	114.29%
Master in Economics and Management of the public sector	[illegible]	[illegible]	[illegible]	22.73%
Sum	[illegible]	[illegible]	[illegible]	41.45%

Faculty of Computer Science	Student Places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%
Bachelor in Computer Science and Engineering	[illegible]	[illegible]	[illegible]	30.43%
Master of Science in Computer Science	[illegible]	[illegible]	[illegible]	-44.44%
PhD in Computer Science	[illegible]	[illegible]	[illegible]	#VALUE!
Sum	[illegible]	[illegible]	[illegible]	-25.37%

How Reliable are the Figures in the Report?

Faculty of Economics	Student places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%
Bachelor in Economics and Management	[illegible]	77	93	20.78%
Bachelor in Tourism, Sport and Event Management	[illegible]	51	89	74.51%
Bachelor in Economics and Social Sciences	[illegible]	29	34	17.24%
Master in Entrepreneurship and Innovation	[illegible]	14	30	114.29%
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Sum	176	181	272	41.45%

Faculty of Computer Science	Student Places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%
Bachelor in Computer Science and Engineering	[illegible]	69	90	30.43%
Master of Science in Computer Science	[illegible]	36	20	-44.44%
PhD in Computer Science	[illegible]	2	[illegible]	#VALUE!
Sum	135	67	50	-25.37%

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Faculty of Economics	Student places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%
Bachelor in Economics and Management	[illegible]	72	87	20.78%
Bachelor in Tourism, Sport and Event Management	[illegible]	51	89	74.51%
Bachelor in Economics and Social Sciences	[illegible]	29	34	17.24%
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Bachelor in Computer Science and Engineering	[illegible]	92	120	30.43%
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PhD in Computer Science	[illegible]	9	[illegible]	#VALUE!
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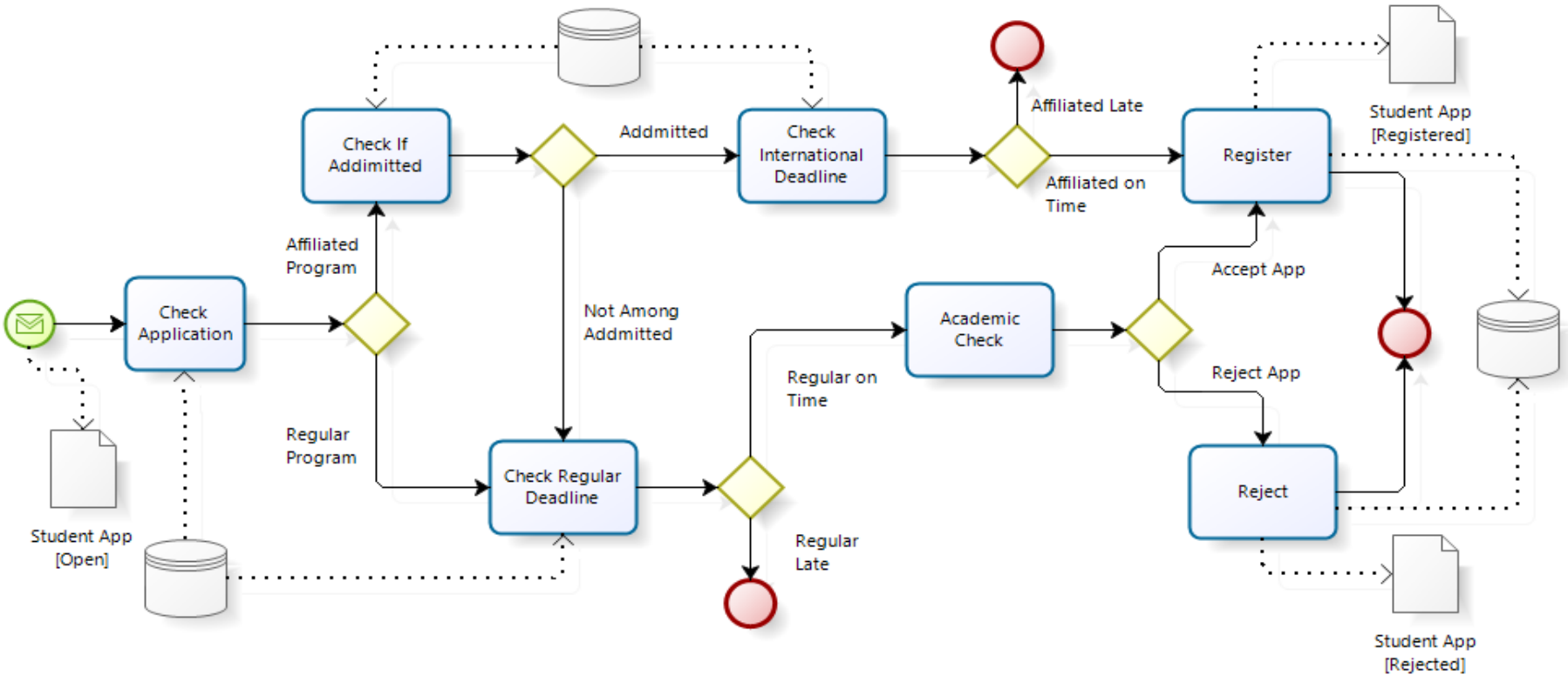
Look at the **Business Processes** that **generates** and **manipulates data**.

