INDUSTRIA 4.0 Processamento de Big Data



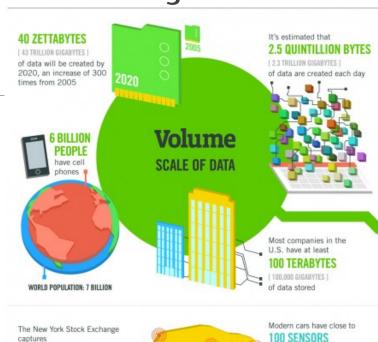
Aula #8 - Transações e concorrência

EDUARDO CUNHA DE ALMEIDA

Agenda

- Transações
- Atomicidade
- Consistência
- Isolamento
- Durabilidade

Transações criam e atualizam dados



captures

1 TB OF TRADE INFORMATION

during each trading session



Velocity

that monitor items such as

fuel level and tire pressure

ANALYSIS OF STREAMING DATA

By 2016, it is projected there will be

18.9 BILLION NETWORK CONNECTIONS

- almost 2.5 connections per person on earth



The FOUR V's of Big Data

break big data into four dimensions: Volume, Velocity, Variety and Veracity

4.4 MILLION IT JOBS



As of 2011, the global size of data in healthcare was estimated to be

150 EXABYTES



Variety DIFFERENT

FORMS OF DATA

PIECES OF CONTENT are shared on Facebook every month



30 BILLION



By 2014, it's anticipated there will be 20 MILLION **WEARABLE, WIRELESS** HEALTH MONITORS

4 BILLION+ HOURS OF VIDEO

are watched on YouTube each month

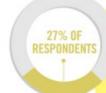


OO MILLION TWEETS

are sent per day by about 200 million monthly active users

1 IN 3 BUSINESS

don't trust the information they use to make decisions



in one survey were unsure of how much of their data was inaccurate



Poor data quality costs the US economy around

\$3.1 TRILLION A YEAR



Veracity UNCERTAINTY

OF DATA

Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

"Uma transação é uma sequência de uma ou mais operações de acesso em um banco de dados compartilhado."

ex: depositar R\$ 100,00



"Uma transação é uma sequência de uma ou mais operações de acesso em um banco de dados compartilhado."

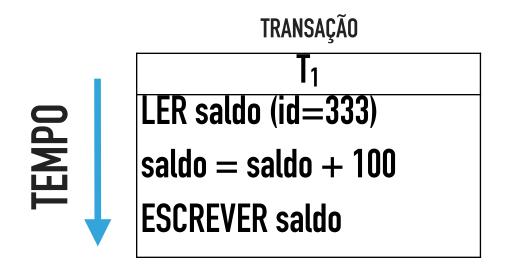
ex: depositar R\$ 100,00



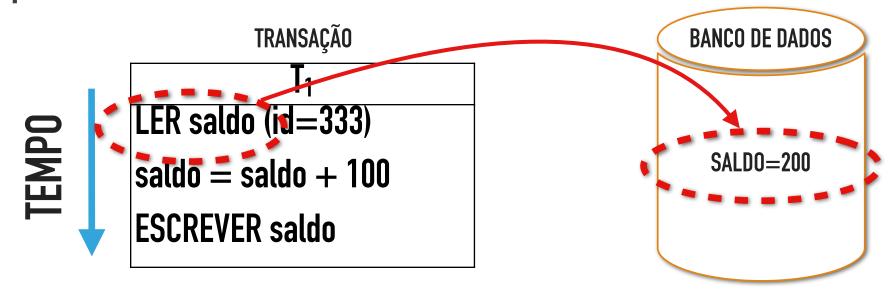
LER saldo R\$ 200,00 depositar R\$ 100,00 ATUALIZAR saldo R\$ 300,00

