Robustness against Parallel Snapshot Isolation

Giovanni Bernardi

jointly with

Andrea Cerone Alexey Gotsman

institute IMDEA

strong consistency

Sequential DB

High Latency

weak consistency

Eventual Consistency,
Causal Consistency,
Parallel Snapshot Isolation

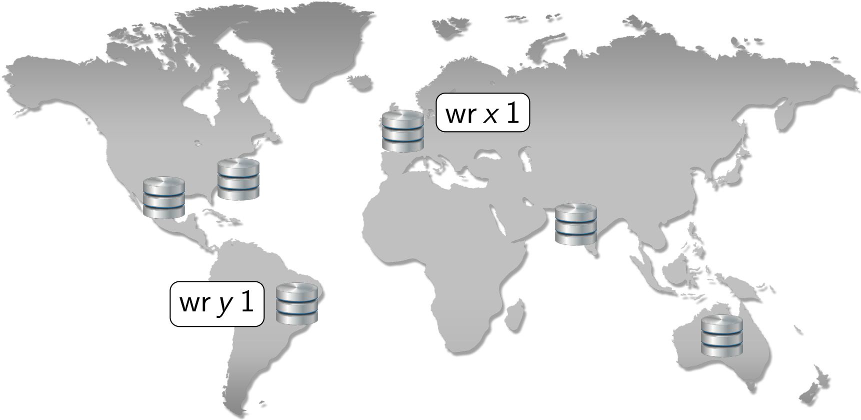
Low Latency

$$\mathcal{P} = \quad \texttt{wr}(y, 1) \qquad \texttt{txn}\{\texttt{rd}(x); \texttt{rd}(y)\} \qquad \texttt{wr}(x, 1)$$

$$\not\approx$$

Sequential DB

$$\mathcal{P} = \quad \texttt{wr}(y, 1) \qquad \texttt{txn}\{\texttt{rd}(x); \texttt{rd}(y)\} \qquad \texttt{wr}(x, 1)$$



$$\not\approx$$

Sequential DB

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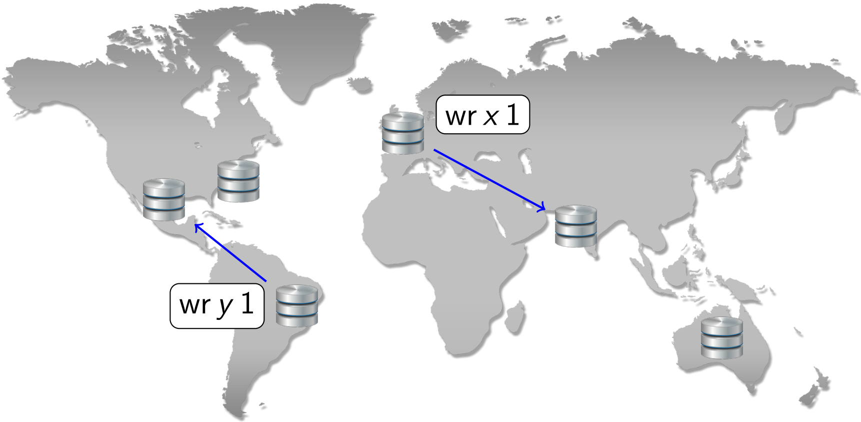
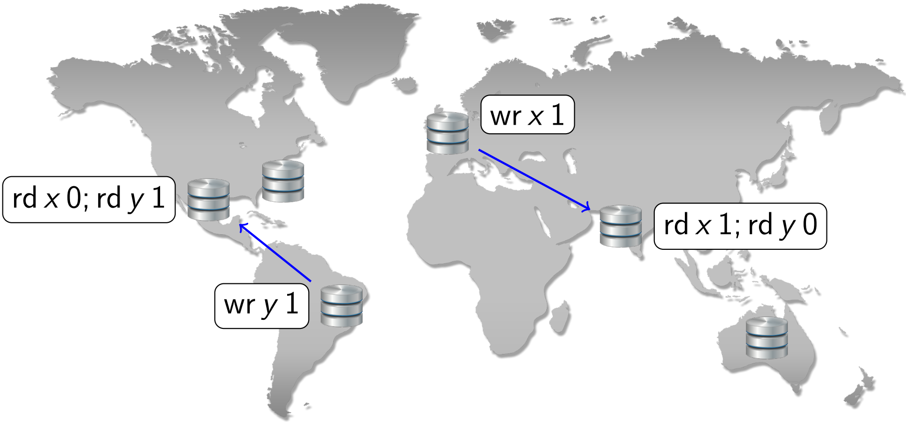


