TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

Institute of Theoretical Computer Science Chair of Automata Theory

QUERY ANSWERING

Stefan Borgwardt Marcel Lippmann Veronika Thost

Ulm, July 24, 2013

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QUERY ANSWERING IN *DL-LITE*

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TEMPORAL QUERY ANSWERING IN *DL-LITE*

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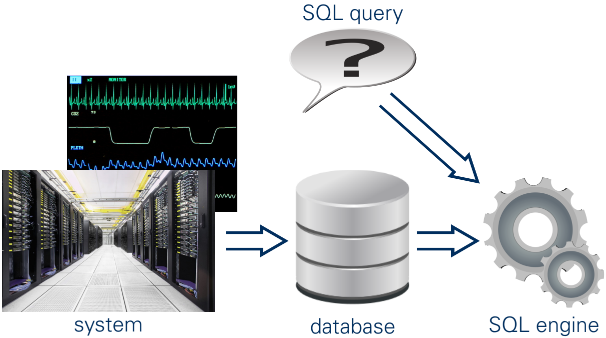
Situation awareness

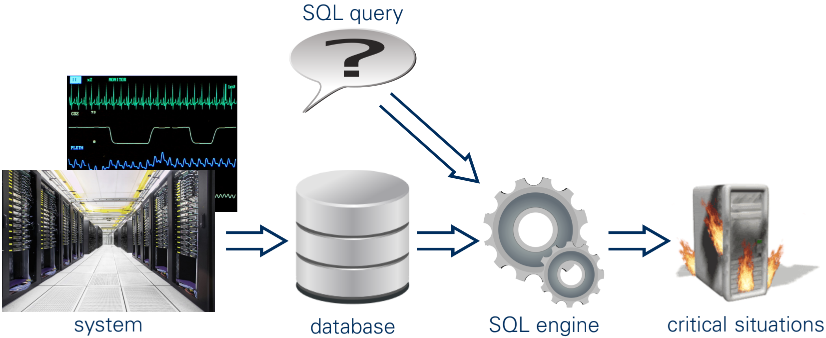
system

database

Situation awareness



Situation awareness



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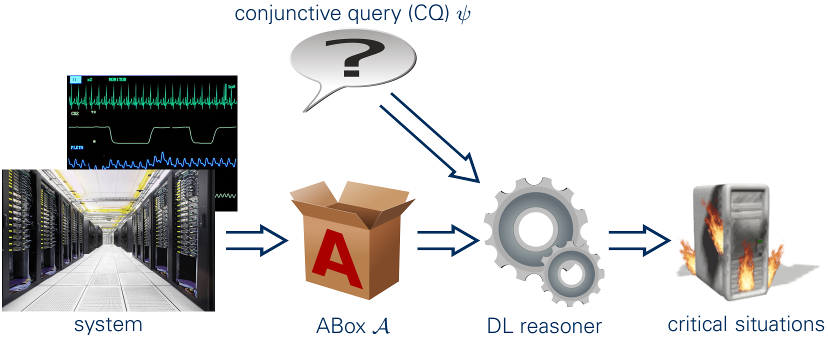
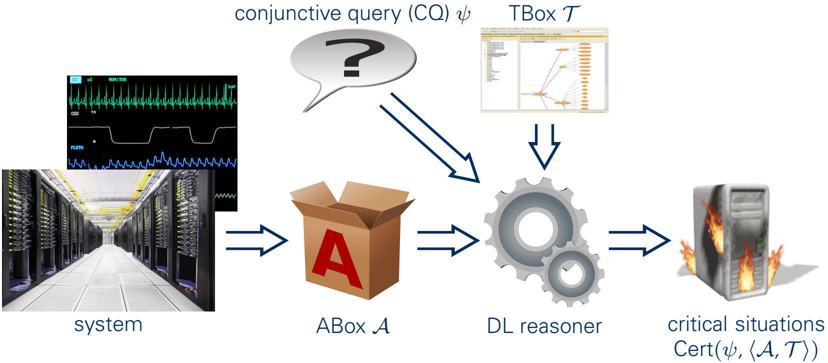