Student Registration Processes at FUB



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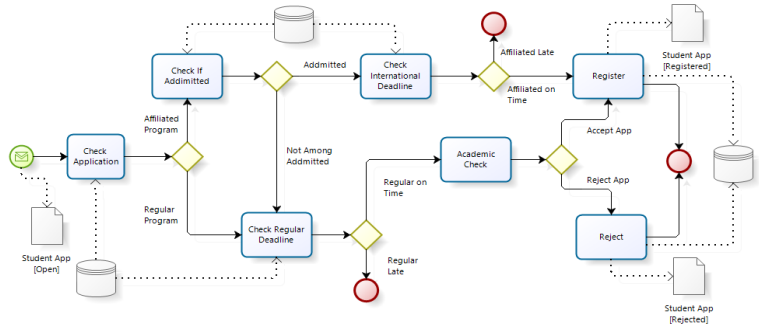

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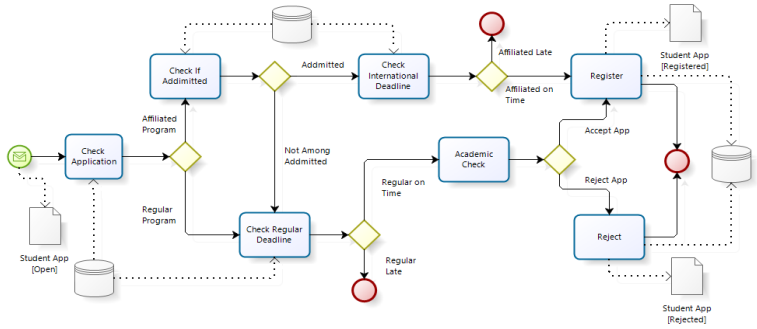

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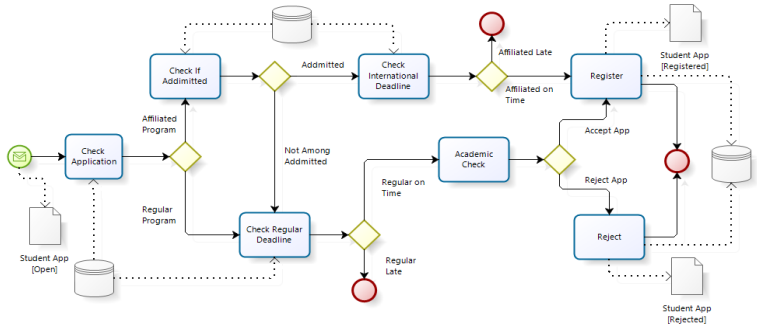

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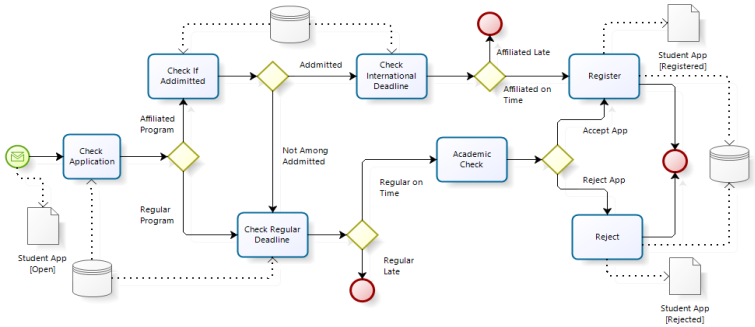

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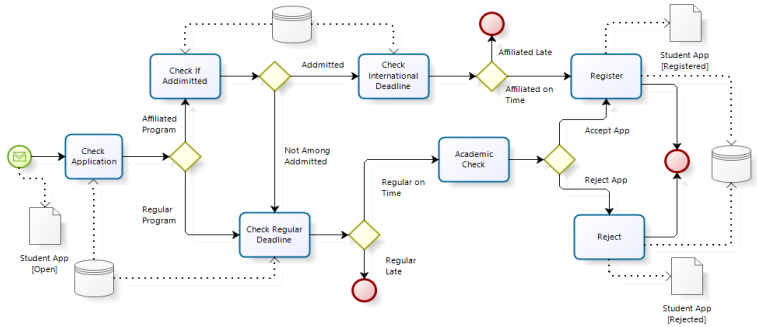

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- BPs **fail to model** interaction with **databases**
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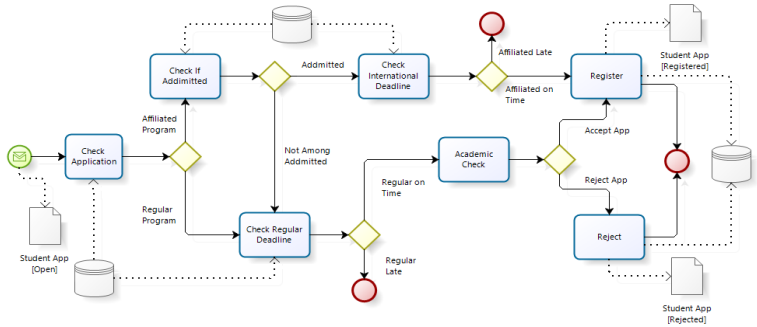