$$\not\approx$$

Sequential DB

$$\mathcal{P} = \quad \mathtt{wr}(y, 1) \qquad \mathtt{txn}\{\mathtt{rd}(x); \mathtt{rd}(y)\} \qquad \mathtt{wr}(x, 1)$$



$$\not\approx$$

Sequential DB

Robustness against PSI

behaviours of $\mathcal{P}$ $\stackrel{?}{=}$ behaviours of $\mathcal{P}$

PSI

SC

Definition PSI: $\textsc{TransHB} + \textsc{Ext} + \textsc{NoConflict}$

Transactions: $R, S, T, \ldots$ $\quad T\,\mathrm{WR}\,(m,\ z) \quad T\,\mathrm{RD}\,(n,\ y)$

Histories: $H, H', \ldots$ $\quad H = \{T_1, T_2, T_3, T_4\},$ finite

(H, hb)

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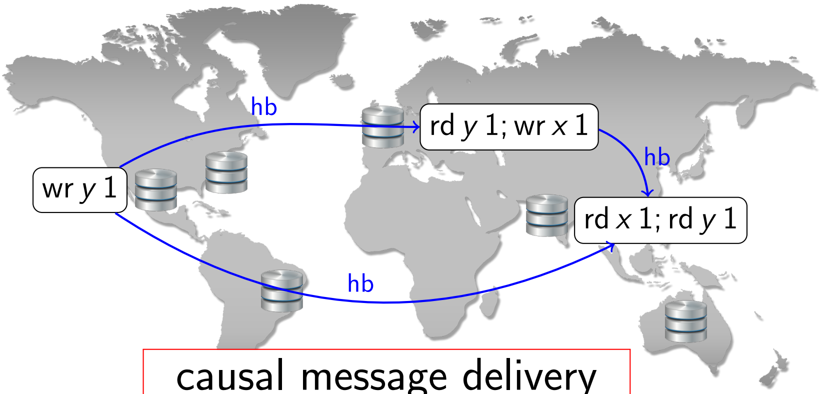
Histories: $H, H', \ldots$ $\quad H = \{T_1, T_2, T_3, T_4\}$, finite

(H, hb) $\quad \forall R, S, T \in H.\ R \text{ hb } S$ and $S \text{ hb } T \Rightarrow R \text{ hb } T$



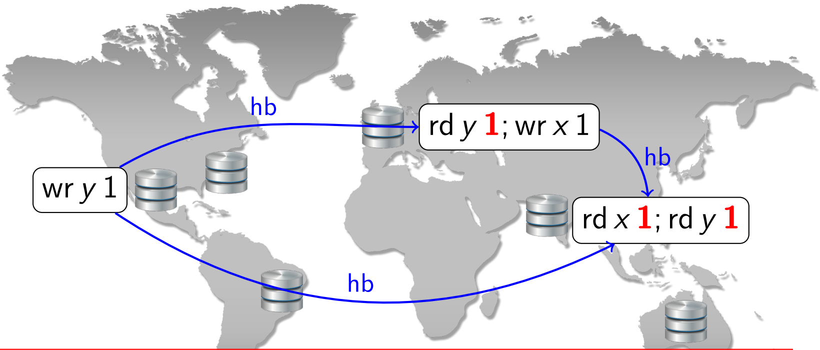
causal message delivery

Definition PSI: TransHB + Ext + NoConflict

Transactions: $R, S, T, \ldots$ $\quad T\ \mathrm{WR}\,(m,\ z) \quad T\ \mathrm{RD}\,(n,\ y)$