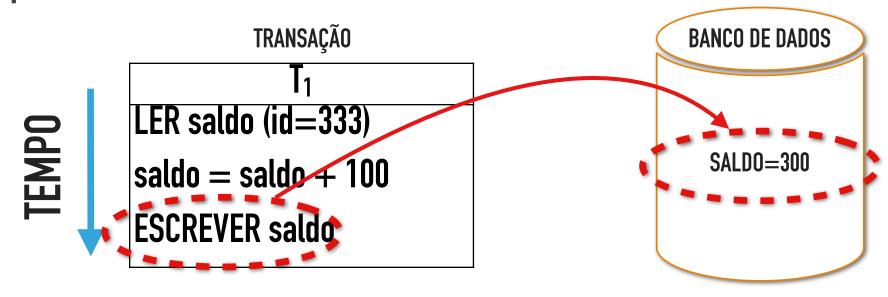




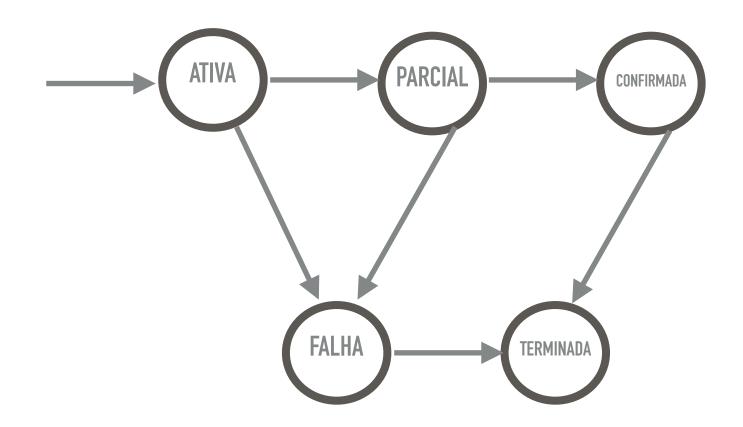




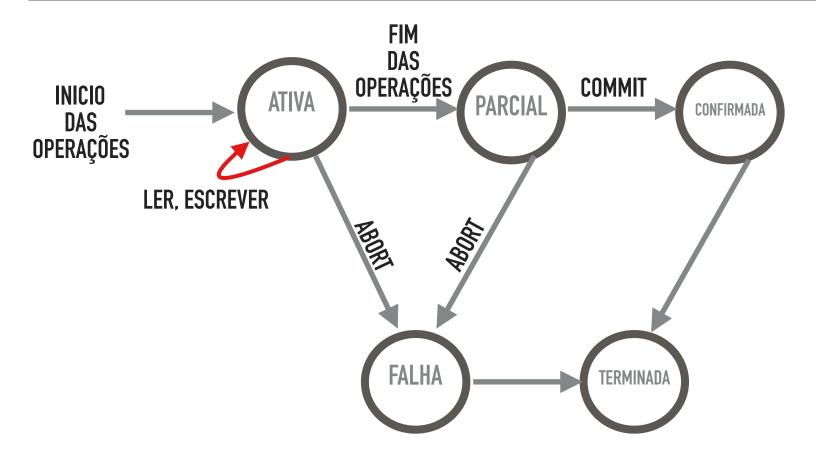




Estados de uma Transação



Estados de uma Transação



Propriedades de exatidão ACID

- Atomicidade: "tudo ou nada"
- Consistência: "parece correto"
- Isolamento: "como se estivesse sozinho"
- Durabilidade: "modificações persistem após commit"

- Logging: "caixa preta do avião"



Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

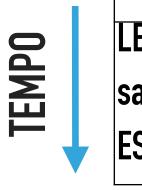
INSERT id=335, saldo=350

DELETE id=334

UPDATE saldo=90 (id=335)

•••

- Logging: "caixa preta do avião"



LER saldo (id=333)
saldo = saldo + 100
ESCREVER saldo

ESCRITAS

Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

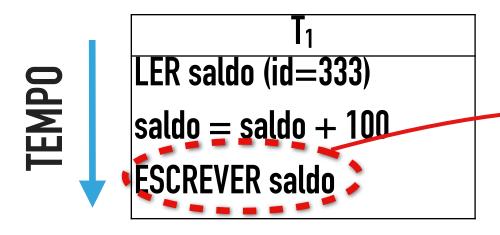
INSERT id=335, saldo=350

DELETE id=334

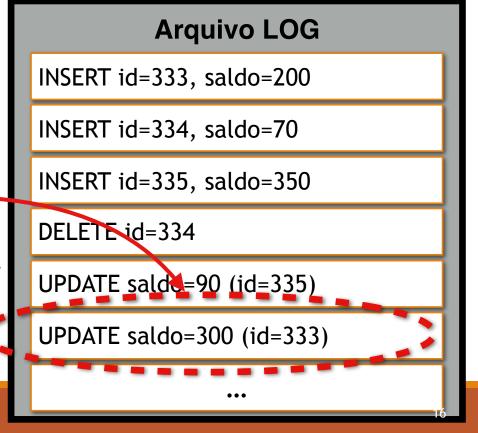
UPDATE saldo=90 (id=335)

•••

- Logging: "caixa preta do avião"