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  - In `BPEL` operations on the database are **hidden in the code**
- However, **data** is often the **main driver** when **executing** BPs
  - E.g., a student can register for a program
    only if the student was firstly admitted to the program

Property of Query Stability

Query Stability

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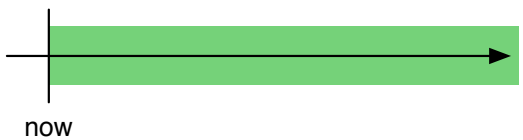

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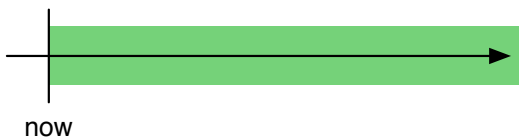

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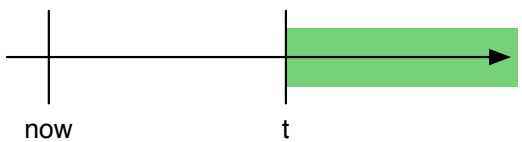

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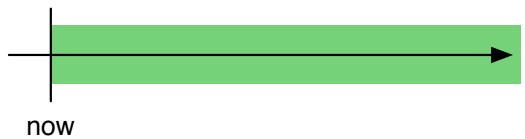

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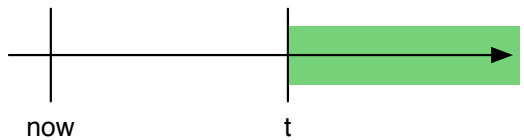
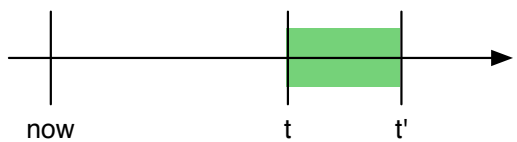


- What are the **time intervals** in which Q is stable?