- incomplete knowledge

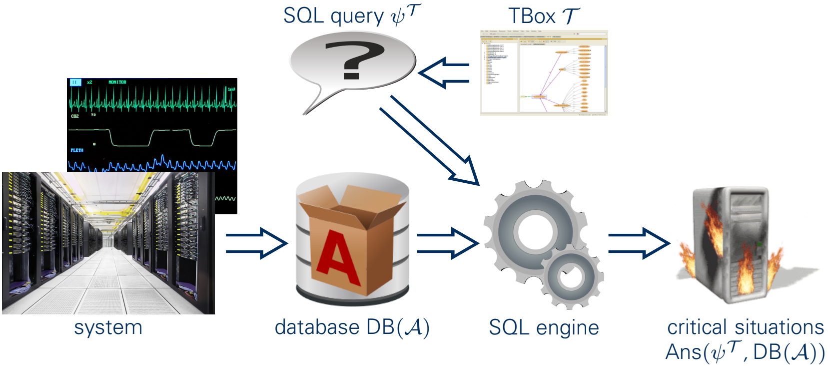
Situation awareness



- incomplete knowledge
- background knowledge

$\left.\begin{array}{l}\text{incomplete knowledge}\\ \text{background knowledge}\end{array}\right\}$ OBDA

Situation awareness



- incomplete knowledge
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$\}$ OBDA

- rewrite ψ w.r.t. $\mathcal{T}$ (possibly exponential)
- $\mathrm{Cert}(\psi, \langle \mathcal{A}, \mathcal{T} \rangle) = \mathrm{Ans}(\psi^{\mathcal{T}}, \mathrm{DB}(\mathcal{A}))$

DL-Lite$_{core}$

- concept names: $\mathsf{Employee}$, $\mathsf{Manager}$, $\mathsf{Unemployed}$
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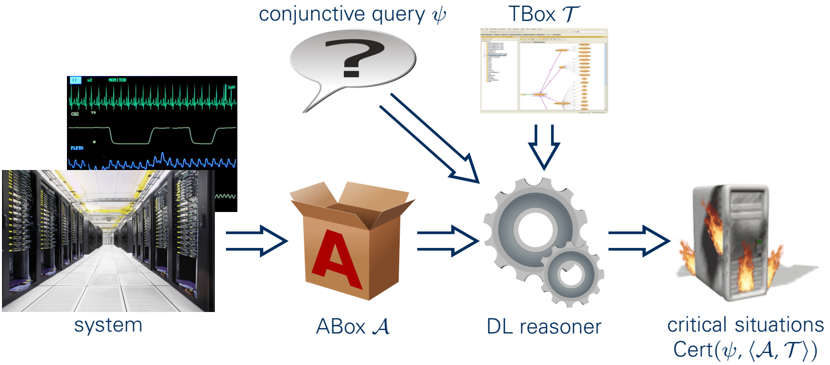
  $\rightsquigarrow$ (SELECT * FROM Manager) UNION (SELECT first FROM manages)

Dynamic systems



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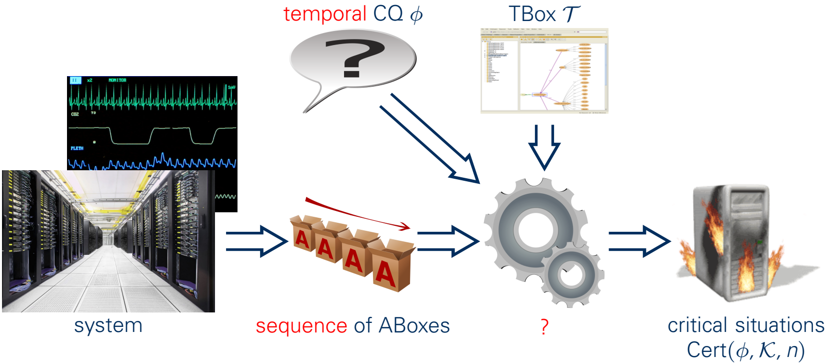

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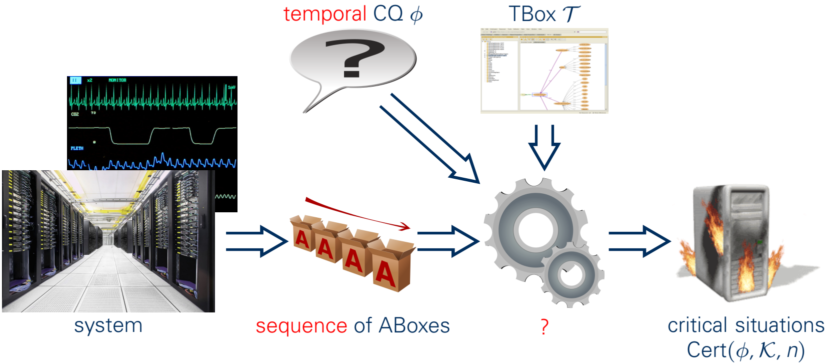