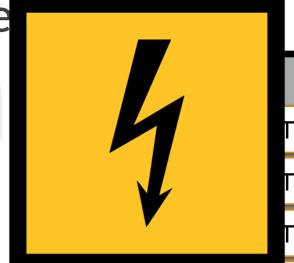
- Logging: "caixa pre

ex: falta de energia elétrica

TABELA



id	saldo
333	200
334	70
335	90



Arquivo LOG

T id=333, saldo=200

T id=334, saldo=70

T id=335, saldo=350

DELETE id=334

UPDATE saldo=90 (id=335)

UPDATE saldo=300 (id=333)

• • •

- Logging: "caixa preta do avião"

TABELA



id	saldo
333	200
334	70
335	90



Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

INSERT id=335, saldo=350

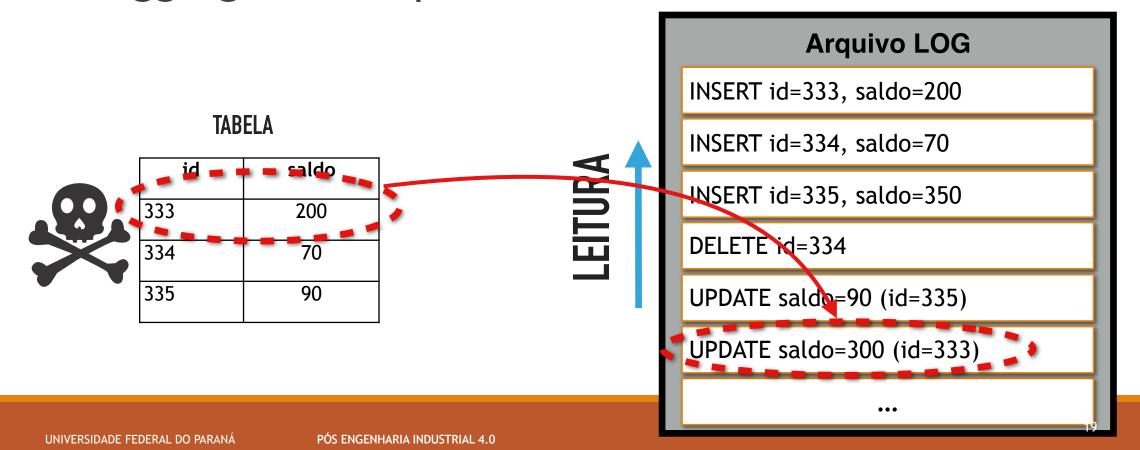
DELETE id=334

UPDATE saldo=90 (id=335)

UPDATE saldo=300 (id=333)

•••

- Logging: "caixa preta do avião"



- Logging: "caixa preta do avião"

TABELA id saldo 333 300 DELETE id 334 90

Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

INSERT id=335, saldo=350

UPDATE saldo=90 (id=335)

UPDATE saldo=300 (id=333)

- Logging: "caixa preta do avião"

TABELA id saldo 333 300 334 70 335 90

LEITURA

Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

INSERT id=335, saldo=350

DELETE id=334

UPDATE saldo=90 (id=335)

UPDATE saldo=300 (id=333)

•••

- Logging: "caixa preta do avião"

TABELA

id	saldo
333	300
335	90



Arquivo LOG

INSERT id=333, saldo=200

INSERT id=334, saldo=70

INSERT id=335, saldo=350

DELETE id=334

UPDATE saldo=90 (id=335)

UPDATE saldo=300 (id=333)

•••

Isolamento

Transações concorrentes não se interferem



T ₁	T ₂
operação	operação

TEMPO

Problemas de Isolamento (1)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 100,00

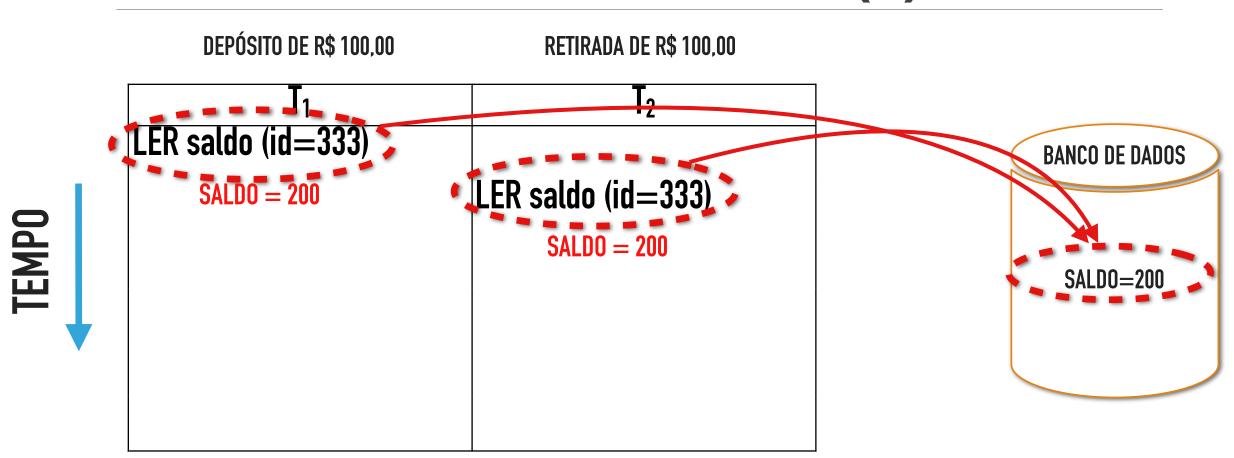
T_1	T_2
LER saldo (id=333)	
	LER saldo (id=333)
saldo = saldo + 100	
	saldo = saldo - 100
ESCREVER saldo	
	ESCREVER saldo