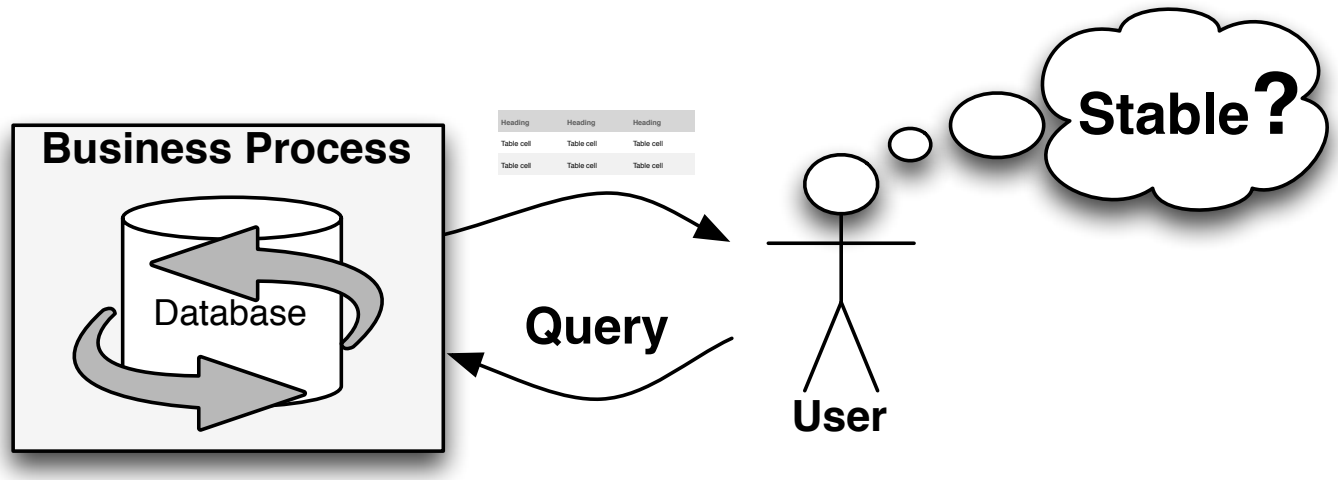


Outline

Data-aware Business Processes (DABPs) model

Query Stability

Reasoning about Query Stability in DABPs



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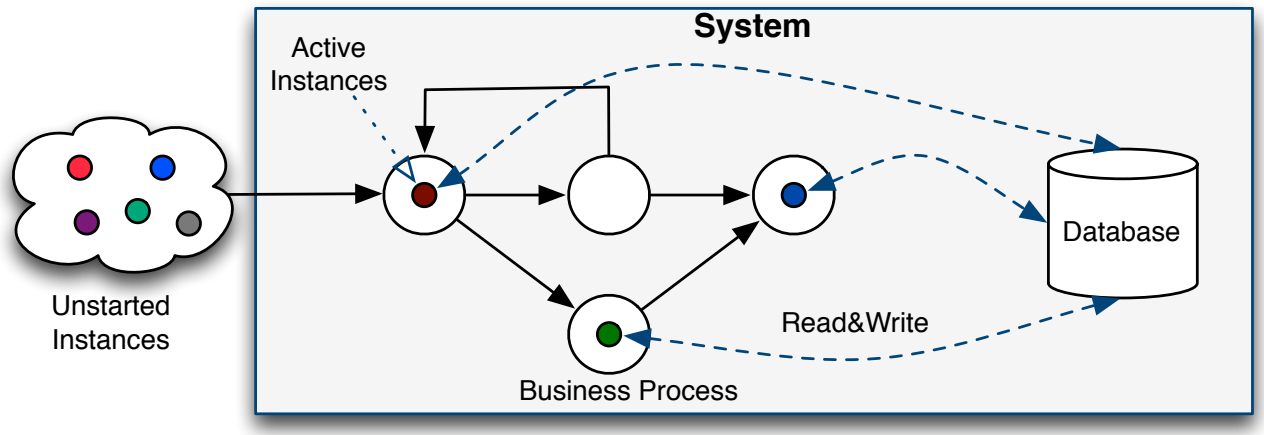

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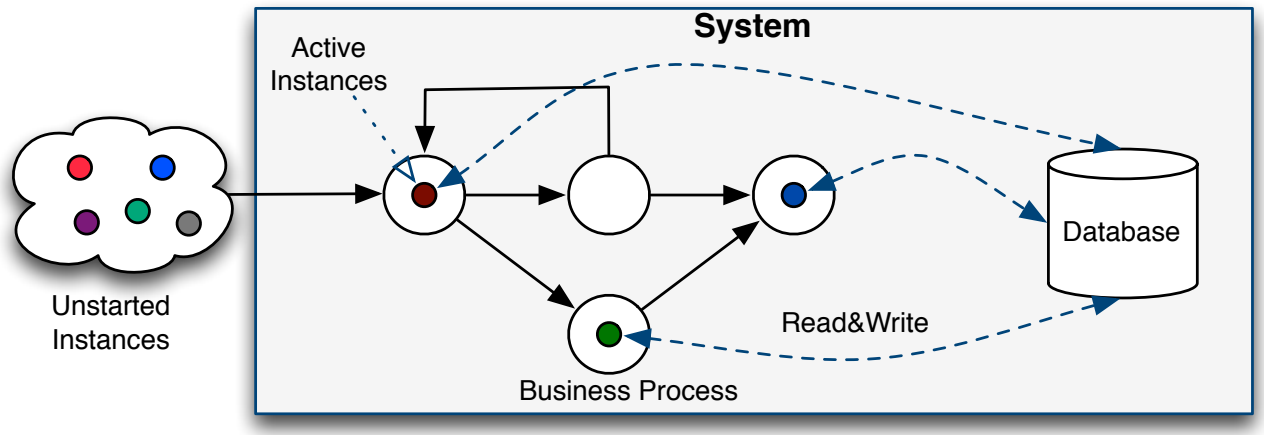

New Information in the system is brought with **new process instances**

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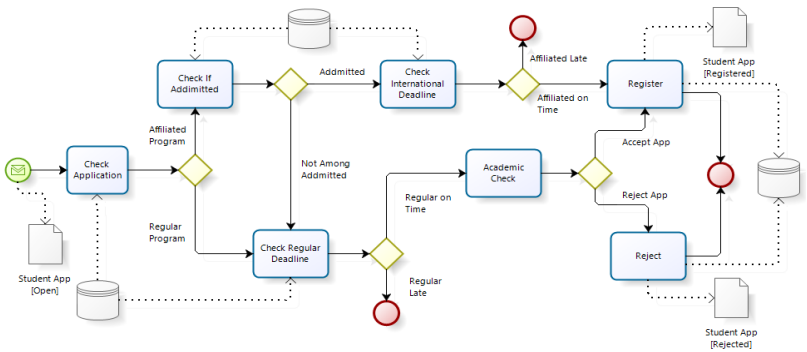