Histories: $H, H', \ldots$ $\quad H = \{T_1, T_2, T_3, T_4\}, \quad$ finite

$(H, \mathrm{hb}) \quad \forall T \in H.\ T\ \mathrm{RD}\,(x,\ n) \Rightarrow \mathit{lastwrite}(x, T, \mathrm{hb})\ \mathrm{WR}\,(x,\ n) \ldots$



reads return value written last according to hb

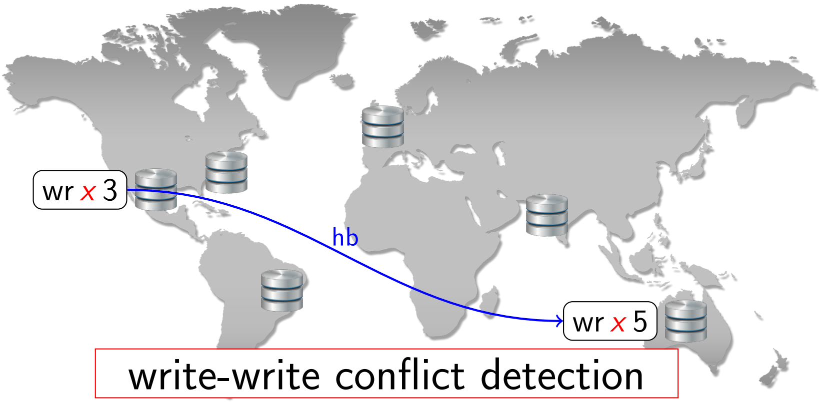
or default initial

Definition PSI: TransHB + Ext + NoConflict

Transactions: $R, S, T, \ldots$ $\qquad T\ \mathrm{WR}\,(m,\ z) \quad T\ \mathrm{RD}\,(n,\ y)$

Histories: $H, H', \ldots$ $\qquad H = \{T_1, T_2, T_3, T_4\}$, finite

(H, hb) $\quad \forall S, T \in H.\ T, S\ \mathrm{WR}\,(x,\ \_) \implies S = T$ or S hb T or T hb S



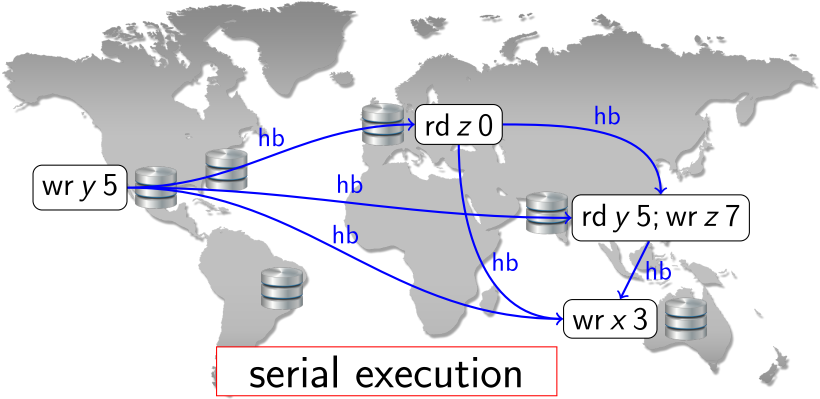
Definition SC: TRANSHB + EXT + TOTALHB

Transactions: $R, S, T, \ldots$ $\quad T\ \mathrm{WR}\,(m,\ z) \quad T\ \mathrm{RD}\,(n,\ y)$

Histories: $H, H', \ldots$ $\quad H = \{T_1, T_2, T_3, T_4\},$ finite

(H, hb) $\quad \forall S, T \in H.$

$$\frac{}{S = T \text{ or } S \text{ hb } T \text{ or } T \text{ hb } S}$$



serial execution

Robustness against PSI

behaviours of $\mathcal{P}$ $\stackrel{?}{=}$ behaviours of $\mathcal{P}$


PSI


SC

Idea: define ϕ s.t.

$$\forall (H, \mathsf{hb}) \in \textsc{psi}.\ \phi(H, \mathsf{hb}) \text{ implies } \exists\, \mathsf{hb}'.(H, \mathsf{hb}') \in \textsc{sc}$$

easy — show a total hb' over H s.t.