BANCO DE DADOS

SALDO=200

ESPERADO APÓS T₁ E T₂ SALDO=200

Problemas de Isolamento (1)



TEMP0

Problemas de Isolamento (1)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 100,00

T_1	T ₂
LER saldo (id=333)	
SALDO = 200	LER saldo (id=333)
saldo = saldo + 100	SALDO = 200
SALDO = 300	saldo = saldo - 100

BANCO DE DADOS

SALDO=200

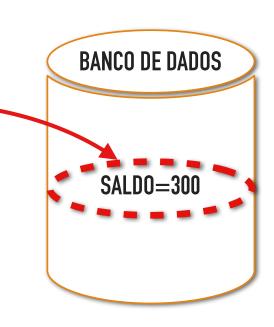
Problemas de Isolamento (1)

DEPÓSITO DE R\$ 100,00

TEMP0

RETIRADA DE R\$ 100,00

 $T_1 \qquad T_2$ LER saldo (id=333) saldo = saldo + 100 saldo = saldo + 100 saldo = saldo - 100 $ESCREVER saldo \qquad SALDO = 100$

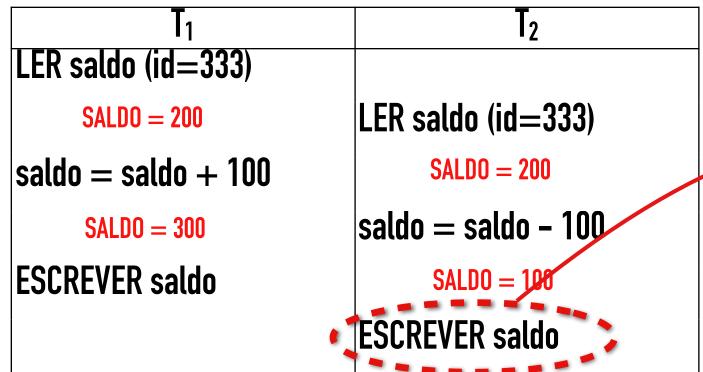


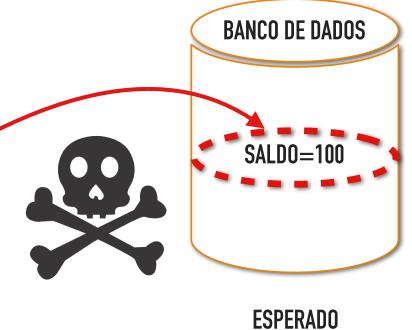
TEMP0

Perda de atualização

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 100,00





SALDO=200

TEMPO

Problemas de Isolamento (2)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 300,00

- 4
R saldo (id=333)
ldo = saldo - 300
CREVER saldo

SALDO=200

ESPERADO COM ABORT T₁ SALDO=-100

TEMPO

Problemas de Isolamento (2)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 300,00