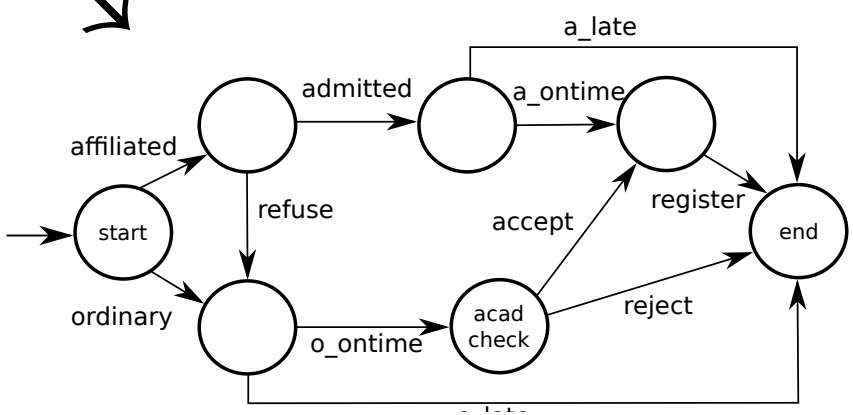

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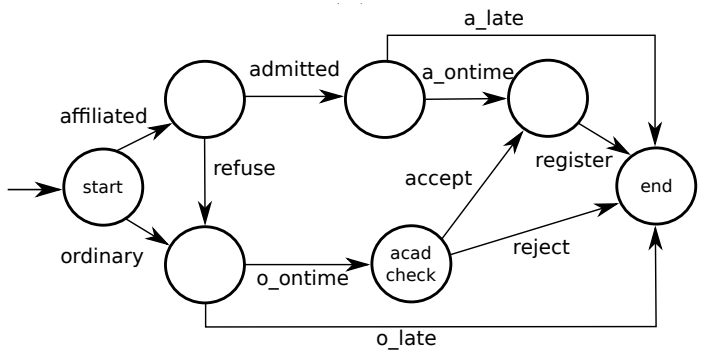
- Here, E_t and Q_t are **CQ with safe negation** over signature $\Sigma \cup I$ and $R \in \Sigma$
- Relation I is the input relation that describes process instance
  - e.g., student application form I('J. Smith','EMCL','Thursday 20$^{\text{th}}$ October, 2016')
    (the last I-argument is reserved for the instance timestamp)

Running example: process part



Transition	*Execution Condition* E_t
affiliated	$I(s,p,\tau),\ \mathit{StudyPlan}(p,\text{'affil'},m)$
ordinary	$I(s,p,\tau),\ \mathit{StudyPlan}(p,\text{'ord'},m),\ \neg\mathit{StudyPlan}(s,\text{'affil'},p)$
admitted	$I(s,p,\tau),\ \mathit{Admitted}(s,p)$
refuse	$I(s,p,\tau),\ \mathit{Admitted}(s,p),\ \mathit{StudyPlan}(p,\text{'ord'},m)$
a_late	$I(s,p,\tau),\ \mathit{Deadline}(\text{'affil'},d),\ \tau > d$
a_ontime	$I(s,p,\tau),\ \mathit{Deadline}(\text{'affil'},d),\ \tau < d$
o_late	$I(s,p,\tau),\ \mathit{Deadline}(\text{'affil'},d),\ \tau > d$
o_late	$I(s,p,\tau),\ \mathit{Deadline}(\text{'ord'},d),\ \tau > d$
o_ontime	$I(s,p,\tau),\ \mathit{Deadline}(\text{'ord'},d),\ \tau < d$
	Writing Rule W_t
register	$I(s,p,\tau),\ \mathit{StudyPlan}(p,r,m) \rightarrow \mathit{Registered}(s,m,p)$

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- **Database instance** D over schema Σ
- Set of **process instances** O (called **data objects**)
- **Mapping function** M that for every data object $o \in O$
  determines **current place** in the process $M_P(o) = p \in P$ and
  a single I-record $M_S(o) = I(\bar{s})$ of the input relation $I \notin \Sigma$
- **Current timestamp** τ of the configuration

Running Example: Initial Configuration

- Database instance D

StudyPlan

program	*registr.*	*master*
emSE	*affil*	mscCS
emCL	*affil*	mscCS
emCL	*reg*	mscCS
econ	*reg*	mscECO

Admitted

student	*program*
bob	emCL
mary	emSE

Deadline

registr.	*date*
reg	1^{st} Oct
affil	1^{st} Dec

Registered

student	*master*	*program*
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- Data objects $O = \{o_1, o_2, o_3\}$

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- Mapping M

Mapping

id	*I*-record	place
o_3	(john, db, τ_3)	*start*
o_2	(alice, econ, τ_2)	*end*
o_1	(bob, emCL, τ_1)	*end*

Running Example: Initial Configuration

- Database instance D

StudyPlan

program	*registr.*	*master*
emSE	*affil*	mscCS
emCL	*affil*	mscCS
emCL	*reg*	mscCS
econ	*reg*	mscECO

Admitted

student	*program*
bob	emCL
mary	emSE

Deadline

registr.	*date*
reg	1^{st} Oct
affil	1^{st} Dec

Registered

student	*master*	*program*
bob	mscCS	emCL

- Data objects $O = \{o_1, o_2, o_3\}$
- Mapping M

Mapping

id	*I*-record	place
o_3	(john, db, τ_3)	*start*
o_2	(alice, econ, τ_2)	*end*
o_1	(bob, emCL, τ_1)	*end*

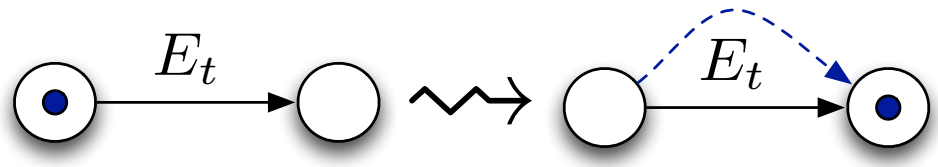
- Current time

$\tau =$ 'Thursday 20^{th} October, 2016'

