Integrating Reliable Memory in Databases

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Objectives

Introduce the Rio file cache

software-based reliable memory

Examine three different ways of using reliable memory and their implications

I/O interface: non-persistent database buffer cache memory interace: persistent database buffer cache protected memory interface: protected persistent database buffer cache

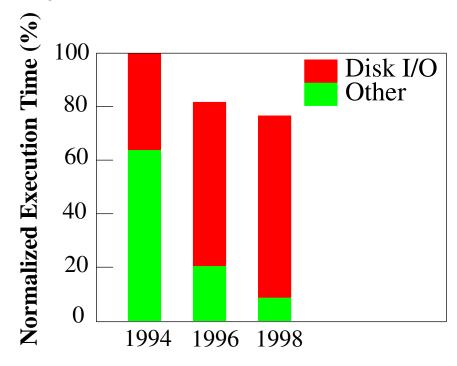
Show quantitatively that it is safe to mmap reliable memory directly into database address space

simplify database design

significant performance advantage

Reliable Memory Reliable memory = main memory as safe as disk from operating system crashes

Reliable memory is important for current and future database systems [Rosenblum95]

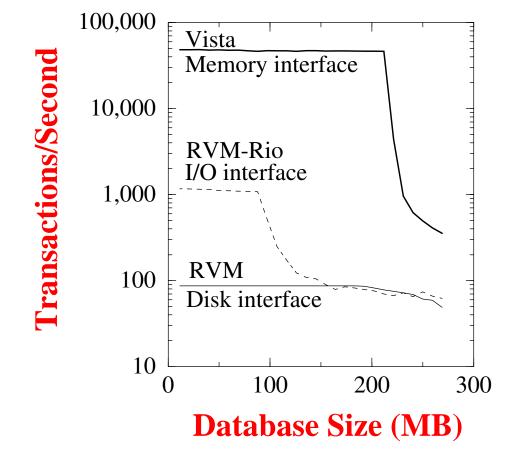


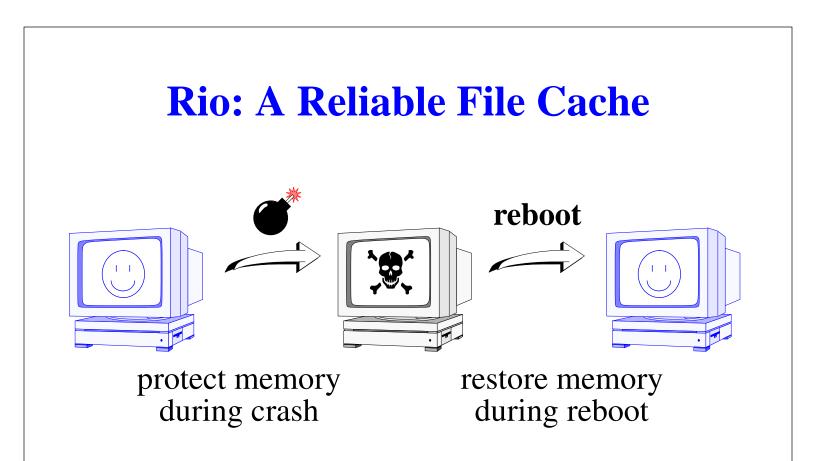
Benefits of Reliable Memory

Simplify database design

fast recovery (no redo log, checkpt, warm cache) direct control of buffer cache (optimized for DB) simpler and smaller code (less bugs)