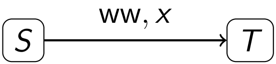
hard — reads return values written last according to hb'

Dynamic dependency graph

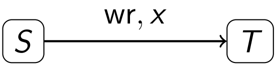
function

$$DDG(H, \text{hb}) = (H, \xrightarrow{\lambda})$$

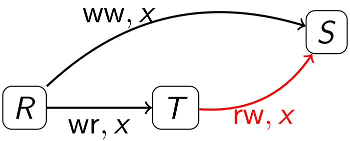
- T overwrites value written by S on x — S hb T

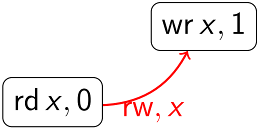


- T reads the value written by S on x — S hb T

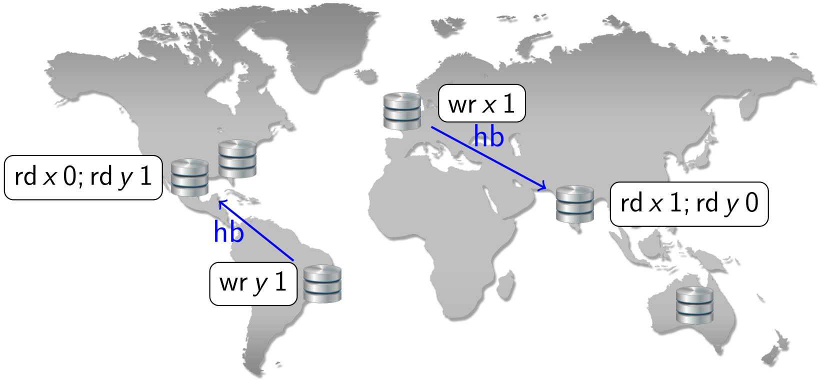


- S overwrites a value read by T

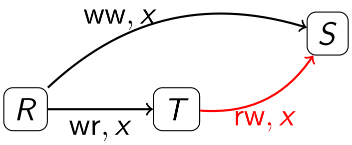


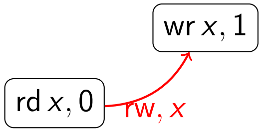


Dynamic dependency graph

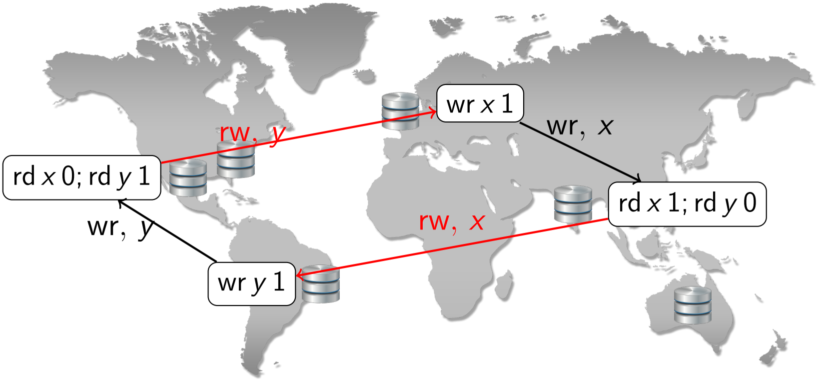


rw edges $\Rightarrow$ $DDG(H, \mathrm{hb})$ may contain cycles

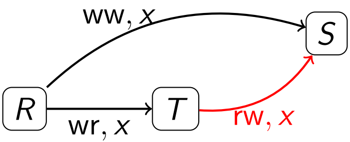


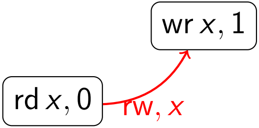


Dynamic dependency graph



rw edges ⇒ $DDG(H, \mathrm{hb})$ may contain cycles





Robustness against PSI

behaviours of $\mathcal{P}$  PSI $\stackrel{?}{=}$ behaviours of $\mathcal{P}$  SC