Execution of DABPs

There are two kinds of **atomic execution** in DABPs

- **Traversal** of a transition in the net by an object



An object o with I-record $I(\bar{s})$ can traverse transition t if $E_t(D \cup I(\bar{s})) = \mathit{true}$
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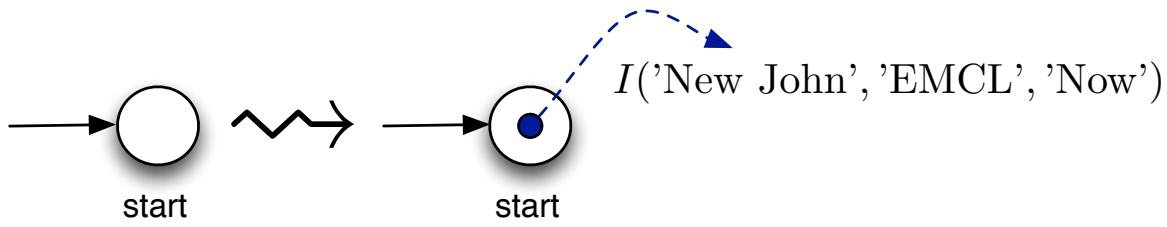

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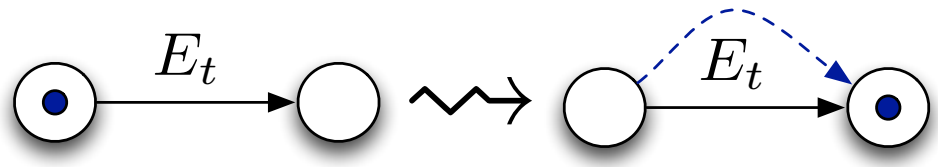

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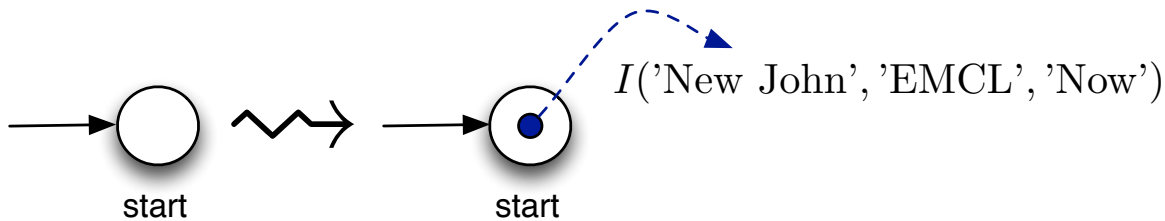

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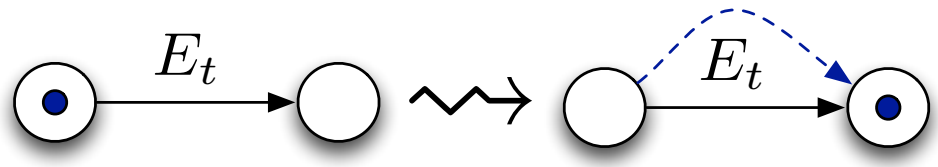

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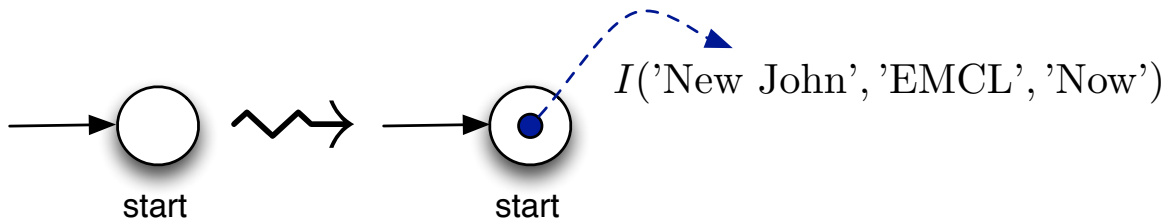

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- **Executions** in DABPs are finite sequences of atomic executions

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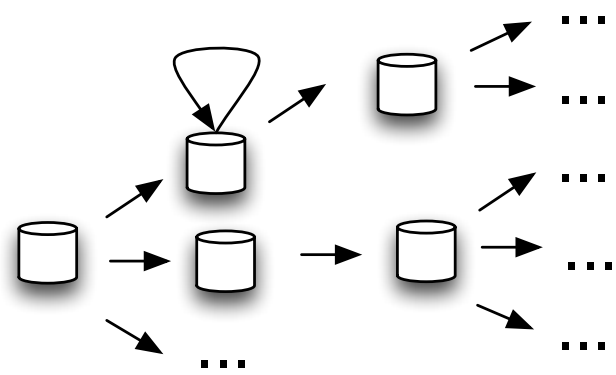
Query Stability Formally