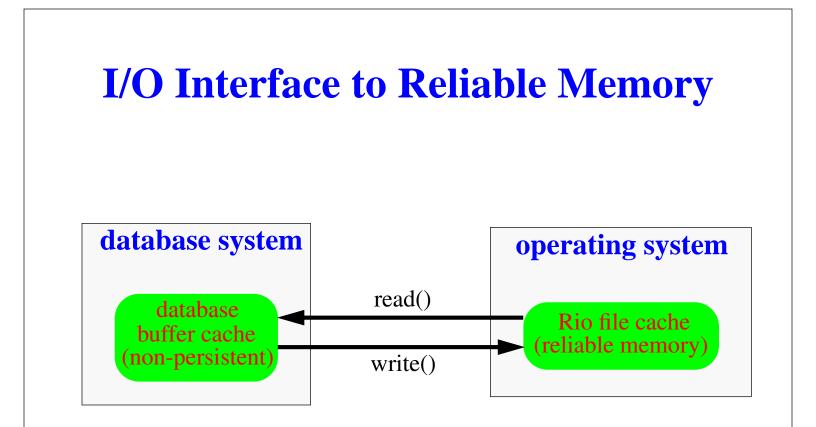
Significant performance improvements





Remove reliability-induced writes to disk (sync, fsync, bwrite, bawrite)

Makes memory safe from operating system crashes, requires no hardware

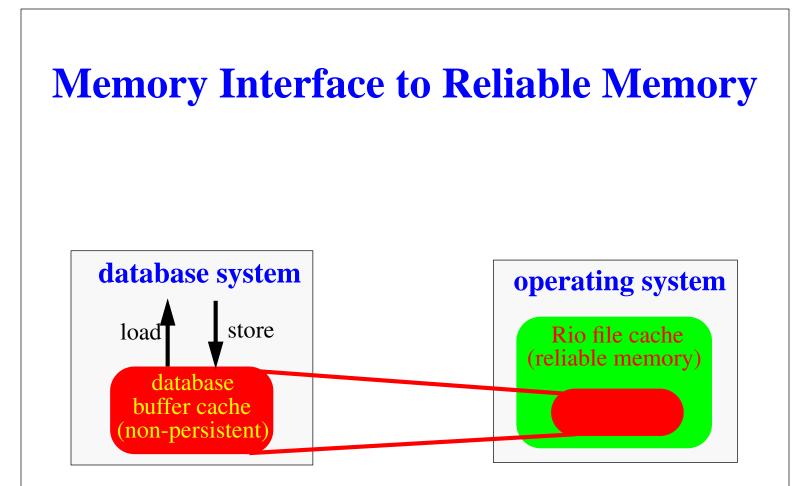


Benefits

- + performance improvement without any change to application code
- + as safe as standard database from operating system crashes

Drawbacks

- performance (we can do better)
- double buffering

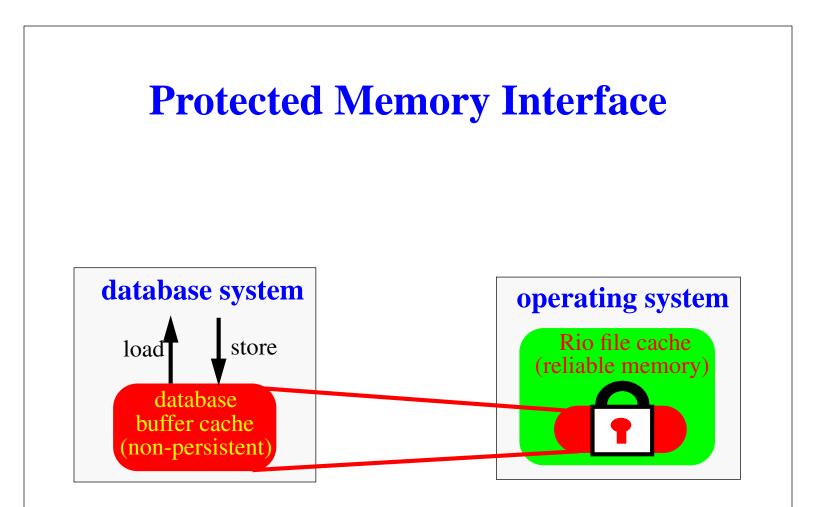


Benefits

- + significant performance improvements
- + simplify database design
- + safe from operating system and database failures

Drawbacks

- require some changes in database design
- increase database's vulnerability to software errors



Benefits

- + same as memory interface
- + minimize database's vulnerability to software errors

Drawbacks

- affect performance due to protection overheads
- does it really help?