$\forall (H, \mathsf{hb}) \in \textsc{psi}.$

1. if acyclic($DDG(H, \mathsf{hb})$) then $\exists\ \mathsf{hb}'\ .(H, \mathsf{hb}') \in \textsc{sc}$

2. if $\exists$ total po hb' . hb' contains edges $DDG(H, \mathsf{hb})$ then

   reads return values written last according to hb'

   or default initial

Robustness against PSI

behaviours of $\mathcal{P}$

PSI

$\stackrel{?}{=}$

behaviours of $\mathcal{P}$

SC

$\forall(H, \text{hb}) \in \text{PSI}.$

1. if acyclic($DDG(H, \text{hb})$) then $\exists\ \text{hb}'\ .(H, \text{hb}') \in \text{SC}$

2. if $\exists$ total po hb′ . hb′ contains edges $DDG(H, \text{hb})$ then

   reads return values written last according to hb′

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As it is, useless for static analysis!

Robustness criterion

Cycle π in $DDG(H, \mathrm{hb})$ *PSI-critical* if

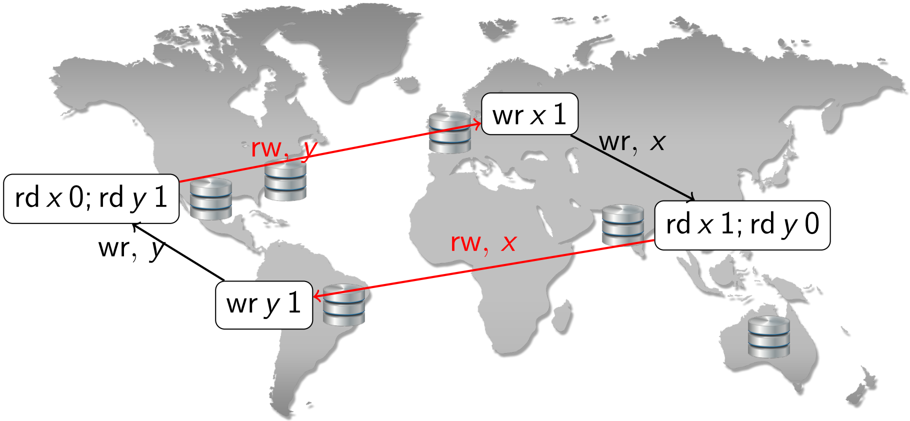
- π contains $S \xrightarrow{\mathrm{rw}, x} T, \quad S' \xrightarrow{\mathrm{rw}, y} T'$
- $x \neq y$

for all $(H, \mathrm{hb}) \in \mathrm{PSI}$

no critical cycles in $DDG(H, \mathrm{hb})$

implies

$$\exists\, \mathrm{hb}' \,.\, (H, \mathrm{hb}') \in \mathrm{SC}$$


wr x 1
wr, x
rd x 1; rd y 0
rw, x
wr y 1
wr, y
rd x 0; rd y 1
rw, y

in this talk

First robustness criterion for PSI

on going work

Reasoning techniques for geo-replicated DBs

- Uniform axiomatisation weak consistency levels
  - Paper to appear at CONCUR'15
- Systematic investigation robustness/chopping
  - First chopping criterion for SI — ask Andrea
- Checking robustness of applications against PSI
  - TPC-C, RUBiS, ...

That's the story.
Thank you

Questions?