- Query Q is **stable** in DABP $\mathscr{B} = \langle \mathscr{P}, \mathscr{C} \rangle$ with database D if for any *reachable* configuration with the database D'

$$Q(D) = Q(D')$$



Running Example: Stability of Queries

- Q_{cs} : Who are the registered students at the Faculty of Computer Science?
  e.g., $Q_{cs}(x) \leftarrow Registered(x, \text{'mscCS'}, p)$
- Q_{eco} : Who are the registered students at the Faculty of Economics?
  e.g., $Q_{eco}(x) \leftarrow Registered(x, \text{'mscECO'}, p)$

Faculty of Economics	Student places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%	Stable?	< 1st Oct	1st Oct-1st Dec	> 1st Dec
Bachelor in Economics and Management	[redacted]	[redacted]	[redacted]	20,78%		NO!	YES!	YES!
Bachelor in Tourism, Sport and Event Management	[redacted]	[redacted]	[redacted]	74,51%		NO!	YES!	YES!
Bachelor in Economics and Social Sciences	[redacted]	[redacted]	[redacted]	17,24%		NO!	YES!	YES!
Master in Entrepreneurship and Innovation	[redacted]	[redacted]	[redacted]	114,29%		NO!	YES!	YES!
Master in Economics and Management of the public sector	[redacted]	[redacted]	[redacted]	22,73%		NO!	YES!	YES!
Sum	[redacted]	[redacted]	[redacted]	41,45%		NO!	YES!	YES!

Faculty of Computer Science	Student Places 2012 / 2013	Enrollments 2011 / 2012	Enrollments 2012 / 2013	%		< 1st Oct	1st Oct-1st Dec	> 1st Dec
Bachelor in Computer Science and Engineering	[redacted]	[redacted]	[redacted]	30,43%		NO!	YES!	YES!
Master of Science in Computer Science	[redacted]	[redacted]	[redacted]	-44,44%		NO!	NO!	YES!
PhD in Computer Science	[redacted]	[redacted]	[redacted]	#VALUE!		NO!	NO!	YES!
Sum	[redacted]	[redacted]	[redacted]	-25,37%		NO!	NO!	YES!

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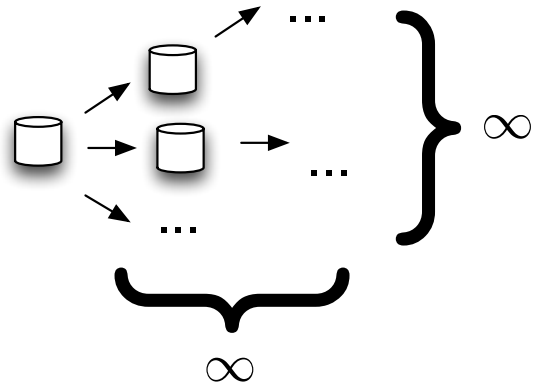

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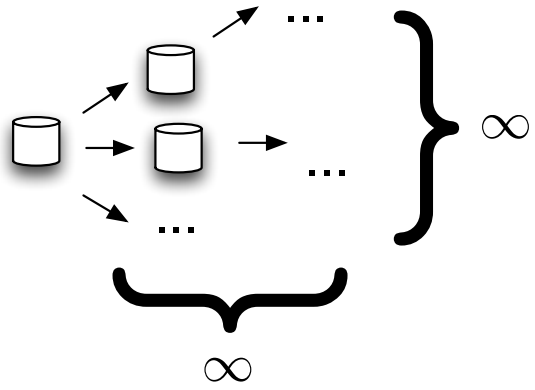

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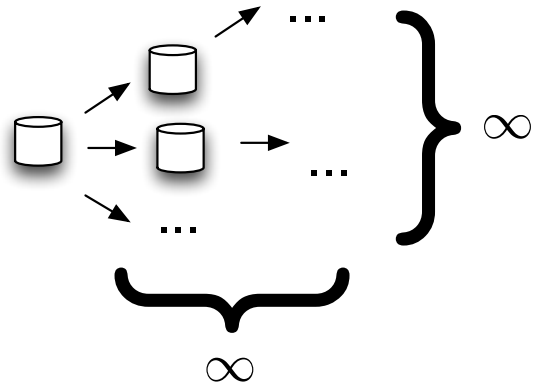

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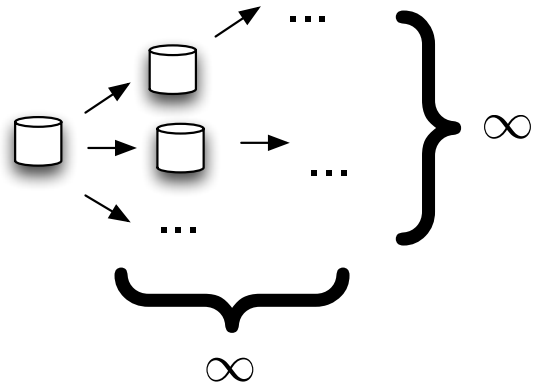