Fault Models

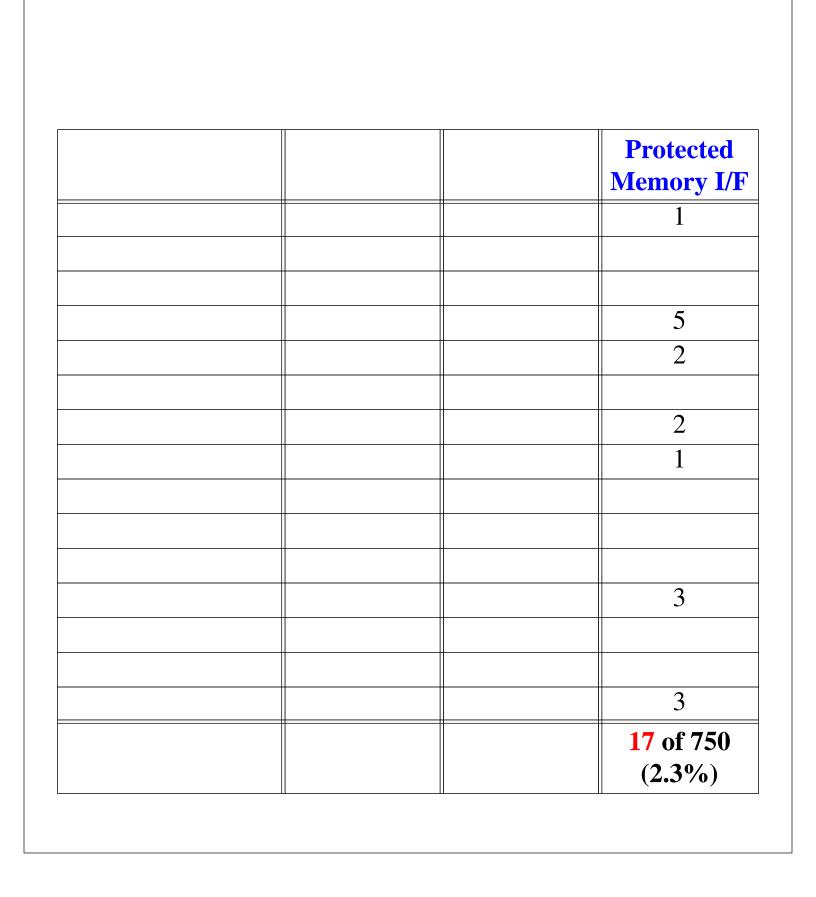
Goal is wide variety and realism [Sullivan91]

Fault Type	Example of Programming Error
destination register	<pre>numFreePages = count(freePageHeadPtr)</pre>
source register	numPages =physicalMemorySize/pageSize
delete branch	if white () {body}
delete random inst.	for (i=0; i<10; i++,j++) {body}
initialization	function () {int $i > 0;$ }
pointer	ptr = ptr->next->next;
allocation	<pre>ptr = malloc(); use ptr; use ptr; free(ptr);</pre>
copy overrun	for (i=0; i <size <math="">bscd; i++) {a[i] = b[i]};</size>
off-by-one	for (i=0; i 🔀 <= size; i++)
synchronization	getWriteLock; write(); freeWriteLock;
memory leak	{code} free(ptr); {more code}
interface error	insert(bufTemp, index);

Reliability Results

Fault Type	I/O Interface	
kernel text	1	
kernel heap		
kernel stack		
destination register	4	
source register	2	
delete branch	1	
delete random inst.	2	
initialization		
pointer		
allocation		
copy overrun		
off-by-one	5	
synchronization		
memory leak		
interface error	4	
Total	19 of 750 (2.5%)	

	Memory Interface	
	1	
	5	
	2	
 	1	
	2	
	5	
 	3	
	20 of 750	
	(2.7%)	



Conclusions

Reliable memory yields huge benefits, particularly when using a memory interface to it (persistent buffer cache)

Memory interface does not hurt reliability, so we should use it

Need to verify our findings on commercial database

More information available at

http://www.eecs.umich.edu/~pmchen/