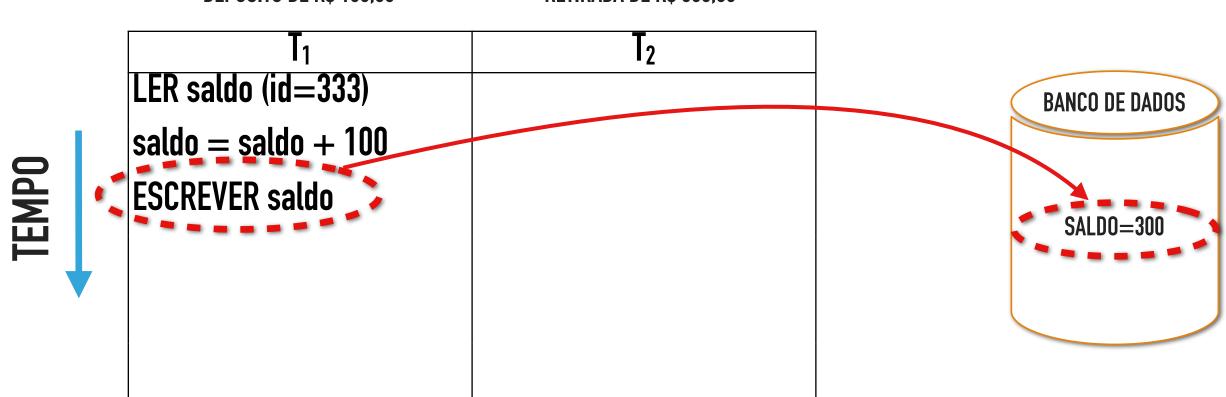
T ₁	T ₂
LER saldo (id=333)	
saldo = saldo + 100	
ESCREVER saldo	
	LFR saldo (id=333)
ABORT	saldo = saldo - 300
	ESCREVER saldo



Problemas de Isolamento (2)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 300,00



TEMPO

Problemas de Isolamento (2)

DEPÓSITO DE R\$ 100,00

RETIRADA DE R\$ 300,00

T ₁	T ₂
LER saldo (id=333)	
saldo = saldo + 100	
ESCREVER saldo	
	LER saldo (id=333) SALDO = 300
	saldo = saldo - 300

BANCO DE DADOS

SALDO=300

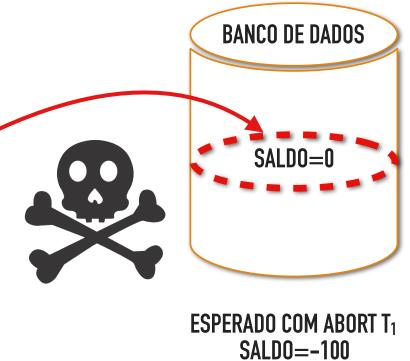
Perda de leitura

DEPÓSITO DE R\$ 100,00

TEMP0

RETIRADA DE R\$ 300,00

12 LER saldo (id=333) saldo = saldo + 100**ESCREVER** saldo LER saldo (id=333) **ABORT** saldo = saldo - 300



Mecanismo pra manter Isolamento

- Pessimista: "evitar que aconteça um problema"
- Otimista: "tratar o problema quando acontecer"

Mecanismo pra manter Isolamento

Reorganizar agenda de operações

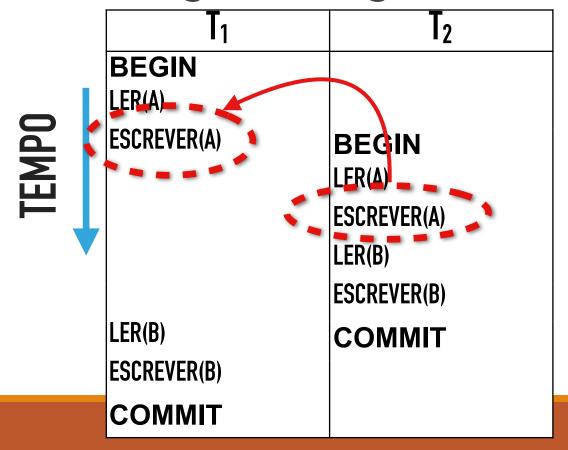
	l 1	12
	BEGIN	
	LER(A)	
LEMP0	ESCREVER(A)	BEGIN
		LER(A)
= 1		ESCREVER(A)
		LER(B)
		ESCREVER(B)
	LER(B)	COMMIT
	ESCREVER(B)	
	COMMIT	