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  - shared domain
  - rigid individuals

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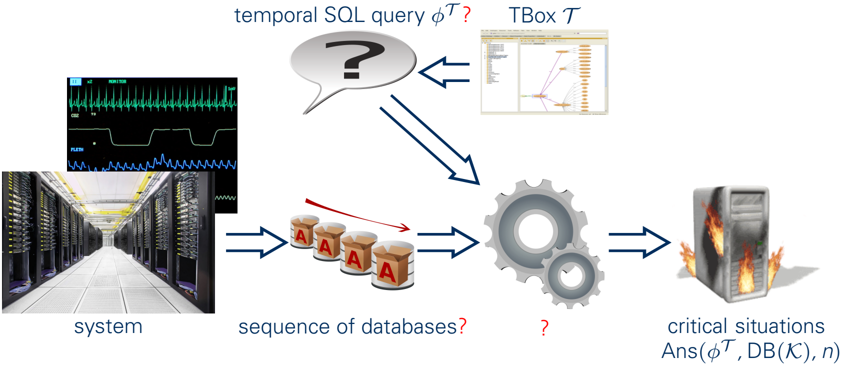

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Temporal conjunctive queries (TCQs)

$$\phi := \psi \mid \phi_1 \land \phi_2 \mid \phi_1 \lor \phi_2 \mid \bigcirc\phi \mid \bullet\phi \mid \phi_1 \,\mathsf{U}\, \phi_2 \mid \Box\phi \mid \Diamond\phi \mid$$
$$\bigcirc^-\phi \mid \bullet^-\phi \mid \phi_1 \,\mathsf{S}\, \phi_2 \mid \Box^-\phi \mid \Diamond^-\phi$$

- LTL-based syntax, as in [Gutiérrez-Basulto, Klarman 2012] and [Baader, Borgwardt, Lippmann 2013]
- past and future operators, no negation

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$$\bigcirc^{-10}\Diamond(\mathrm{Overheated}(x) \wedge \bigcirc\Diamond\mathrm{Overheated}(x))$$

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Semantics of TCQs

$$\phi = (\mathrm{Running}(x) \lor \bullet\mathrm{Running}(x) \lor \bullet\bullet\mathrm{Running}(x))\ \mathsf{S}\ \mathrm{Started}(x)$$

"all processes that have never been inactive
for three consecutive time points since they were started"

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i	$\mathcal{A}_i$	$\mathrm{Started}(x)$	$\mathrm{Running}(x)$	$\bullet\mathrm{Running}(x)$	$\bullet\bullet\mathrm{Running}(x)$	ϕ
0	$\{\mathrm{Started}(a)\}$					
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3	$\emptyset$					
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$\rightarrow$ store all past data in a temporal database and use a temporal query language, e.g. ATSQL
[Chomicki, Toman, Böhlen 2001]

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- query is fixed and always evaluated at the last time point
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bounded history encoding: required space independent of the length of the history

What about the future?

future operators do not add expressivity ...

[Gabbay 1989]:

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- non-elementary blow-up

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our approach:

- adapt Chomicki's algorithm for future operators
- keep the bounded history encoding

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idea:

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$$\psi \equiv \mathrm{B}(x) \vee (\mathrm{A}(x) \wedge \underbrace{\bigcirc(\mathrm{A}(x)\,\mathsf{U}\,\mathrm{B}(x))}_{x^{\psi}})$$

i	$\mathrm{A}(x)$	$\mathrm{B}(x)$	$\mathrm{C}(x)$	ψ	ϕ	answers
0	$\{a\}$	$\{a, b\}$	$\{a, c\}$	$\{a, b\} \cup (\{a\} \cap x_0^{\psi})$	$\ldots \cup (\{a, c\} \cap \emptyset)$	$\{a, b\}$
1	$\{b\}$	$\{c\}$	$\{a, c\}$	$\{c\} \cup (\{b\} \cap x_1^{\psi})$	$\ldots \cup (\{a, c\} \cap \ldots)$	

Our approach

idea:

- use answer formulae instead of sets of answers
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$\rightarrow$ bounded history encoding

Conclusions

Summary:

- temporal query language over CQs w.r.t. a *DL-Lite* TBox
- first-order rewritability follows from the atemporal case
- generalization of Chomicki's idea (only relevant data is kept)

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Summary:

- temporal query language over CQs w.r.t. a *DL-Lite* TBox
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Future work:

- allow rigid names [FroCoS 2013]
- implement and compare
- more expressive DLs

Thank You

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