- Still, many **decidable** cases :) by restricting DAPBs to
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  - **positive rules** (little less obvious)

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Process Rules	Process Net	Semantics	Configuration	Data	Process	Query	Combined
Normal	*Cyclic / Acyclic*	*Open*	*Arbitrary*	UNDEC.	UNDEC.	UNDEC.	UNDEC.
	Cyclic / Acyclic	*Open*	*Fresh*	UNDEC.	UNDEC.	UNDEC.	UNDEC.
	Cyclic	*Closed*	*Arbitrary*	CO-NP	CO-NEXPTIME	Π_2^P	CO-NEXPTIME
	Acyclic	*Closed*	*Arbitrary*	CO-NP	PSPACE	Π_2^P	PSPACE
Positive	*Cyclic / Acyclic*	*Open*	*Arbitrary*	CO-NP	EXPTIME	Π_2^P	EXPTIME
	Cyclic / Acyclic	*Open*	*Fresh*	PTIME	EXPTIME	Π_2^P	EXPTIME
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	Acyclic	*Closed*	*Arbitrary*	co-NP	PSPACE	Π_2^P	PSPACE
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	Cyclic / Acyclic	*Open*	*Fresh*	PTIME	EXPTIME	Π_2^P	EXPTIME
	Cyclic	*Closed*	*Arbitrary*	co-NP	EXPTIME	Π_2^P	EXPTIME
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Can we obtain interesting **tractable** cases?

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- Split schema Σ into **Read-only** schema Σ_R and **Write-Only** schema Σ_W

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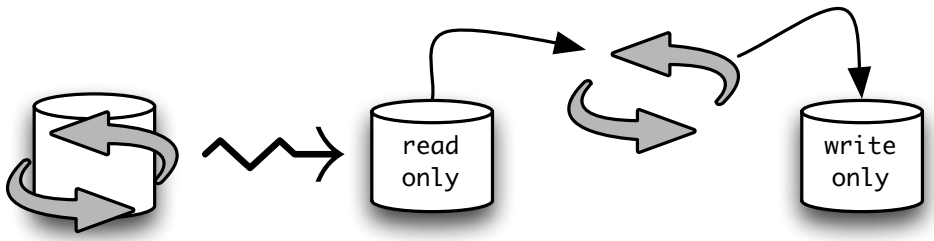

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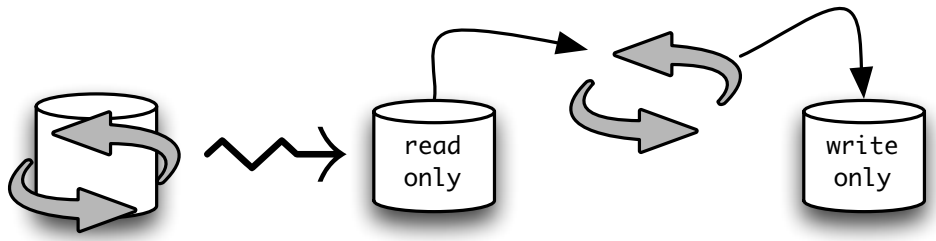

- *Thus, objects cannot read what they have written*

Checking stability in Read-Only Write-only DAPBs

- nicer complexities :)

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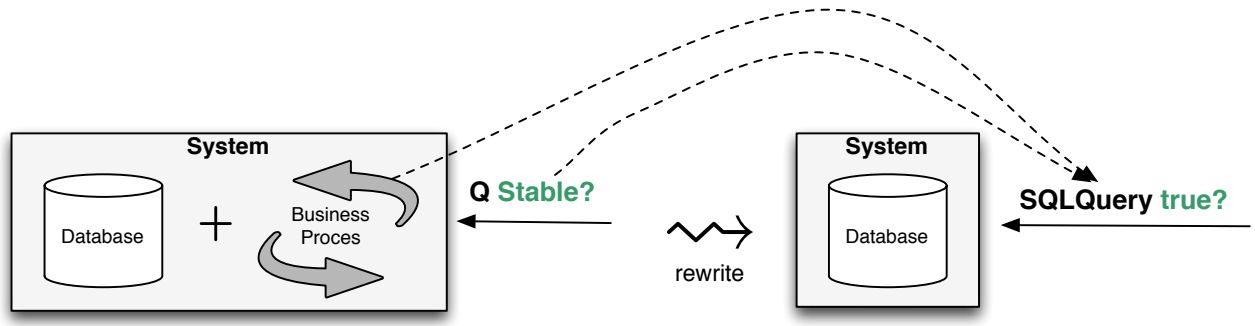
	Acyclic	*Closed*	*Arbitrary*	in AC^0	co-NP	Π_2^P	Π_2^P

- Checking Stability in rowo DABPs is **FO-rewritable**



Future Work

We plan to consider

- *More expressive queries*, e.g., CQ with negation or FO;
- *Stability of aggregate queries* / *aggregates in the process rules*;
- *Quantify instability*,
  e.g., compute the minimal/maximal number of new answers;
- Other data quality aspects such as *data timeliness* and *data currency*.

Thank you!