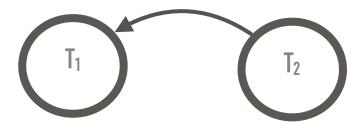




Mecanismo pra manter Isolamento

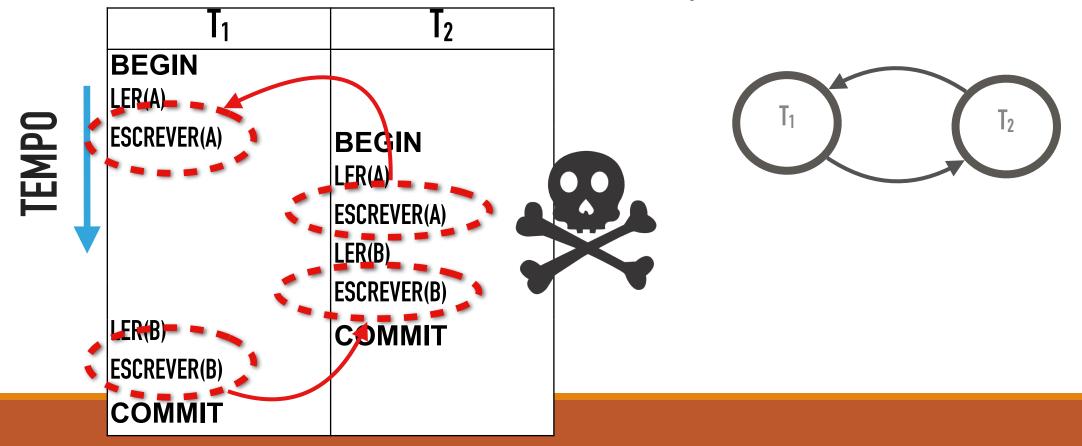
Reorganizar agenda de operações





Mecanismo pra manter Isolamento

Reorganizar agenda de operações



Mecanismo pra manter Isolamento

Reorganizar agenda de operações

	T_1	T_2
	BEGIN	
	LER(A)	
2	ESCREVER(A)	
LEMP0	LER(B)	
⊨ ↓	ESCREVER(B)	BEGIN
	COMMIT	LER(A)
		ESCREVER(A)
		LER(B)
		ESCREVER(B)
		COMMIT

Execução serial!!!

Teste de Conflito de Serialidade

- Criar nó para cada Ti do agendamento S
- Criar aresta $T_i \longrightarrow T_j$ para cada r(x) em T_i depois de w(x) em T_j
- Criar aresta $T_i \longrightarrow T_j$ para cada w(x) em T_i depois de r(x) em T_j
- Criar aresta $T_i \longrightarrow T_j$ para cada w(x) em T_i depois de w(x) em T_j
- Agendamento S é serializável se não existe ciclo

Legenda: r(x) leitura do atributo "x", ex. r(saldo) w(x) escrita do atributo "x", ex. r(saldo)

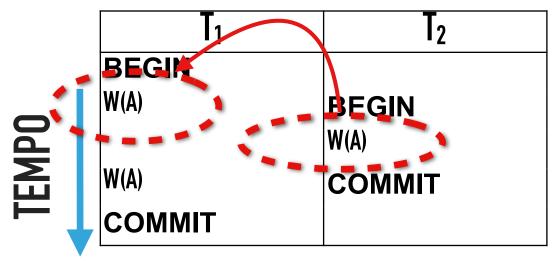
Exemplo

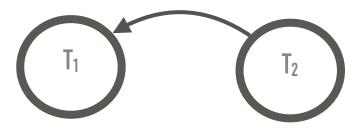
	I ₁	
	BEGIN	
	W(A)	BEGIN
		W(A)
TEMP0	W(A)	СОММІТ
	COMMIT	



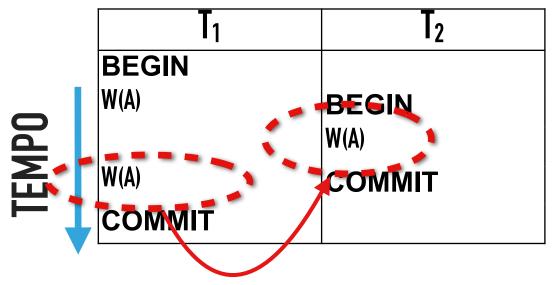


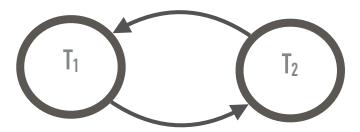
Exemplo





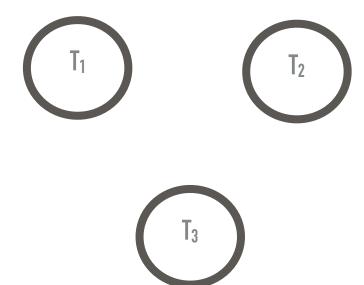
Exemplo





Exercício

	I_1	T_2	T ₃
	BEGIN		
	R(A)		BEGIN
P0			R(A)
TEMP0	W(A)	BEGIN	
F		R(A)	
		COMMIT	W(A)
	COMMIT		COMMIT



Mecanismo pra manter Isolamento

Protocolos para manter a "serialidade" dos agendamentos

- Bloqueio
- MVCC (timestamp)
- Certificação

Consistência do banco de dados

Banco de dados representa o mundo real de forma precisa e segue restrições de integridade.

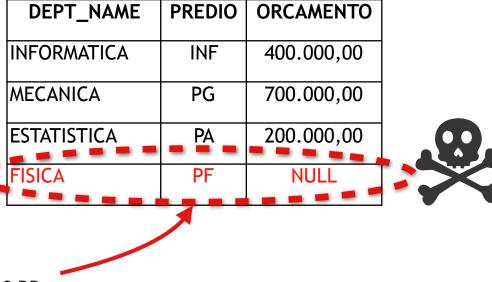
Transações no futuro observam os efeitos das transações passadas no banco de dados.

Restrições NOT NULL

DEPT_NAME	PREDIO	ORCAMENTO
INFORMATICA	INF	400.000,00
MECANICA	PG	700.000,00
ESTATISTICA	PA	200.000,00

Restrições NOT NULL

TABELA: DEPARTAMENTO



NAO PERMITIDO PELO BD

Restrições: Cláusula CHECK

DEPT_NAME	PREDIO	ORCAMENTO
INFORMATICA	INF	400.000,00
MECANICA	PG	700.000,00
ESTATISTICA	PA	200.000,00

Restrições integridade referencial

```
CREATE TABLE DEPARTAMENTO(
DEPT_NAME VARCHAR(8) PRIMARY KEY,
PREDIO VARCHAR(4),
ORCAMENTO FLOAT NOT NULL
);
```

DEPT_NAME	PREDIO	ORCAMENTO
INFORMATICA	INF	400.000,00
MECANICA	PG	700.000,00
ESTATISTICA	PA	200.000,00

Restrições integridade referencial

CREATE TABLE DEPARTAMENTO(

DEPT NAME VARCHAR(8) PRIMARY KEY,

DDEDIO WARALIA

CREATE TABLE PROFESSOR(

VARCHAR(5) PRIMARY KEY,

NOME VARCHAR(40),

SALARIO CHECK (SALARIO > 900.0),

FOREIGN KEY DEPT_NAME REFERENCES (DEPARTAMENTO)

);

TABELA: DEPARTAMENTO

DEPT_NAM	ΙE	PREDIO	С	RCAMENTO	
INFORMATICA	ID	INF NOME		400 000 00 SALARIO	DEPT_NAME
MECANICA ESTATISTICA	1	JOSE		1200,00	ESTATISTICA
LSTATISTICA	2	MARIA		3000,00	INFORMATICA
	3	PEDRO		3000,00	INFORMATICA
	4	PABLO		8000,00	MECANICA

TABELA: PROFESSOR

Restrições integridade referencial

CREATE TABLE DEPARTAMENTO(

DEPT NAME VARCHAR(8) PRIMARY KEY,

CREATE TABLE PROFESSOR(

VARCHAR(5) PRIMARY KEY,

VARCHAR(40),

SALARIO CHECK (SALARIO > 900.0),

FOREIGN KEY DEPT NAME REFERENCES (DEPARTAMENTO)

NAO PERMITIDO PELO BD

	DEPT_NAM	١E	PREDIO	C	DRCAMENTO	
ľ	INFORMATICA		INF NOME		400 000 00 SALARIO	DEPT_NAME
ł	MECANICA					_
ļ		1	JOSE		1200,00	ESTATISTICA
	ESTATISTICA	2	MARIA		3000,00	INFORMATIC <i>A</i>
		3	PEDRO		3000,00	INFORMATIC <i>A</i>
		4	PABLO		8000,00	MECANICA
		5	MARCUS		8000,00	FISICA
PI	LO BD	TABELA: PROFES				SSOR SSOR

Restrições: Asserções

Asserções são generalizações das restrições anteriores.

```
CREATE TABLE DEPARTAMENTO(
DEPT_NAME
PREDIO
ORCAMENTO
);

CREATE ASSERTION ORACAMENTO_CONST CHECK(
NOT EXISTS (SELECT DEPT_NAME
FROM DEPARTAMENTO
WHERE
ORACAMENTO < 0.0)
);
```

Durabilidade das transações

Atualizações de **transações falhas** não são escritas no banco de dados.

Registros de arquivos de log (e shadow paging) podem ser usados para garantir a durabilidade.

Transações no mundo real?



1800 txn/sec



1milhão txn/sec



9 bilhões txn/dia

OLTP continua hot topic!!!

High Performance Transactions via Early Write Visibility

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Joseph M. Hellerstein UC Berkeley hellerstein@berkeley.edu

ABSTRACT In order to guarantee recoverable transaction accustion, daubase systems permit armanisms whites to be observable only at the ord of its energian. As a connection where it generally a delay between the same a transaction performs where the present of transaction transaction performs the same and transaction performs the performance of serializable daubase transactions are permitted to useful and according to the performance of serializable daubase continuous memory and according to the performance of serializable daubase and management of the performance of serializable daubase and management of the performance of serializable daubase and management of the performance of serializable daubase and the performance of the performance of serializable daubase and the performance of the p

can significantly impact the performance of serializable dashane with the control of the control tism' series visible grier to the end of their enecution. We design a new serializable concurrency control protocol, piece where visibility (PWV), with the explicit grin of enabling engly write visibility. We couldnet PWV against state of the serializable personols and a highly opinismed implementation of rend committed and find that PWV can outselferine serializable protocols by an order of magni-tude and rend committed by 3X on high contention workloads.

1. INTRODUCTION Over the past decade, concurrency control research has seen are-Over the past decade, concurrency control research has seen a re-naissance due to the abustiance of parallelism in milit-core servers and datecenters. Modern certaintable persocols are explicitly de-signed to explore this abustiant parallelism [17,19,28–30,32,37,38, 4,46]. While these new procords propose morel instinumecha-nisms that address the incompubility between conventional con-currency control protocols and massively parallel consensuents, control protocols and massively parallel consensuents, there our delates for procordinal life 1121 flort use decades ed.d. Xukand currency control protection and massively parallel environments, they use ideas for recoverability [12] that are decades odd. Indeed, the last widely-adopted concerns on recoverability, group control 1221, was proposed on the 1980s. These conventional concernency forms of the 1980s, these conventional concurrency forms a workload.

concurrency from a workload.

Recoverability is the property that all of a committed tunsaction's writers arounded starker, and that more of an aborded tunsaction's writers are made durable or observed by the starker of the starker

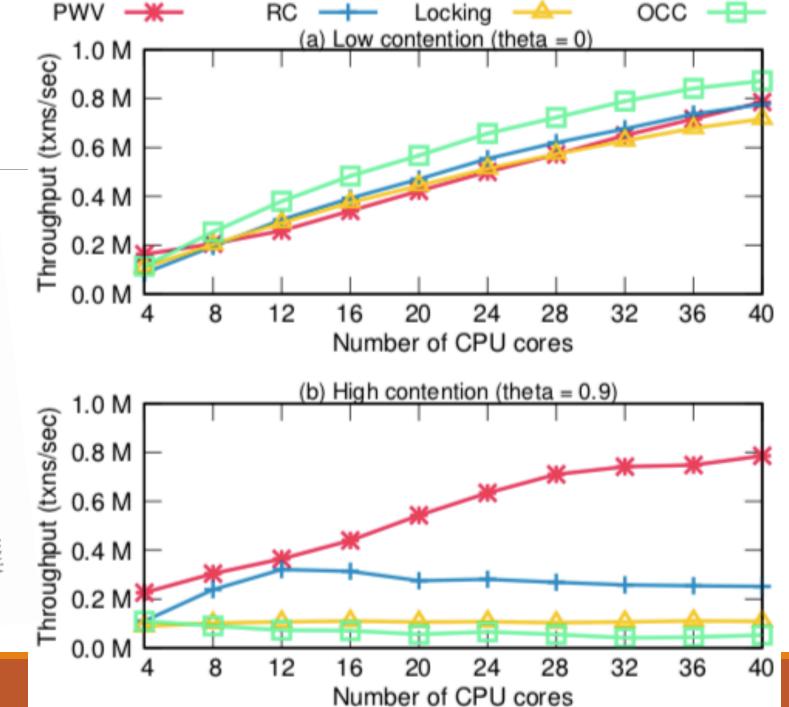
anyuse beyonder indoffvidborg. Proceedings of the VLDB Endowment, Vol. 10, No. 5 Proceedings of the VLDB Endowment 2150-8097/17/01. Copyright 2017 VLDB Endowment 2150-8097/17/01.

it commits or at least finishes executing [16,22]. These protocols effectively delay making a transaction's writes visible. This write visible of the control of the contro

optimistic validation errors, or sampo
quant resources that are in short supply. Databate oy steems' ability
to substantly short manusciones forces recoverability mechanisms
to make extremely remismatic assumptions along the whom a transcition's writers are shown being solided local.

This poper makes the case for certaining shathness system with
the stransactions. We
system only aborts transactions. We
system only aborts transactions
the
next care to show the care care and
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next care of the
system only aborts transactions
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statements
so and
so are
very
switch
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description,
cardy write
cardy, which can salve
that
convergence,
can
care
so the
cardy
statement
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convergence,
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care
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a preceding measurement whose as an as transaction commits, even if a preceding writes visible as soon as a transaction hore not yet executed on more pieces of the same transaction hore not yet executed by performing a data of measurement of the preceding a data of the properties o



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